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Lyttelton Harbour Extensions

NEW ZEALAND.

REPORT

— BY —

Messrs. COODE, SON & MATTHEWS,

16th APRIL, 1908.

Accompanied by Eight Drawings.

Also Memorandum by CYRUS J. R. WILLIAMS,

Engineer Lyttelton Harbour Board, dated 12th June, 1908.

CHRISTCHURCH:
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LYTTELTON HARBOUR EXTENSIONS,

NEW ZEALAND.

THE CHAIRMAN
LYTTELTON HARBOUR BOARD,
NEW ZEALAND.

WESTMINSTER CHAMBERS
9 VICTORIA STREET, LONDON, S.W.
16TH APRIL, 1908

SIR —

In June 1906 we received a letter from the High Commissioner of New Zealand informing us that he had been desired by his Government to obtain for the Lyttelton Harbour Board expert advice as to the practicability of certain schemes set out in a report of the Engineer to the Board (copy of which was forwarded to us) "for the provision of further Harbour Extensions and of a Canal from the sea towards "Christchurch and also upon any other scheme for connecting Christchurch with the sea that may "commend itself to the expert after inspection of the surrounding country." The High Commissioner further desired to know if we would be willing to undertake to advise the Board in the sense desired.

2. On the 16th July following we replied expressing our willingness to undertake the duties required, proposing that our partner, Mr. M. F. G Wilson, should visit Christchurch for the purpose of making the necessary investigation upon the spot and of arranging for the preparation of such data and particulars as might be necessary for the proper consideration of the subject after his return home and for the preparation of such report, plans and estimates as might be required. We further made our proposals with regard to the payment to be made to us for our services and expenses in connection therewith.

3. On the 10th November 1906, the High Commissioner wrote to inform us that he had received the following cable message from New Zealand :—

> "Lyttelton Harbour Board authorise you to accept Coode, Son and Matthews' offer as "mentioned in their letter of 16th July last to investigate and report on Harbour questions at "Lyttelton and Christchurch, including Ship Canal, and would like visiting Engineer to come to "Colony as soon as possible."

We accordingly communicated by cablegram with Mr. Wilson, who was at the time in Singapore engaged upon professional work, and arranged with him to proceed to Christchurch for the purpose of the investigation, and on November 21st we wrote to the High Commissioner, informing him that Mr. Wilson would leave Colombo for Christchurch on the 29th of the following month.

4. Mr. Wilson duly arrived at Christchurch on 25th January, 1907, and the same day met Mr. Waymouth, then Chairman of the Lyttelton Harbour Board, in company with the Board's Secretary, Mr. Hood Williams, and Engineer, Mr. Cyrus Williams.

5. The following day Mr. Wilson attended a meeting of a Committee of the Board, specially appointed in connection with his visit. At this meeting the general scope of the enquiry was discussed, and it was explained to Mr. Wilson that the Board desired that our report should deal with the Engineering features of the proposals and the cost of the same, but it was not desired that we should deal with the financial aspect, or with questions of policy as affected thereby. They then visited Lyttelton and Sumner, and inspected the sites of the proposed harbour extensions and canal entrance, after which Mr. Wilson, in company with Mr. Cyrus Williams, commenced a thorough investigation, by examination on the ground and enquiry, of all questions affecting the proposals for increased harbour accommodation at Port Lyttelton and for the construction of a canal and docks in the neighbourhood of Christchurch. These investigations occupied Mr. Wilson up to the 18th February, upon which day he left for Auckland, en route for England. Here he was unfortunately delayed owing to the breakdown of the steamship service, and it was not until March 24th, that he was enabled to sail for San Francisco. While so delayed Mr. Wilson paid a visit to Gisborne at the invitation of the Gisborne Harbour Board, in connection with which he had some correspondence with your Board.

6. Before leaving Christchurch Mr. Wilson made arrangements with Mr. Cyrus Williams for taking certain borings and for the preparation of plans and photographs and other information which would be required in connection with this report. These documents, together with samples of the borings, were duly despatched, and were received by us in October of last year.

7. We desire here to express our regret at the somewhat long interval which has elapsed since the receipt of these documents and the completion of this report. The delay has been quite unavoidable, and is due to a great press of work in connection with the starting of some large works at Singapore, and also in connection with some extensive works in progress on the West Coast of Africa. We sincerely trust that the Board will have experienced no inconvenience on account of this delay which, as above stated, has been quite unavoidable.

8. Having now had an opportunity of fully studying the whole question, we are in a position to present this report.

Mr. Williams Report.

9. Mr. Williams has submitted in his report two main propositions, whereby the harbour or dock accommodation necessary for the increasing trade of Christchurch and the surrounding district may be obtained, as follows :—

(1) To increase the present harbour accommodation in the Port of Lyttelton.

(2) To form a large wet dock, provided with the necessary quays and jetties, in the neighbourhood of Christchurch, and to give access thereto by means of a canal from the sea at Sumner, the entrance to the canal being protected by rubble stone moles.

Alternative Schemes.

10. We are requested in our instructions already referred to, to report upon any other scheme for connecting Christchurch with the sea which may commend itself to us.

General as to Canal Scheme.

11. The City of Christchurch is situated upon Canterbury Plain, at the foot of the high, mountainous ground of volcanic origin known as Banks Peninsula. To the east of Christchurch the plain extends continuously to the sea, the coast being from 3 to 4 miles distant. The general surface level in the neighbourhood of the city is about 14 feet above high water, dropping to about 2 feet above high water at the estuary of the Avon and Heathcote Rivers. The material in the neighbourhood of the city consists almost entirely of hard, grey shingle and gravel intermixed with varying proportions of sand and silt, and is in general quite permeable to water. This formation extends to a great depth below the surface, as has been proved by numerous borings which have been made for water supply by means of artesian wells. A little to the eastward of Christchurch, the gravel is gradually replaced by fine sand, and it is through this latter material that the canal, as proposed by Mr. Cyrus Williams, would for the most part be formed. Southward of Christchurch, the nearest point at which the Canterbury Plain reaches to the coast is at the northern end of " Ninety Mile " Beach, just to the southward of the high ground of Banks Peninsula. The distance from Christchurch to the sea is here upwards of 20 miles, which would render the cost of constructing a canal in this direction prohibitive. In addition to this, such a canal would open upon a beach exposed to the full force of the S.E. gales which at times blow with great violence, whereas Sumner beach is much protected from the S.E. by Banks Peninsula. Moreover, there is a great travel of shingle along " Ninety Mile " Beach, as already experienced at Timaru, which would render it impracticable to maintain the necessary depth of water at the canal entrance. We have, therefore, no hesitation in saying that if Christchurch is to be connected with the sea by a canal, the only feasible method of accomplishing this end must be, speaking generally, somewhat upon the lines proposed by Mr. Williams.

Scope of Report.

12. We purpose, therefore in the following remarks, to discuss the harbour and canal schemes as proposed by Mr. Williams, making suggestions as to such modifications in the same as may appear to us to be desirable.

Drawings.

13. In order that the various questions discussed, and the accommodation set forth, may clearly be understood we have prepared the following drawings :

Drawing No. 1 is a general plan of the district showing the relative positions of the various places referred to in this report.

Drawing No. 2 is a similar plan whereon are shown the schemes proposed by Mr. Cyrus Williams.

Drawing No. 3 shows in a similar manner our own proposals.

Drawing No. 4 is an enlarged plan of Port Lyttelton showing Mr. Williams' proposal for a harbour at Gollan's Bay.

Drawing No. 5 is a similar plan showing our own proposal for a harbour at Gollan's Bay.

Drawing No. 6 is an enlarged plan of the estuary of the Rivers Avon and Heathcote, and including Sumner Head. On this plan is shown Mr. Williams' scheme for a dock at Heathcote connected with the sea by a canal.

Drawing No. 7 is a similar plan showing our own proposal for a canal and dock.

Drawing No. 8 gives typical cross sections in connection with our proposals.

14. It will be observed from the notes upon the plans that they have been prepared from the Admiralty Chart, from maps of the New Zealand Survey Department, and from drawings supplied by Mr. Cyrus Williams. In compiling these plans several discrepancies were discovered between the different plans and the Chart, but wherever available the ground line as shown upon the drawings furnished by Mr. Cyrus Williams has been adopted. Should it ultimately be decided to carry out any of the works now proposed, we would point out the extreme desirability of having a complete and correct survey of the whole site of the works prepared before the detail drawings are proceeded with.

HARBOUR EXTENSION AT PORT LYTTELTON.

15. We propose in the first instance to deal with the proposed Harbour Extension in Port Lyttelton.

Present Harbour.

16. The present harbour at Lyttelton is formed by two rubble stone moles, the western mole extending from Naval Point for a length of about 1,480 feet, the eastern mole commencing at Officer's Point and extending for a length of about 2,000 feet. The area enclosed is about 107 acres, with a clear width of entrance of about 550 feet. Within the harbour, jetties and breastworks (or wharves) have been constructed for the accommodation of vessels, the total length of these works, reckoning both sides of the jetties, being given as 12,847 lineal feet, of which 5,841 lineal feet is available for ocean steamers. At present the middle section of the harbour, wherein are placed the jetties is maintained by dredging to a depth of 25 feet below low water of ordinary spring tides, and we understand that the eastern portion of the harbour is now being dredged to that depth preparatory to the erection of two new jetties for the accommodation of ocean steamers. The harbour is approached by means of a channel about 7,000 feet in length and 400 feet in width, dredged to a depth of 24 feet, but now being deepened to a depth of 28 feet at low water of spring tides.

Deposit of Silt within Harbour.

17. Although from a comparison of recent soundings taken by Mr. Cyrus Williams, with those given upon the Admiralty Chart of 1849, it appeared that no general diminution of depth was apparent within Port Lyttelton, nevertheless, within the harbour and the dredged channel considerable deposit takes place, necessitating a large amount of dredging for maintenance purposes, which will now doubtless be augmented due to the increased area of deep water to be maintained within the harbour itself and to the increased depth of channel to which allusion has been made above.

Necessity for Extension.

18. Mr Williams, in his report, quotes figures to show that the trade of the Port has maintained for some years a large and steady increase, and he gives a table and diagram indicating the probable trade in future years. It is not desirable to place entire reliance upon the rate of increase shown by such tables being continued for many years, but it may be stated that the returns up to the end of 1906 showed the rate of increase to be fully maintained, and there is apparently no reason to anticipate any falling off in the near future.

19. We understand, as above referred to, that owing to this increase of trade the Board are about to proceed with the construction of two new jetties within the existing harbour which will no doubt provide for immediate requirements. Meantime it becomes desirable to consider how still further accommodation, which it is reasonable to expect will in the course of some years show itself to be necessary, can best be afforded.

20. One of the first points to be considered in connection with harbour extension is the draught, together with the general dimensions of the vessels likely to use the Port.

Draught and Dimensions of Vessels.

21. With regard to the draught of vessels, Mr. Wilson was informed by the Committee that the Harbour Board had decided that a depth of at least 30 feet below low water ordinary spring tides should be provided, and the matter was further considered in New Zealand and valuable information kindly

afforded by Mr. Bennett (Manager of the New Zealand Shipping Company), Captain Bone (Marine Superintendent of that Company), Captain McDougall (of the Shaw, Savill and Albion Company), and others, from which it appeared that they considered the maximum draught of vessels would be from 27 feet to 28 feet. We have since been in communication with the London offices of the New Zealand Shipping Company and Messrs. Shaw Savill and Albion Company with regard to this matter and to the dimensions generally of their vessels trading with New Zealand, from which it appears that the deepest draught vessels visiting New Zealand are those of the "Corinthic" type belonging to Messrs. Shaw Savill and Albion and in writing to us they quote the following dimensions as applying to these vessels, viz. :— Length, 500 ft. 3 in.; breadth, 63 ft. 3 in.; depth 45 ft.; maximum mean loaded draught, 32 ft. 3 in. The New Zealand Shipping Company give 29 feet as the present maximum draught of their vessels. We have also had the advantage of interviews with Captain Kempson, of the "Athenic," and Captain McKellar, of the "Kaikoura." Captain Kempson informed us that they frequently left Wellington drawing upwards of 31 feet. We consider, therefore, having regard to the general tendency to increase the draught of vessels, that although a depth of 30 feet at low water alongside the jetties and wharves might in the first instance prove generally sufficient, they should be so constructed as to admit of future dredging to a depth of say 35 feet alongside.

22. Another important point to be kept in mind in designing the harbour is to so arrange it that the amount of dredging required to properly maintain the necessary depth of water within the harbour and its approaches may be reduced to a minimum.

Physical Conditions.

23. Before proceeding further it is necessary to refer to the physical conditions with regard to wind and sea which are met with in Port Lyttelton, and for which provision must be made.

1863 Commission.

24. In 1863 a Commission was appointed to consider the whole question of harbour and wharfage accommodation at Lyttelton, and the existing harbour was the outcome of the recommendation of that Commission. They enquired very minutely into the question of the prevailing winds and sea and it may be of interest here to refer to their report. Referring to the Port it is stated, "The anchorage does not lie within a land-locked harbour but is open to the ocean swell which sweeps round Banks Peninsula and "sets up the bay from E. and N.E.—at times with great violence and in very long undulations." It was further stated in evidence that "South-easterly gales **which do not blow home** send a heavy "swell round Banks Peninsula which penetrates the Port of Lyttelton in a long, blind roll." Again: "The anchorage is also exposed to S.W. gales which blow with great force over a low saddle of lofty hills "surrounding the harbour, and raise in only two or three fathoms water a short, chopping sea, for which "the sailor is at a loss to account as there is but a short 'fetch' of only two miles. Each of these two "dangers spring from a quarter of the compass at right angles to that from which the other comes. The "violent S.W. gales prevail mostly in winter, last generally for three days, and almost invariably begin at "N.W. . . . . veering round gradually by W. to S.W. At W. and W.S.W. it often blows with "greatest violence but more steadily, and raising much less sea than when it has settled down from S.W."

Weather and Sea.

25. We may say that the above description was entirely corroborated in the course of the enquiries made during our recent investigation, and are further borne out by the abstract of weather reports with, wind diagrams since the year 1879, so kindly prepared by Mr. Williams. It was abundantly proved that the heaviest seas experienced are those due to S.E. gales, which send in a long ground swell round Banks Peninsula and up the Port of Lyttelton. It is a curious fact, however, that the S.E. gales which create this swell never blow "home" at Lyttelton. It was stated that when S.E. gales were experienced at Timaru, or elsewhere along the coast, the wind at Lyttelton was almost invariably S.W. This absence of S.E. winds is shown in a striking manner in Mr. Williams' abstract of weather reports above referred to.

26. As already mentioned, the strongest winds experienced in Port Lyttelton are from a south-westerly direction. These winds blow at times with great violence, and it is considered essential that jetties and wharves should be built approximately in that direction, so that vessels may lie head or stern to the wind.

Height of Waves.

27. With regard to the height of waves experienced, the general local opinion appeared to be that these seldom exceed four feet in height from trough to crest as far up as Lyttelton Harbour, though they have occasionally, on an ebb tide, been known to break opposite the harbour entrance. Mr. Williams, in his memorandum accompanying the documents forwarded to us and referring to the sea outside the "Heads," says :—"The direction of the heaviest sea has been observed and measured by looking along the wave "crests and then measuring the height of the observer's eye above the water level. The result of these "observations gave a height of 9 feet from trough to crest, which is put down as 10 feet on plan to allow

" for any slight error in observation. The sea was steep and angry . . . . . The observations " we e made in nine fathoms water about half a mile north-east from Godley Head. . . . These observa- " tions were made after three days' heavy easterly weather, and the seas were breaking on their crests " just inside Sumner Head in about nine fathoms. The long, rolling seas do not ever seem to reach as great " height as that above mentioned."

? Four, not nine fathoms. See Harbour Board Engineer's letter, 14th June, 1907.—C.H.W.

28. It appears, therefore, that any harbour constructed in Port Lyttelton must be protected to the eastward from the long ocean swell caused by S.E. gales, and to the southward and westward from the short, choppy sea which is raised within the Port itself by the exceedingly violent gales which are experienced from that direction.

Shelter Required.

STICKING POINT HARBOUR.

29. Mr. Williams, in his report, proposes two alternative schemes. The first proposal is for the construction of a comparatively small harbour to the eastward of and adjoining the present harbour. It would be formed by two moles, the Western mole springing from the outer bend of the existing " Officers' Point " mole, the Eastern mole starting from " Sticking Point." Within the area enclosed (about 90 acres) four jetties would be erected, breastworks to form wharves at which vessels could lie, being constructed as required along the inner faces of the moles themselves. This harbour is shown by brown colour on Drawing No. 2. There is no doubt that a very material addition to the present accommodation could thus be afforded, but in connection with this scheme there are certain considerations to be borne in mind.

General Description.

30. In the first place, owing to the steep and mountainous nature of the land surrounding the whole of Port Lyttelton it is not possible, once the area of the harbour has been fixed by its enclosing arms, to extend that area. Consequently, when further extension is found to be necessary, an entirely new harbour must be formed. It is, therefore, extremely desirable that ample area should be provided when carrying out any further extension, and in this connection the increasing draught and dimensions of vessels, and the space required for manœuvring, must be taken into consideration.

Difficulties of Extension.

31. The natural depth of water in the neighbourhood of the proposed harbour at " Sticking Point " is about 22 feet. Consequently, in order to obtain a minimum depth of 30 feet within the harbour and approach channel, a large amount of dredging would be necessary, and, moreover, judging from the experience gained at Lyttelton, there can be no doubt that constant dredging would be required to maintain this depth. Added to this, the harbour, as designed, is cramped in area and less commodious for the purpose of handling large vessels than is the existing harbour.

Probability of Silting.

32. For these reasons we are unable to recommend the construction of a harbour at " Sticking Point," and we believe that this is also Mr. Williams' opinion.

GOLLAN'S BAY HARBOUR.

33. Mr. Williams' alternative scheme for a harbour in Port Lyttelton is that proposed to be constructed at Gollan's Bay, and is indicated by red colour on Drawings Nos. 2 and 4. This appears to be in every way a well-thought-out and carefully considered scheme. Speaking generally, and subject to certain remarks which we have to make thereon, we are of opinion that a harbour, very much on the lines and in the position of that shown by Mr. Williams, would fully meet the requirements of the Port and the special local conditions. The entrance is placed practically at the 30 feet contour line, so that in the first instance no dredged approach channel would be required, and seeing that as already mentioned it has been found that no appreciable silting is taking place generally within the Port, the full depth at the entrance should be readily maintained. Within the harbour, owing to the considerable natural depth of water already existing, the amount of dredging which would be necessary in order to give the required depth of 30 feet below low water is not excessive.

General.

34. Looking first at the ground plan of the Harbour, as proposed by Mr. Williams, we consider that some slight improvement might be made in the entrance. The Eastern mole does not appear to us to sufficiently overlap the head of the Western mole so as to shut out the swell coming up the Port, and we would, therefore, propose to slightly lengthen this arm.

Plan of Harbour

35. We also consider that the width of 250 feet proposed between the jetties is somewhat small for the convenient berthing of the large vessels which are expected to use the Port.

Jetties.

36. Furthermore, as the trade increases it is extremely probable that the need of warehouse accommodation in the neighbourhood of the harbour may become felt. In connection with the western mole and jetties, the space available for such accommodation and also for railway sidings appears to be very limited in extent. It is assumed that the first jetties to be constructed would be those projecting from the Western mole, and that the jetties and reclamation works shown upon the northern side of the harbour would not be undertaken until rendered necessary by the future requirements of the Port.

Breakwater.

37. With regard to the sheltering breakwater on the eastern side of the harbour, it is proposed that this should be constructed of rubble stone, quarried from the cliffs adjoining the site of the works. Seeing that there is an unlimited supply of hard stone, mostly of basaltic formation, in the surrounding hills, this will clearly be the most expeditious and economical method of constructing the work.

Mr. Williams' Section for Moles.

38. Mr. Williams proposes that the section of the mound should be generally similar to that of the existing "Officers Point" mole, with the exception that the stones should be of somewhat larger size, and the slope slightly flatter. We understand that the outer slope of this work stands at from 1½ to 2 to 1, and has required practically no maintenance during the four years that Mr. Williams has been in Lyttelton.

39. From the cross sections which have been supplied to us, it appears that the heart of the breakwater would be constructed of stones from 1 cwt. upwards, with an outer coating of 5-ton stones and a slope of 2 to 1, the inner face being coated with 2-ton stones at a slope of 1 to 1. The top of the mound to be 10 feet wide and placed at 6 feet above high water of ordinary spring tides.

Eastern Mole

40. It is, no doubt, the fact that the heaviest swells which are experienced in Port Lyttelton are of no great height and are unaccompained by wind at the back; nevertheless, in the case of a long ocean swell of that nature, the weight of blow received by any obstruction would be severe. The breakwater, as proposed by Mr. Williams, is placed practically at right angles to the direction of the swell, and would, therefore, experience its force to the full, whereas the existing mole at "Officers Point," forms but a slight angle with the direction of the waves, thus materially diminishing their effect. Moreover, a harbour at Gollan's Bay would be some 2 miles nearer the mouth of the Port and in much deeper water than the harbour at Lyttelton, which would increase the weight of sea to be encountered at the former place as compared with the latter. In the report of the 1863 Commission, to which reference has already been made, it is stated that "the swell receives no serious check in sweeping up the northern shore of Port Lyttelton until it has "passed about one mile and a-quarter above Gollan's Bay."

41. For these reasons, and from our own experience of the effect of the sea upon rubble mounds, we are of opinion that the proposed section of the breakwater mound should be increased to the extent hereinafter referred to.

Western Mole

42. With regard to the Western mole, this work not being directly exposed to heavy seas, we consider that the slope as provided by Mr. Williams should prove satisfactory. We should propose, however, to make the top width somewhat greater than that shown by Mr. Williams, and to use somewhat heavier material.

Jetties and Breastworks

43. A careful examination of these structures, as constructed and in use in Lyttelton, has shown them to be well adapted for the work required of them and we, therefore, do not propose any alteration in the general design, which has been adopted for many years with success. In the proposed new jetties and breastworks Mr. Williams contemplates the use of Australian Ironbark timber for piles, beams and bracing, Jarrah or Red Mahogany being used for decking. In connection with the use of timber for these structures, we may mention that the Teredo Navalis, which elsewhere in New Zealand is exceedingly destructive of timber work, is not active in Port Lyttelton, Ironbark being specially free from its attacks. In this connection also we may say that piles of that material were pointed out which had been in the water thirty-seven years and, with the exception of some slight worm action near the surface, were in perfectly sound and good condition. We therefore consider that under these circumstances the use of the timber would be justified.

RECOMMENDATIONS.

44. We have given careful consideration to the whole question, and upon Drawing No. 5 have shown a design for a harbour at Gollan's Bay which, we consider, will best meet the more immediate requirements of the Port and give ample space for future extension. As will be observed, it is upon the general lines of that proposed by Mr. Williams, but embodies some modifications which we consider desirable.

45. The head of the East breakwater by projecting somewhat beyond the head of the Western mole as shown will afford better protection to the harbour in the matter of shutting out the swell coming up the harbour.

46. It will be observed from the drawing that we propose a width of entrance of 700 feet clear waterway, which, we believe, will meet all requirements of navigation, while at the same time giving ample protection to the harbour from the sea. When the moles are drawing together to form the entrance it will, however, be possible to modify if desired either the aspect of the entrance or its width or the amount of overlap of the East breakwater to such an extent as experience may show to be necessary. We have already alluded to the interviews which, through the courtesy of Messrs. the Shaw, Savill and Albion Steamship Company and the New Zealand Shipping Company, we have been afforded with the Captains of the "Athenic" and "Kaikoura." We may here add that those officers have expressed themselves as entirely saitsfied with the general design of the harbour and the position and aspect of the entrance.

General Description of Proposed Works.

47. We propose to commence the Western mole at Sticking Point in lieu of at Battery Point, as in Mr. Williams' design. The outer end will be canted inwards so as to afford protection to the jetties from the easterly swell. By commencing the mole at Sticking Point railway access to the jetties will be quicker and more direct than in the case of the mole starting from Battery Point; this should prove of great advantage in the working of the traffic. At the inner end of the mole and extending across to Battery Point a reclamation of about 36 acres in extent would be formed as shown upon the drawing, affording valuable space suitable for offices, sheds, warehouses, railway sidings, &c., which would be required as the trade of of the Port developed.

48. We have provided for jetties 1,200 feet long in lieu of 800 feet, as in Mr. Williams' scheme. The extra width of the harbour, as derived by commencing the western mole at Sticking Point instead of Battery Point enables this to be done while still affording ample space for manœuvring vessels entering or leaving the Port. These jetties, however, need only be constructed 800 feet long in the first instance, being extended hereafter as required. The large accommodation which would thus be afforded at the jettles projecting from the Western mole, where the railway access is direct and convenient, should prove of great value, inasmuch as the necessity for constructing jetties off the northern shore where, in addition to their remoteness, access thereto must be by the inconvenient method of back shunting, would be postponed for many years to come.

49. We have, however, shown by green colour on the drawing, an extension of the breastwork quay, about 2,900 feet in length, along the western shore of the harbour, and a reclamation with jetties along the northern shore, which could be constructed in the future, should such additional accommodation be found necessary.

50. It may possibly be urged that in thus commencing the Western mole at Sticking Point, the easterly swell might be led along the back of the arm and across the entrance of the present harbour at Lyttelton, to the inconvenience of vessels using the same. Having regard, however, to the information we received at Lyttelton with respect to the sea experienced at that place, and also to the large extent to which the sea will be cut off by the Eastern breakwater of the proposed harbour, we do not anticipate any difficulty on this account, and feeling confident of the advantages which would be obtained by means of the longer jetties permissible, and of the direct access thereto and of the valuable site which could be reclaimed at the root of the mole, we have no hesitation in recommending the adoption of our proposals as shown upon the drawing.

51. To the westward of Sticking Point an area has been shown crossed by red lines, which represents approximately the distance to which the hill would be cut back in order to provide material for the Western mole. This would afford valuable space for railway sidings, and would allow a convenient approach with easy curves to the proposed harbour.

East Breakwater.

52. The East breakwater, as proposed by us, is on the same line as that shown on Mr. Williams' design, but we have increased its length by 200 feet in order to give greater overlap at the entrance.

53. We have already alluded in general terms to the breakwater as designed by Mr. Williams, and expressed the opinion that the section should be increased. A cross section of the breakwater which we would recommend is shown upon Drawing No. 8. From this it will be observed that we propose the mound should be constructed with a slope seaward of $2\frac{1}{2}$ to 1 to a depth of 10 feet below low water, the slope thence to the sea bed being taken at $1\frac{1}{2}$ to 1. The inner slopes would be $1\frac{1}{2}$ to 1 to 5 feet below low water,

and 1 to 1 below that level. The top width of the mound will be 20 feet at a level of 7ft. 6in. above high water of ordinary spring tides. We further consider that the outer slopes should be formed of stones 8 tons and upwards in weight. It will be noticed that the section we recommend is considerably in excess of that proposed by Mr. Williams, but, taking into account the considerably heavier swell which it will encounter as compared with the existing breakwater at Lyttelton, we do not consider it to be excessive. A lighter section would, we fear, require a large amount of maintenance.

West Mole

54. For the West mole we consider that the section as adopted by Mr. Williams with outer slope of 1½ to 1 should prove sufficient, but propose covering this slope with stones of say 5 tons in weight. We propose to construct the outer end, seaward of the jetties, with a top width of 15 feet in place of 10 feet. The cross section of this work is shown on Drawing No. 8 It will be noticed that from the commencement of the mole proper to the outer jetty we have provided for widening the mole on the inside to a width of 55 feet, measured from the inside of the small parapet also shown upon the cross section. Seeing that the whole of the traffic to and from the jetties will have to pass along this work, we consider that the above-named width should be allowed in order to provide space for four lines of rails. We also consider it desirable to provide a parapet along the seaward side of the mole in order to protect the railways and quay surface from damage during S.W. gales. This parapet would be constructed of concrete blocks laid dry in order that they might be taken up and re-set as settlement of the mound took place. When the mound had become thoroughly consolidated they could be finally re-set in cement, if so desired.

Jetties.

55. As already stated, we do not propose, seeing that the jetties now in existence have proved entirely satisfactory, to suggest any alteration in their general design. Inasmuch, however, as the jetties in Gollan's Bay Harbour will be in considerably deeper water than those in Lyttelton Harbour, we are of opinion, in order to give sufficient lateral stiffness, that it will be necessary to provide either cross bracing below low water level or to deposit a mound of rubble stone along the centre of each jetty.

56. In view also of the information received as to draught of vessels to which reference has been made in a preceding paragraph, we consider that the piles of the jetties should be driven down to a sufficient distance to allow of dredging alongside to the depth of 35 feet, should this ever become necessary.

Dredging

57. We should propose that in the first instance dredging to provide a depth of 30 feet below low water ordinary spring tides should be undertaken to the extent necessary to give access to the jetties projecting from the West mole as shown by red colour on the drawing. The extent of this dredging is shown by crossed red lines.

Reclamation.

58. The dredgings would be deposited, as far as possible, within the bay to the westward of Battery Point. They would be retained by means of a rubble bank tipped from the root of the mole towards Battery Point, an opening being left to enable the hoppers to pass in and out for the purpose of depositing their loads. When dredgings had been deposited to the fullest extent practicable, the opening in the bank should be closed. The dredgings would then be dumped at a convenient spot and pumped by means of a suitable pontoon pump dredger provided with cutters into the reclamation area to the required level. By this means a valuable area could be reclaimed at a comparatively small cost.

59. We estimate the cost of the works, if carried out to the extent shown by red colour on Drawing No. 5, as follows :—

Eastern Mole, in general accordance with the cross section shown upon Drawing No. 8 ..	£64,870
Western Mole, ditto, ditto, and including widening out on Harbour side for railway access to jetties and also concrete blockwork curtain wall	£133,015
Rubble protection banks from root of Western Mole to Sticking and Battery Point ..	£31,800
Dredging, to the extent shown upon the drawings, the dredged material being deposited in, or pumped into, reclamation	£36,455
Timber jetties, as shown upon Drawing No. 5, together with breastwork wharf along front of reclamation	£285,560
Shed accommodation	£21,945
Buoys	£660
Navigation lights	£1,650
Cranes, locomotives, trucks and miscellaneous plant in quarry, and for railway ..	£57,475
Pontoon Pump Dredger for pumping dredgings into reclamation, &c.	£11,000
Laying railways on wharvesand connecting same with Government Railway ..	£11,000
	£655,430

Say, £655,500.

The above estimate includes 10 per cent. for engineering and contingencies.

60. In framing this estimate we have, after very careful consideration, adopted generally the prices taken by Mr. Williams. The prices for rubble stone are based upon the actual cost of quarrying similar material at Timaru, allowing for the advantage in the present case of having the material actually at the spot, thus avoiding the long lead and special railway required at Timaru.

61. In view, however, of the section of the East breakwater having been increased and heavier stones having been adopted for the sea slope, it would be necessary, in order that these may be properly got into position, to provide for a 15-ton travelling crane with, say, 45 feet radius, and we have consequently allowed in our estimate for the provision of such a crane. Similarly with regard to the West mole, we have provided for a 10-ton travelling crane with 30 feet radius.

62. In connection with the use of these cranes, the stone would be loaded at the quarry into loose boxes or trays, which would be placed upon undercarriages and run to the moles. The cranes would then lift the boxes and deposit the stone in the moles and upon the slopes thereof where required.

63. The cost of jetties, breastworks and dredging are derived from those actually experienced in Lyttelton. We have, however, somewhat increased the price of the jetty work to cover the increased length of piles and the under water cross bracing or rubble mound to which we have already called attention. With these qualifications we see no reason to depart from the prices allowed by Mr. Williams.

64. We have provided in the estimate for sheds and railways, but not for dock equipment in the shape of cranes, electric lighting, &c. With these exceptions our estimate covers the cost of the whole of the work shown by red colour on Drawing No. 5, though in all probability it would not be necessary to construct more than two or three of the jetties in the first instance, and these only to a length of 800 feet. These could be lengthened and other jetties added as required. Similarly the dredging of the harbour to the necessary depth would be completed as required.

65. It will be seen that we have included in the estimate a sum of £68,475, to cover the provision of plant. Under this head we have provided for the following :—

13 Cranes in the quarry.
2 Cranes upon the moles.
3 Locomotives.
100 Underframes carrying tipping boxes.
30 Side and end tip muck waggons.
1 Pontoon pump dredger.

Which we consider will be required in order to complete the work within seven years, and is based upon our experience in the carrying out of similar works. We have adopted the prices for which such plant could be obtained in England, and have added thereto 50 per cent. to cover the cost of freight, Customs duty, and erection, which, we understood, was a fair allowance to make. It is, of course, possible that a considerable portion of the plant may be obtained in the Dominion, thereby effecting some saving in this respect.

Dredging Plant.

66. In going into the question at Lyttelton, Mr. Williams expressed his belief that in the event of a harbour being constructed either at Sticking Point or Gollan's Bay, no additional dredging plant would be necessary, the existing plant being sufficient to undertake all that would be required. We have consequently not provided for any dredging plant in the above estimate, with the exception of the small pontoon pump dredger for reclamation purposes, to which reference has already been made.

Railway to Lyttelton.

67. One principal consideration always to be borne in mind in connection with harbour extension in Port Lyttelton, is that the whole of the goods shipped or unshipped have to be carried along a single line of railway through a tunnel 1¼ miles in length, penetrating the Port Hills There is no doubt that the railway could deal with a large increase upon the present traffic, especially if improved siding accommodation could be formed at the Lyttelton end of the tunnel, which, we understand, is in contemplation. But there is also no doubt that with a considerably increasing trade the time must come when the duplication of the tunnel will become necessary and have to be seriously entertained.

? The length of Lyttelton Tunnel is 1 mile 50 chains—C.H.W.

68. With a view of obviating this difficulty it has been proposed to form a dock in the vicinity of Christchurch itself, connected with the sea at Sumner Beach by a canal through which the largest vessels could pass.

69. We purpose now to consider the proposals which have been put forward with this object.

CANAL AND DOCK SCHEME.

Alternative Schemes.

70. Mr. Williams, in his report, put forward two alternative schemes for providing dock accommodation in the vicinity of Christchurch. The first proposal is for the construction of a Port or Tidal Basin in the estuary near the mouth of the Heathcote River. As an alternative it is proposed to construct the Port or Basin at Linwood, some three miles nearer the city. In either case the connection with the sea would be by means of an open ship canal with an entrance at Sumner.

Difficulties with regard to possible Quicksands, Etc.

71. In the course of our investigation at Christchurch, it was in some quarters very strongly urged that the construction of such a canal would be impracticable, chiefly for the following reasons :—

(1) That quicksands exist at the entrance of the proposed canal, which would render the construction of the northern mole impossible.

(2) That the existence of quicksands generally along the line of canal would render its construction impracticable.

(3) That the entrance to the canal would silt up owing to sand travel and could only be maintained in a navigable condition at prohibitive cost.

72. Instances were given of vessels sinking into the sand at Sumner Bar, also of a well near Heathcote, the sinking of which had to be abandoned owing to the quicksands which were encountered. Another instance given was the putting in of the foundations for a sewage tank at Christchurch, some 30 feet in diameter, where the work had to be discontinued owing to quicksands. During the course of our investigation at Christchurch, these points received careful attention, and the particular instances quoted were specially enquired into.

73. With regard to quicksands at Sumner Bar, a very careful examination was made upon the spot and nothing in the nature of quicksands could be discovered. A 2 cwt. anchor was dropped and buoyed on the line of the proposed north mole. After two days this was raised with the greatest ease, having scarcely penetrated into the sand. Careful enquiries were also made of Mr. Day, pilot at Sumner, who has known the place intimately for more than 50 years, covering the period before the construction of the railway to Lyttelton, when the lightering of goods from Lyttelton to the Heathcote River was carried on to a large extent. He had known many lighters to be lost on the bar. They would gradually break up and be carried away, but he was convinced that no boat had ever sunk into sand. The channel was constantly shifting to and fro, and a wrecked vessel might consequently become buried by the moving sand, which would possibly account for the suggestion that it had been swallowed up by a quicksand. Much bathing was carried on in the vicinity, persons swimming across the channel and about the bar. He was in charge of the bathers and had never heard of anyone ever getting into difficulties on account of quicksands.

74. Mr. Sowden, the foreman who had actual charge of the sinking of the well at Heathcote, to which reference has been made, stated that the well consisted of cast iron cylinders about 4ft. 6in. diameter, and that it had been intended to sink these by hand, the water being kept down by pumps. When about 18 ft. down the sand flowed in so rapidly that it was impossible to continue. Eventually the water was allowed to rise, and sinking was continued by a diver excavating inside the cylinder without any difficulty, and no further trouble was experienced on account of sand flowing in.

75. Mr. Cuthbert, Engineer to the Christchurch Drainage Board, kindly afforded particulars with regard to the trouble experienced in putting in the foundations for a sewage tank. The foundations were carried about 25 feet below the surface of the ground. It was attempted, in the first instance, to sink the excavation in the dry, the water being kept down by pumping, but it was soon found that the sand ran in so rapidly that the work had to be abandoned. A timber cylinder 30 feet in diameter was then constructed, and after being weighted, was sunk through the water by grabbing from the inside, all pumping being discontinued. This method of procedure was entirely successful, and the cylinder was sunk to the required depth of 25 feet without any further trouble. The bottom was then sealed with concrete deposited through the water, after which the water was pumped out and the tank completed.

76. Mr. Dobson, Borough Surveyor, of Christchurch, also gave valuable information upon this subject. He had a large experience in sinking wells and bores in the district, and had found no evidence of specially

wet or running sand having been met with. Mr. Dobson had further been engaged upon what is known as the " Avon Cut," near New Brighton, which consists of a cut about 14 feet deep connecting two bends of the river Avon. This was carried out in the dry, and no difficulty was experienced from running sand.

Saturation Level of Ground.

77. There is no doubt that the whole district is saturated with water, the natural level of the subsoil water being about 4 feet below the surface at Christchurch, i.e., about 10 feet above the level of high water of ordinary spring tides, and whenever open excavations are attempted for the purpose of foundations for buildings, pipe laying and the like, trouble is experienced on account of water laden with sand flowing into the excavation, but the difficulty ceases upon allowing the water to rise and continuing the excavation within the water without pumping.

78. In the case of the canal and dock, it is proposed that the whole of the excavations shall be carried out by means of dredges working in the water, so that we do not anticipate that any difficulty would be encountered due to running sand, as has been found to be the case with open excavations executed in the dry.

Sand Travel.

79. With regard to the question of possible silting up of the Entrance, this is a matter to which we have given the most careful attention, seeing that it is a danger which invariably attends the projection of a solid pier across a sandy beach. So far as we were able to ascertain, no appreciable alteration in the foreshore from New Brighton to Sumner has taken place since the date of the original survey some 50 years ago. Mr. Day, the Lyttelton Harbour Board pilot at Sumner, did not consider that Sumner Beach had appreciably altered within his recollection, i.e., upwards of 50 years, though it was possible that the low water line had somewhat receded, but he could not speak with certainty as to this.

Comparative Soundings.

80. Upon Plan No. 1, accompanying Mr. Williams' report, recent soundings taken by him are shown, a few soundings taken from the Admiralty Chart of 1849 being also given by the underlined figures. An inspection of the soundings shows that no material alteration has taken place since the date of the Admiralty survey. Mr. Williams forwarded with his notes and recommendations a plan of Sumner Entrance, showing comparative soundings taken in 1854 and 1904. With the exception of a single line of soundings in front of Sumner Beach, and generally parallel thereto, the two sets of soundings are practically identical. The same plan gives the present high water line on Sumner Beach as derived from actual levels and an " approximate' high water line as agreed some years ago (the date is not given) between the Lyttelton Harbour Board and the Sumner Borough Council, and it will be seen that the two lines agree very closely.

81. It appears, therefore, that there is no direct evidence of any appreciable alteration in the foreshore of Sumner and New Brighton beaches during the past fifty years, and upon careful examination on the spot no indications of sand travel could be detected.

82. It is, however, apparent that the mouth of the River Avon has in the course of time been pushed to the southward until the rocky ground prevented any further movement in that direction. This is evident from the sand spit extending southward from New Brighton to the river mouth. Further northward, near Kaiapoi, a similar spit extending to the southward of the Waimakariri River gives some indication of the same action.

83. Moreover, a closer comparison of the Admiralty soundings of 1849 with those recently taken by Mr. Williams appears to show some diminution of depth between the 3 and 5 fathom contour line, off Sumner Head. The Admiralty soundings are very few and far apart, and the scale of the chart so small that an entirely reliable comparison is not possible. It appears to us, however, that there is probably a slight movement of sand to the southward, but inasmuch as the indications of this movement are so slight and indeterminate over a period of more than fifty years, we see no reason to anticipate any special difficulty in maintaining the entrance to the required depth, though it is certain that dredging to some extent would be required for this purpose.

84. For the foregoing reasons, and upon careful consideration, of the whole question we are, therefore, of opinion that the construction of the canal and dock presents no insuperable engineering difficulties, and we are consequently in a position to discuss in detail the proposals put forward.

Alternate Proposals for Constructing a Dock at Linwood or Heathcote.

85. It appears to us that the proposal to form a dock at Linwood is open to objection on account of expense. In the first place, it would necessitate the construction of nearly three miles of additional canal, and secondly, the dock would be constructed upon ground already occupied and to a large extent built over, thus involving heavy expense in the purchase of land both for the immediate necessities of the case and for possible future extensions. A large expense would also be involved in the diversion of the existing light

railway to Sumner so as to pass to the southward of the dock and canal. Failing this diversion, it would be necessary to construct a swing bridge with a large opening span across the canal, which would be exceedingly costly, besides being very inconvenient for traffic.

86. At Heathcote, on the other hand, in addition to the saving effected by the shorter length of canal, the avoidance of the light railway diversion, etc., the dock would be constructed upon ground of little value and for the most part below present high water mark of the estuary. Valuable property in the immediate vicinity of the dock would be formed by reclamation with the material dredged from the site of the dock and canal, and would be the property of the Board and available for extensions or for letting purposes.

87. The principal objection to the formation of the dock at Heathcote is, of course, its greater distance from the city, involving extra cost in the conveyance of goods to and fro. We do not, however, apprehend that the inconvenience resulting therefrom would be very great. For all goods to be despatched by rail direct from the docks to the country districts, and for goods sent by rail from the country for shipment, a dock at Heathcote would be as convenient as if at Linwood. In the case of goods destined eventually for the country districts, but which would not be despatched direct by rail from the ship's side, warehouses would, without doubt, be constructed in the immediate neighbourhood of the docks, where ample space is available, in which the goods would remain until ready for despatch. The only goods, therefore, which would necessarily be affected by the extra haulage between Christchurch and the docks would be those intended for actual consumpton within the limits of the city, and would form a relatively small proportion of the total dealt with, and we are doubtful if this comparatively small advantage would be worth the large extra cost involved, estimated by Mr. Williams at upwards of £690,000 (being the difference between his estimates for the Canal Scheme with a port at Linwood, and for the same with a port at Heathcote.)

88. We propose, therefore, to confine our remarks to a consideration of Mr. Williams' scheme for a dock at Heathcote, with a canal opening into the sea at Sumner Beach, as shown in red colour upon Drawing No. 6. These remarks, however, would apply equally to the scheme in connection with the construction of a port at Linwood, the only difference being the length of the canal required.

Position and Aspect of Entrance.

89. The first point to be considered is the position of the entrance of the Canal. By making a direct cut to the sea from the dock in a north-easterly direction, the length of the canal would have been considerably reduced, and a curved channel would have been avoided. On the other hand, by making the entrance at Sumner, the fullest advantage is taken of the protection afforded by the land to the southward, a consideration of great importance. The entrance as at present faces the long S.E. swell, as it bends round Banks Peninsula during S.E. gales, which we consider to be an advantage in case of vessels making the harbour; whereas in the case of the direct and shorter cut the entrance would have pointed considerably to the northward. In the course of our enquiry whilst at Christchurch we had the advantage of an interview with several captains of vessels belonging to the large shipping companies trading with the Port, and throughly discussed with them the position of the proposed entrance. They were generally of opinion that the aspect of the entrance as shown was good, and that it would be easy to make, and except in unusually heavy weather, would present no difficulties to vessels making the entrance. With regard to the width of entrance, it was considered that this should be at least 700 feet clear waterway. Opinions differed as to the minimum depth of water required, but varied from five to ten feet in excess of the draught of the vessel in order that the entrance might be taken during ordinary seas. These opinions were further corroborated by Captains Kempson and McKellar, of the "Athenic" and "Kaikoura" respectively, at the interviews to which we have already alluded. They were both, however, of opinion that during heavy storms it would probably be necessary to lie off until the weather moderated. This contingency was inherent to "making' a harbour with a comparatively narrow entrance in a heavy sea, and could not be obviated by any alteration in the position or aspect of the entrance, which they considered was correctly placed.

90. We have, therefore, to express our general concurrence with Mr. Williams' proposal to place the entrance at Sumner Beach, and also with the aspect of the same.

Width and Depth of Entrance.

91. Having regard to the opinions expressed above, we consider that it would be advantageous to increase the width of entrance of 700 feet between the centres of the mole heads to 800 feet, which would allow a clear waterway of 700 feet wide at the full depth. We are also of opinion that assuming a depth of 30 feet at low water is to be provided as the working depth of the canal, the entrance should be placed in a depth of at least 35 feet at low water ordinary spring tides.

92. The north mole is shown by Mr. Williams to run parallel with and close to the canal itself. This would tend to lead into the canal any swell from the east and south-eastward. We should prefer to commence

the northern mole some little distance further to the northward in order to provide a spending beach for waves upon the north side of the canal proper, the existing Sumner Beach acting in a similar capacity on the south side of the canal.

Canal

93. With regard to the canal itself, keeping in view the fact that it will be constructed almost throughout its entire length upon the curve, and that vessels navigating the same will be of the largest class, and will at times be subject to strong cross winds, we consider that a bottom width of at least 250ft. should be provided, the banks being so placed as to admit of the width being increased to 300 feet, should this be found necessary hereafter. We also think it would be well with a view to further facilitating navigation that the curves be formed of a radius of not less than 10,000 feet. There would appear to be no difficulty in providing for this. The slopes provided for by Mr. Williams, viz.:—6 to 1 outside Sumner Bar and 5 to 1 inside the Bar should, in our opinion, prove to be adequate.

Protection of Banks.

94. We notice that Mr. Williams, in his estimate, has made no provision for protecting the sides of the canal from the wash of steamers. Considering the sandy nature of the material through which the canal would be constructed, we are strongly of opinion that the canal sides from somewhat below low water upwards should be adequately protected with a coating of rubble stone.

Docks at Heathcote.

95. With regard to the proposed dock or basin at Heathcote we consider it would be preferable that the discharge of the Heatchote River should be carried into the canal below the dock, rather than discharge into the corner of the dock opposite the jetties, as shown on Mr. Williams' drawing. We notice in the cross section of the breastworks as given by Mr. Williams, that the sand is shown standing at a slope of $1\frac{3}{4}$ to 1, without any protection. We fear that the wash from steamers and the action of the propellers would render such a slope unstable, and that subsidence of the ground at the back of the wharfing would be liable to ensue. In our opinion the more preferable mode of construction would be by means of a rubble bank with a timber wharf or breastwork similar to that adopted in the harbour of Lyttelton. In this case the rubble bank would afford potection to the sand and prevent scouring.

Jetties.

96. With regard to the proposed jetties, we consider, as already remarked in connection with the proposed harbour in Port Lyttelton, that it would be necessary to provide either cross bracing below low water or to deposit a mound of rubble stone along the centre of the jetty in order to give sufficient lateral stiffness.

RECOMMENDATIONS.

97. Drawing No. 7 shows by red colour our recommendations with regard to this scheme which embody such modifications of Mr. Williams' proposal as appear to us to be necessary.

Entrance.

98. We propose to maintain the aspect of the entrance the same as in Mr. Willliams' design, but to place the heads of the moles at a depth of 35 feet at low water ordinary spring tides, which we consider is the minimum allowable. We have also somewhat increased the width of entrance so as to provide a clear 700 feet of waterway between the heads.

Wave Trap.

99. It will be observed that the northern mole, instead of running parallel to the line of the canal, has been spread out at the landward end, thus providing a beach at the north side of the canal upon which waves entering the harbour may break and disperse. This beach, together with the existing Sumner Beach on the south, will materially assist in quieting the water at the entrance to the canal proper.

Sections of Moles.

100. Drawing No. 8 gives cross sections of the north and south moles respectively. It will be noticed that the section of the mound which we propose is considerably heavier than that shown by Mr. Williams, which latter, we understand, is derived from the cross section of the breakwater recently constructed at Timaru. Having had large experience of rubble mound breakwaters, however, we consider that the cross section we have shown is the minimum which we could recommend with confidence, in which connection it must further be remembered that the moles at Sumner will be carried out into considerably deeper water than obtains in the case of the work at Timaru. The mounds should be constructed of as large angular stones as practicable, the top and sea slopes being protected by stones of 10 tons and upwards in weight.

101. At the re-entrant angle formed on the seaward side of the southern mole where it projects from Sumner Head, there will be a considerable concentration and rebound of the sea from the cliffs during south easterly weather. We would, therefore, propose to widen the mound by 5 feet for a distance of say 300 feet from its commencement, making it 25 feet wide at the top over that length.

Training Banks.

102. Mr. Williams proposes to construct a training bank on the south side only of the canal entrance. Owing to the modification in the line of the north mole which we propose, it will be necessary to construct a parallel training bank on the north side of the canal, commencing near the southern extremity of the tongue of land forming the present eastern boundary of the estuary. The level of the top of the training banks at their commencement would correspond with that of the retaining banks of the adjoining reclamation, and at their termination would be about low water level. They would be formed of stone obtained from the quarry and deposited from barges or flats.

Canal.

103. With regard to the canal, it will be seen that we have adopted practically the same line as Mr. Williams, with the exception that we propose, as above referred to, to flatten the curves to not less than 10,000 feet. We have retained the slopes of 1 in 6 seaward of Sumner Bar, and 1 in 5 landwards of that point, as provided for by Mr. Williams. We propose to protect the banks of the canal from the wash of passing steamers by means of a coating of rubble stone extending from 4 feet above high water to the level of low water ordinary spring tides, as shown on Drawing No. 8.

Proposed Passing Place.

104. We think it would be advisable for the safe and convenient navigation of the canal that a passing place for vessels should be provided somewhere near the middle of its length. We propose, accordingly, that no dredgings should be pumped to form reclamation into the small bay opposite Moncks, but that this bay should be left open and the canal widened by 500 feet over a length of 1,200 feet, as shown upon the drawing. This would form a convenient " lay by " space, and would be provided with moorings, where vessels could tie up when required, in order to allow others to pass. By this arrangement, also the yachting station and fishing village at Moncks would be preserved intact, which would be a further advantage. At the eastern end of Moncks Bay the southern training bank of the canal would be commenced as shown.

105. It will be observed that we have shown the navigable channel marked by buoys placed about 800 feet apart. These will be essential for the safe working of the canal, the distance apart being parctically that found necessary in the Suez Canal in order that two pairs of buoys might always be in view.

Retaining Banks.

106. Throughout the greater portion of the canal it would be necessary to form a rubble bank on each side to the proposed height of 4 feet above high water ordinary spring tides, in order to retain the reclamations. The stone facing above referred to would, of course, be combined with these retaining banks. This is clearly shown upon the section. The stone would be deposited from barges or flats as described in the case of the training banks. That portion of the retaining bank reaching from the commencement of the south training bank opposite the Cave Rock to the eastern side of the small bay opposite Moncks, might, with advantage, be tipped direct from waggons.

Dock.

107. With regard to the dock, we propose to construct a basin about 3,500 feet in length by 1,750 feet in breadth. The north and south sides of the dock would be provided with breastwork quays 2,000 feet and 2,500 feet in length respectively. Within the dock would be constructed two large jetties 2,000 feet in length by 300 feet in breadth. Ample shed accommodation immediately alongside the quays would also be provided. We are strongly of opinion that such a system of quays and sheds would be much more convenient for the storing of goods awaiting shipment and the general handling of cargo, than narrow jetties, and as the site lends itself to the construction of wide jetties, we have no hesitation in recommending their adoption. The breastworks or wharves would be constructed upon the same principle as now adopted in Lyttelton Harbour, viz. : with a timber facing and rubble slope at the back. The wide jetties would consist of two such breastworks forming the quay faces, the space between being filled in with sand pumped from the dredging operations. The surface of the quays would be placed at a height of 6 feet above high water ordinary spring tides.

Dredging and Reclamations

108. It is proposed that the whole of the excavations for the canal and the dock should be executed by dredging. The material to be dealt with consists almost entirely of sand with, in places, an admixture of clay, as is shown by the borings, and could in our opinion be satisfactorily raised by a pump dredger. The material so raised would be similarly pumped over the sides of the canal banks to form reclamations approximately to the extent tinted red upon the drawing. The exact extent of the reclamations would, of course, depend upon the amount of material raised and the level to which the surface is finished. We have assumed, except in the neighbourhood of the dock, a general surface level of 4 feet above high water ordinary spring tides, which is that shown upon Mr. Williams' cross sections. We will refer to this matter again in dealing with the plant required for the work.

Proposed Depth for Canal and Dock.

109. We propose that the canal and dock should in the first instance be dredged so as to give a minimum depth of 30 feet at low water ordinary spring tides, the bottom width of the canal being 250 feet, to be

widened to 400 feet at the outer end of the training banks, the depth being gradually increased to 35 feet, as shown upon Drawing No. 7.

River Avon Diversion.

110. In order to confine the River Avon to the new channel shown upon the drawing, it would be necessary to form two low mounds of rubble stone, one on either side of the river. In any case, these banks would be required to retain the reclamation dredgings, and we have accordingly provided for them in the estimate.

Quarry and Temporary Works.

111. The stone for the moles and retaining banks, &c., would be obtained from quarries, which it is proposed to open for the purpose at Sumner Head, where an ample supply of suitable material is available.

112. The rubble in the moles would be deposited from stagings carrying three lines of railway. Mr. Williams proposes to adopt a type of staging exactly similar to that used in the construction of the breakwater at Timaru, and which has proved successful. The proposed moles would, however, be carried into much deeper water than at Timaru, and we consider that additional cross bracing, such as wire guys or chains with coupling screws, carried below low water to the ground level, or some other means for stiffening the structure laterally should be adopted. Owing to the increased width of mound a somewhat wider staging than that at Timaru would be necessary.

113. Material for the north mole would be conveyed along a temporary railway crossing the River Avon by means of a timber viaduct, at some convenient point above the Cave Rock. It would be necessary to provide an opening span of say 60 feet to enable dredging and other craft to pass up and down as required, and we have provided accordingly in our estimate.

Quarry and Other Plant

114. We have very carefully looked into the question of quarry and railway plant required, and consider that in order to complete the works in ten years, the following plant would be required :—

20 Cranes in quarry.
9 Locomotives.
120 Side and end tip waggons.

Dredging and Reclamation

115. As already stated it is proposed to utilize the material dredged from the site of the canal and dock to reclaim the area upon either side of the canal now forming the estuary of the rivers Avon and Heathcote, to a level of 4 feet above high water ordinary spring tides, and to the extent tinted red on the drawing, a channel 200 feet wide being provided for the discharge of the River Avon in the position shown. It is proposed to effect this reclamation by pumping the dredgings direct on to the site.

116. The area to be reclaimed is of large extent, and the extreme distance to which the dredgings would require to be pumped, viz. : to the northern corner of the estuary, is upwards of 9,000 feet, a distance, we believe, largely in excess of anything which has hitherto been attempted.

117. The problem, therefore, presents some difficulties, and it is one to which we have given very careful attention, and we have gone into the matter in considerable detail with Messrs. Simons & Co., of Renfrew, who have had great experience in the construction of every description of dredging plant.

118. It is considered that 5,000 feet is the limit to which it would be advisable to pump direct from the dredger. For distances beyond this limit, it would be desirable to provide an auxiliary pump with extra pipe line complete. The auxiliary pump would be coupled up direct to the end of the 5,000 feet of discharge pipe line from the dredger, the discharge pipe from the latter becoming, as it were, the suction pipe of the auxiliary pump. This last pump would be fitted with 3,000 feet of pipe line, making in all a length of 8,000 lineal feet from the dredger to the final discharge. This, we consider, would be sufficient pipe line to provide, seeing that the material would largely flow for the remaining distance required. In any case, the area to be filled beyond the 8,000 feet is too small to justify any large addition to the cost of the pipe line and pumping power.

119. In general we would propose to provide :—

(1) One pontoon pump dredger, capable of dredging to a depth of 40 feet and of delivering 1,000 cubic yards of sand per hour through 5,000 feet of pipe line.

(2) One auxiliary pump to be attached when required to the extremity of the 5,000 feet of pipe line leading from the first-named dredger, and capable of delivering the same quantity of material, viz. : 1,000 cubic yards per hour, through 3,000 lineal feet of pipe line.

(3) One twin screw bucket hopper dredger of 1,100 tons hopper capacity, and capable of lifting 900 tons per hour.

120. Part of the discharge pipe line of dredger (1), say 500 feet in length, would be of flexible type carried on pontoons, so as allow of movement of the dredgers. All delivery pipes would be of the same character and interchangeable. All necessary branch pieces, ball and socket joints, &c., required to allow of ready adjustment in the line and direction of the pipes, would be provided.

121. The auxiliary pump (No. 2) would be driven either by steam or by electric power. Electric power would be the more advantageous, inasmuch as greater speed could be given to the engines and their weight correspondingly reduced, which would render them more portable in the event of it being necessary to move them from place to place.

122. We have provided for a bucket dredger because, although there does not appear from the borings to be any great likelihood of material unsuitable for pump dredging being met with, we consider that in a dredging work of this magnitude, it would be advisable to provide a dredger capable of dealing with such material in the event of it being found.

123. Our estimate for the above plant delivered in New Zealand is £200,000, including the cost of all work in connection with the auxiliary pumping station. This is considerably in excess of the sum provided by Mr. Williams for dredging plant, but, after considering the matter very carefully with Messrs. Simons, we are of opinion that it would not be prudent to reduce it.

124. The plant provided for should be capable of completing the work in ten years.

125. Should it be determined to carry out this scheme there is no doubt that an electrical equipment of lighting and cranes would be installed at the docks. The power station might be proceeded with in the first instance, and current taken therefrom for driving the auxiliary pump (No. 2) by which means some saving in cost would be affected.

126. We estimate the cost of the works as follows :—

North Mole, in general accordance with the cross sections shown upon Drawing No. 8, and including staging	£470,910
South Mole, ditto, ditto	£127,405
Training banks, retaining banks for dredgings and lining of canal banks, as indicated upon the drawings	£78,180
Rubble banks under breastwork wharves in dock	£150,220
Dredging of dock and canal to dimensions and depths shown upon the drawings, including depositing material at sea or in reclamations	£233,010
Timber breastwork wharves in dock	£248,705
Shed accommodation, and surfacing roadways with broken stone, steam rolled ..	£262,305
Buoying channel	£5,060
Navigation Light	£2,420
Laying railways on wharves and connecting same to Government Railway ..	£14,300
Cranes, locomotives, trucks and miscellaneous plant in quarry and for railway ..	£77,715
Dredgers, miscellaneous floating plant and shore pumping station	£233,750
Temporary viaduct over canal entrance with rolling bridge and temporary railways ..	£17,380
	£1,921,360

Say £1,925,000.

The above estimate includes 10 per cent. for engineering and contingencies.

127. The above estimate contains 10 per cent. for engineering and contingencies, but does not provide for interest and depreciation of plant, nor does it take any credit for the value of the plant upon the completion of the works.

128. In framing the estimate we have, as in the case of the proposed harbour at Gollan's Bay, adopted Mr. Williams' prices for stone, seeing that they are based upon the actual cost of similar work as carried out at Timaru. For the reasons above explained, we have somewhat increased his estimate for the temporary staging for the moles in order to provide for additional bracing and extra width and increased depth of water.

129. The remarks which we have made above in connection with the Gollan's Bay Harbour scheme with reference to the plant provided in the estimate apply generally in the present instance. We have provided plant which, in our opinion, would be sufficient to complete the works as shown by red colour in ten years, the price of the plant being estimated at its cost in England, plus 50 per cent. for freightage, Customs dues, and erection in the Dominion.

130. We presume that if the Canal scheme be adopted, the harbour at Lyttelton would be practically abandoned, so that it would probably be found necessary to provide in the first instance the full dock accommodation as indicated by red colour on the drawing. The length of quay there shown is practically the same as now exists at Lyttelton, the advantage in favour of the former being that it is all deep water berthage, whereas at Lyttelton a considerable proportion is suitable only for small vessels.

General Considerations

131. We have now considered in detail the whole project of providing a dock in the vicinity of Christchurch with access to the sea for the largest vessels by means of a ship canal, and subject to certain modifications which we have recommended, have in general concurred in the main lines of the proposal put forward by Mr. Williams. In the event of it being ultimately decided to proceed with the works all details in connection with the carrying out thereof would, of course, require to be very carefully reconsidered, particularly with regard to the plant necessary for dredging and reclamation purposes, which will require to be of very special character.

132. It will be observed that our remarks as hereinbefore set forth have so far resolved themselves into two alternative recommendations, as follows :—

I. In the event of the future requirements of the Port being met by harbour extension in Port Lyttelton, we recommend the execution of works at Gollan's Bay, to the extent shown by red colour on Drawing No. 5. The same drawing shows by green colour means by which still further accommodation could be provided when required.

II. In the event of its being decided to construct a dock in the neighbourhood of Christchurch connected with the sea by a ship canal, we recommend that the dock be constructed at Heathcote with a canal to Sumner in general accordance with the design shown in red upon Drawing No. 7. Future possible extensions are indicated by green colour upon the drawing.

133. It now remains to consider the relative merits of the two main alternative proposals as above briefly set forth.

134. In the consideration of this question we have borne in mind the desire of the Board as referred to at the outset of this report, viz. : that we should not take into account questions of finance and general policy, leaving these to be decided by the Board hereafter. We have consequently confined our remarks more particularly to the engineering and navigation aspect of the question.

135. A dock as proposed within the estuary of the Avon and Heathcote Rivers, the basin being formed almost entirely by dredging, could be constructed comparatively cheaply. Most of the land required for wharves, warehouses, railways, &c., would be reclaimed by the Board with dredgings obtained from the forming of the dock itself, and the canal. Other land required could, no doubt, be obtained at small cost. Extensions to the dock could be made as required to practically an unlimited extent, and at a minimum cost by dredging, owing to the flat and sandy nature of the soil. There would be ample space adjoining the dock for all requirements in the way of sheds, warehouses, railway and tram accommodation, easy connections being possible with the existing Government Railways and the Municipal Tramway system.

136. On the other hand at Port Lyttelton, owing to the steep and rocky nature of the shore, extensions of a harbour once constructed cannot readily be made. Space for sheds, warehouses, railway sidings, &c., can only be obtained or added to by means of rock excavation or reclamations. We are, however, of opinion, that should the harbour at Gollan's Bay be carried out to the extent already recommended and shown upon Drawing No. 5, ample accommodation for all future requirements, so far as can with reason be anticipated, would be provided.

137. The approach to the proposed dock at Heathcote would be through a narrow channel some 3½ miles in length, measuring from the entrance near Sumner Head to the Basin This, in itself, would always to a certain extent be inconvenient to navigation, and in the case of strong winds blowing across the

channel, navigation will be difficult. The passage of vessels up and down would necessarily be regulated by signal, and delays would be inevitable. The width of the entrance itself must of necessity be limited, in order as far as possible, to preclude heavy seas from entering the canal, and although captains of ships and pilots have generally expressed themselves satisfied with the proposed entrance, there can be no doubt that the entering of a comparatively narrow channel of this description in heavy weather would be attended by a certain amount of difficulty.

138. On the other hand, the proposed works at Gollan's Bay would be situated within the magnificent natural harbour of Port Lyttelton, which can be entered with perfect ease and safety in all weathers, the width between the " Heads " being upwards of a mile in extent, all in deep water ; this deep and ample waterway moreover, extending practically to the entrance to the proposed harbour.

139. The depth of water to be provided has been fixed provisionally at 30 feet below low water of ordinary spring tides. Should it be required at any time to increase this to say 35 feet, a very large amount of dredging would be required in order to deepen the canal and dock by this amount.

140. On the other hand, in the case of the proposed harbour at Gollan's Bay, the natural depth of the water at the entrance is at present approximately 30 feet, and in the event of an ultimate depth of 35 feet being required, this could be obtained with comparatively little dredging.

141. The further very important consideration must also be borne in mind viz. : that in the case of harbour extension in Port Lyttelton, it may be said that practically all the conditions affecting the construction of the works and the future maintenance thereof are known, being merely a repetition on a somewhat larger scale of what has already been carried out at Lyttelton. The general depth of water in Port Lyttelton iftself has been proved unaltered during the past fifty years. The cost of dredging for the maintenance of the required depth in the present harbour at Lyttelton and approach channel is accurately known.

142. In the matter of the canal scheme, however, it is not possible to speak with the same certainty with regard to the dredging which would be required to maintain the entrance, together with the canal and basin.

143. With regard to the entrance, we have already expressed the opinion that the maintenance dredging which would be required in connection therewith would not prove excessive.

144. With respect to the canal and basin, however, the conditions are somewhat different. We have already alluded to the fact of the ground in the neighbourhood of Christchurch being saturated with water, the natural level at Christchurch being about 10 feet above high water level, falling to about high water level at the estuary. This water is, of course, constantly percolating through the ground on its way to the sea, and in the case of a deep cut being formed as by the proposed canal a proportion of the water would percolate through the sides of the cut, possibly carrying with it a small amount of sand into the canal, depending upon the rate of percolation and the fineness of the sand. The removal of sand thus brought into the canal would, we believe, be the chief item of maintenance, and it is impossible to forecast with certainty the extent to which this would be necessary.

FINAL RECOMMENDATION.

145. Knowing the importance which attaches to this question and the interests involved, we have given the most anxious and careful attention to the considerations above set forth, and after full deliberation are of opinion that, apart from questions of finance and general policy, the Board would on the whole be best advised in adhering to Port Lyttelton for future harbour extension, and we have therefore, finally to recommend for adoption the scheme for a harbour at Gollan's Bay in Port Lyttelton, as shown upon Drawing No. 5, accompanying this report, as being under all circumstances the most suitable.

In conclusion, we have to express our thanks to yourself and the members of the Lyttelton Harbour Board for their kindness and courtesy, and for the assistance rendered to us in connection with our inspection. Also to those gentlemen connected with the shipping interests and others who so kindly afforded us information. In particular, we desire to express our appreciation of the invaluable assistance which we received from the Board's Engineer, Mr. Cyrus Williams, throughout the whole of the enquiry, and of the admirable manner in which all the detailed information required for this report was prepared and tabulated.

We have the honour to be,

Sir,

Your obedient servants,

COODE, SON & MATTHEWS.

ENGINEER'S OFFICE,
LYTTELTON HARBOUR BOARD,
JUNE 12TH, 1908.

Memorandum on Report of the Consulting Engineers on Proposals for Harbour Extensions in Port Lyttelton.

In this memorandum it is not proposed to discuss the report of the Consulting Engineers, but merely to make some reference to the points on which their conclusions have differed from my own, and to give some reasons that led to my conclusions.

PROPOSALS FOR EXTENSIONS IN PORT LYTTELTON.

In the main, their conclusions and recommendations are very close to my own. The slight increases in the strength of the works proposed are all in favour of extra efficiency (though not in my opinion necessary). The commencement of the Western mole at Sticking Point, instead of Battery Point, is an improvement, though it adds considerably to the cost, against which, however, we would have a place of deposit for the dredgings. The small amount of overlap in my moles was deliberately arranged to make the entrance easier for vessels, but would, if found necessary, have been increased in carrying out the work. Their estimates of cost agree very closely with my own.

PROPOSAL FOR HARBOUR AT HEATHCOTE WITH ENTRANCE AT SUMNER HEAD.

The Consulting Engineers generally agree with me in the placing of the entrance and in the location of the canal, but propose to increase the entrance width by 100 feet, to which there can be no objection, and this alteration would not affect the cost.

The difference in cost of construction as estimated by the Consulting Engineers and by me arise from the following :—

(A) North mole splayed out at the inner end to form a wave trap, and another training pier to be carried along parallel with the canal as on the south side, instead of the mole being carried out parallel with the canal.

(B) Increase in bottom width of the canal from 200 feet to 250 feet.

(C) Increasing the radius of the canal to 10,000 feet.

(D) Coating the sides of the canal with rubble stone.

(E) Discharging the Heathcote into the canal below the basin instead of into the basin.

(F) Carrying the moles and entrance into 35 feet at low water instead of 30 feet.

(G) Increasing the section of the moles.

(H) Increasing the strength of the staging for the moles.

(K) Increasing the shed accommodation.

(L) Increase in cost of necessary plant.

(A) **With regard to the North Mole being parallel to the Canal in my report.**—The provision of a wave trap on the north side was not overlooked in my proposal, but owing to the action of the land in influencing the direction of the waves, the seas always come in at an angle of at least 29° with the line of the canal, so that I do not see how the seas could run up the canal. The entrance of the Suez Canal from the Mediterranean Sea has the weather side jetty or mole parallel and close to the canal, and no difficulty is experienced on that account. Moreover, at Westport it has been found that the weather side wave trap provided by Sir John Coode was unnecessary, only increasing the cost of the work, and it is being done away with.

(B) **With regard to increasing the bottom width of the Canal from 200′ to 250′.** Obviously the greater the width the better, and due provision for enlargement in this respect is desirable. The Suez Canal, however, had for many years a bottom width of only 72 feet, has now a bottom width of only 120 feet, and is ultimately to have a bottom width of only 213 feet. The Manchester Ship Canal has a bottom width of 120 feet only

(C) **With regard to increasing the radius of the Curves.** The very considerable practical advantage of being able to start the work inside the bar with the dredges afloat fixed for me the location of the canal at the Shag Rock and to a certain extent governed the radius of the curves, the smallest radius being about 8,000 feet, which, in view of the experience in the Suez Canal, would have proved quite workable. The proposed increase would, of course, make the navigation easier.

(D) **Coating the sides of the Canal with rubble stone** would obviously be an improvement, but I do not see how it could be carried out until the work had been in use for some time and had taken its final slopes and dimensions, by which time I expect it would be found not to be necessary, as there is considerable clayey earth among the sand and a growth of aquatic plants is a good protection for the banks, as was found in the Suez Canal, the banks of which were entirely unprotected for many years, and are only now, as the canal is being widened, being faced with stone pitching.

(E) **Discharging the Heathcote River below the basin instead of into it.** The flow of the river is so insignificant that I considered it could do no harm, while its tidal effect would help to keep sweet the water in the basin.

(F) **With regard to the depth of water at the Entrance,** I fixed upon 30 feet at low water as sufficient because at Fremantle, which is the last port of call for Australia, there is only 30 feet at low water, with a rise of tide of 2 feet 9 inches at ordinary high water, or a daily working depth of 32 feet 9 inches at high water, **the entrance channel being cut through rock.** My provision of 30 feet at low water spring tides with a daily rise of 5 feet would provide a working depth of 35 feet, against 32 feet 9 inches at Fremantle, and would be sufficient for a vessel drawing 30 feet. Moreover, the bottom is sand and easily dredgeable in view of further depths being required. The full depth is required in the canal to allow vessels to steer easily and to travel at a reasonable speed. Of course, the entrance would only be taken by the largest vessels at high water.

(G) **With regard to the section of the moles which the Consulting Engineers propose to increase.** The section I proposed was that which has proved sufficient at Timaru in the eastern extension, with slight flattening of the slopes as an extra precaution. The Timaru mole is founded in 26 feet at low water, and is placed square to the blow of the seas, which are heavier there than any which are experienced at Sumner Head, in addition to which the Sumner moles would meet the seas at an acute angle.

(K) **The provision for shed accommodation** is largely in excess of what I considered necessary.

(L) **Increase in cost of necessary plant.** I allowed for the plant which I considered necessary, the general increase of the magnitude of the work would naturally increase this item.

Generally, to look too far ahead is as bad policy as not to look far enough. Harbour works can be, and are every day throughout the world being, increased and enlarged to meet increments to trade : but if planned on too large a scale in the first instance, the excessive charges necessary simply drive trade away. I think the Consulting Engineers' Sumner proposals are on an unnecessarily large scale. With this exception, I am very pleased with their report, which deals with the questions submitted to them in a most exhaustive manner.

I have the honour to be,

Sir,

Your obedient servant,

CYRUS J. R. WILLIAMS,

ENGINEER TO THE BOARD.

THE CHAIRMAN,

LYTTELTON HARBOUR BOARD.

DRAWING No 1

LYTTELTON HARBOUR EXTENSIONS.

GENERAL PLAN OF CHRISTCHURCH, PORT LYTTELTON & SUMNER.

TO ACCOMPANY REPORT BY MESSRS COODE, SON & MATTHEWS
DATED 16TH APRIL, 1908.

NOTE

This Plan is compiled from the Admiralty Charts, the "Christchurch & Sumner Survey Districts" maps of the New Zealand Lands and Survey Department and the drawings supplied by the Lyttelton Harbour Board through Mr. Cyrus J. R. Williams.

Coode Son & Matthews
April 1908

LYTTELTON TIMES CO. PHOTO.-LITH.

DRAWING Nº 2.

LYTTELTON HARBOUR EXTENSIONS.

GENERAL PLAN OF CHRISTCHURCH, PORT LYTTELTON & SUMNER.

SHOWING

ALTERNATIVE WORKS PROPOSED FOR THE EXTENSION OF LYTTELTON HARBOUR

PLAN TO ACCOMPANY REPORT BY MESSRS COODE, SON & MATTHEWS.

DATED 16TH APRIL, 1908.

WORKS PROPOSED BY Mr WILLIAMS ARE SHOWN THUS:—

ADDITIONAL HARBOUR IN PORT LYTTELTON AT GOLLANS BAY	BY	1
Dº	Dº STICKING POINT	2
SHIP CANAL AND WET DOCK AT HEATHCOTE		3
Dº	LINWOOD	4

NOTE.

This Plan is compiled from the Admiralty Charts, the "Christchurch & Sumner Survey Districts" maps of the New Zealand Lands and Survey Department and the drawings supplied by the Lyttelton Harbour Board through Mr Cyrus J. A. Williams.

Coode Son & Matthews
April 1908.

LYTTELTON TIMES CO. PHOTO:LITH.

DRAWING No.3

LYTTELTON HARBOUR EXTENSIONS.

GENERAL PLAN OF CHRISTCHURCH, PORT LYTTELTON & SUMNER.

SHOWING

ALTERNATIVE WORKS PROPOSED FOR THE EXTENSION OF LYTTELTON HARBOUR

PLAN TO ACCOMPANY REPORT BY MESSRS COODE, SON & MATTHEWS.

DATED 16TH APRIL, 1908.

THE WORKS DESCRIBED IN THE REPORT WHICH ARE RECOMMENDED FOR CONSTRUCTION ARE THOSE SHOWN HEREON BY 2 IN GOLLANS BAY, PORT LYTTELTON.

NOTE.

This Plan is compiled from the Admiralty Charts, the "Christchurch & Sumner Survey Districts" maps of the New Zealand Lands and Survey Department, and the drawings supplied by the Lyttelton Harbour Board through Mr. Cyrus J. H. Williams.

Coode Son & Matthews
April 1908

LYTTELTON TIMES Co PHOTO-LITH.

LYTTELTON HARBOUR EXTENSIONS.

DRAWING Nº 4.

PROPOSED ADDITIONAL HARBOUR IN PORT LYTTELTON.

PLAN TO ACCOMPANY REPORT BY MESSRS COODE, SON & MATTHEWS.
DATED 16TH APRIL, 1908.

WORKS PROPOSED BY Mr WILLIAMS ARE SHOWN BY 3

DIVIDE PEAKS
GODLEY HEAD
LIGHTHOUSE Fixed white light.
OBSERVATORY
BEACON
LYTTELTON HARBOUR
ERSKINE POINT
BEACON
RECLAMATION BANK
STICKING POINT
BATTERY POINT
RECLAMATION PUMPING STATION
AREA 30 ACRES
COLLANS BAY HARBOUR AREA 200 ACRES
WESTERN 1,000 MOLE
EASTERN 2,300 MOLE
Direction of seas in Easterly gales
DIRECTION (White light)
BEACON (Red light)
Entrance channel dredged to 24.0' at L.W.O.S.T.
SHAG REEF
PORT LYTTELTON
Direction of seas in N.W. gales
PARSON ROCK
RIPA ISLAND
5 Fathoms Contour Line
LITTLE PORT COOPER
TOLOA HEAD
QUAIL ISLAND
2 Fathoms Contour Line
3 Fathoms Contour Line
CHURCH BAY
CAMP BAY
POULAO BAY
CHARTERIS BAY
PORT LEVY

NOTE. Soundings shown hereon were taken by Mr Williams and give depths in Feet below Low Water Ordinary Spring Tides.

NOTE – This Plan is compiled from the Admiralty Charts and the Drawings supplied by the Lyttelton Harbour Board through Mr. Cyrus J. R. Williams.

FEET 500 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000 10,000 FEET

Coode Son Matthews
April 1908

LYTTELTON TIMES CO. PHOTO.-LITH.

LYTTELTON HARBOUR EXTENSIONS.

DRAWING No 5.

PROPOSED ADDITIONAL HARBOUR IN PORT LYTTELTON.

PLAN TO ACCOMPANY REPORT BY MESSRS COODE, SON & MATTHEWS.
DATED 16TH APRIL, 1908.

THE PROPOSED WORKS ARE SHOWN BY 3
THE FUTURE EXTENSION WORKS ARE SHOWN BY 2

DIVIDE PEAKS
GODLEY HEAD
LIGHTHOUSE
LYTTELTON HARBOUR
OBSERVATORY
BEACON
ERSKINE POINT
PROPOSED RECLAMATION 36 ACRES
PROPOSED HARBOUR AREA 260 ACRES
PROPOSED WESTERN MOLE 5,050.0'
PROPOSED EASTERN MOLE 3,700.0'
Direction of seas in Easterly gales.
Entrance channel dredged to 24.0' at L.W.O.S.T.
SHAG REEF
PORT LYTTELTON
Direction of seas in S.E. gales.
5 Fathoms Contour Line
3 Fathoms Contour Line
PARSON ROCK
RIPA ISLAND
CAMP BAY
LITTLE PORT COOPER
TOLOA HEAD
PORT LEVY
QUAIL ISLAND
1 Fathom Contour Line
CHURCH BAY
POULAO BAY
CHARTERIS BAY

NOTE. Soundings shown hereon were taken by Mr Williams and give depths in feet below Low Water Ordinary Spring Tides.

NOTE - This Plan is compiled from the Admiralty Charts and the Drawings supplied by the Lyttelton Harbour Board through Mr. Cyrus J. R. Williams.

SCALE
FEET 1000 500 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 FEET

Coode Son Matthews
April 1908

LYTTELTON TIMES CO. PHOTO. LITH.

LYTTELTON HARBOUR EXTENSIONS.

DRAWING No 6

PROPOSED WET DOCK AT HEATHCOTE AND SHIP CANAL.

PLAN TO ACCOMPANY REPORT BY MESSRS COODE SON & MATTHEWS
DATED 16TH APRIL, 1908.

WORKS PROPOSED BY Mr WILLIAMS ARE SHOWN BY × × ×

EXISTING ESTUARY TO BE RECLAIMED WITH DREDGINGS

TOTAL AREA OF PROPOSED RECLAMATIONS 1,300 ACRES

PROPOSED CHANNEL FOR RIVER AVON

PROPOSED WET DOCK AREA 116 ACRES DREDGED TO 30 FEET BELOW L.W.O.S.T.

PROPOSED SHIP CANAL BOTTOM WIDTH 200 FEET DREDGED TO 30½ FEET BELOW L.W.O.S.T.

PROPOSED NORTH MOLE

PROPOSED HALF TIDE TRAINING BANK

Existing Tramway Embankment

Existing Roads

Jetty

To Christchurch

RIVER HEATHCOTE

To Christchurch RAILWAY

To Lyttelton

MONCKS

SUMNER

SUMNER HEAD

Shag Rock

Cave Rocks

3 Fathoms Contour Line

L.W.O.S.T.

TAYLOR'S MISTAKE

LIGHTHOUSE. Fixed white light.

GODLEY HEAD

PORT LYTTELTON

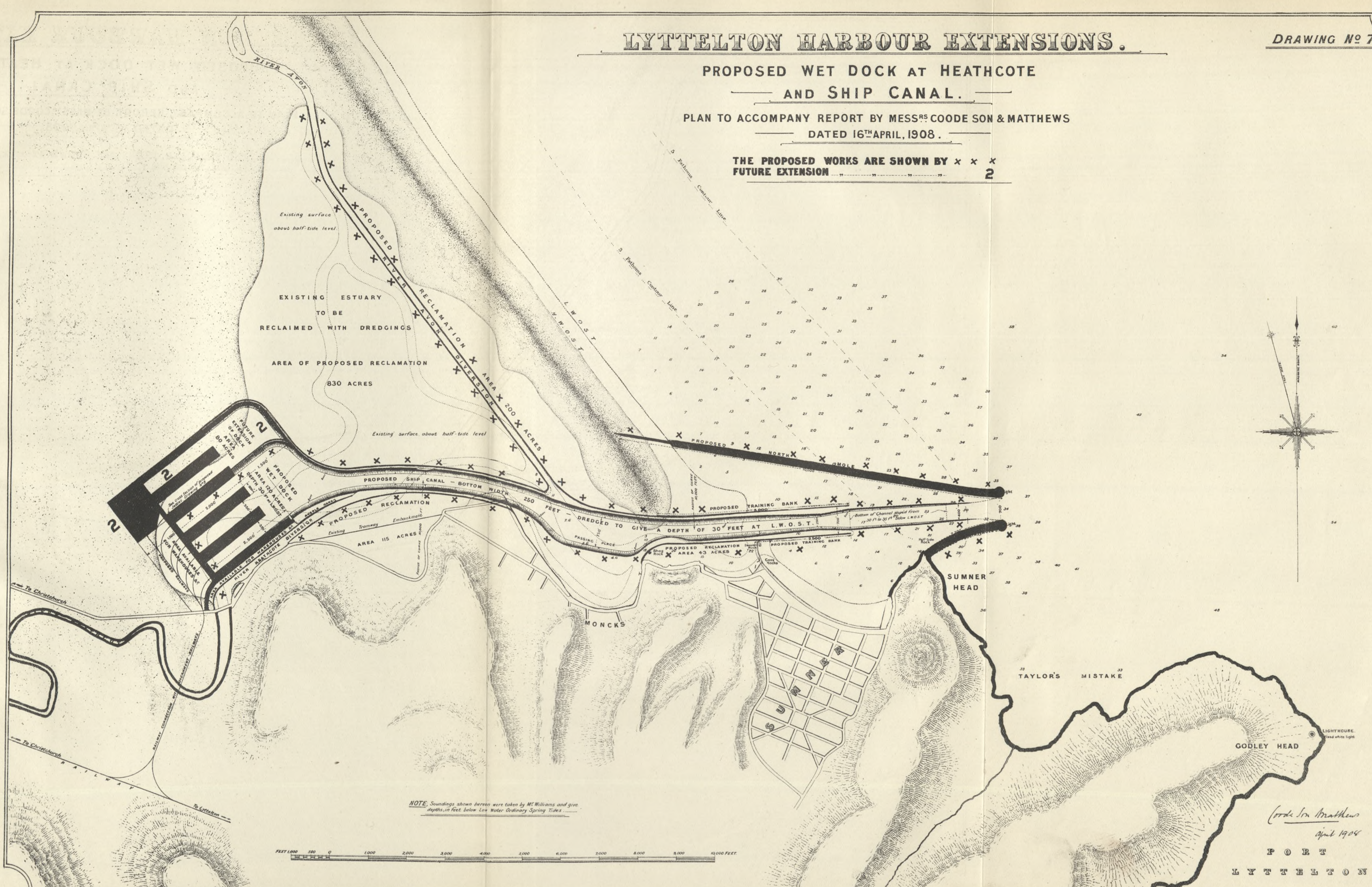
NOTE. Soundings shown hereon were taken by Mr Williams and give depths in feet below Low Water Ordinary Spring Tides.

SCALE

FEET 1,000 500 0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 9,000 10,000 FEET.

Coode Son Matthews April 1908

LYTTELTON TIMES CO. PHOTO:-LITH.



LYTTELTON TIMES CO. PHOTO.-LITH.

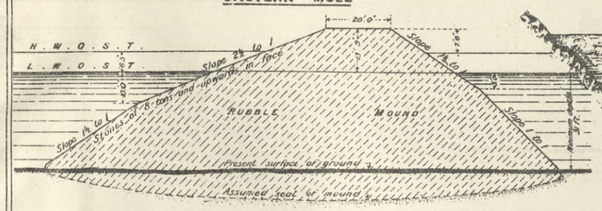
LYTTELTON HARBOUR EXTENSIONS. — TYPICAL SECTIONS OF PROPOSED WORKS SHOWN ON DRAWINGS Nos 5 & 7.

DRAWING No 8

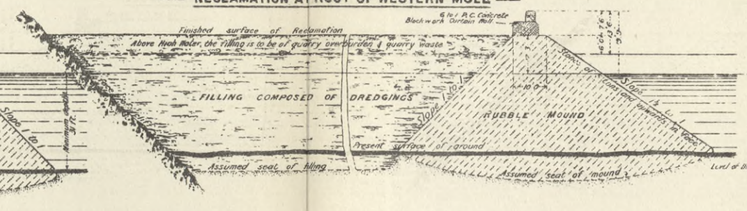
— TO ACCOMPANY REPORT BY MESSRS COODE, SON & MATTHEWS. DATED 16TH APRIL, 1908. —

— PROPOSED ADDITIONAL HARBOUR AT PORT LYTTELTON, SEE DRAWING No 5. —

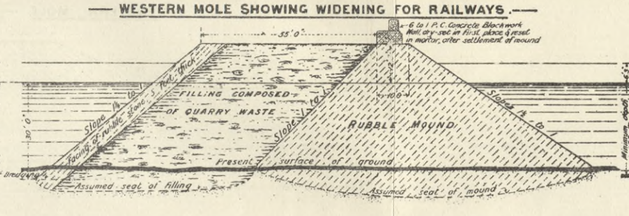
— EASTERN MOLE —



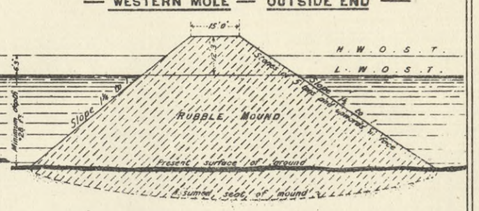
— RECLAMATION AT ROOT OF WESTERN MOLE —



— WESTERN MOLE SHOWING WIDENING FOR RAILWAYS. —



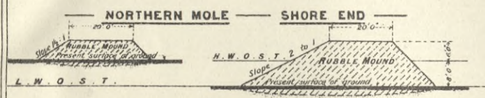
— WESTERN MOLE — OUTSIDE END —



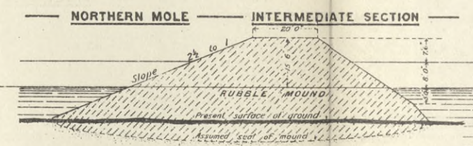
— PROPOSED WET DOCK AT HEATHCOTE AND SHIP CANAL, SEE DRAWING No 7. —

— MOLES AT ENTRANCE —

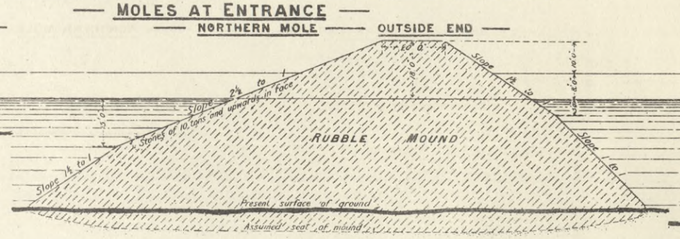
— NORTHERN MOLE — SHORE END —



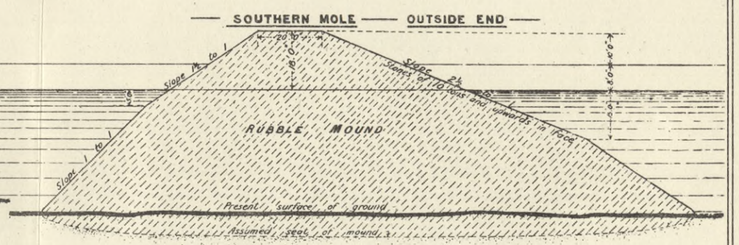
— NORTHERN MOLE — INTERMEDIATE SECTION —



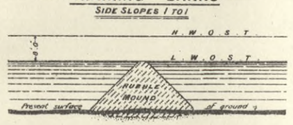
— NORTHERN MOLE — OUTSIDE END —



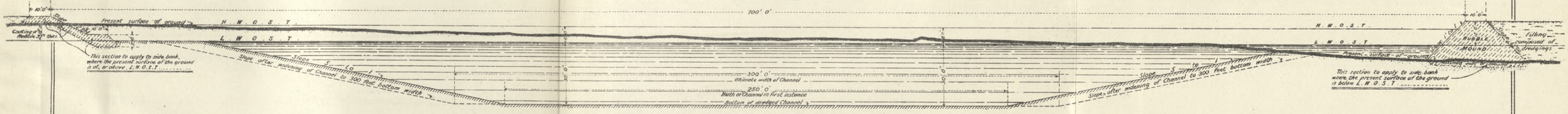
— SOUTHERN MOLE — OUTSIDE END —



— TRAINING BANKS —
SIDE SLOPES 1 TO 1

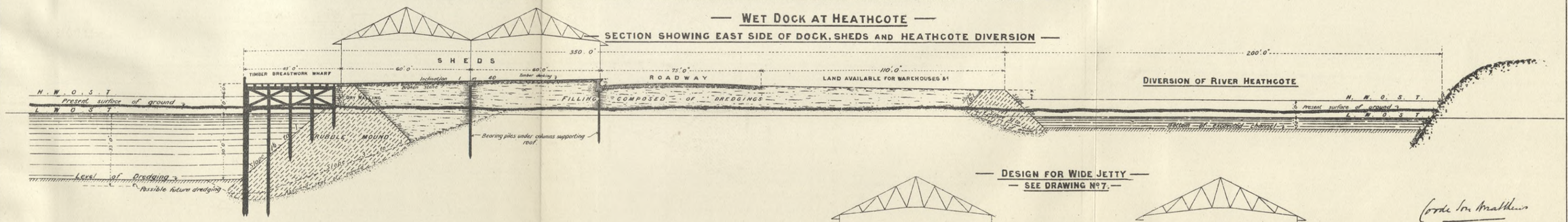


— SHIP CANAL —



— WET DOCK AT HEATHCOTE —

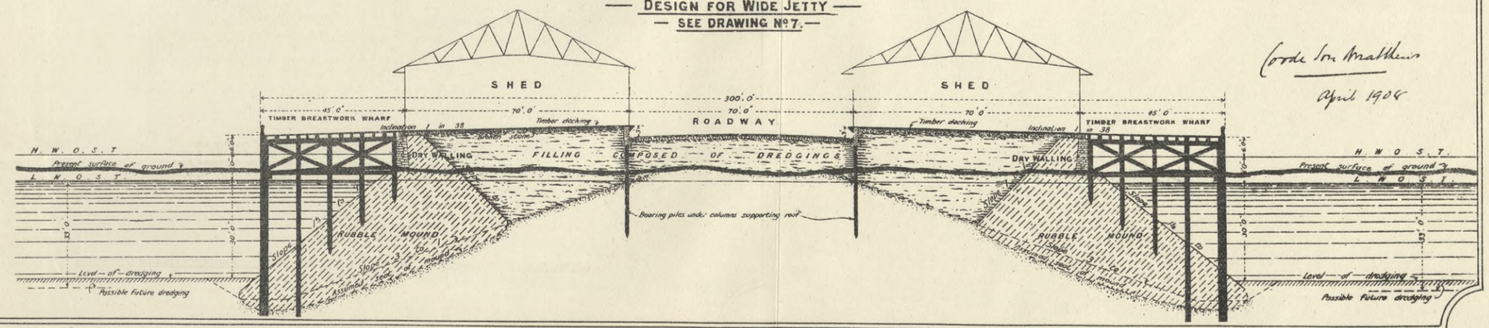
— SECTION SHOWING EAST SIDE OF DOCK, SHEDS AND HEATHCOTE DIVERSION —



— NOTE —

The timber moorings or breastworks shown upon this drawing are similar to those existing in Lyttelton Harbour, details of which were supplied by the Board's Engineer. They should be anchored back in a manner similar to that at present adopted.

— DESIGN FOR WIDE JETTY —
— SEE DRAWING No 7. —



Coode Son & Matthews
April 1908

FEET 10 5 0 10 20 30 40 50 60 70 80 90 100 150 FEET

LYTTELTON TIMES CO. PHOTO-LITH.

BIRD'S-EYE VIEW OF THE PROPOSED CHRISTCHURCH CANAL.

No. 1, Sticking Point; No. 2, Gollan's Bay; No. 3, Estuary, Heathcote; No. 4, Canal.

Memorandum on the Subject of Further Harbour Extensions, and on the Feasibility of Constructing a Canal from the Sea towards Christchurch.

The Lyttelton Times Co., Ltd., Printers, Gloucester St., Christchurch.

ENGINEER'S OFFICE,
LYTTELTON HARBOUR BOARD,
25th November, 1905.

Memorandum on the Subject of Further Harbour Extensions, and on the Feasibility of Constructing a Canal from the Sea towards Christchurch.

IN accordance with paragraph 5 of my General Instructions, dated 21st January, 1903, and further instructions of 3rd October, 1904, I now submit the following report on the subject of "In what direction further harbour extensions can be made and the estimated cost," and also on "The feasibility and advisability or otherwise of the formation of a canal from the sea at Sumner to Christchurch, and also of other accommodation for shipping at Sumner."

As pointed out in my Annual Report dated 16th January, 1905, assuming a steady growth of trade on the basis of the figures from 1893 to 1904, in about 1925 the accommodation in the inner harbour at Lyttelton may be exhausted, in which case extensions will be necessary outside the present moles.

On the accompanying plan of part of Port Lyttelton are shown outline plans of two propositions for such harbour extensions, capable of being worked through the Moorhouse Tunnel.

Sticking Point Harbour, No. 1.

No. 1 proposition shows a small additional enclosed harbour in connection with the reclaimed land eastward of Officers' Point, a curved breakwater being run out in a South-westerly direction from Sticking Point, and another protecting mole being built in a south-easterly direction from the elbow of Officers' Point breakwater, leaving an entrance 500 feet wide.

This arrangement would enclose a water area of about 90 acres, and effective berthing lengths of about 3,800 feet at breastworks, and 5,200 feet at four jetties, or a total of 9,000 feet of deep water berthage.

Such a basin would be less subject to shoaling than the present inner harbour, because it would be free from the discharge from drains and less exposed to the south-westerly wash from the upper bays, and its jetties and breastworks could be conveniently connected to the present railway system. Its disadvantages would be that it would not be a commodious harbour for the largest class of steamers now afloat, bringing ships in and berthing them would be fully as inconvenient as at present, and dredging outside would still always be necessary, as the natural depth abreast of the entrance is only 22 feet at low water datum.

The cost is estimated at:—

	£	s.	d.	£	s.	d.
Breakwater	38,015	0	0			
Protecting Mole	26,400	0	0			
Dredging inside	27,185	0	0			
Breastworks	68,400	0	0			
Jetties, No. 4	90,000	0	0			
				250,000	0	0
Contingencies, 10 %	...			25,000	0	0
Total ...				£275,000	0	0

This estimate makes no provision for rails on the wharves, which, under our present constitution are laid by the Railway Department, who work the cargo, nor for payment to the Government on account of reclaimed land eastward of Officers' Point, work which has been assessed by them at a cost of £26,000.

The accommodation provided would thus cost about £30 11s. per lineal foot of efficient berthage.

Gollan's Bay Harbour, No. 2.

The second proposition provides for a completely new harbour at Gollan's Bay, with the necessary reclamation to connect it with the present railway system.

The water area enclosed would be about 200 acres, and the ultimate effective berthage about 5,000 lin. feet at breastworks, and 17,000 lin. feet at the 12 jetties, which could each be suitable for berthing a 700-foot vessel, and still leave manœuvring space between the ends of the jetties on opposite sides of the harbour. The entrance would be situated in 30 feet at low water datum, so that no dredging outside the moles would be required. The dredgings from the inner harbour could be used to make reclamations, unless it was found, as has previously been the case, that the waste from the quarrying operations was supplying sufficient material for this purpose. The reclamation bank extending from Officers' Point to Sticking Point would be extended as shown, enclosing the small bay between Sticking Point and Battery Point, and continued in an easterly direction to form a shelter from the south-west, and to carry a series of jetties running north-east and south-west, so that vessels could berth head or stern to wind as they do at present.

I estimate the cost at :—

	£	s.	d.	£	s.	d.
Breakwater	58,216	0	0			
Western Mole and Reclamation Bank from Sticking Point	139,906	0	0			
Reclamation Bank inside Moles	20,515	0	0			
				218,637	0	0
Dredging and Reclaiming with Dredgings	42,000	0	0			
Breastworks	75,000	0	0			
				117,000	0	0
				335,637	0	0
Contingencies, 10% on above				33,564	0	0
				369,201	0	0
Jetties, No. 12				300,000	0	0
Total ...				£669,201	0	0

or about £30 per lin. feet of effective berthage.

This estimate, like the last, makes no provision for rails on the wharves, nor for payment for the Sticking Point reclamation.

In comparing the costs of these proposals, it is necessary to take into account the cost of keeping open a dredged channel into the Sticking Point harbour. A moderate estimate would be £3000 per annum, which, capitalised at 4½ per cent., equals £66,667, which should be added to the cost of the Sticking Point harbour, bringing the cost up to £341,667, or nearly £31 per foot of berthage. Or, comparing them on a basis of equal additions to the berthage, the Gollan's Bay harbour would only require three of the twelve jetties, making the cost only £435,201 as against £341,667 for the Sticking Point proposal. That is to say, for a 50 per cent. increase to the present accommodation, the Sticking Point proposal is the cheaper; but looking further ahead and taking into account the increase in the size of vessels to be provided for, it would be better to go straight to Gollan's Bay, and provide a commodious tidal basin there suitable for the largest vessels.

Harbour Entrance at Sumner, No. 3.

In considering such proposals as these, involving the expenditure of £275,000 or £369,000, as the case may be, in the first instance, and of nearly £700,000 ultimately, it is necessary to take into consideration the question of whether it is desirable or good economy that the trade of the district should depend on railway communication through the hills. I am not among those who think that the capacity of the present tunnel is likely to be soon overtaxed, as I know that it is capable of dealing with a large increase to the present traffic, and when necessary it can be duplicated, though the cost of such duplication, which would probably be at least £125,000, would really be a charge against the harbour works, however it might be paid for.

The point is that as regards general merchandise, coal, timber, and imports generally, the district is handicapped by the railage charges, and though these could be considerably reduced, and still leave a large margin of profit, they are not likely to be so reduced as to put Christchurch and the district served by its Port on an equality with large seaport centres. Under the present system manufactures will always be handicapped. The position as regards export of produce is not so acute.

Consequently data have been obtained with a view of ascertaining the feasibility of constructing a canal from the sea towards Christchurch, and the accompanying plan No. 2 shows outlines of two such propositions.

Port or Tidal Basin at Heathcote, No. 3 "A."

This proposition provides for a tidal basin formed in the Estuary, near the mouth of the Heathcote River, connected to the sea by means of an open cutting 30 feet deep at low water springs, with bottom width of 200 feet, and side slopes calculated at 5 to 1 inside the present Sumner Bar, and 6 to 1 outside the Bar, opening into the open sea just outside Sumner Head in five fathoms at low water of spring tides. The channel would be protected on the north side by a mole about 7500 feet long, of similar construction to the outer mole now being built at Timaru, and the entrance would be narrowed to 700 feet between the centres of the moles by a short mole from Sumner Head, covering the half tide rock near there. The ebb currents in the channel through Sumner Bay would be directed and confined on the north by the north mole, and on the south by a low training wall to be covered at quarter-flood, thus allowing for the dispersal of waves and for the free ingress of the flood-tide. The present Sumner Bay would thus be converted into a wave-trap or stilling basin, its shoalness precluding its use as an anchorage, unless dredged out, which is not contemplated in this proposition, as anything in the nature of a harbour of refuge or anchorage for large vessels would be unnecessary with Port Lyttelton so near; while vessels waiting for a pilot could lie off or anchor outside in fair weather. The sides of the channel from the mouth of the Estuary to the Port would be protected by means of reclamation banks, behind which the dredgings would be deposited, which would result in the reclamation of upwards of 800 acres of land.

At the Port itself sufficient land would be reclaimed round the margin, seaward of the present high-water line, for administration, storage and other purposes, no provision being required for land resumptions.

The berthage accommodation would consist of breastworks and jetties with sheds, with rails between the sheds and wharf faces, this space being spanned by travelling electric gantry cranes, capable of lifting the goods from the vessel's hold on to small platforms in front of the sheds or into drays or trucks on the rails as required. The wharf rails could be connected to the Tramway Board's system. An export wharf would be constructed along the south side of the basin and channel, connected to the railway system of the Colony by means of the old railway line along the Heathcote River.

Under this system the cargo would be handled by the Board as at Wellington.

The construction of these works would occupy from five to seven years.

Canal from the Sea and Port at Wilson's Road, No. 3 "B."

This proposition provides for a tidal basin or port just below Wilson's Road, opposite the Linwood Railway Station. The ultimate area would be 162 acres, which would form the basis of the necessary land resumption here of 236 acres. Only 70 acres, however, would be excavated at first, the basin being enlarged as trade increased. The depth in the Port would be 30 feet at low water, and it would be connected with the sea by means of an open cutting, with 130 feet bottom width and side slopes at the natural angle of the material, out to the present high-water mark, and 200 feet bottom width thence seawards, the lower works being identical with those described under propositio n 'A"

At the Port the wharves would be provided with sheds, cranes, etc., as before, but no rails would be laid on any except the export wharf, along the south side of the basin, which would be connected with the railway system.

In this proposition it would be necessary to provide for the acquisition of 358 acres of land, 122 acres for the canal and 236 acres for the terminal port; while the whole of the Estuary would be required to dispose of the dredged spoil.

Under this system also the cargo would be handled by the Board as at Wellington.

The construction of these works would occupy from seven to ten years.

ESTIMATES OF COST.

Port at Heathcote Bridge.

I estimate the cost of Proposal 3 "A," with a Port at Heathcote as hereinbefore described, at:—

Estimate of Cost of Proposal 3 "A" with Port near Heathcote Bridge, with area 176 acres, channel 30 feet at low water, 200 feet bottom with side slopes, 6 to 1 outside present bar, and 5 to 1 inside bar.

	£ s. d.	£ s. d.
PLANT, including necessary Cranes and Dredges	152,000 0 0	
PRELIMINARY EXPENSES in connection with Quarry, Rails and Temporary Bridge	11,750 0 0	
		163,750 0 0
NORTH MOLE, with Staging	168,000 0 0	
SOUTH MOLE	16,340 0 0	
TRAINING WALL in Sumner Bay	7,048 0 0	
RETAINING WALLS to contain Dredgings	3,575 0 0	
		194,963 0 0
DREDGING—		
Present Bar to Open Sea	22,316 0 0	
Present Bar to Port	128,012 0 0	
Tidal Basin or Port	241,354 0 0	
		391,682 0 0
WHARFAGE	130,000 0 0	
SHEDS	37,500 0 0	
CRANAGE OUTFIT	30,000 0 0	
RAILS ON WHARVES	10,000 0 0	
		207,500 0 0
		957,895 0 0
Contingencies and Engineering Expenses 10%		95,789 0 0
TOTAL ...		£1,053,684 0 0

ESTIMATE OF COST OF FIRST INSTALMENT OF WORKS—

Total Estimated Cost as above	1,053,684 0 0	
Saving by only Excavating 50 Acres of Tidal Basin, continuing as extensions become necessary	200,000 0 0	
TOTAL COST IN WORKING ORDER ...		£853,684 0 0

Port at Linwood.

And I estimate the cost of Proposal 3 "B," with a Port at Linwood as hereinbefore described, at:—

Estimate of Cost of Proposal 3 "B" with Port near Wilson's Road, of area 162 acres, channel 30 feet at low water, 200 feet bottom width from sea to high-water mark, and 130 feet bottom width from high-water mark to Port.

	£	s.	d.	£	s.	d.
Plant including necessary Cranes and Dredges	152,000	0	0			
Preliminary Expenses	11,750	0	0			
				163,750	0	0
North Mole, with Staging	168,000	0	0			
South Mole	16,340	0	0			
Training Wall in Sumner Bay	7,048	0	0			
Reclamation Walls to contain Dredgings	3,575	0	0			
				194,963	0	0
Dredging—						
Present Bar to Open Sea	22,316	0	0			
Present Bar to High-water Mark	174,861	0	0			
High-water Mark to Port	121,916	0	0			
Tidal Basin or Port at Wilson's Road, with area 162 acres	359,571	0	0			
				678,664	0	0
Wharfage	130,000	0	0			
Sheds	37,500	0	0			
Rails on Wharves	5,000	0	0			
Cranage Outfit	30,000	0	0			
				202,500	0	0
				1,239,877	0	0
Contingencies and Engineering Expenses 10 %				123,987	0	0
TOTAL COST OF CONSTRUCTION				1,363,864	0	0
Land Resumptions and Compensations for Canal 122 acres						
For Tidal Basin, Store Space, etc. 236 acres						
358 acres				379,528	0	0
				£1,743,392	0	0

Cost of Canal Proper, not including Land Resumptions or Compensation to property owners, about £900 per chain, or £72,000 per mile.

ESTIMATE OF COST OF FIRST INSTALMENT OF THE WORKS.

	£	s.	d.	£	s.	d.
Total Estimated Cost of Construction as above...	1,363,864	0	0			
Less Difference in Cost of Tidal Basin Constructed 70 Acres in extent, instead of 162 Acres as finally proposed	210,000	0	0	1,153,864	0	0
Add estimated Cost of Resumption and Compensation—						
For Canal ... ... 122 acres						
For Tidal Basin, Store Space, etc. 236 acres						
358 acres				379,000	0	0
TOTAL COST IN WORKING ORDER				£1,532,864	0	0

The cost of the project 3 "B" modified to provide a depth of 26 feet in the channel, and with the lesser width of 130 feet on the bottom continued out to the site of the present bar, at:—

Estimate of Cost of Proposal 3 "B" with Port near Wilson's Road, cut to 70 acres, with provision for subsequent enlargement to 162 acres, channel 130 feet bottom width, cut to 26 feet at low water.

	£	s.	d.	£	s.	d.
Plant, including Cranes and Dredges	152,000	0	0			
Preliminary Expenses	11,750	0	0			
				163,750	0	0
North Mole, with Staging	168,000	0	0			
South Mole	16,340	0	0			
Training Wall in Sumner Bay	7,048	0	0			
Reclamation Walls to contain Dredgings	3,575	0	0			
				194,963	0	0
Dredging—						
Present Bar to Open Sea	15,667	0	0			
Present Bar to High-water Mark	139,176	0	0			
High-water Mark to Port	103,549	0	0			
Port 70 acres, 30 feet deep	155,458	0	0			
				413,808	0	0
Wharfage	130,000	0	0			
Sheds	37,500	0	0			
Rails	5,000	0	0			
Cranage Outfit	30,000	0	0			
				202,500	0	0
				975,021	0	0
Contingencies, etc.				97,502	0	0
				1,072,525	0	0
Land Resumption				379,528	0	0
TOTAL				£1,452,051	0	0

Works at the Entrance.

The system of construction proposed for the north mole would be that which is proving sufficiently stable and effective at Timaru ; the stone in large blocks would be brought by rail from quarries between Bell's Baths and Sumner Head, carried across the present entrance by means of a temporary bridge, with opening span to admit the dredges, and tipped from a staging. Such work at Timaru, where the haulage is longer, costs 2s. 10½d per ton tipped in the work. Taking into account the shorter haulage, and that all the smaller stuff quarried would be used in the foundation of the mole and in the training wall and reclamation banks, it would be quite safe to estimate the cost of the work at 2s. 9d. per ton or 4s. 10d. per cubic yard, exclusive of all costs for plant, staging, railway, bridge, and all preliminary work. The weight of the stone is about 163 pounds per cubic foot, and the proportion of voids about 20 per cent. at Timaru.

The short mole from Sumner Head would be constructed in a similar manner to the north mole, but is much nearer to the quarries.

The dredged and trained channel through Sumner Bay should not require much attention after the completion of the works, as the current between the north mole and the low training wall would prevent any deposit in that part of the channel, and the movement of the sea and cross currents at the entrance would prevent the deposit of the alluvium there. There might be some slight deposit of sand there which would require the occasional attention of a suction dredge, but at the worst the quantity would be inconsiderable.

With regard to the sand travel, which is under present conditions slowly causing accretion on the Sumner beach and in the corner at Bell's Baths, the north mole would cut this off and the prevailing direction of the waves would prevent it extending along the mole towards the entrance. A comparison of the soundings in Sumner Bay, with such as are available showing former conditions, indicates that the quantity of sand is not such as to become a menace for hundreds of years, if at all.

The sea bed at the proposed entrance is composed of muddy sand, changing to almost pure sand at the site of the present bar and for some distance inside.

A comparison of the recent soundings with those of the Admiralty chart, dated 1849, indicates a condition of stability in the natural conditions of the sea bed at the site of the proposed entrance.

The whole of the material is suitable for handling with a suction dredge, that in the outer part might have to be carried to sea, but in the inner part the spoil could all be pumped over the north mole.

Dredged Channel from the Entrance to High-water Mark.

The material here throughout is sand and alluvium, very suitable for being dealt with by a suction dredge, which could dredge and discharge the spoil over the reclamation banks in one operation. Such work is now being carried out on the Brisbane River in Queensland at about 2d. per ton.

Channel from High-water Mark to Port near Linwood.

The material to be dealt with is sand, alluvium, and gravel. It could all be removed by means of suction dredges, but the spoil would need to be carried down in hoppers and would be deposited in suitable positions to be discharged over the walls by pump dredges stationed in the lower channel.

The tidal basin or port would be excavated in the same way.

The sides of the whole of the channel would be allowed to assume their natural slopes. Such slopes in existing ship canals vary from 1—1 to 2½—1, but the estimated costs have been based on still flatter slopes to be on the safe side.

It is not expected that the upper part of the channel, and the canal proper, would maintain their depths without continuous dredging in some part or another, and I have assumed that in the project for a Port at Linwood a sum of £15,000 per annum would be necessary to provide for this, and that £10,000 would be necessary in connection with a Port near Heathcote Bridge.

Canal Reserve.

I cannot see any special benefit in attempting to make use of the Canal Reserve. It could never, in my opinion, have been laid out for the purpose of constructing a ship canal, or its width would have been more than 2½ chains, and I doubt whether the whole of this width would be available without compensation to the property owners on both sides, as it is also a road reserve. Even if the whole width were available without compensation the small saving in land resumption would not make up for the increase in the length of the canal to reach an equally central site for the Port. The land, which would require to be reserved, however, seems to me to be somewhat less valuable than that required for the work on the lines indicated, and on the whole, where so many interests are involved, there is plenty of room for difference of opinion as to the best location. For the purpose of settling the feasibility, or otherwise, of a canal towards Christchurch, a decision on this point is hardly necessary at this juncture.

Any smaller canal than one suitable for the largest vessels, does not seem to me to be worth discussing. The works at the entrance would need to be the same, land resumption in need of future development would need to be the same, and work at a port at Sumner would, as regards wharfage, etc., cost as much as at Linwood ; while, after all the expenditure had been incurred, the conditions would not be much improved, if at all, on those at present obtaining.

Possible Savings on the Estimated Cost.

There are many directions in which savings would almost certainly be effected in the actual execution of the works. For instance, the construction of the training walls would almost certainly induce such scour in the channel during the progress of the work that the amount of dredging would be considerably reduced. Then the height of the north mole has been calculated at 6 feet above high water of spring tides. It is unlikely that the full height would be required, the stilling effect being only that needed for safe navigation purposes, which is much less than would be necessary were vessels required to berth and discharge cargo along the mole. Further, it is hardly likely that the sides of the cutting would assume such flat slopes as those allowed for. As nearly half the amount of the excavation estimated on is included in the allowance for side slopes, it will be seen how important this point is.

I have preferred, however, to keep these savings, among which must be included the fact that the canal could be used and would be producing revenue long before its completion to the full width and depth, as a set-off against such contingencies as are bound to arise in a work of this magnitude, and against additions to the capital cost on account of interest during construction.

The value of the contingent reclamations has not been taken into account. In the case of Proposal 3 "A" the area reclaimed would be about 800 acres, while in the case of Proposal 3 "B" the whole of the estuary, except the ship channel and the necessary channels for the Avon and Heathcote rivers, would be reclaimed, an area of 1477 acres. A great deal of the land would not be very valuable for some years at least, but those portions facing the channel would be a valuable asset immediately.

Financial Aspects.

The above remarks only deal with the constructive aspect of these propositions. The financial working aspect cannot, however, be overlooked even at this preliminary stage.

With regard to Propositions 1 and 2 for extensions inside Port Lyttelton, they are at best only extensions of the present harbour, and would only be undertaken under pressure, or threatened pressure, of trade overtaking the present accommodation. They provide no remedies for the present disabilities, nor can they do so. When necessary, they or something else must be undertaken, and there is an end of it.

Propositions 3 "A" and 3 "B" are on a different footing. Their function is not only to provide further accommodation, but to entirely reorganise the sea-borne trade of the district. It is therefore necessary that some comparison, however rough, be made of the conditions and costs under this system and under the present one.

The first stage is to estimate the cost of working them.

For a rough estimate, it will be sufficient to take the cost of working the present harbour, as all the conditions which affect this one will be somewhat similar, with the exception of the cost of working the cargo, which will be taken separately.

Estimate of Annual Working Cost, Proposal 3 "A."

HARBOUR IN ESTUARY, NEAR HEATHCOTE BRIDGE.

	£ s. d.	£ s. d.
Annual Working Cost of Port on basis of present Harbour, not including Dredging or Interest on Loans	18,871 0 0	
Dredging for Maintenance	10,000 0 0	
Annual Cost of handling Cargo on basis of probable trade in 1910, say 600,000 tons, @ 1/-	30,000 0 0	
		58,871 0 0
Interest on Cost of Construction of first instalment of Work £853,684, @ 4½ %	38,416 0 0	
Interest on balance of Unredeemed Loans on account of Works at present Lyttelton Harbour, say £200,000 in 1910, @ 4½ %	9,000 0 0	
		47,416 0 0
TOTAL ANNUAL COST		£106,287 0 0

Estimate of Annual Working Cost, Proposal 3 "B."

PORT NEAR TO LINWOOD RAILWAY STATION.

	£ s. d.	£ s. d.
Annual Working Cost of Port on basis of present Harbour, not including Dredging or Interest on Loans	18,871 0 0	
Dredging for maintenance	15,000 0 0	
Annual Cost of handling Cargo on basis of probable trade in 1915, say 700,000 tons, @ 1/-	35,000 0 0	
		68,871 0 0
Interest on Cost of Construction of first instalment of the Work £1,153,636, at 4½ %	51,913 0 0	
Interest on balance of Unredeemed Lyttelton Harbour Loans, say £150,000 in 1915, @ 4½ %	6,750 0 0	
		58,663 0 0
Interest on Cost of Land Resumptions and Compensations, say £379,000, @ 4½ % ...		17,055 0 0
TOTAL ANNUAL COST		£144,589 0 0

Revenue likely to be available.

It is not necessary at this stage to discuss the various sources of revenue. It will be sufficient for our present purpose to show at what date sufficient revenue could be collected to meet the necessary yearly cost without excessive charges.

A comparison with a model port like Wellington will, therefore, not be out of place.

At that port, with a quantity of about 630,320 tons of cargo inwards and outwards, not including transhipments, they were able to collect a revenue of about £113,583, exclusive of rents, which works out at about 3/6 per ton of cargo.

In these comparisons and estimates all classes of goods have, for the sake of simplicity and convenience, been converted into tons.

On the above basis the cost of cargo from Lyttelton to Christchurch, and *vice versa*, amounted in 1904 to more than £169,607, made up of the total revenue of the Board, and the handling and railage between Lyttelton and Christchurch. This works out at something over 7/- per ton on 486,135 tons; but the total charges could, perhaps, be reduced to about 5/- per ton by reductions in the railage.

I propose, therefore, to discuss the question on the above basis of so much revenue per ton of cargo, without going into the question of how the charges should be allocated.

In this connection it is necessary to make some estimates of the quantities of cargo to be dealt with at various dates as a working basis. I have, therefore, shown in diagram form the quantities of inward, outward and total cargo, exclusive of transhipments, which passed over the Lyttelton wharves from 1881 to 1904, a period of 23 years, with fair lines showing average increases of cargo during the whole period and during the last 11 years.

There is room for difference of opinion as to which of these lines of average (if either) should be used as a basis of estimates of future trade. The average for the last 23 years seems a decidedly conservative view to take, while that for the last 11 years, may, to some people, seem unduly optimistic. Accurate trade predictions are impossible, and I express no opinion; but as some basis of discussion is necessary, I have worked out the following table on the basis of both these lines of average increase of trade.

This table shows the revenue that would be available at future dates on the basis of the average increases for the last 23 years and for the last 11 years at various total charges per ton of cargo, the lowest rates being substantially on the basis of the Wellington charges, and the highest on the basis of what the charges under the present system might be reduced to.

The table will, therefore, show by inspection, at what dates the canal proposition becomes a workable scheme on the above assumptions.

That is to say, it shows that, taking the conservative view based on the average increase for the last 23 years, and on a working basis equal to 5/- per ton, the Canal scheme would be financial in 1917, at 4/6 per ton in 1923, and on a basis of 4/- per ton in 1931; or taking the optimistic view of trade expansion based on the average rate of increase for the last 11 years, it would become financial in 1910 at 5/- per ton, in 1913 at 4/6 per ton, in 1917 at 4/- per ton, and in 1921 at 3/6 per ton. It also indicates that a Port near Heathcote Bridge would be a financial success to-day by reducing the total charges from 7/- per ton to 5/- per ton; that in 1907 the charges would be reduced to 4/6 per ton; and that if the work were commenced now, by the time it was finished the charges would be reduced to 4/- per ton.

In speaking of a basis of 4/-, etc., per ton, it must not be assumed that such rate would be the direct wharfage rate on the cargo; some of it would take the form of dues on the ships, pilotage, etc., so that the actual wharfage rate would be much less than the assumed total charge for estimating purposes.

In the following table what may be described as the financial points in connection with Proposal 3 "B" are underlined with a double line, similar points in connection with Proposal 3 "A" with a single line.

Conclusion.

In this report I have endeavoured, while withholding my own opinions as far as is consistent with my office, to so put the matter before those interested, that they shall have something definite on which to base their judgments.

The plans accompanying this report are:—

Diagram of annual increase of trade, 1881 to 1904.
General plan (No. 1), showing limits of Port, with outlines of various propositions indicated in red colour.
Plan (No. 2) of Sumner Bay and suggested Christchurch Canal.

THE CHAIRMAN,
LYTTELTON HARBOUR BOARD,
Christchurch.

CYRUS J. R. WILLIAMS,
M. Inst. C.E., Am. Soc. C.E.,
Engineer to the Board.

TABLE I.

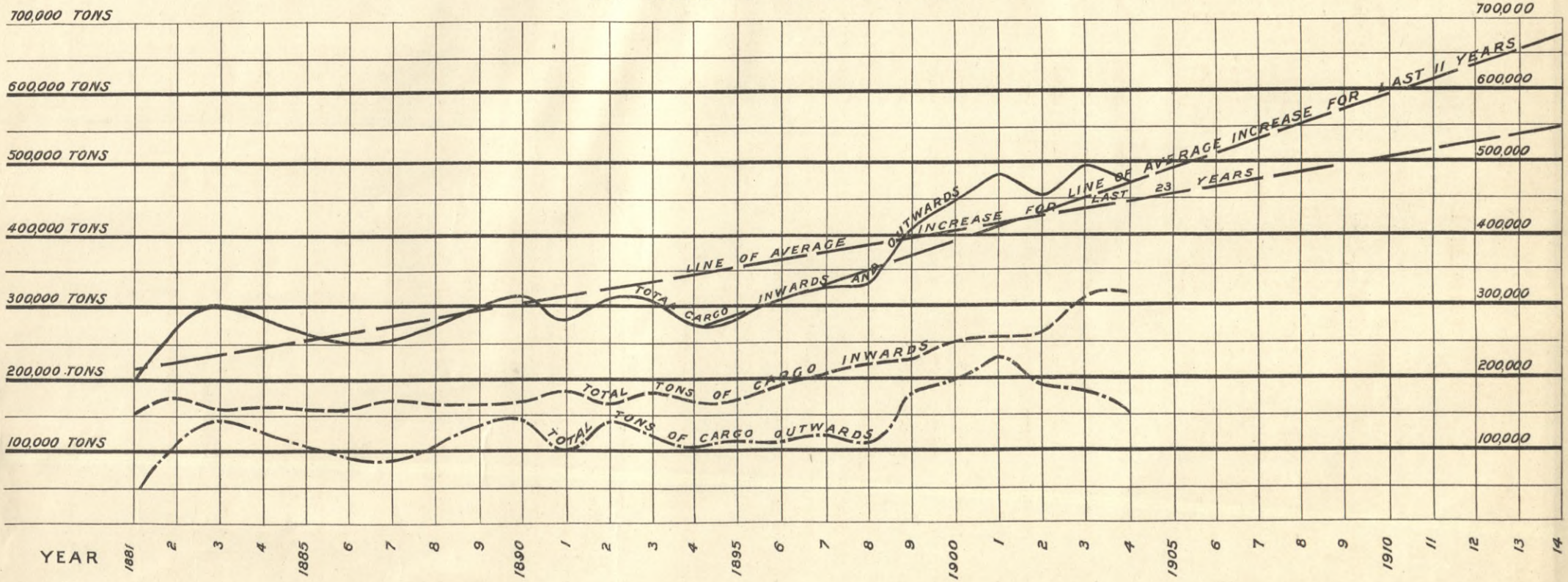
Assumed quantity of goods to be dealt with and approximate income derivable from trade generally at various future dates.

Year.	On basis of average increase for the last 23 years.					On basis of average increase for the last 11 years.				
	Total Estimated Quantity of Cargo, in tons.	Estimated Income derivable on basis of 3/6 per ton.	Estimated Revenue derivable on basis of 4/- per ton.	Estimated Revenue derivable on basis of 4/6 per ton.	Estimated Revenue derivable on basis of 5/- per ton.	Total Estimated Quantity of Cargo, in tons.	Estimated Revenue derivable on basis of 3/6 per ton.	Estimated Revenue derivable on basis of 4/- per ton.	Estimated Revenue derivable on basis of 4/6 per ton.	Estimated Revenue derivable on basis of 5/- per ton.
	Tons	£	£	£	£	Tons	£	£	£	£
1905 ...	460,000	80,500	92,000	103,500	115,000	490,000	85,700	98,000	110,250	122,500
1906 ...	470,000	82,250	94,000	105,750	117,500	510,000	89,250	102,000	114,750	127,500
1907 ...	480,000	84,000	96,000	108,000	120,000	530,000	92,750	106,000	119,250	132,500
1908 ...	490,000	85,750	98,000	110,250	122,500	550,000	96,250	110,000	123,750	137,500
1909 ...	500,000	87,500	100,000	112,500	125,000	570,000	99,750	114,000	128,250	142,500
1910 ...	510,000	89,250	102,000	114,750	127,500	590,000	103,250	118,000	132,750	147,500
1911 ...	520,000	91,000	104,000	117,000	130,000	610,000	106,750	122,000	137,250	152,500
1912 ...	530,000	92,750	106,000	119,250	132,500	630,000	110,250	126,000	141,750	157,500
1913 ...	540,000	94,500	108,000	121,500	135,000	650,000	113,750	130,000	146,250	162,500
1914 ...	550,000	96,250	110,000	123,750	137,500	670,000	117,250	134,000	150,750	167,500
1915 ...	560,000	98,000	112,000	126,000	140,000	690,000	120,750	138,000	155,250	172,500
1916 ...	570,000	99,750	114,000	128,250	142,500	710,000	124,250	142,000	159,750	177,500
1917 ...	580,000	101,500	116,000	130,500	145,000	730,000	127,750	146,000	164,250	182,500
1918 ...	590,000	103,250	118,000	132,750	147,500	750,000	131,250	150,000	168,750	187,500
1919 ...	600,000	105,000	120,000	135,000	150,000	770,000	134,750	154,000	173,250	192,500
1920 ...	610,000	106,750	122,000	137,250	152,500	790,000	138,250	158,000	177,750	197,500
1921 ...	620,000	108,500	124,000	139,500	155,000	810,000	141,750	162,000	182,250	202,500
1922 ...	630,000	110,250	126,000	141,750	157,500	830,000	145,250	166,000	186,750	207,500
1923 ...	640,000	112,000	128,000	144,000	160,000	850,000	148,750	170,000	191,250	212,500
1924 ...	650,000	113,750	130,000	146,250	162,500	870,000	152,250	174,000	195,750	217,500
1925 ...	660,000	115,500	132,000	148,500	165,000	890,000	155,750	178,000	200,250	222,500
1926 ...	670,000	117,250	134,000	150,750	167,500	910,000	159,250	182,000	204,750	227,500
1927 ...	680,000	119,000	136,000	153,000	170,000	930,000	162,750	186,000	209,250	232,500
1928 ...	690,000	120,750	138,000	155,250	172,500	950,000	166,250	190,000	213,750	237,500
1929 ...	700,000	122,500	140,000	157,500	175,000	970,000	169,750	194,000	218,250	242,500
1930 ...	710,000	124,250	142,000	159,750	177,500	990,000	173,250	198,000	222,750	247,500
1931 ...	720,000	126,000	144,000	162,000	180,000	1,010,000	176,750	202,000	227,250	252,500
1932 ...	730,000	127,750	146,000	164,250	182,500	1,030,000	180,250	206,000	231,750	257,500
1933 ...	740,000	129,500	148,000	166,500	185,000	1,050,000	183,750	210,000	236,250	262,500
1934 ...	750,000	131,250	150,000	168,750	187,500	1,070,000	187,250	214,000	240,750	267,500
1935 ...	760,000	133,000	152,000	171,000	190,000	1,090,000	190,750	218,000	245,250	272,500

Lyttelton Times Company, Limited, Printers.

DIAGRAM OF INWARD, OUTWARD AND TOTAL CARGO THROUGH LYTTELTON

NOT INCLUDING TRANSHIPMENTS



PLAN Nº 1

LYTTELTON HARBOUR BOARD

N Z

PORT OF LYTTELTON

KEY PLAN

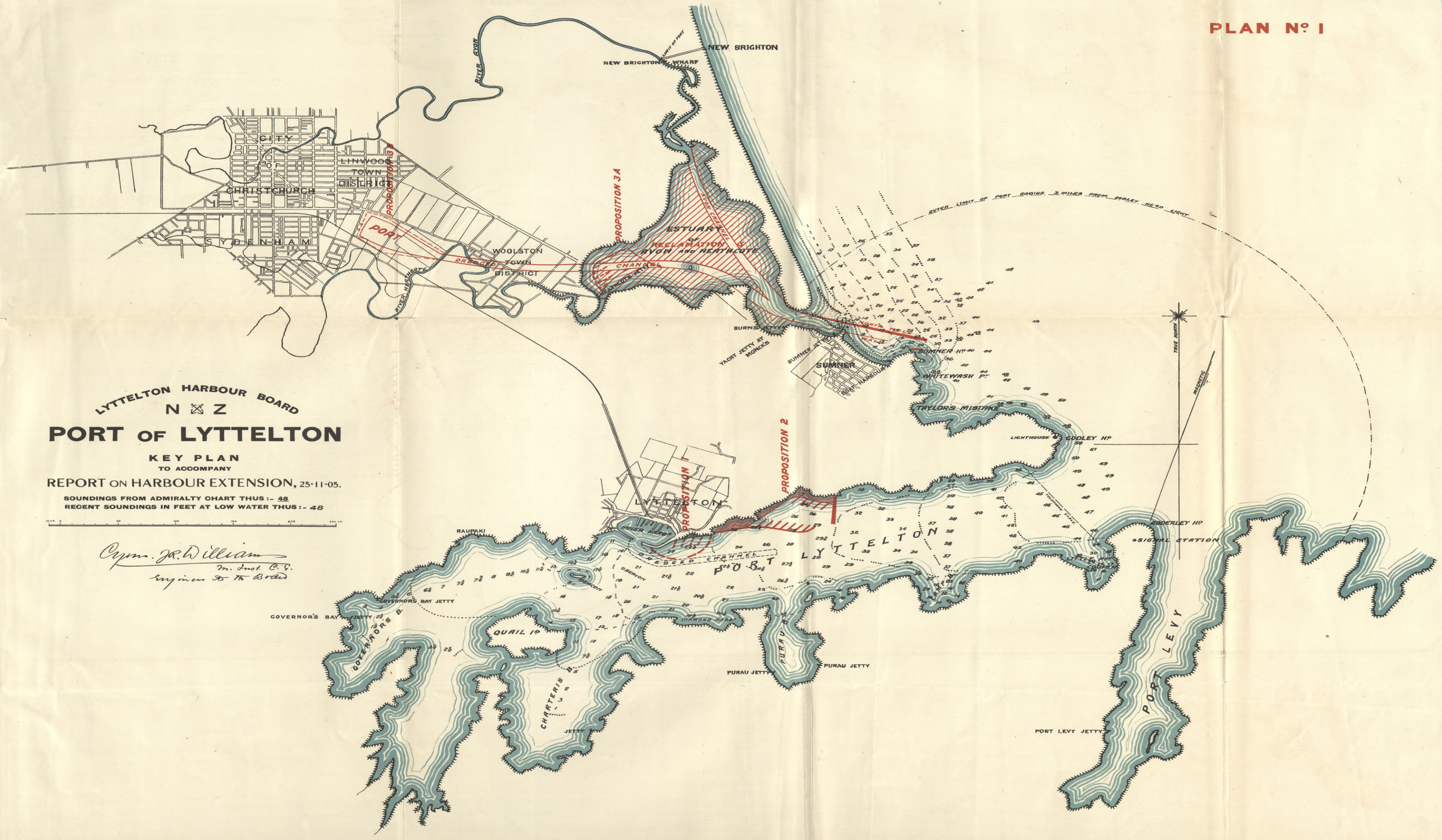
TO ACCOMPANY

REPORT ON HARBOUR EXTENSION, 25-11-05.

SOUNDINGS FROM ADMIRALTY CHART THUS :- 48

RECENT SOUNDINGS IN FEET AT LOW WATER THUS :- 48

Cyrm. J.R. William
M. Inst. C.E.
Engineer to the Board




LYTTELTON HARBOUR BOARD
N Z
PLAN SHOWING
SUMNER BAY AND PROPOSED CANAL
FROM THE
SEA TOWARDS CHRISTCHURCH
SCALE OF FEET
1000 0 1000 2000 3000 4000 5000
Soundings in feet below Low Water of Ordinary Spring Tides, or 14·00 feet below top of Survey Stone at Sumner, marked B.M. on plan. Datum for levels, 30·00 feet below Low Water O.S.T., or 44·00 feet below B.M. Springs range 8 feet, Neaps 4'.6". H.W. at F. & C., IVh. 10m. Land work by Messrs. McIntyre and Lewis. Soundings by Engineer of Harbour Board, assisted by Mr. E. Crow.
LINWOOD
CHRISTCHURCH
WOOLSTON
OPAWA
TIDAL BASIN B
MONCK'S
SUMNER
TAYLOR'S MISTAKE
RIVER HEATHCOTE
RIVER AVON
TO BE RECLAIMED WITH DREDGINGS
CHANNEL BOTTOM WIDTH 200 FT
PORT A
"PROPOSED" NORTH MOLE
PROPOSED HALF TIDE WALL
LONGITUDINAL SECTION
VERTICAL SCALE OF FEET
STAGING LEVEL 47·00
MOLE LEVEL 44·00
H.W.O.S.T. 38·00
L.W.O.S.T. 30·00
CROSS SECTION OF MOLE

S. 61