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COCHIN HARBOUR DEVELOPMENT

HISTORY OF PROPOSALS

COMPILED FROM THE

RECORDS OF THE MADRAS GOVERNMENT

WITH AN INTRODUCTION

BY

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MADRAS

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ERRATA.

Page 3, eighth line.—Alter “15” into “16.”

Page 29, eighth line from bottom.—For “in sufficient” read “insufficient.”

Page 60, last line of paragraph 15.—For “331/3” read “33 $\frac{1}{3}$ ”.

Page 86, third line of paragraph 79.—For “gdreder” read “dredger.”

Page 139, enclosure No. 1.—For “Indla Office” read “India Office.”

Page 151, third line of paragraph 24.—For “poy” read “pot.”

Page 152, paragraph 31, first line.—For “rhat” read “that.”

COCHIN HARBOUR DEVELOPMENT.

HISTORY OF PROPOSALS.

The first part of this book deals with the geography of Cochin, its physical characteristics, its special engineering problems, viz., coast erosion and the dredging of outer bar and its import and export trade.

The second part summarizes previous reports and refers to work done before April 1920.

The third part describes what happened between 1920 and 1924. It also includes the report of the Committee of Consulting Engineers to whom the question of dredging the outer bar was referred by the Government of India in 1924.

The fourth part contains all important technical reports made prior to 1920.

PART I.

Geographical.—The town of British Cochin is situate approximately in Lat. $9^{\circ} 55'$ N., and Long. $76^{\circ} 14'$ E. It is on the south-west coast of India about 100 miles north of the southernmost point. It has an area of about one square mile and a population (in 1924) of 130 Europeans and 20,507 Indians and others. East and south-east of British Cochin lies the Indian town of Mattancheri. Both these places are on the south side of the harbour entrance. Facing them is the Island of Vypeen, the southern tip of which is British, and, further to the east, Candle Island. The one square mile of British Territory includes both these small areas.

The harbour entrance between Cochin and Vypeen is about 440 yards wide. This entrance gives access to about 125 square miles of navigable backwater, part lying to the north of the entrance, but by far the greater area stretching to the south. British Cochin is a triangular area at the northern end of a long peninsula which starts from Alleppey about 40 miles to the south. The mainland of India is about 3 miles east of the entrance to the harbour. The plan opposite illustrates these general particulars.

Geological.—From Calicut southward to Cape Comorin through Cochin, Alleppey, Quilon and Trivandrum, there is a stretch of recent deposit, practically all alluvium. The south end of the

Western Ghats drains out into the Vembanad lake, a large expanse of water lying just to the north of Alleppey. The long peninsula leading to Cochin has been formed very largely by alluvium from this source.

It is most probable that the island of which Vypeen is the southern extremity has been caused by alluvium brought down from the Western Ghats by the Periyar river and its tributaries. The term "Vypeen" means "new accretion" and it is stated in one of the early reports that this arm of land reached its present limit about the year 1341.

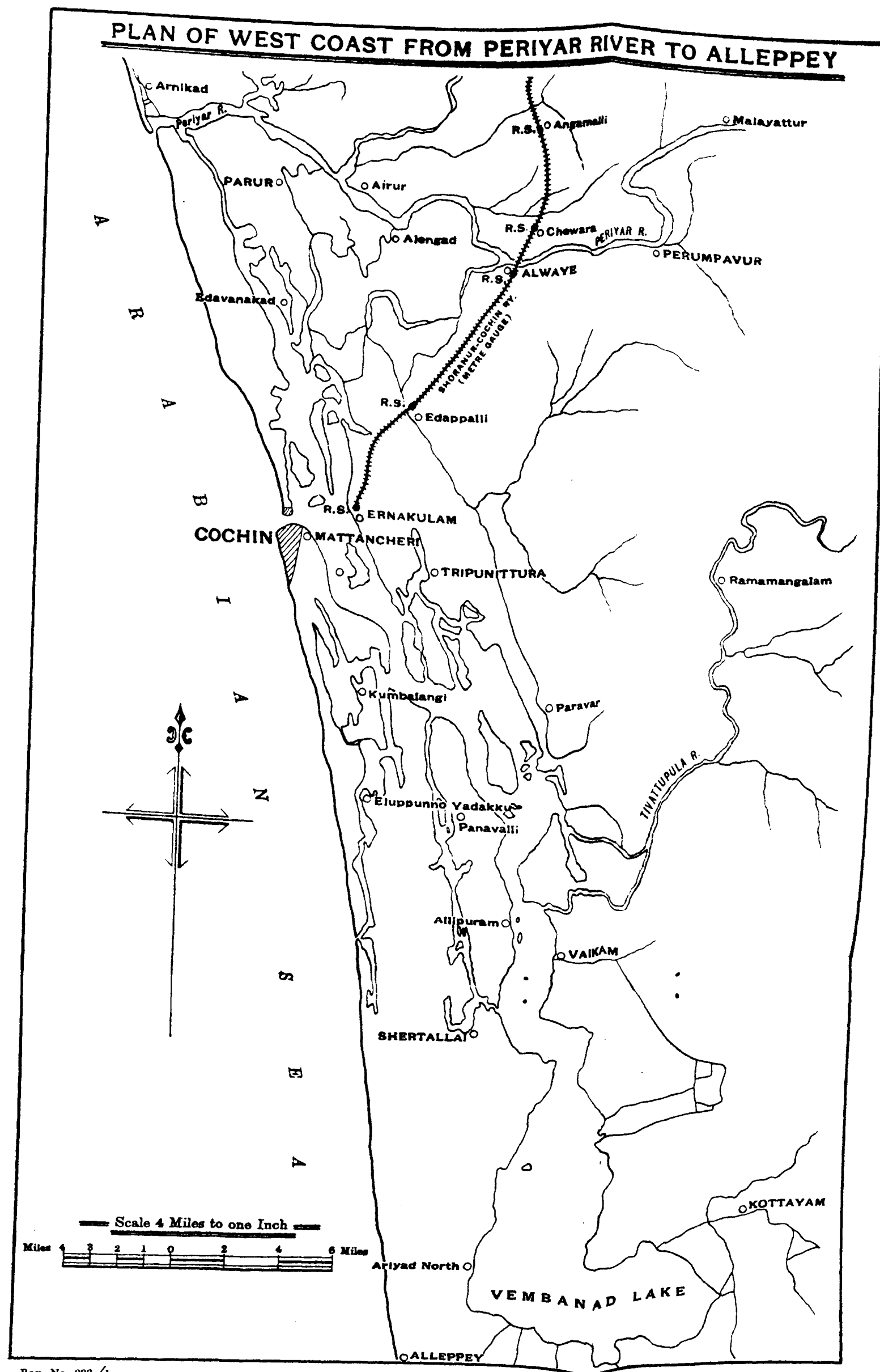
The Cochin accretion is considerably older. No dates are available, but it is known that the Jewish and Syrian churches were established there in the 8th century.

Behind the coastal strip of alluvium, there is a parallel strip of laterite which marks the edge of the granitoid gneiss formation of southern India.

Meteorological.—The rainfall at Cochin averages about 120 inches and the distribution throughout the year is as follows (taking three years):—

Month.	1921.	1922.	1923.
	IN.	IN.	IN.
January ...	8.32	1.08	0.84
February ...	0.03	0.39	...
March ...	0.42	2.05	4.03
April ...	8.99	5.69	1.71
May ...	7.80	13.06	4.50
June ...	22.77	20.76	33.28
July ...	18.43	25.97	31.17
August ...	22.80	15.30	29.06
September ...	5.73	9.80	16.09
October ...	9.92	9.53	9.59
November ...	8.07	8.77	0.70
December ...	0.20	...	0.70
Total ...	108.57	122.40	181.65

The temperature averages 85° F. in the summer and 78.6° F. in the "cold" weather. The degree of humidity is high. The south-west monsoon bursts about the first week in June and the worst of it is over by the end of July. There are, however, squalls with rain in August and during this month a considerable amount of flood water passes out to sea. During the remainder of the year the weather is moderate, with intervals of light airs and calm seas from December to March. A noticeable feature of the wind is that for a considerable period of the year, it blows off the land during the night and forenoon and off the sea during the afternoon and evening.



Trade and Trade Areas.—The principal exports at Cochin are coir yarn, rope, fibre and matting, copra, hides, nux-vomica, salted fish, coculus indicus, lemon-grass oil, turmeric, pepper, ginger, coffee, tea, rubber and timber.

The principal imports are rice and paddy, piece-goods, hardware, European liquors and stores, petroleum, sugar, metals, cotton twist and wheat. The following table shows the amount and value of tonnage dealt with during the 15 years 1908—1923:—

Year.	Imports in tons.	Exports in tons.	Total in tons.	Import value.	Export value.	Total value.
				RS.	RS.	RS.
1907-08	137,486	75,137	212,623	1,69,69,174	2,22,21,517	3,91,90,691
1908-09	205,850	105,501	311,351	2,39,35,036	2,98,52,576	5,37,87,612
1909-10	231,388	100,041	331,429	2,98,67,985	3,22,91,882	6,21,59,867
1910-11	231,057	96,987	328,044	2,37,23,568	2,97,77,854	5,35,01,422
1911-12	198,580	116,092	315,272	2,48,14,118	3,85,33,201	6,33,47,319
1912-13	242,803	106,784	349,587	2,96,32,344	3,78,38,273	6,74,70,617
1913-14	277,696	117,699	395,395	2,67,72,287	4,33,16,802	7,00,89,039
1914-15	267,453	96,829	364,282	2,87,68,977	3,61,97,465	6,49,66,442
1915-16	204,207	97,856	302,063	2,18,85,763	3,70,23,942	5,89,09,710
1916-17	112,573	92,618	205,191	1,52,89,623	3,84,20,888	5,36,00,011
1917-18	63,687	73,620	137,307	1,09,84,865	2,63,33,963	3,73,18,828
1918-19	89,299	106,136	195,435	1,75,43,277	4,61,98,638	6,40,42,115
1919-20	139,743	100,599	240,252	3,02,32,364	5,20,01,384	8,22,33,748
1920-21	203,291	98,705	301,996	4,35,82,076	4,61,85,301	9,27,67,377
1921-22	231,310	124,123	355,433	4,71,86,919	5,14,49,506	9,86,36,425
1922-23	273,291	107,760	381,051	4,94,49,747	4,48,70,604	9,44,20,351

This trade is handled by foreign and coasting vessels the former represented by the Clan, Hall, City and Ellerman Lines, the Lloyds Sabado and Associete Generalo Italiano, and the latter very largely by the British India, Asiatic, Scindia Steam Navigation Company and by a number of small native owned brigs and schooners. The exports of Cochin are derived mainly from the Western Ghats and the low-lying land stretching westward to the seashore.

The Cochin Bar.—The Cochin Bar is a roughly semi-circular ridge of sand the centre of which is about a mile and a quarter west of the harbour entrance. It has a long flat slope on the harbour side and a steeper slope on the sea-side. The crest of the ridge is about 200 yards wide and at its shallowest place the top is about 10 feet below L.W.O.S.T. at the worst season of the year. Underneath the ridge of sand there exists alluvial silt, mud and soft clay, at a depth of 20 feet on the bar sloping down towards the harbour.

The conception of the bar as a ridge has been greatly magnified in the popular imagination. Modelled to a natural scale, i.e.,

with the vertical and horizontal scales equal, the projection would be hardly noticeable in a model of the same size as the Admiralty charts, about 40 inches by 27 inches. In fine weather, there is no outward evidence of a bar at Cochin. In moderate weather, the height of the swell increases on the bar and in the roughest monsoon weather a line of breakers follows the ridge all the way round.

The bar has varied in depth but little during a long period. The chart of 1851 shows a depth of $10\frac{1}{2}$ feet at L.W.O.S.T. and before dredging started the least depth was about 11 or $11\frac{1}{2}$ feet at L.W.O.S.T. Small surveys made by the local staff show changes of about 18 inches during the year. The position of the bar may vary laterally from time to time but it always returns to about the same place. There is in fact no great difference between the general contours of the bar as shown on the surveys from 1835 onwards.

Cochin Erosion.—This has been a special problem at Cochin during the past 70 years. The facts are that although Cochin and Vypeen have undoubtedly been formed by accretion consequent upon material brought down from the hills, and although this state of accretion continued for centuries, it appears that at some time not less than 70 or 100 years ago, visible accretion stopped and erosion of the outer sides of the accretion began. The erosion is caused by the force of the sea in rough weather, but why the land should have remained intact for many centuries and then suddenly become subject to erosion has not yet been discovered.

It is a matter of much importance to the port as, should either the Vypeen Island or the Cochin peninsula be washed away, the existence of a harbour at Cochin would be seriously threatened. These two spits of land are, in fact, natural breakwaters, and their preservation is essential. On the south side, erosion and accretion about balance each other. On the north side erosion has been checked by artificial means, but the causes are obscure and the problem of alternate accretion and erosion at Vypeen and Cochin must rank with the mysterious formation of Chesil Beach on the south coast of England, which has been described as a sort of prize puzzle among foreshores.

Tides and Currents.—Spring tides rise about 3 feet with a highest known tide of 5 feet 9 inches. The neap tides do not range more than about a foot or 18 inches. This is at the entrance of the harbour. The range decreases in the backwaters and at a point 40 miles south, the maximum difference is only about 8 inches between high and low water. High water at full

and change of the moon occurs at 11–26 hours. There is no considerable diurnal variation.

The currents at Cochin are normal. On the flood tide the in-going current starts about 2 miles north and south of the harbour entrance and creeps along at a rate between a quarter and half a mile per hour. On the out-going tide this coastal current merely reverses its direction. In mid stream the current varies from about a knot at neap tides to two knots at spring tides. At extraordinary springs or during the monsoon floods the ebb current may increase to $2\frac{1}{2}$ or even $3\frac{1}{2}$ knots, through the harbour mouth. (In previous years the currents were stated to be stronger but these present figures are the result of actual measurement during the last three years.) This current then spreads fanwise as it leaves the harbour mouth, the centre of effort running slightly north of west until it reaches the bar. It has not hitherto been possible to ascertain any regular tidal currents outside the bar.

Surveys and Charts.—The available charts of Cochin are as follows:—

(1) *Dated March 1835, Surveyed by the Indian Navy.*—It is probable that this plan is an approximation. Several points on the Cochin shore are obviously incorrect; the full and change of moon is $10\frac{1}{2}$ hours out; other parts of the harbour appear to be sketched in and not surveyed at all. Shows a minimum depth of 15 feet on outer bar.

(2) *Dated 1851, Surveyed by the Indian Navy.*—This also appears to be a rough survey. No information is given as to what datum is adopted for soundings which appear to have been taken more or less promiscuously. The survey notes are obviously rough and ready and the result more of casual observation than measurement. Least depth on outer bar shown to be $10\frac{1}{2}$ feet.

(3) *Dated 1852 (before monsoon), Surveyed by the Indian Navy.*—This plan appears to have been made in order to illustrate a proposal for putting in training groynes or “stakes” outside the harbour entrance. It is generally more carefully prepared and with more definite notes than the previous ones. Least depth of water on outer bar shown to be 11 feet.

(4) *Dated 1852 (after monsoon), Surveyed by the Indian Navy.*—Made by the same staff as the previous chart. Bottom apparently very irregular. Least depth on bar 6 feet at one spot but general least depth about 12 feet. Plan probably fairly correct. Currents seemed to be swifter at this date than now. Springs stated to be $4\frac{1}{2}$ knots and monsoon freshets $5\frac{1}{2}$ to 6 knots. This was probably judged by observation and not measurement.

(5) *Dated December 1858, Surveyed by the Indian Navy.*—By far the best survey made up to 1858. The soundings and contours are well delineated and the Surveyors Lt. A. D. Taylor and Mr. G. Lewis, I.N., were obviously careful and accurate in their work. This chart may be relied upon. Least depth on outer bar shown to be 13 feet L.W.O.S.T.

(6) *Dated 1881, Surveyed by the Chief Engineer and the Master Attendant, Madras.*—This plan was made to illustrate a report, dated February 1881 (to be found in Appendix I). With the exception of one or two draughtsman's errors it appears to be fairly accurate and was probably reduced from the 1858 chart—several features being coincident and obviously copied. The depth on bar is not stated but would not be more than 12 feet—the 2-fathom contour line being shown.

(7) *Dated 1883, Surveyed by Commander Dawson, R.N., and the Indian Navy.*—The map is the result of a careful survey and gives definite evidence of the erosion at Vypeen and the state of the foreshore at Cochin. Least depth on bar 12 feet. Some of the notes appear to be wrong, e.g., spring tides are said to rise 5 feet and neaps 2½ feet. It is very doubtful if the tides ranged to this extent in 1883.

(8) *Dated 1913, Surveyed by the Royal Indian Marine*—during the period October 1912 to January 1913. This chart is based on the 1883 map, but is still more complete. Some of the previous mistakes are corrected, e.g., the rise of spring tides is given as 3½ feet and of neaps 2 feet, figures which are approximately correct to-day. Least depth on bar is shown as 9 feet below L.W.O.S.T.

(9) *Dated 1923, Surveyed (as regards the outer bar) by the Harbour Engineer to Government* before the monsoon of 1923. Least depth on bar is 10 feet below L.W.O.S.T. The bar is 200 yards further seaward than in 1913, but it may be added that after the monsoon of 1923 the 1913 position was found to have been restored.

The essential fact to be deduced from a comparison of these charts is that there has been no radical change in the conditions at Cochin for nearly ninety years. The entrance to the harbour at Vypeen and Cochin has remained fixed, and although erosion has been considerable on the Vypeen side north of the entrance, other modifications may be considered negligible.

It is true that over the same period the bar has shallowed from a depth of 15 feet to 10 feet, i.e., assuming that the chart of 1835 is correct, which is doubtful, but the shallowing of 5 feet in eighty-nine years is not serious and certainly there has been little, if any, change since 1851. It has been stated that the cause of the deterioration on the bar was the breaking through

of the sea at the Cruz Milagre gap, about two miles north of Cochin, where for a number of years a second outlet to the sea existed. It is very doubtful, however, if there is sufficient detailed evidence to support this assertion.

PART II.

Operations up to April 1920.

Record of reports.—The marine and engineering history of Cochin Harbour goes back to about 1835. As stated in Part I, the earliest survey of which any record exists was made then.

It is unnecessary, however, to refer to the earliest reports. This "outline" of the case will be marked by salient events only.

In 1880 and 1881, the Chamber of Commerce had an effective, though non-professional, combination in the Chairman and the Honorary Secretary, Messrs. J. H. Aspinwall and W. T. Holmes, respectively. These gentlemen understood the problem at Cochin and expressed themselves cogently in advocating the making of a deep water harbour. The Madras Government was moved to investigate the matter and while unable to recommend the prosecution of the scheme at the time, admitted that the Chamber had put up a strong case.

Subsequently professional reports were made by a large number of Engineers including Mr. G. Robertson, M.I.C.E., Mr. N. Parkes, Chief Engineer, Madras Harbour Works, Messrs. Coode, Son and Matthews, Harbour Engineers (Consulting Engineers for the Colombo Harbour), Mr. Allan Campbell, Executive Engineer, Public Works Department, Mr. Browning, Chief Engineer, Cochin State, Mr. J. R. Bell, Consulting Engineer, Chittagong Port Commissioners, Messrs. Sir John Wolfe-Barry, Lyster and Partners, Sir George Buchanan, and Mr. W. Hutton, Chief Engineer, Public Works Department. All these reports form an appendix to the present volume.

In dealing with this mass of correspondence and reports, one outstanding consideration has to be borne in mind, viz., whereas all the evidence shows that the physical conditions at Cochin have not changed appreciably since 1858 (and possibly not since 1835) no such comparison can be drawn between the knowledge and practice of harbour engineering in 1835 and 1924. Any report dealing with the practical side of the work is probably of little value before say the year 1900. It is interesting to note how this affects the tone of the reports by professional advisers from 1858 onwards. For example, in 1877, the only dredger built was a bucket dredger of what is now an obsolete type. At

that time it was considered by engineers that such a vessel could not open the bar and keep it open; undoubtedly they were justified in their opinion.

Another early proposal was to increase the scour over the outer bar by constructing two long sea-groynes to act as training walls. This proposal no doubt arose as the insufficiency of dredging was realized and probably the suggestion for constructing the groynes was the best that could be made at the time. Since then, however, as is well known, the general experience is that where the bottom is sand or shingle, such groynes merely lead to the formation of a further bar at some point beyond their limits.

Thus, in 1881, Mr. Parkes, Chief Engineer, Madras Harbour Works, considered that a scheme of dredging and sea-groynes would cost Rs. 81 lakhs. It is realized now that the result would have been doubtful, but in any case the cost was beyond the financial capacity of the port at the time. Mr. Robertson had also recommended a combination of dredging and training walls. His opinions, however, were based largely on the chart of 1835, which as already stated, cannot be considered very reliable.

In 1903, when suction dredging was comparatively new, Messrs. Coode, Son and Matthews were dubious as to the possibility of opening and maintaining a channel by dredging alone: they also thought that training and sheltering moles on each side of the entrance would be necessary, and the cost of these in their opinion vetoed the scheme.

The Cochin Chamber of Commerce pointed out that Messrs. Coode, Son and Matthews had to rely on documents which "were apparently insufficient for the purpose", but their protest was unavailing at the time. In 1912, however, they reappeared with the definite statement that they did not accept the opinion of Messrs. Coode, Son and Matthews as final, and considered there was reason to hope that, as harbour engineering had made such strides since 1903, the idea of opening the bar by a powerful suction dredger might not be found hopeless.

It is interesting to note here that it was in 1910 that the British Admiralty bought their first large suction dredger, and in 1909 the "Leviathan" had started work at Liverpool under the control of the Mersey Dock and Harbour Board. Before this date, however, the 3,000-ton suction dredger "Brancker" had started work at Liverpool in 1893 and the "Coronation" in 1903. It was *after* 1903, the date of Messrs. Coode, Son and Matthews' report, that the rapid development in modern suction dredging took place.

In 1911 and 1912, by which time the results of the dredging by the "Jinga" and the "Kalu" at Bombay and by the Liverpool

and Admiralty dredgers at Home were available, both Mr. Campbell, Executive Engineer on the West Coast, and Mr. Browning had arrived at the conclusion that the dredging was practicable and would, in itself, be sufficient to keep the channel open. This led in due course to a fresh opinion being obtained, this time from Mr. J. R. Bell, a retired officer of the Indian Public Works Department (Railways) and late of the Chittagong Port Commissioners.

Mr. Bell arrived at Cochin in January 1913 and submitted his report a month later. He confined himself to reading the official records, making enquiries and paying personal visits. He carried out no experiments nor had he the basis of any real experimental work to go upon. Nevertheless he made a serious attempt to cover the whole ground. He pointed out the necessity for further investigation and thought that an experiment of dredging on the outer bar was the first essential of valid progress.

Generally, Mr. Bell was cautious to the degree of pessimism, and in view of the absence of good scientific data to guide him, and of any acquired knowledge coming from personal experience over a number of years, he could not well be otherwise. Moreover, Mr. Bell was in a poor state of health at the time and died shortly after leaving Cochin.

As a result of Mr. Bell's report, however, Mr. Allan Campbell of the Public Works Department proceeded with his investigations and made a further report in 1914-15 in which he wholeheartedly advocated a scheme of dredging to keep the bar open. There had thus been from the year 1877 to 1914 a slow change of professional opinion from the impossible to the possible, but doubtful. And it was at this stage that the papers were referred to Messrs. Sir John Wolfe-Barry, Lyster and Partners, whose representative, Mr. L. H. Savile, made a personal inspection of the conditions.

This important report stated that it would be possible under certain conditions to make a deep water harbour at Cochin and gave an outline of how it should be done. The worst difficulty was thought to be the dredging and maintenance of a channel across the bar during the monsoon, but the report also emphasized the fact that the erosion of the coastal strips north and south of the Cochin entrance would have to be stopped before anything else was attempted.

Sir George Buchanan in 1919 commenting upon the report of Messrs. Sir John Wolfe-Barry, Lyster and Partners, whilst criticizing it in detail, said that there were no insuperable difficulties in dredging a channel through the bar, and making a port at Cochin.

Mr. W. Hutton, Chief Engineer, Public Works Department, following on these remarks in 1919, draws particular attention to the statement of Sir George Buchanan that there were no insuperable difficulties in dredging a channel through the bar, and adds "This, I think, is everyone's opinion", a note of optimism largely, but not entirely, justified at that time.

It may be fairly stated, however, that between 1912 and 1920, the merely possible had become the probable. It is necessary to draw attention to this gradual and consistent increase in the case for probability as, otherwise, the impression may easily be obtained that out of a large number of opinions that have been given, the Ayes and Noes are about equally balanced and therefore cancel each other. And of course there is the important factor that progress towards probability had coincided exactly with development in engineering knowledge and practice.

So far, in this brief resumé of the reports, attention has been devoted to the question of keeping the bar open. It is advisable now to refer to the subject of erosion.

Although erosion had been persistent for 70 years, it was not until 1911 that it was adequately realized by Government how serious the matter was, and in that year protective works were carried out on the Vypeen side by Mr. Allan Campbell. This does not mean that the matter had not been talked about before. As far back as 1881 Mr. Robertson had said that he would not join in the "battle of the groynes", thereby indicating a considerable difference of opinion, which in fact existed. It was thought by some that the form of protection should consist of "long low adjustable groynes" placed about *right angles* to the foreshore, whilst others advocated the construction of a bund or small sea-wall *parallel* to the foreshore. The protective work carried out by Mr. Allan Campbell consisted of the latter type and when he found it necessary shortly after the completion of the bund to deposit an enormous quantity of granite rubble to form a toe to his wall (in order to prevent scour), the other side claimed it as a victory. Nevertheless, he stopped all erosion to the extent of his defences. Unfortunately, owing to shortage of funds, these were not of a very durable character.

Previously, groynes at right angles to the foreshore had also been tried but the results in this case were uncertain. In some instances the groynes seemed to have been successful and in others to have failed. Up to the year 1920 there was still nearly a mile of the coast of Vypeen in a dangerously vulnerable state, and Messrs. Sir John Wolfe-Barry, Lyster and Partners in their report of 1918 recommended a protective combination of both systems, i.e., of ordinary groynes at right angles to the foreshore connected on land by a long bund above high water mark. The

outcome of their recommendation will be referred to later. (Pages 61—63, paragraphs 18—29.)

On the Cochin side there had been considerable accretion since about the year 1900, and as this accretion seemed to have coincided more or less with the construction of heavy stone groynes at right angles to the foreshore, it was thought locally that there was something to be said for this principle. It is probable that the cause of accretion at Cochin is not so easily accounted for, but whether this is so or not the fact remains that the Cochin beach appears now to be fairly stable, and there need be no apprehension as to its future, consequent upon the successful measures established at Vypeen. (Page 83, paragraphs 56—61.)

PART III.

Operations after April 1920.

The Cochin development having reached the stage of probability, it was decided by the Madras Government that a whole-time engineer with considerable experience in harbour works should be engaged in order to carry the scheme further. The writer was accordingly transferred from the permanent staff of the Civil Engineer-in-Chief's Department of the Admiralty to the Madras Government.

The stages in the progress of the scheme since the arrival of the writer in April 1920 are marked chiefly by three communications:—

- (1) In August 1920, a report by the Cochin Ad Hoc Committee, pages 20—49.
- (2) Report of investigations and experiments made, dated December 1921—January 1922, pages 57—71.
- (3) Report on the completion of the experimental works, dated September 1923, pages 73—87.

The Ad Hoc Committee referred to, which consisted of sixteen members including Government officers, presented an agreed report in which a complete scheme for developing Cochin at an estimated cost of Rs. 248½ lakhs was outlined. On the strength of this report, Government decided to carry out certain experimental works which are fully dealt with in the two other reports abovementioned.

Summarizing them into as brief a form as possible, these reports state—

- (1) that the general scheme of development recommended by Messrs. Sir John Wolfe-Barry, Lyster and Partners was feasible;

(2) that the addition of a reclamation, however, inside the harbour was a practicable and financially advantageous proposition;

(3) that the problem of erosion at Vypeen was solved by the writer during the monsoon of 1920 and that the protective works erected after that time had been found entirely satisfactory;

(4) that actual dredging operations consisting of a small channel across the outer bar and another one within the harbour, the purpose of which was to assist in training the ebb and flow in the right direction, had shown the true nature of the forces at work;

(5) that the littoral forces had also been ascertained and the geological conditions made clear for the first time.

As a result of detailed and careful work extending over a period of four years, the writer gave his opinion that the problem at Cochin resolved itself into the practical expedient of dredging a wider and deeper channel than is necessary for navigation, merely in order to provide a safe margin for any sand which will be beaten across the sides of the channel during the monsoon; and it was shown that, by making use of the latest developments in suction dredging, the cost of making and maintaining this channel was within the financial resources of the port. The interesting observations and experiments which led to this conclusion may be read in detail in the reports.

The conclusions of the writer were concurred in by two Chief Engineers of the Public Works Department, Madras, by the Port Conservancy Board, and by the Chamber of Commerce, Cochin. Accordingly in February 1924, the proposals were forwarded to the Government of India for decision. These proposals provided for the purchase of a suitable dredger, pipeline, and other plant; as well as for all work necessary to bring deep vessels into harbour and to moor them safely in stream. The estimated cost was Rs. 15 lakhs.

The details of the work done since 1920 may be read in the three reports which follow (pages 18—87). The concluding appendix contains the principal reports between 1880 and 1920, which are referred to in the foregoing summary (pages 88—204).

For obvious reasons it is not convenient to provide all the plans referred to in the following reports. These drawings, although of considerable interest technically and necessary to support statements made to Government, are sufficiently described in the text and their exclusion does not materially detract from the usefulness of the present volume. It would add so considerably to the cost of production to include them and necessitate so great a time for their reproduction that such a proposal is really impracticable.

Acting upon the advice of the Government of Madras, the Government of India referred the reports and plans prepared by the Harbour Engineer to the India Office requesting that an independent opinion be given by an authoritative Committee of Consulting Engineers. Accordingly in June 1924, a committee of three gentlemen drawn from the firms of Messrs. Rendel, Palmer and Tritton, Messrs. Coode, Fitzmaurice, Wilson and Mitchell, Messrs. Sir John Wolfe-Barry and Partners, was appointed by the India Office. Mr. Frederick Palmer of Messrs. Rendel, Palmer and Tritton acted as Chairman and the other members were Mr. H. H. G. Mitchell and Mr. G. E. W. Crutwell. The Harbour Engineer to Government was deputed to attend this Committee and give all possible assistance. Ultimately after a series of ten meetings, during which the whole subject was exhaustively considered, the Committee forwarded the following report:—

Report of the Committee of Harbour Engineers appointed to advise on the points arising in connexion with the proposals for the improvement of the Port of Cochin.

TO THE UNDER SECRETARY OF STATE FOR INDIA,
PUBLIC WORKS DEPARTMENT, INDIA OFFICE, S.W.

[Cochin Harbour.]

SIR,

In accordance with your instructions we have carefully perused all the documents which accompanied your letter of 7th May and the plans which accompanied your further letter of 23rd June, together with a number of plans and other particulars supplied by the Harbour Engineer to the Government of Madras. We have seen samples of materials likely to be encountered, and a small wooden model of the harbour, the bar, and approach channel. We have had an opportunity, further, of examining the plans and particulars forwarded to Messrs. Sir John Wolfe-Barry, Lyster and Partners in 1918, when that firm was asked to give an opinion on the subject, and have read all the important reports previously made by other Engineers.

2. After making ourselves generally acquainted with the various matters to be considered, we held our first meeting on 9th July and we continued to meet at intervals until 6th August, when our tenth, and final meeting was held. At all these meetings Mr. Bristow was present, and we have to thank him for the very full and complete information which he has given to all our enquiries.

3. The Committee consider that there is a reasonable probability of establishing a channel across the bar by dredging in the manner proposed and are unanimous in giving the following answers to the questions submitted in the letter of the Deputy Secretary to the Government of Madras addressed to the Secretary to the Government of India and dated 4th March 1924, viz. :—

Question 1.—Is the opinion expressed in paragraph 27 of the Harbour Engineer's report, on the result of the experiment at Cochin No. 1923/23-1, dated 26th September 1923, that silting due to littoral drift will be so small as to be practically negligible, a justifiable inference from the results of the experiments and investigations described in Part I of the report?

Answer 1.—The Committee consider that the littoral drift is comparatively negligible, and will not materially affect the ordinary maintenance of the channel.

Question 2.—Do the recorded soundings in plan No. 4 accompanying the report on the experiment support the conclusion arrived at in paragraph 46 of the report that silting in the experimental channel occurred gradually and rapidly at the beginning?

Answer 2.—The Committee consider that the silting was naturally more rapid at the beginning of the monsoon but was continuous during June and July; also, in a part of the channel, during August as well. In other parts of the channel, however, some erosion took place during August, due to the continuous ebb from the backwaters in that month having a preponderant scouring effect.

Question 3.—Do the results of the investigations and observations described in Part III of the Harbour Engineer's report mentioned above support the view that littoral drift is negligible?

Answer 3.—The results of the observations described in the Harbour Engineer's report confirm the Committee in the opinion that littoral drift is comparatively negligible.

Question 4.—From the results obtained in the case of the experimental channel, can any conclusion safely be drawn as to what will occur in a deeper channel particularly as to the amount of silting likely to occur?

Answer 4.—The Committee are of opinion that the silting will probably be much the same in a wide channel as in a narrower channel of the same depth; but, that as the depth of the channel is increased, the silting will also increase. Making an approximate estimate on the basis of the experimental channel, the

Committee consider that the silting will not be more in a year than about 20 per cent of the dredged quantity. This indicates that, even at the worst, the silting will not amount to more than 800,000 cubic yards in a year, and that in all probability this quantity will diminish considerably as the sides of the channel flatten out in succeeding years.

Question 5.—Is the design of the permanent channel, as described in paragraph 66 of Part VI of the Harbour Engineer's report, such that the channel is likely to be of not less than 30 feet depth at the shallowest place during the monsoon when dredging is impracticable and accurate sounding cannot be taken? Is it safe to assume that at a depth of 25 feet wave action has no effect?

Answer 5.—The Committee are of opinion that, during the monsoon when dredging is impracticable the design of the permanent channel, with the outer part dredged to 35 feet below low water for a width of 600 feet, is likely to afford not less than 30 feet depth at the shallowest place throughout the channel for a width of not less than 400 feet at any point. This temporary narrowing is not likely to interfere to any material extent, with the ordinary use of the channel.

The Committee consider that as soundings can be taken throughout the monsoon, if not accurately at least with sufficient accuracy for practical purposes, it would reasonably be safe to adopt a channel of this design.

The fact that there is a rise of at least 2 feet at high water twice daily is an additional element of safety.

It must not be forgotten that, on occasional days during the monsoon when weather conditions might not permit of approximate soundings being taken, the same condition would also prevent a ship entering the harbour.

The Committee consider that wave action at Cochin is not likely to cause a surface breaking of water where a depth of 25 feet prevails. The effect of ground swell cannot be limited to a depth of 25 feet, but any effect likely to arise from this cause has been taken into consideration in dealing with the question of probable silting of the channel.

Question 6.—Is there a reasonable probability that the permanent channel will not be temporarily blocked up during the monsoon? In fine, are the proposals of the Harbour Engineer for the permanent channel such that sea-going vessels of 25 feet draught are likely to be able to get into and out of the harbour at all seasons of the year without risk of grounding?

Answer 6.—The Committee have no hesitation in answering this question in the affirmative. The safeguards previously mentioned—(i) that the channel can be approximately sounded at any time when it is practicable for a ship to “make” the harbour, (ii) that at high water there is an additional depth of at least 2 feet,—together with the fact that before the channel is completed the Government will have had at least two years’ experience of the silting which actually occurs and will be able to determine whether somewhat deeper or wider dredging is required at places, all confirm the Committee in the opinion that sea-going vessels of 25 feet draught are likely to be able to get into and out of the harbour at all seasons of the year, with but very little risk of grounding.

Question 7.—Is a powerful suction cutter dredger of the “Jinga” type discharging through a floating pipe-line, as proposed in paragraph 78 of the Harbour Engineer’s report, the best type for the work at Cochin and will one such dredger supplemented by the ex-German dredger “Seetief”, be adequate for the initial work and subsequent maintenance?

Answer 7.—The Committee are of opinion that a powerful suction cutter dredger of the “Jinga” type, discharging through a floating pipe-line, as proposed in paragraph 78 of the Harbour Engineer’s report is the best type for the work at Cochin, and that one such dredger, supplemented by the ex-German dredger “Seetief” may reasonably be expected to carry out the initial work; further, that once the channel is created, there need be no doubt as to the capacity of the same dredgers to maintain it.

Question 8.—Is the dredged material likely to be dispersed as stated in paragraph 70 of the Harbour Engineer’s report and not driven back into the channel?

Answer 8.—The Committee are of opinion that the statement contained in paragraph 70 of the Harbour Engineer’s report, that the dredged material is likely to be dispersed, is generally correct. It is probable, however, that some comparatively small portion will find its way back into the channel, but not in such quantity as to be beyond the capacity of the maintenance dredging plant.

Question 9.—In the project estimates for the next stage of the work sent by the Harbour Engineer with his letter No. 2306/23-2, dated the 11th/13th December 1923, is the provision for repairs to “Jinga” and the pipe-line given in the data sheet adequate?

Answer 9.—The Committee consider that the estimate of the repairs to the “Jinga” and the pipe-line, as given in the Abstract

Estimate on page 11 of the Harbour Engineer’s report is adequate.

We have the honour to be,

Sir,

Your obedient servants,

E. CRUTTWELL.

H. H. G. MITCHELL.

F. PALMER.

WESTMINSTER, S.W. 1, .
7th August 1924.

In due course the findings of the Committee were referred to the Port Conservancy Board at Cochin, who again passed a resolution in favour of proceeding with the scheme at once. Finally, after reference to the Government of India, the Madras Government issued a general order No. 314, Finance (Marine), dated 18th May 1925, approving the next stage of the work. The important letter No. XII is in the following terms:—

Letter from J. B. BROWN, Esq., I.C.S., Deputy Secretary to the Government of Madras, Finance (Marine) Department, to the Secretary to the Government of India, Department of Commerce, dated Fort St. George, the 19th February 1925, No. C. 255-4.

[Cochin Harbour Scheme—Correspondence ending with your telegram No. 55-S., dated 12th February 1925.]

I am directed to state that the Madras Government are satisfied that the Harbour Engineer’s report on the experimental works at Cochin and the report thereon of the Committee of Engineers appointed in England indicate that a harbour can be constructed at Cochin within an amount which the Harbour Authority can afford to raise by a loan. The Cochin Darbar sees no objection to the next stage of the scheme being proceeded with; although the Travancore Darbar has not formally expressed an opinion, it is not likely to raise any objection. In the circumstances this Government have decided that the scheme should be proceeded with and I am to request the Government of India to be pleased to accord sanction to the project estimates forwarded with my letter No. 50, dated 4th February 1924, as early as possible. Deviations from these estimates that may be found necessary in future will be reported to the Government of India when the Accountant-General considers that such report is necessary.

* * * *

This concludes the history of the scheme up to the time the capital works were started. In a further volume it is hoped to give an account of the major works. This will be chiefly of

technical interest but it may also be of some value from an administrative standpoint.

R. C. BRISTOW,
1928.

I

G.O. No. 106, Finance (Marine), 26th March 1921.

(i)

Letter from J. M. TURING, Esq., I.C.S., Secretary to the Government of Madras, Revenue (Special) Department, to the Secretary to the Government of India, Department of Commerce, Simla, dated the 15th July 1920, No. 583-IV 20-5.

I am directed to address the Government of India on the subject of the classification of the ports in this Presidency.

2. I am to invite a reference to Mr. Campbell's letter to the Secretary to the Reforms Committee, dated the 21st January 1919, in which the Government of India were informed that this Government were opposed to the proposal made in Bengal that ports should be transferred to the control of the Government of India.

In schedule I to the draft rules published by the Government of India in their notification, Reforms Office No. 131, dated the 13th May 1920, it was stated that ports declared to be "Major" by the Governor-General in Council or by or under legislation by the Indian Legislature would be treated as Central subjects. It is clearly desirable, with reference to the various harbour schemes at present under the consideration of this Government, that they should know whether the Government of India are likely to declare any ports in this Presidency to be "Major" ports and as a result of such declaration, to take these ports under their control. The question is one of urgency as regards the ports of Cochin and Tuticorin. The stage reached in the investigation of the improvement schemes of these two ports is briefly described below.

3. *Cochin*.—A report on this harbour has been submitted by Sir John Wolfe-Barry Lyster and Partners, and for the further investigation of the problems involved an Engineer has been appointed. This Government are unable immediately to form a Port Trust for Cochin Harbour as they are confronted with a difficulty in regard to the settlement of its local jurisdiction, the proposed harbour lying partly in the British territory and partly in the adjacent State of Cochin. It is hoped however to settle the question and form a Port Trust in a few months' time.

Meanwhile the Government have decided to have the approach channel across the bar dredged, as the success of the harbour

scheme depends mainly on the maintenance of such a channel. For this purpose the Government of India were addressed in letter No. 48-O/IV-2, dated the 7th June 1920, to move the Admiralty for the loan of a dredger. The execution of certain other works for the harbour is also considered to be imperatively necessary. It is estimated that these preliminary works alone will cost at least Rs. 1½ lakhs.

4. This Government are unable to find funds at present to meet this expenditure without borrowing. The Government of India will be approached shortly on the subject of raising a loan for the above purposes, should it be decided that the port is not to be a "Major" port and that the works necessary for its improvement are to be financed by the Government of Madras.

5. *Tuticorin*.—A report on this harbour with four others has also been submitted by Sir John Wolfe-Barry Lyster and Partners. In that report Tuticorin is considered to be much more favourably situated for development than any other of the five ports discussed. The general view of the reporting firm is summarised as follows in paragraph 66 on page 16 of their report: "We consider that the construction of a deep water port at Tuticorin would be fully justified from the financial point of view, and we are strongly of opinion that the works should be carried out as soon as circumstances permit." The further consideration of these recommendations has not advanced so far in the case of Tuticorin as in the case of Cochin, but similar dredging work is involved and financial questions similar to those described above in the case of Cochin will have to be considered.

6. I am to ask that the Government of India will be pleased to favour this Government with a definite statement as to their intentions as regards these two harbours. I am also to inquire, in case they are to be declared "Major" ports, whether the Government of India is prepared to put in hand at once the schemes for their development and to undertake the immediate expenditure necessary, including that described in paragraph 3 above which will precede the formation of a Port Trust Board at Cochin.

(ii)

Letter from the Hon'ble Mr. C. A. INNES, C.I.E., I.C.S., Secretary to the Government of India, Department of Commerce, to the Secretary to the Government of Madras, Revenue (Special) Department, dated Simla, the 12th August 1920, No. 5183.

In reply to Mr. Turing's letter No. 583-IV/20-5, dated the 15th July 1920, I am directed to say that as at present advised

the Government of India propose to classify as "Major" ports in the Madras Presidency the port of Madras and for special reasons that of Vizagapatam. They have no present intention of declaring Tuticorin and Cochin as "Major" ports, but the Government of Madras will of course understand that the classification proposed above may require reconsideration as the circumstances of the different ports change.

(iii)

Memorandum No. 1846-O/Wks.-B. 20-1, dated 23rd August 1920.

The Harbour Engineer to Government is requested to report *very urgently* what amount will be required for expenditure during the ensuing year (i.e., from April 1921 to March 1922) for works connected with the Cochin Harbour Scheme.

J. M. TUNING,
Secretary to Government.

To the Harbour Engineer to Government.

(iv)

Letter from R. C. BRISTOW, Esq., A.M.I.C.E., Harbour Engineer to Government, to the Chief Engineer, Public Works Department (Buildings and Roads), dated the 28th August 1920, No. C.H. 50/20.

With reference to Memorandum No. 1846-O/Wks.-B. 20-1, dated 23rd August 1920, I have the honour to report that if the proposals for the development of Cochin Harbour are approved, it is anticipated that the sum required from April 1921 to March 1922 will be about 50 lakhs.

2. If, however, the scheme is not proceeded with, and it is only necessary to make provision for dredging through the bar and the new works on the foreshore, if any, the sum required would probably not exceed 15 lakhs.

(v)

Letter from E. F. THOMAS, Esq., L.C.S., President, Cochin Harbour Committee, to the Secretary to the Government of Madras, Revenue (Special) Department, dated Camp, Cochin, the 10th September 1920, No. Ref. 8362/C-1.

[G.O. No. 271, dated 9th July, constituting Cochin Harbour Committee.]

We have the honour to report that the Cochin Harbour Committee held its first meeting on 16th July and at this meeting the procedure to be followed was discussed and settled. It was suggested by the President that it would be difficult if not

impossible for the Committee as a whole to proceed to the consideration of the subjects placed before it and that it was advisable to appoint Sub-Committees to make a detailed examination of the several questions and make definite reports to the main Committee for its consideration. By adopting this procedure it was thought likely that every local interest would get a hearing and that the preliminary examination of the several questions involved would best be made by local members of the Committee in concert with the Harbour Engineer to Government and the Port Officer, Cochin. This proposal was accepted by the Committee.

2. On the motion of the Chairman, Chamber of Commerce, two more representatives of the Chamber were co-opted and joined the Committee forthwith. As one of these was the local Agent of the Bank of Madras it was decided to entrust to the same Sub-Committee the preparation of a report which should deal with the question of jetties and storehouses and also the raising of a loan by a Harbour Authority when constituted to finance the projected improvements in the Port.

3. This Sub-Committee consisted of the following gentlemen:—

The Diwan of Cochin.

Mr. E. H. Cooper, Chairman, Chamber of Commerce.

Mr. W. T. Anderson, Secretary, Chamber of Commerce.

Mr. R. C. Bristow, Harbour Engineer to Government.

Lieut.-Comdr. A. E. Godfrey, R.N.R. (Retired), Port Officer, Cochin.

Messrs. J. E. Pitcairn and C. W. Cole, Members of the Chamber of Commerce.

M.R.Ry. Rao Sahib A. L. Shirgaokar Avargal, Merchant, Cochin.

Mr. S. S. Koder, Municipal Chairman.

A second Sub-Committee was constituted consisting of Capt. E. W. Huddleston, C.I.E., O.B.E., R.I.M., Presidency Port Officer, and Mr. H. H. Hood, Collector of Customs, Madras, to report on the constitution of a Cochin Harbour Trust.

4. It may be claimed, we think, that the procedure adopted has been entirely justified by results.

The enclosed report and proceedings of the Sub-Committee to consider the question of jetties and storehouses will make it abundantly clear that the question was approached by all the members of that Sub-Committee with a completely open mind and that they spared no pains to arrive at a report which might fairly be considered as in all probability the best practical solution of a

question regarding which it is no secret that there were several different and widely divergent opinions amongst those best qualified to judge. The best evidence of this is the fact that the general Committee which met on the 9th September to receive and pass judgment on that report has accepted it as a whole with one modification which was proposed by Captain Huddleston, the Presidency Port Officer.

5. Captain Huddleston's amendment is this: that the jetty (vide plan) should be shifted between 100 and 200 feet to the south and east and that the arm should run approximately to the south-east instead of westwards in the direction of the harbour mouth, and that ships should be berthed only on the outside of this jetty. His reason for moving this amendment was that in his opinion the proposed jetty was not in the safest position, having regard to the weather conditions frequently prevailing at the port and that there would be special danger under certain conditions to ships berthed inside the jetty. He considered that if the position of the jetty were altered as he recommended, it would, from the nautical point of view, be entirely satisfactory and safe.

6. The modification thus proposed is practically similar to one of six alternatives which had already been put before the Sub-Committee by the Harbour Engineer who had given it as his opinion that, to start with, a jetty in the existing deep water would be safe at least for the greater part of the year and would give berthing facilities in the shortest possible time. Speaking on the amendment, Mr. Bristow stated that he was ready to concur in the modification, if the Committee was prepared to wait at least another year for the jetty for which extra dredging would be necessary, if built in the new position. The Committee decided to adopt the proposed amendment especially as the delay involved met the views of some of the members of the Committee that some experience of the results of dredging on the bar should be obtained before spending considerable sums on jetties.

7. It would be useless to attempt to summarize the recommendations of the Sub-Committee. The report is there to speak for itself. It should be read with the minutes of the proceedings of the Sub-Committee in order that it may be realized how the Sub-Committee reached their conclusions. Briefly the proposals allow for development not only in British Cochin where the greater part of the business of the port now is, but also at Vengaloor within the limits of Cochin State at a site which besides being the most natural scene of development, has the further intrinsic advantage that it affords to the State of Cochin that share in the development of the port to which it is entitled, without affecting Ernakulam as a residential quarter and without

prejudice to private interests at Ernakulam, in Muttancheri and in British Cochin.

8. We unanimously recommend this report for acceptance by Government. The report deals also in a manner which we accept as satisfactory with the question of a loan. The provision of a harbour of the magnitude and importance that we anticipate for Cochin seems to afford sufficient justification for approaching Government with the request for a loan free of interest of 68 lakhs.

9. The only remaining question is the constitution of a Cochin Harbour Trust. We believe that it is not the desire of Government that we should produce a Port Trust Act ready for enactment and perhaps seeing that the scheme as it now is includes a great portion of State territory it would be useless to do so. We have therefore considered it sufficient merely to recommend that a harbour trust should be constituted by enactment on the model of the Act constituting the Madras Port Trust; but would ask that the Chairman of the Trust should be appointed by Government and that the Trust should consist of twelve members, one third elected by the Cochin Chamber of Commerce, one-third representatives of the Cochin State and one-third nominated by the Government of Madras.

10. We would also recommend that the enactment should stipulate that none but British subjects or subjects of an Indian State should be eligible for appointment as trustees. With regard to the office of Chairman, we desire to suggest that for the first five years or so while the construction of the harbour is in progress the bulk of the work and responsibility will be on the shoulders of the Engineers in charge of works and that there will be little for a whole-time chairman to do. On this account and in view of the interlocking of British and State interests, we desire respectfully to submit to Government that if possible the services of the Resident in Travancore and Cochin may be made available for the office of Chairman during the constructional period; but that if this is not possible it is desirable to select for the office of Chairman a senior officer of the British service. Subject to these remarks we submit that the enactment constituting the Port Trust may well follow the Madras Port Trust Act for Madras.

11. It will be observed that we have not attempted to propose a schedule of the properties and lands to be vested in the Board. It was not considered that this fell within the scope of the reference and probably it will be held to be more convenient and more proper that the boundaries of the port should be settled by direct negotiation between representatives of the Government and of Cochin State.

12. Copies are appended of the minutes of the meeting at which the reports referred to above were adopted and this report passed.

We have, etc.,

E. F. THOMAS, <i>President</i> .	} <i>Members.</i>
E. W. HUDDLESTON	
H. H. HOOD	
R. C. BRISTOW	
A. E. GODFREY	
T. VIJAYARAGHAVA ACHARYA	
S. S. KODER	
A. W. ACRES	
E. H. COOPER	
W. T. ANDERSON	
A. WADDINGTON	
W. L. BRUCE	
A. L. SHIRGAOKAR	
J. E. PITCAIRN	
C. W. COLE	
Haji Fasa Haji Moosa	
LATHI UMMER SALT	

ENCLOSURES.

(1)

Extract from the Minutes of the second meeting of the Cochin Harbour Committee, dated 9th September 1920.

* * * * *

4. The Diwan of Cochin proposed and Mr. R. C. Bristow seconded the following resolution:—
 "That the report of the Sub-Committee on jetties, warehouses and finance be adopted subject to such modifications as may be approved by the committee."
 Carried unanimously.

5. Capt. E. W. Huddleston proposed and Mr. W. T. Anderson seconded the following proposal:
 "That with a view to the greater safety of ships berthing alongside the jetty to be constructed at the north-eastern corner of British Cochin, the jetty should be moved 100-200 feet further south and east from the place now proposed; that the arm should run approximately to the south-east and that ships should lie only on the outside berths of the jetty."
 Carried unanimously.
 The committee then unanimously adopted the report as thus amended.

6. Captain E. W. Huddleston proposed and Mr. S. S. Koder seconded the following proposal which was carried unanimously:—

"This Committee recommends that a Port Trust be constituted for Cochin by an enactment modelled on the Madras Port Trust Act subject to the following recommendations:—

- (i) that the chairman be appointed by Government;
- (ii) that the trustees should be twelve in number consisting as to one-third of members elected by the Cochin Chamber of Commerce, one-third representatives appointed from the Cochin State, and one-third nominated by Government;
- (iii) that none but British subjects and subjects of Indian States should be qualified to be elected as trustees."

E. F. THOMAS,
President, Cochin Harbour Committee.

(2)

Minutes of the third meeting of the Cochin Harbour Committee, dated 10th September 1920.

I. Minutes of the previous meeting read and confirmed.

II. Proposed by Mr. W. T. Anderson and seconded by Mr. A. W. Acres.

"That the report of the Committee as drafted be approved and submitted to Government with the signatures of the members of the Committee."

Carried unanimously.

E. F. THOMAS,
President, Cochin Harbour Committee.

(3)

Proceedings of the Cochin Harbour Committee, dated 16th July 1920.

P R E S E N T :

President :

E. F. Thomas, Esq., I.C.S., Collector of Malabar.

Members :

- (1) Capt. E. W. Huddleston, C.I.E., C.B.E., R.I.M., Presidency Port Officer.
- (2) H. H. Hood, Esq., Collector of Customs.
- (3) R. C. Bristow, Esq., Harbour Engineer to Government.
- (4) Lieut.-Comdr. A. E. Godfrey, R.N.R. (Rtd.), Port Officer.
- (5) M.R.Ry. Rao Bahadur T. Vijayaraghava Acharya Avargal, Diwan of Cochin.

- (6) S. S. Koder, Esq., Chairman, Cochin Municipal Council.
- (7) A. W. Acres, Esq., General Traffic Manager.
- (8) E. H. Cooper, Esq., Chairman, Cochin Chamber of Commerce.
- (9) W. T. Anderson, Esq., Secretary, Cochin Chamber of Commerce.
- (10) A. Waddington, Esq., Secretary, United Planters' Association of Southern India.
- (11) W. L. Bruce, Esq., Senior Manager of the Madura Company.
- (12) M.R.Ry. Rao Sahib A. L. Shirgaokar Avargal, Cochin.
- (13) Haji Essa Haji Moosa, Esq., Merchant, Mattancheri.
- (14) Latif Ummer Sait, Esq., Merchant, Mattancheri.

Resolution.

I. Mr. R. C. Bristow appointed Secretary and should be ex-officio member of all sub-committees.

Proposed by the Chairman and seconded by Capt. E. W. Huddleston that Mr. R. C. Bristow should be appointed.
Carried unanimously.

II. Proposed by Mr. R. C. Bristow and seconded by Mr. H. H. Hood That sub-committees be appointed to consider and report to this committee on the various matters referred for the consideration of the Committee.

Carried unanimously.

III. Proposed by Mr. E. H. Cooper that Messrs. J. E. Pitcairn and C. W. Cole, nominees of the Chamber of Commerce, be co-opted by the Committee. Seconded by Lieut.-Comdr. A. E. Godfrey.
Carried unanimously.

The gentlemen co-opted were invited to join the meeting forthwith.

Mr. Bristow addressed the Committee on the engineering side of the scheme for a harbour.

IV. The Committee then proceeded to the appointment of a sub-committee to discuss the first point raised in the Government Order.

Mr. W. L. Bruce proposed the following sub-committee: Mr. Cooper, Mr. Pitcairn, Mr. Godfrey, the Diwan of Cochin, and Messrs. Haji Essa Haji Moosa and Latif Ummer Sait.

Proposed by Mr. C. W. Cole and seconded by Mr. R. C. Bristow that Mr. W. T. Anderson and Mr. A. L. Shirgaokar do replace the two last-named gentlemen.

Messrs. Haji Essa Haji Moosa and Latif Ummer Sait withdrew their names.

The sub-committee was appointed by an unanimous vote.

V. Mr. R. C. Bristow proposed, seconded by Mr. W. T. Anderson, that Capt. E. W. Huddleston and Mr. H. H. Hood be appointed to report on the constitution of a Cochin Harbour Trust in consultation, if necessary, with the Landing and Shipping Committee, Cochin.

Carried unanimously.

VI. Mr. H. H. Hood proposed, seconded by Capt. E. W. Huddleston that the sub-committee appointed to consider the first point, consider also the question of raising a loan by the Harbour Trust when constituted, co-opting for this purpose Messrs. C. W. Cole and S. S. Koder.

Carried unanimously.

The sub-committee agree to report not later than the 9th August. The reports will be circulated and the Committee will meet on the 16th August.

(4)

Proceedings of the Cochin Harbour Sub-Committee on Jetty and Warehouse Facilities, dated 16th July 1920.

PRESENT:

The Diwan of Cochin.	Mr. Anderson.
Mr. Cooper.	Mr. Shirgaokar.
Mr. Pitcairn.	Mr. Cole.
Mr. Godfrey.	Mr. Bristow.

1. The Diwan of Cochin was unanimously elected Chairman.
2. Mr. Bristow was unanimously elected Secretary.
3. Mr. Bristow, Harbour Engineer, explained his proposals as regards the provision of warehouses and jetties. The matter was freely discussed and various points of view and suggestions were put forward.
4. It was resolved that the next meeting should be at 3 p.m. on the 17th July when Mr. Bristow would supply preliminary sketches and estimates and other gentlemen of the Committee would bring forward figures as to the amount of trade at Cochin, so that the financial aspect of the matter could be investigated.

(5)

Minutes of meeting held on 17th July 1920.

PRESENT:

Full Committee.

The Diwan of Cochin in the chair.

1. The minutes of the previous meeting were circulated and confirmed.
2. Mr. Bristow produced preliminary sketches and estimates amounting to Rs. 36 lakhs for harbour works as follows:—

	LAKHS.
	RS.
New jetties	14
Warehouses	11
New front to wharf	1
Powerhouse, machinery, etc.	10
	36

3. These were discussed at some length particularly in reference to
 - (a) Congestion to traffic.
 - (b) Alternative method of berthing ships by moorings in stream.
4. Mr. Cooper produced approximate figures relating to tonnage from which it appeared that the trade report in 1913-14 was 125,000 tons and that for seven years prior to the war the average import of rice and paddy by British India steamers was 160,000 tons.
5. Eventually it was agreed that—
 - (a) A definite statement should be made by Port Officer as to number of vessels that could be berthed in stream with and without jetties.
 - (b) Figures should be given for cost of dredging bar and also for those other items that will fall upon the Port Trust.
 - (c) As to alternative costs of berthing ships in stream and against jetties.

(6)

Minutes of Jetties Sub-Committee held at Chamber of Commerce, Cochin, on Tuesday the 20th July 1920.

1. The minutes of the previous meeting were read and confirmed.
2. The Committee proceeded to discuss the points brought forward from the previous meeting, first as to the number of berths for vessels already available in the harbour.
3. The Port Officer produced a plan made by his predecessor, Mr. Leverett, which showed five berths on the south side of harbour in deep water. He also indicated three others which would be available on the north side of harbour, provided a comparatively small amount of dredging were done.
4. After discussion, it was generally agreed that the same number of berths would be available either in the jetty scheme or by mooring in stream—the three berths on the north side being common to both proposals, and there being room for perhaps one other berth besides the four accommodated at the proposed jetty.
5. The questions of dredging and finance were also discussed, but it was difficult to arrive at exact figures owing first to lack of knowledge as to what contractors would be willing to execute the dredging for, and secondly, owing to the absence of any figures showing the tonnage handled at the port under various heads.
6. Ultimately it was decided to send a telegram to the Collector of Customs, Madras, asking for figures as to tonnage at Cochin under the head of imports and exports by foreign and coasting steamers, and also by native craft for the three years prior to the war.
7. The meeting then adjourned.

(7)

Minutes of meeting of Sub-Committee on the Jetties and Warehouses held at the Chamber of Commerce, Cochin, on the 21st July 1920.

1. The minutes of the previous meeting were read and confirmed.
2. The Committee proceeded to discuss further the general question. The Port Officer produced some figures got out by his predecessor, Mr. Leverett, from which it appeared that a total of over 493,000 tons of shipping were dealt with in the year 1913-14. It further transpired that the quantity of registered tonnage entering and leaving the port for six years prior to the war was between 800,000 and 900,000 tons yearly.
3. The question having arisen as to whether warehouses and jetties could be expected to pay, Mr. Bristow put in a statement dealing with the subject generally. This statement was intended to show that jetties and storehouses must be regarded as an integral part of the scheme of development, and should be regarded in this light. But that there was every prospect that they would pay for themselves, in the same way that experience has shown such facilities to pay at other ports in India and elsewhere.
4. Mr. Anderson spoke of the advantages and development that would accrue to Cochin by the provision of increased facilities and instanced the fact that trade was bound to come to Cochin from other ports and that the convenience to merchants of having jetties and storehouses at Cochin was considerable.
5. Mr. Cole also spoke of the advantages, political and practical, of making early development at Cochin.
6. After further discussion, it was agreed that the Committee should adjourn and that the representatives of the Chamber of Commerce should discuss the matter with their colleagues on the Chamber, while Mr. Bristow proceeded to discuss the matter with Government, and that a further meeting should be held on the 2nd of August following.

Memorandum by the Harbour Engineer on the proposal to construct storehouses and jetties at Cochin.

1. The proposal to dredge the bar at Cochin is based on the assumption that there will be an expansion of trade as a result, and this alone can be the justification for the expenditure of a large sum of money on dredging and foreshore works.
2. The landing and storing facilities in the harbour are at present rudimentary in design and restricted as to capacity. It has been admitted, for example, that the godown space is in sufficient even for the present needs. It follows that better facilities must be provided in order that any expansion of trade may be dealt with.
3. Further, it follows that the additional facilities must be regarded as an integral part of the whole scheme. Otherwise the bar would be dredged and the foreshore protected merely to maintain the existing inadequate conditions and the existing amount of trade. I take it that no one desires this.

4. The necessary improvement may be effected in the first place :—

(a) by the provision of up-to-date methods of clearing cargo enabling vessels to leave in the shortest time possible;

(b) by the provision of additional storage accommodation.

5. These proposals are on the lines of those adopted in all first-class ports throughout the world, and go a long way towards meeting the ultimate requirements of a modern port, viz

(i) Exporting or importing food and raw materials

(a) light, (b) heavy, needing mechanical power.

(ii) Exporting or importing manufactured articles

(a) light, (b) heavy, needing mechanical power

(iii) Dealing with passenger traffic.

(iv) Providing for repair of vessels—

(a) alongside wharf, (b) in dock.

(v) Providing other ship's necessities—

(a) water, (b) fuel, (c) food, (d) stores.

(vi) Providing (iv) and (v) of the above for war vessels; and in addition, offering a harbour and base for strategic purposes, with all the attendant naval requirements.

6. The possible expansion of the trade at Cochin consequent upon the above can be estimated or imagined by any business man, and it is not proposed to enumerate the attendant items of development at this stage.

7. Apart, therefore, from any question as to whether jetties and stores will pay by themselves, or not, they should be looked upon as a part of the scheme of development. But it may be shown that there is every prospect of their paying—and paying well. They are estimated to cost Rs. 36 lakhs, the annual charges on which for sinking fund and interest might be reckoned at 8½ per cent or say 3 lakhs. If the warehouse proposed is let at the same rent as those in Madras it will produce yearly one lakh revenue per annum so that the whole question as regards paying comes down to this—will the warehouse be used to its full capacity—or at any rate sufficiently to pay charges upon it, all the year round?

8. The experience of other ports cannot be neglected in regard to this. I understand that as soon as warehouses are built they are rented by business firms whose trade seems to increase automatically with the opportunities provided for it. If, therefore, it is admitted first that more godown space is required even now, and secondly, that an expansion of trade will undoubtedly result upon the opening up of the harbour, it is difficult to resist the conclusion that the warehouse and jetties will fill a real necessity.

9. There are just one or two general points which seem to me deserving of the Sub-Committee's consideration.

I believe you will agree with me that it is desirable that the final decision on these questions now before us should, if possible, be based on our unanimous agreement. The appearance of discord at this stage would necessarily have a somewhat depressing effect upon the public mind and would possibly be exaggerated by less well-informed people into a suspicion of the soundness of the harbour scheme as a whole. On the other hand,

unanimity and hearty co-operation would be important factors in ensuring uniform and continuous progress.

10. Lastly, I would appeal to those members of the Sub-Committee, if any, who have not yet been convinced by my arguments to try and look at the matter once again from a rather different angle. May I appeal to you, gentlemen, to do your best to look at this question imperially rather than locally, and to think of Cochin as a link in the chain of commerce which is the strongest binding force of the Empire.

If you do this, you will perhaps follow me in my earnest desire to see advantage taken of the almost unique potentialities of Cochin, so that it may be made not into a moderate second-class harbour, but into a first-class harbour and that with the least possible delay and without going through any stages of makeshift and incompleteness which might get it a bad name and so retard its ultimate success.

(8)

Sub-Committee Meeting, Friday, 23rd July 1920, at 4 p.m.

PRESENT:

The Diwan of Cochin, Ernakulam.
Mr. E. H. Cooper.
Mr. A. L. Shirgaokar.

Mr. S. S. Koder.
Mr. W. T. Anderson.
Mr. J. E. Pitcairn.

The figures applied for to Mr. H. Hood of the foreign and coastal steamer and sailing vessel totals of imports and exports not having been received the meeting were only able to estimate possible cargo revenue from the figures obtained by Mr. Cooper approximately 350,000 tons per annum.

	RS.
The total estimate of revenue so obtained were	
350,000 tons at Rs. 2 per ton dues	7,00,000
Port dues on steamers at As. 3 and sailing vessels at As. 1½ per nett registered ton	1,50,000
Rent of godowns	1,00,000
	9,50,000

The Sub-Committee had been informed that for a start Rs. 75,00,000 would be required made up as follows :—

	RS.
Jetty and warehouses	36,00,000
Purchase of dredger "Triton"	1,00,000
Repairs to do. do.	1,00,000
Dredging	30,00,000
Contingencies	7,00,000
	75,00,000

Two tugs would also be required; present estimate of cost would be 50,000 each.

Provision of four moorings would probably cost Rs. 1,50,000.

Beyond this the meeting could not proceed until further information is available.

It was thought undesirable to suggest increase of harbour dues beyond Rs. 2 per ton especially seeing that Madras rates apparently average between Rs. 1-8-0 and Rs. 1-12-0 per ton.

Therefore the further revenue required could only be looked for from increased trade and on the assumption that an annual increase of 10 per cent might be expected the present revenue figures ought to double themselves in ten years.

The meeting requested Mr. Cooper to telegraph Bombay, Karachi and Rangoon for copies of their schedules of charges and tonnage dues, also for administration reports of these ports if obtainable. This valuable information to be placed before the next meeting of the Sub-Committee to be held on Tuesday the 3rd August.

(9)

Minutes of Sub-Committee Meeting held at Chamber of Commerce on 4th August 1920.

P R E S E N T :

All members including Messrs. Cole and Koder with the Diwan of Cochin in the chair.

1. The minutes of the meetings of 21st and 23rd July were read and confirmed.

2. Mr. Bristow suggested that the meeting should now confine itself specifically to the question of finance; that to-morrow it should, if possible, come to a decision on this point; that members should then give notice of any questions they wish to raise on engineering or nautical matters and that the Committee should consider these on Friday so that a report may be drafted, if possible, by the end of the week. This was agreed to.

3. Mr. Bristow then read a statement from which it appeared that the average total trade for the five years prior to the war was 375,136 tons avoirdupois and the registered tonnage 840,000. He considered it would be fair to increase these figures by 33½ per cent in estimating average revenue over a period of ten years ahead, after which it might be considerably more. On this basis a revenue of 14 lakhs would be forthcoming yearly.

4. An estimate was then compiled for what might be called the first stage of the work. This came to about 100 lakhs principally made up of 30 lakhs for contract dredging of the bar and foreshore work, 36 lakhs for jetties, warehouses, etc., and 16½ lakhs for half the cost of a permanent port suction dredger. It was shown that a revenue of 14 lakhs would just

pay for this expenditure allowing 8 per cent for interest and sinking fund and 40 per cent of gross revenue for establishment and maintenance.

5. The meeting agreed that these figures should be put into proper financial shape by Messrs. Cole and Bristow and submitted to them on 5th August at 10-30 a.m. in order that a decision could be arrived at as regards the financial aspect.

(10)

Minutes of meeting of Sub-Committee on Jetties and Warehouses held at the Chamber of Commerce on 5th August 1920.

P R E S E N T :

1. The full Committee including Messrs. Cole and Koder. The Diwan of Cochin in the chair.

2. The minutes of the previous meeting were read and confirmed subject to the addition of the words "if possible" in the second paragraph after the words 'so that a report may be drafted.'

3. Mr. Cooper raised the question of taking evidence from merchants in order to comply with the terms of reference which include a question as to 'the terms on which the mercantile community and the shipping interests involved will be likely to avail themselves of these new facilities' (i.e., jetties and storehouses). It was agreed evidence should be taken from Messrs. Haji Easa Haji Moosa, Dewji Hansraj and Latif Ummer.

4. Mr. Cooper also raised the question as to the actual area and earning power of the warehouses, etc., at Madras and it was agreed the Secretary should write to Madras to get the information.

5. Mr. Bristow read the financial statement prepared by Mr. Cole and himself, and after discussion it was agreed to include the whole cost of the dredger in the first estimate together with an approximation as to its earning capacity. The statement to be amended accordingly.

6. Arising out of the above Mr. Cooper gave figures as to the cost of handling rice out of vessels—viz., Rs. 11 per 100 bags in ordinary weather and Rs. 17 per 100 bags in monsoon periods.

It was agreed this was approximately equivalent to a handling charge of Rs. 1½ per ton and Rs. 2¼ per ton respectively.

7. Mr. Cooper gave it as his opinion—

(a) Whether or not the scheme as a whole (that is the preliminary scheme, including jetties and stores) can be shown to pay the work of godowns and jetties should be postponed pending experience as to the keeping open of the bar.

(b) In any case equal berthing accommodation can be provided for steamers by laying moorings as constructing jetties.

(c) That the outlay of 36 lakhs of rupees on jetties, etc., is not by itself a paying proposition.

8. Mr. Godfrey, Port Officer, read a statement giving his views. These might be summarized as follows:

(a) Eminent engineering advisers have either been against the opening of the bar—or cautious in their expressions of opinion. Therefore it would not be wise to incur greater expense than necessary before seeing whether the bar can be kept open or not.

(b) Moorings, at least in the first place, will be equally useful and far cheaper than jetties.

(c) Warehouses, etc., ashore will be useful and should be erected.

9. Mr. Bristow put the following questions to the Sub-Committee which were answered in the affirmative:—

(a) Would it be generally agreed that storehouses were necessary whatever be the ultimate decision as to jetties? Agreed to with reservation as to height of warehouse.

(b) Would it be generally agreed that assuming a sufficient number of cranes and no congestion, a vessel could unload quicker against a wharf than by derricks in stream? Agreed to.

10. In answer to inquiries, the following points were given to the Harbour Engineer for consideration and reply:

(a) As to height of jetties above H.W.

(b) As to possibility of swell coming into harbour.

(c) As to congestion of area of jetty, etc.

11. During discussion on the foregoing points it became apparent that a report could not be drafted this week. The Harbour Engineer stated for instance, that he would require at least a week to prepare particulars as to reclamation of certain area in the harbour. It was therefore agreed to write to the President pointing out cause of delay and promising to report definitely by 23rd instant at latest and suggesting a full meeting one week after receipt of report.

12. A message having been received that three out of the four Indian merchants could attend to give evidence at 4.30 in the afternoon, it was decided to adjourn until that time—the next meeting to be held at 10 a.m. on Monday following, 9th instant.

(11)

*Minutes of meeting of Sub-Committee on Jetties and Warehouses
held at the Cochin Chamber of Commerce on 5th August
at 4 p.m.*

PRESENT:

1. The full Committee including Messrs. Cole and Koder with the Diwan of Cochin in the chair.
2. The minutes of the previous meeting were read and confirmed.
3. The Secretary read a draft letter to the President of the Ad Hoc Committee acquainting him of the postponement for two weeks of the Sub-Committee's report which was approved and despatched.

4. Three Indian merchants of Mattancheri, Messrs. Haji Easa Haji Moosa, Latif Ummer Sait and Hansraj Dewji, attended the Committee to give their views on the construction of godowns and jetties.

5. After considerable discussion which had to be translated these gentlemen were asked definite questions which with their replies are given as under:—

(a) Is the godown space at the Cochin harbour sufficient or insufficient now? Reply from all three:—It is insufficient now and there will be acute insufficiency if trade increases.

(b) Will additional godown space be provided by private enterprise and is there suitable space for such godowns? Reply by Messrs. Haji Easa Haji Moosa and Dewji:—Land is difficult to get and godowns should be built by Government. Reply by Mr. Latif Ummer:—Private enterprise may supply the godowns.

(c) Would Government godowns, if erected, be used and on what terms? Reply by Messrs. Haji Easa Haji Moosa and Dewji:—Godown would be used and a rate of Rs. 2 per 100 bags of rice per month would be acceptable. Reply by Mr. Latif Ummer:—Use of Government godowns would depend upon the rent charged.

6. The Sub-Committee therefore decided that as regards godown accommodation this evidence confirmed their decision at the previous meeting, viz., that warehouses should be built irrespective of the jetty question.

7. Arising out of other points brought forward during the previous discussion the following alternatives as regards handling of goods to and from ships were discussed:—

Case 1.—In those goods which would not have to pass through transit sheds and would be stored direct in Government or private warehouses—

	Ships lying at moorings in stream.	Ships lying at jetty.
First operation	Cost of getting goods ashore by boat.	Cost of landing on to jetty.
Second do.	Cost of handling into godowns.	Cost of handling into godowns.
Third do.	Cost of subsequent distribution.	Cost of subsequent distribution.

Case 2.—In those goods which would have to pass through transit sheds before storing in Government or private warehouses—

	Ships lying at moorings in stream.	Ships lying at jetty.
First operation	Cost of getting goods ashore to transit sheds by boat.	Cost of landing on to jetty.
Second do.	Cost of handling through sheds and back to native boat.	Cost of handling through sheds and into Government godowns.
Third do.	Cost of transport to merchants' godowns.	.....

	Ships lying at moorings in stream.	Ships lying at jetty.
Fourth operation...	Cost of storage in merchants' godowns.	Cost of storage in Government godowns.
Fifth do. ...	Cost of subsequent distribution.	Cost of subsequent distribution.

8. It was agreed that figures should be obtained as to—

(a) The reduced cost of handling to and from ships to shore, when vessels are able to lie in the harbour.

(b) The cost of handling from ships to warehouses over jetty.

Mr. Cooper undertook to provide the former and Mr. Bristow the latter.

9. The Chairman expressed the thanks of the Sub-Committee to the Indian merchants for their valuable assistance and the meeting terminated.

(12)

Minutes of meeting of Sub-Committee on Jetties and Warehouses held at Chamber of Commerce, Cochin, on 9th August 1920 at 10 a.m.

PRESENT:

1. The whole Committee including Messrs. Cole and Koder. The Diwan of Cochin in the chair.

2. The minutes of the previous meeting were read and confirmed.

3. Mr. Bristow replied to the queries raised at the meeting on 5th instant as follows:—

(a) As regards height of jetties he gave a list of twenty important ports where the height of jetties was 6 feet or less, above H.W. He explained that the height of wharves was dependent largely upon the level of mainland, and he agreed with the Port officer that in some of the cases that although there was more shelter than at Cochin. He further explained that although there was more rise and fall of tide at most of these ports than at Cochin yet frequently the worst winds occurred at H.W. (when most of the ship also was exposed above the surface) and it was this condition that had to be used for purposes of comparison. He stated finally that the vessels would be kept off the jetty some 4 or 5 feet by means of fixed fenders and floating fenders and that in his opinion a jetty level of 6 feet above H.W. was permissible at Cochin.

(b) Dealing next with the question of swell entering the harbour he produced a clay model showing the bar and its relation to the harbour mouth and showed the proportion of an opening through the bar 600 feet wide at bottom to the whole width of bar and the space available inside the bar for the diffusion of waves or swell entering this opening. He gave it as his considered opinion that unless a very strong wind equal to 50 miles per hour were to blow for six hours on end the amount of swell within the harbour would not be materially increased by the cutting of a channel 600 feet wide through the bar.

4. The Committee then proceeded to discuss the question of congestion, which might arise on shore. The Harbour Engineer produced a plan showing the suggested method of transport over the proposed jetty in the worst possible case, namely, with vessels moored on both sides of a jetty with arms running east and west from a central stem or approach. He explained that the plan had been prepared on purpose to show the worst possible conditions and it was for the Committee to suggest which section, if any, of the scheme should be embarked upon.

5. General discussion followed and various points were elucidated. Eventually one or two members had doubts in their mind as to the distance apart of the various railway tracks and another important point was raised by Mr. Pitcairn as to the distribution of rice cargo in monsoon weather. But apart from these no serious objection was raised as to the practicability of the scheme.

6. The Harbour Engineer undertook to provide alternative estimates for different arrangements of godowns and jetties based upon the general scheme submitted and also in relation to modifications thereof shown on tracings Nos. 2 to 6 shown to the Committee.

7. The meeting then terminated having arranged to meet on the following Wednesday at 10 a.m.

(13)

Minutes of meeting of Sub-Committee on Jetties and Warehouses held at the Chamber of Commerce, Cochin, 11th August 1920, at 10 a.m.

PRESENT:

1. The full Committee with the exception of the Diwan of Cochin, and in his absence Mr. Cooper was elected to the chair.

2. The Secretary read a letter from the Diwan apologizing for his absence due to the visit of the Diwan of Travancore.

3. The Harbour Engineer produced sketch plans of three alternative schemes for development at Cochin together with an abstract of estimates. The latter are given in appendix hereto.

4. It was explained that the two godowns suggested to be built on the eastern half of the site should be used for imports and the godown on the new Customs wharf for transit and export sheds.

5. Mr. Bristow also produced figures showing what the cost of handling rice from the jetty to the Government godowns might be expected to be. He explained to the Committee the manner in which the estimate was made up, resulting in a total of 2 annas per ton, after allowing 100 per cent over the theoretical cost.

6. As against this charge of 2 annas, it transpired that the cost of getting material from a ship at moorings to godowns on shore would equal about 6 annas per ton irrespective of other charges, such as towing, tarpaulins, etc.

7. Mr. Cooper raised a question as to how charges could be met for upkeep of the existing godowns at Candle Island, if storage were diverted to Government godowns, pointing out that trade in some way or other would have to stand the burden. He said that out of the charge of Rs. 11 per 100 bags of rice 12 annas were allotted for rent of godowns.

8. It was agreed :—

(a) that the Secretary should circulate the minutes together with alternative estimates showing how the total estimates of the 116½ lakhs would be affected by the proposed modifications ;

(b) that figures should also be given as to the sums likely to accrue from reclamation of land in the harbour ;

(c) that the above should be considered at a meeting to be held on Monday at 10 a.m.

Estimated cost of works for alternative preliminary schemes.

COCHIN HARBOUR.

Scheme for providing 1,000 feet jetty and three godowns, etc., on shore.	Scheme for providing deep water wharf for one vessel and two godowns, etc., on shore.	Scheme for providing 500 feet jetty and three godowns, etc., on shore.
LAKHS.	LAKHS.	LAKHS.
Contract work for dredging of bar and foreshore. 30	Contract work for dredging of bar and foreshore. 30	Contract work for dredging of bar and foreshore. 30
Cost of suction dredger. 38	Cost of suction dredger. 33	Cost of suction dredger. 33
Two tugs ... 10	Two tugs ... 10	Two tugs ... 10
Four moorings for steamers. 2	Four moorings for steamers. 2	Four moorings for steamers. 2
Dredger "Triton" and repairs to same. 2	Dredger "Triton" and repairs to same. 2	Dredger "Triton" and repairs to same. 2
77	77	77
LAKHS.	LAKHS.	LAKHS.
Godowns ... 11.23	Godowns ... 11.23	Godowns ... 11.23
Wharf along side do. dumping space, etc. 9.39	Wharves and dumping spaces. 18.92	Wharves and dumping spaces. 20.62
Jetty with western arm 1,000 feet long, dolphins. 17		Jetty ... 8.05
Extra dredging ... 1	Dredging, powerhouse and land acquisition as in first case. 14.50	Dredger, powerhouse and land acquisition as in first case. 14.50
Powerhouse ... 10		
Land acquisition ... 3.50		
Total ... 129.12	Total ... 121.65	Total ... 120.62
Say 130 lakhs.	Say 122 lakhs.	Say 121 lakhs.

Abstract of alternative estimates.

Extent of provision.	Jetty.	Godowns and wharf space in front.	Extra dredging.	Powerhouse.	Land acquisition.	Total.
	LAKHS.	LAKHS.	LAKHS.	LAKHS.	LAKHS.	LAKHS.
SCHEME No. 1 AS AMENDED.						
Jetty western arm 1,000 feet long by 42 feet wide with approach 80 feet wide by 400 feet long.	17	20.62	1	10	3.50	52.12
Godowns with wharf in front 2 storeys on site of new customs and 1 storey on both eastern sites.	...	Wharves and dump. 9.39	Go-downs 11.23	...	...	77
						129.12
SCHEME No. 4.						
No jetty ...	...	80.15	...	1	10	3.50
1 deep water wharf for steamer.	...	Wharves and dump. 18.92	Go-downs 11.23	...	...	44.86
Godowns with wharf in front 2 storeys on site of new customs and 1 storey on both eastern sites.	...					...
SCHEME No. 6.						
Jetty western arm 500 feet + 42 feet with approach 42 feet wide by 400 feet long.	8.5	20.62	1	10	3.50	43.62
Godowns with wharf in front 2 storeys on site of new customs and 1 storey on both eastern sites.	...	Wharves and dump. 9.39	Go-downs 11.23	...	...	...

(14)

Minutes of meeting of Jetty's Sub-Committee held at the Chamber of Commerce, Cochin, 16th of August 1920, at 10 a.m.

PRESENT :

1. The full Committee including Messrs. Cole and Koder. The Diwan of Cochin in the chair.

2. The minutes of the previous two meetings were read and confirmed subject to the deletion of the words "boat hire" from the end of paragraph 6 of the meeting of the 11th of August.

3. The Harbour Engineer read a report on the question of reclamation copy of which is attached, and showed on a plan the area proposed to be reclaimed on the west side of Venduruthy.

4. The Committee proceeded to discuss the possibilities of this scheme and it was generally agreed that it opened out certain aspects of the case as a whole, which had not previously been looked at. For example -

(a) the possibility of doing away with the proposed acquisition of land and development at Ernakulam was pointed out, developing Venduruthy instead;

(b) the feasibilities of getting the railway across to Venduruthy becomes more obvious;

(c) the question of development at Cochin Harbour, as a whole, can be better visualized and estimated if the area of harbour development is principally confined to the shores of Cochin and Venduruthy.

5. After discussion it was agreed that the Secretary should draft a memorandum dealing with the whole subject from this point of view and giving estimated cost of development at Venduruthy including the railway, as compared with development at Ernakulam. He also promised to furnish an estimate of the cost of continuing the railway to Cochin, if time permitted. The meeting then adjourned until 3 p.m. on Tuesday, 17th of August 1920.

(15)

Minutes of the Sub-Committee on Jetties held at the Chamber of Commerce on 17th August 1920.

PRESENT:

1. The full Committee including Messrs. Cole and Koder. The Diwan of Cochin in the chair.

2. The minutes of the previous meeting were read and confirmed.

3. The Secretary read a report dealing with the whole subject of the development of Cochin and summarizing the work of the Committee to date, a copy of which is attached.

4. The Committee agreed that this report with one or two additions made during the meeting should be regarded as the basis of the Sub-Committee's report; that the representatives of the Chamber of Commerce should put the matter before their colleagues on the 19th instant and that a further meeting should be held on 20th at 11 a.m., in order, if possible, to confirm and sign the report.

(16)

Minutes of meeting of Jetty Sub-Committee held at the Chamber of Commerce, Cochin, on 20th August 1920.

PRESENT:

1. The full Committee with Messrs. Cole and Koder. The Diwan of Cochin in the chair.

2. The minutes of the previous meeting were read and confirmed.

3. The Secretary to the Chamber of Commerce reported that at a meeting of the Chamber held on 19th instant it had been agreed *nem. con.* that jetties and godowns in the neighbourhood of the Customs wharf were desirable and could be made use of by the local merchants.

4. The meeting then proceeded to discuss the draft report put up by the Secretary, and members gave in turn various amendments or additions which, after agreement, were incorporated in the report.

5. It was then formally moved by Mr. Bristow and seconded by Mr. Pitoaim that the report be adopted as amended: that it should be printed; and that the Secretary be authorized to print the names of all members as signatories thereto. Carried unanimously.

6. After discussion it was agreed that the next meeting of the full Committee should be postponed until 9th September and that the Secretary inform members accordingly.

7. The Secretary undertook to arrange for the printing of the report and plan in Madras and for its circulation.

8. A vote of thanks to the Chairman for giving up so much of his valuable time and assistance to the Committee was proposed, seconded and carried unanimously.

Note by the Harbour Engineer.

In accordance with the request of the Sub-Committee, I have made a comparative estimate of the cost of developing Ernakulam and Venduruthy as follows:—

	LAKHS.
The cost of a railway bridge, etc., to Venduruthy is approximately	36
The cost of banks and pipe line for reclamation is approximately	7
Total	43

This provides for the reclamation of 640 acres of ground valued at Rs. 10,000 per acre nett.

	LAKHS.
The cost of 260 acres of ground at Ernakulam, say	20
The extra cost of dredging, if reclamation is not carried out, say	15
The further dredging necessary in the Ernakulam channel	5
Total	40

So that the Ernakulam scheme actually costs 3 lakhs less than the other, but Venduruthy provides 384 acres more ground than taken up for on the

Ernakulam side, which at the value stated makes an asset of 38.4 lakhs, giving a result in favour of Venduruthy of 35.4 lakhs.

2. This result appears to me to be so important that I have drafted the following report for the consideration of the Sub-Committee:—

Memorandum on the subject of reclamation in Cochin Harbour by the Harbour Engineer.

[Reclamation.]

The factors which govern the choice of areas for the purposes of reclamation are as follows:—

(a) *Position.*—The position should be such that the ground reclaimed will be commercially useful and can be sold at a high figure.

(b) *Non-interference with private interests.*—The site when reclaimed should not block up canals, water-ways, or any considerable portion of water frontage already developed commercially.

(c) *Height of reclamation.*—The water should be as shallow as possible.

(d) *Banks, etc.*—These should be as small as possible.

2. I have studied the conditions in the harbour in special reference to the above; and have had an interview with the Diwan and the Diwan-Peishkar in regard to the matter and it appears that, while there are comparatively small areas at Ernakulam which can be usefully reclaimed, by far the most advantageous site is to the west of Venduruthy Island.

3. From a survey made of this area, I find at least 640 acres can be reclaimed behind the banks, which latter are for the most part in water only 1 foot deep at low water level. Moreover, the bottom is found to be comparatively firm, and it is not anticipated the banks will sink down any appreciable distance. A further area of 143 acres is also available for possible extension, but the banks in this case would have to be made deeper and more substantial; and the bottom is very soft.

4. The land thus proposed to be reclaimed is in one of the most accessible parts of the harbour, and is approximately half way between Ernakulam and Cochin sides. It would be difficult to find an area of so much direct and immediate use in the development of the port. I am informed that the land would fetch at the very least Rs. 10,000 per acre, so that the proceeds resulting from this reclamation would be no less than 64 lakhs.

5. In order to obtain the spoil to fill this area, it is necessary to dredge the 600 feet channels on both the Ernakulam and Cochin sides, and in addition, where these two meet, to make a wide turning space. But this is not more than would be necessary in any case. If any considerable portion of this spoil is found to escape in the overflow during the process of reclamation, it is possible to extend the channels in width and also the turning space, so that there need be no fear as to the material being available, to fill the reclamation.

6. Dealing now with the question of cost, it is necessary to provide for 2,000 yards run of 24-inch wrought iron piping with wrought iron pontoons to support them and also to allow for a large number of special connecting pipes, so that movement in the pipe line will not start the joints. With wrought iron at £50 per ton, the cost of all this gear, allowing for 20 per cent contingencies, would be 4½ lakhs. The cost of the banks has been estimated at about 2½ lakhs, and a contract price has been offered which, as a matter of fact, brings the latter to 2 lakhs only.

7. The total cost of the dredger, pipe line, banks, etc., would, therefore, be under two-thirds of the sum anticipated to accrue from reclamation, and even supposing much of the land was used for agricultural purposes to start with, it is obvious that the reclamation would at least pay the entire cost of the dredging plant.

8. In view of the importance of this aspect of the question, I have satisfied myself personally as to the nature of the bottom on which the banks would rest and have made an inspection of various kinds of material which would be suitable for constructing the banks. As a result I have little hesitation in saying that the reclamation at Venduruthy is one of the most hopeful parts of the development of the harbour.

(17)

Report of Sub-Committee on Jetties and Warehouses.

[Cochin Harbour Development.]

The terms of reference to this Sub-Committee were:—

To consider (a) the construction of jetties and store-houses, their probable position and the extent to which, and the terms on which, the mercantile community and the shipping interests involved will be likely to avail themselves of the new facilities; and

(b) the raising of a loan . . . for all purposes connected with the Cochin Harbour.

2. The Sub-Committee in dealing with this considered in the first case the tentative proposals of the Harbour Engineer for a jetty, power-house, and warehouse at the site of the new Customs wharf. They took evidence from three Indian merchants, examined several estimates of expenditure and revenue and eventually came to the conclusion that more warehouse or godown space was necessary to deal with increased trade, that such buildings could conveniently and economically be placed on the strip of frontage between the boundary stone and the west end of the new Customs wharf and that a rent of Rs. 4-8-0 per 100 square feet per month, or alternatively Rs. 2 per 100 bags of rice per month could reasonably be expected.

3. With regard to the jetty and power-house, the opinion was not so unanimous. One member of the Sub-Committee expressed the following views:—

(a) All the eminent Engineering advisers consulted hitherto have either been doubtful of the possibility of opening the bar and of keeping

it open or cautious in their expressions of opinion. Therefore it would not be wise to incur greater expense than necessary before seeing whether the bar can be kept open or not.

(b) Moorings, at least in the first place will be equally useful, safer and far cheaper than jetties;

and another took a somewhat similar attitude—

(c) Whether or not the scheme as a whole (that is, the preliminary scheme including jetties and stores) can be shown to pay, the work of godowns and jetties should be postponed pending experience as to the keeping open of the bar.

(d) In any case equal berthing accommodation can be provided for steamers by laying moorings as constructing jetties.

(e) That the outlay of Rs. 36 lakhs on jetties, stores, etc., is not by itself a paying proposition, which, economically, it should be, while yet a third was in general sympathy with both the above views.

4. Against these views, however, the Harbour Engineer and other members were of opinion—

(a) Jetties by themselves were a relatively small item in the total estimate; that the justification for undertaking the scheme at all was that engineering resources had increased enormously of late years; and that it was reasonable to expect that similar and equal difficulties which had been surmounted at other places could be dealt with at Cochin.

(b) Jetties would be of the utmost use to those merchants using the Port Trust godowns who do not possess boats or tugs and would result in decreased landing costs.

(c) That if, with moorings provided in stream and no jetties, merchants had to pay the increased total charges of Rs. 2 per ton harbour dues and boat hire, etc., in addition, they would be considerably worse off than at present.

(d) That vessels would be able to leave the harbour sooner.

(e) That the jetty development was a good advertisement for the port and helped to increase its prestige pending the major developments of the future both at the port and in the interior.

5. The Sub-Committee, therefore, considered the matter further from both the financial and technical aspects. As regards the financial, it was generally agreed there would be a certain revenue from the hire of cranes and a saving in the cost of getting merchandise to and from vessels as compared with ships lying in stream; while arising out of these, there would be the general advantage to the port that—given proper working arrangements—ships would be able to load or unload and leave the harbour quicker than by any other means. It was also agreed that in all probability the people renting the godowns would prefer to use the jetties, provided wharfage and other charges were reasonable.

6. As regards the technical aspect, the Harbour Engineer produced a model showing the bar and the harbour entrance and gave other evidence which tended to show that any material increase of swell inside the

harbour need not be anticipated by the cutting of a comparatively small opening through the bar. He stated also the names of a large number of first-class ports which were provided with jetties of about the same height above water as those proposed and that conditions of tide and current were much worse at several of these other ports than at Cochin. He further produced a plan showing the area laid out to its maximum capacity and the triple system of narrow gauge railway lines by which he proposed to accelerate the transport of goods to and from the vessels and to avoid congestion on shore. He also explained that the jetty shown need not be built all at once: that the central arm, for instance, and a bend of 500 feet to the east or west could be done first, and the rest left to be added as the result of experience. Altogether he gave sketches of six possible alternatives on the same site, and provided the Committee with total estimates of three which appeared to them more suitable than the others.

7. Although several members of the Sub-Committee were of opinion that at least one of these schemes—a common nucleus to any of the other alternatives—was on sound lines and sufficiently conservative in scope, it was agreed to consider further the financial aspect of the matter.

8. Broadly speaking the position was as follows. Allowing for the dredging of the bar by contract, the protection of the foreshore, the construction of warehouses, power station and jetty, and half the cost of a new dredger for maintaining the bar and dredging the harbour channels inside, the scheme just paid for itself. This was assuming interest and sinking fund at 8 per cent, maintenance 40 per cent of gross revenue, harbour dues at Rs. 2 per ton, port dues at As. 3 per registered ton and an increased trade averaging 33½ per cent, over a ten years' period ahead.

9. The Sub-Committee agreed, however, that the whole cost of the dredger should be included in the first estimate, together with some approximation of its earning capacity for reclaiming land in the harbour. The Harbour Engineer, therefore, after consultation with the appropriate authorities, produced a plan and estimate showing that an area of one square mile could be reclaimed on the west side of Venduruthy Island valued at Rs. 64 lakhs and that the extra expenditure for pipe line and retaining banks would be Rs. 7 lakhs. It was agreed in Committee that this valuation of Rs. 64 lakhs was a safe one and consequently that the scheme was of the utmost importance to the harbour finances, especially as the whole of the material for the reclamation would be forthcoming out of the harbour channels which have to be dredged in any case.

10. But an equally important question arose out of this development. If such a large and valuable area could be made available at so little cost, why should it be necessary to acquire an expensive tract of land at Ernakulam—much further away from the harbour entrance and not more sheltered? The Harbour Engineer stated that he saw no reason against the adoption of the reclaimed area for harbour purposes; in fact its position seemed to him almost ideal, while there were no insurmountable difficulties to be anticipated in constructing a bridge across to the mainland to carry the road, railway, water-mains, etc. The bridge would be made about 20 feet clear above high water level, with one span to open.

11. The Sub-Committee were of opinion that this issue of their investigations altered fundamentally some of their previous conceptions. There had always been an uncertainty as to how development at Ernakulam could be co-ordinated with that at Cochin for the good of the port as a whole. It seemed that two places at such a distance apart, with different interests and traditions, but with very similar functions, would be struggling for precedence; that the superior position of Ernakulam on the mainland might eventually result in the subordination if not extinction of Cochin commercially and that this would result not so much from active business rivalry as by a natural process of economic evolution.

12. A development at Venduruthy, however, would make co-ordination much more definite and practicable. Cochin and Venduruthy would be on opposite sides of the same channel and connected by railway. There would be no existing interests to consider at Venduruthy. Cochin would retain its backwater trade to a great extent and Venduruthy would provide docks, slipways, workshops, coal, water and warehouses for inland trade; it would deal with passenger traffic, and provide also an overflow for backwater trade. Ernakulam would still be largely an administrative and residential district and would serve the other two places in this capacity, apart from any commercial extension which would naturally result from the growth of the whole port.

13. Reviewing the situation at Cochin in the light of the above, it would seem that such a process of development affects the construction of jetties in three ways:—it emphasizes the necessity for equipping Cochin to take its place on equal terms with its neighbour Venduruthy; it makes the extension of the railway to Cochin a natural corollary, which in itself adds considerably to the case for the erection of the jetties; and it enables some sort of tacit understanding to be come to, that if expense is incurred at Cochin for building jetties and providing them with power cranes, etc., development at Venduruthy would not be designed in competition with that at Cochin but as a separate unit of the total requirements of the port. By such means the very considerable capital already sunk in Cochin both in money and business effort could be preserved; and this is probably no more than the business community have a right to expect, combining, as they are now, for the good of the port.

The question of the railway to Cochin is considered to be so important that the railway should be regarded as an integral part of the scheme. Its estimated cost built on the same principle as the other bridge is roughly Rs. 45 lakhs and this could be met very largely by sales of land resulting from further reclamation as soon as plant becomes available. There are many large areas in the backwaters eminently suitable for this reclamation.

14. The Committee is also of opinion that it is essential that the general system of communications by rail, road and water from the surrounding district should be improved and developed with a view to accelerating transport towards the port. At present for example, there is no road connexion with Travancore across the Alwaye river. It is assumed that, if the Committee's proposals were approved, this matter would be pressed upon the authorities concerned.

15. Dealing now with the finance of the first part of the scheme as altered by this development and including for jetties at both Venduruthy and Cochin, the estimate of expenditure is as follows:—

	LAKHS.
Cost of suction dredger to maintain channel in bar and dredge for reclamation ...	33·00
Cost of dredging bar by contract and of protecting foreshore, etc. ...	30·00
Purchase of two tugs ...	10·00
Four moorings for steamers ...	2·00
Dredger Triton to start work on bar and work in confined places in the harbour ...	2·00
Godowns on site of Customs wharf and adjoining areas eastward to boundary stone ...	11·23
Wharf area and dumping space in front of last. Cost of first portion of deep water jetty at Cochin (two berths only to start with) ...	9·39
Extra dredging for above ...	8·50
Power house, cranes, etc. ...	1·00
Land acquisition ...	10·00
Reclamation at Venduruthy, pipe lines retaining banks, etc. ...	3·50
Cost of dredging channels in harbour over and above first cost of dredger but not including for maintenance of dredger, allowed for elsewhere ...	7·00
Cost of first deep water jetty at Venduruthy (for two berths) ...	25·00
Cost of railway and bridge from Venduruthy to Ernakulam foreshore opposite southern end of Venduruthy ...	10·00
Premium payable to Cochin Darbar for land to be reclaimed at Venduruthy (640 acres) ...	36·00
Grand total ...	4·80
	203·42

Say 203½ lakhs of rupees.

16. In regard to the raising and repayment of this amount the Sub-Committee is of opinion that in view of the Imperial as well as local interests concerned, the Government should put up a certain amount of "free money" say one-third or Rs. 68 lakhs, which, with the remainder, to be raised by loan in the open market would be paid off in 50 years. Thus the annual amount for interest and sinking fund would be—

	LAKHS.
1/50th of, say, 68 lakhs repayable to Government ...	1·36
Say, 8 per cent on 135½ lakhs raised in open market. ...	10·84
Total ...	12·20

Say 12½ lakhs of rupees per annum.

17. The gross revenue, taking the average over a period of ten years, is estimated as under: (after ten years, the probable inland development and that at Venduruthy make it impossible to estimate even very approximately what the revenue would be)—

I. Harbour receipts—	LAKHS.
Dues on imports and exports, 500,000 tons at Rs. 2 per ton	10.00
Dues on shipping, 1,000,000 tons at As. 3, and 120,000 tons at As. 1½, say	2.00
Transit dues, imports	.33
Rent for storage space—exports and imports	.16
Jetty and wharfage charges	.33
Harbour terminal dues (average for five years distributed over ten years)	.33
Bridge dues—	
(a) Rail	.33
(b) Road	.16
Special portorage and demurrage	.08
II. Rents, fees and penalties—	
Rents of godowns, land for coal, wharf, etc.	1.00
Overtime fees	.07
Passenger tolls, fines and penalties	.02
Rents of lands at Venduruthy, say, 250 acres, average of five years distributed over ten years	.62
III. Sales—	
Water sold to boats	.06
" to works	.02
Sales of unclaimed goods and other sales	.02
Total	15.53

18. Consideration has been given to the figure which should be deducted from this total revenue for maintenance. In a fully-equipped port the average cost for this is about 40 per cent of gross revenue, but during the first busy period of construction taken over ten years, when many of the items included in expenditure will not be completed until the latter end of that time it would be wrong, obviously, to take such a high figure over the total expenditure. At the beginning, for example, maintenance charges would be nil; they would increase to, say, 40 per cent, at the end of ten years, giving an average of 20 per cent over the whole period. Deducting 20 per cent from the gross annual revenue therefore we get

15.53 — 3.11 = 12.42 lakhs, or rather more than the necessary amount for sinking fund interest, etc., as given in paragraph 16.

19. For the reasons given in the above and having regard to the financial conditions, the sub-committee decided to recommend—

(a) That Venduruthy should be regarded as the area of future development—not Ernakulam.

(b) That the capital should be raised and the scheme proceeded with at once on the conditions mentioned.

20. As regards the technical details it is considered that these should be the subject of further consideration and decision by the officers concerned with due regard to the convenience of local interests.

21. At a meeting of the Cochin Chamber of Commerce held on 19th August 1920, it was moved, seconded and carried *nem con*:—
 "That it is the opinion of the Chamber of Commerce that the mercantile community will take advantage of the facilities offered by the construction of jetties and godowns near the Customs House, and that the construction of these should be incorporated in the harbour scheme."

T. VIJAYARAGHAVA ACHARYA (*Chairman*).
 W. T. ANDERSON.
 R. C. BRISTOW (*Secretary*).
 C. W. COLE.
 E. H. COOPER.
 A. E. GODFREY.
 S. S. KODER.
 J. E. PITCAIRN.
 A. L. SHIRGAOKAR.

20th August 1920.

(vi)

Official Memorandum No. 1112-IV/20-1, Revenue (*Special*),
 dated 15th December 1923.

The Presidency Port Officer is informed that the Government have decided that the bar at the entrance of the Cochin harbour should be dredged by the dredger "Manar." The Ceylon Government have applied for the loan of the dredger for a period of one month after her repairs are completed. The question is under consideration. The Presidency Port Officer is requested to place the dredger at the disposal of the Harbour Engineer when she returns from Ceylon.

2. The Presidency Port Officer is also requested to examine and report on the question of the constitution of a Port Conservancy Board for Cochin and of the possible revision of the landing and shipping fees collected at the port and to submit detailed proposals to Government in consultation with the Collector of Malabar.

3. The Government consider that the expenditure incurred on the harbour should be debited to the Cochin Landing and Shipping fund or Port Conservancy Board when formed.

J. M. TURING,
Tempy. Addl. Secretary to Government.

To the Presidency Port Officer.
" Collector of Malabar.
" Harbour Engineer.
" Public Works Department.
" Financial Department.

(vii)

Letter from J. M. TURING, Esq., I.C.S., Temporary Additional Secretary to the Government of Madras, Revenue (Special) Department, to the Secretary to the Government of India Department of Commerce, dated Fort St. George, the 14th December 1920, No. 583-IV/20-9.

I am directed to raise again for the consideration of the Government of India the question of the development of the Cochin port and the authority by which it should be developed and financed. I am to refer to the correspondence ending with the Government of India letter No. 5183, dated 12th August 1920, in which, replying to my letter No. 583-IV/20-5, dated 15th July 1920, the Government of India were pleased to intimate their intention of declaring the ports of Madras and Vizagapatam as major ports and stated that they had no present intention of making a similar declaration as regards the port of Cochin. It was added however that the proposed classification might require reconsideration as the circumstances of the ports changed. It is the purpose of my present letter to suggest that the prospects of the Cochin harbour, provided that the works described below are carried out, and the magnitude of those works justify the immediate inclusion of Cochin among the major ports and the financing of these works by the Government of India.

2. *Possibilities of the port.*—As the Government of India are aware, the port of Cochin lies about 680 miles south of Bombay and 160 miles north of Cape Comorin and affords the most favourable opportunity for the establishment of a safe harbour in all weathers on a stretch of coast on which there is at present no satisfactory harbourage, except in the Portuguese territory of Goa. The coast is exposed to the full force of the south-west monsoon, during which it is almost impossible to work vessels lying at roadsteads. The hinterland is fertile to a degree and has no proper outlet. Nor is the opening up of the immediate hinterland to trade the only purpose which a harbour at Cochin would serve. The possibilities of the trade development that

might follow from the institution of a really good harbour are immense. Such a harbour might carry trade from parts of the Presidency and Mysore. It might receive mails direct from Europe for the south of India. It might relieve Colombo as a port of call and it would also be most useful as a coaling, watering and repairing base and a naval harbour.

3. *Natural facilities.*—These, it is difficult to exaggerate. British Cochin is situated at the mouth of an immense backwater in which, once we have overcome the difficulty of keeping the bar open, it will be a simple matter to construct wharves at which vessels can lie, and these can be connected by means of a railway line across the backwater with the Cochin State Railway and so with the main lines of railway serving the southern part of the Presidency.

4. *Past history of the harbour question.*—The question of improving the port of Cochin has been under consideration for the last fifty years and reports have been received from many engineers, among others, Mr. Parkes of Westminster who designed the original Madras harbour works, Messrs. Coode Son and Matthews, Sir Alexander Rendel, Mr. J. R. Bell and more recently Sir John Wolfe-Barry and Partners, while Sir George Buchanan in February 1919 was good enough to offer some valuable hints on the same subject. As regards the report of Messrs. Coode Son and Matthews, which was unfavourable as regards the possibility of keeping the bar open, it is worth mentioning that they were merely advising on a case stated by the Madras Government and that neither they nor any representative sent by them had ever seen the port. Further it is believed that since 1903, the year in which this report was written, improvements in harbour engineering have rendered possible the solution of problems which then appeared to present insuperable difficulties.

5. *Engineering problems.*—The question has quite recently been examined by Mr. R. C. Bristow, Harbour Engineer to the Madras Government, who has had great experience of harbour engineering under the Admiralty, both at home and abroad. It may be as well at the outset to emphasize that the whole Cochin harbour scheme now, as in the past, depends on the possibility of dredging the bar to a depth of some 30 feet and keeping open this channel by dredging. The Harbour Engineer is confident that, given a dredger of the necessary type, and a proper sequence of dredging operations within and without the harbour this is possible. The Government of Madras are however of opinion that certainty on this point should be arrived at before the major portion of the capital expenditure briefly outlined below is incurred, and should the proposals below be accepted, suggest

that the same course should be followed by the Government of India.

6. *Present scheme of development.*—Following upon the Harbour Engineer's report and in accordance with his suggestion a strong Committee was appointed by Government, consisting of representatives of every interest concerned including the Cochin State, to examine and report on the preliminary proposals. After a most thorough investigation this Committee unanimously agreed to accept those proposals with certain modifications which were concurred in by the Harbour Engineer. Their report together with the minutes of their proceedings, and an important report by the sub-committee appointed by them, form enclosures to this letter. The report of the sub-committee contains a brief description of the scheme, a rough forecast of the capital expenditure necessary and of the receipts and charges of the first ten years, and certain recommendations regarding the methods of finance to be adopted. In very brief outline the engineering portion of the scheme may be described as follows:—

- (1) Dredging of the bar and of interior channels in the backwater;
- (2) the construction of wharves in British Cochin, Ernakulam and Venduruthy island;
- (3) reclamation through the silt dredged from the bar and backwater of considerable areas adjoining Venduruthy island which will thus become available as sites for the construction of warehouses, and a valuable source of revenue through the sale of such site;
- (4) the extension of the railway across a portion of the backwater to Venduruthy island; and
- (5) improvements to the railway on the mainland;
- (6) protection of the foreshore from erosion.

As regards the last item, the erosion by wave action of the foreshore, generally known as the Vypeen shore, which has reduced in successive years the width of the barrier between the backwater and the sea, the Madras Government have reason to believe that the problem is on its way to solution. The Harbour Engineer's first experiments in the direction have been crowned with marked success. Not only has the erosion been arrested, but considerable accretion has been secured already in the most vulnerable places.

The final scheme met with cordial acceptance by the Committee and is believed to represent the wishes of all the interests involved. The Government of Madras consider that, if it is carried out, a really fine harbour will result.

Meanwhile a considerable amount of preliminary work has been carried out by the Harbour Engineer including a trigonometrical survey of both sides of the harbour entrance, a survey of 20 miles of the coast line (in special reference to the question of erosion), observations on tides and currents and other physical conditions. Plant has been assembled, cranes and boilers erected, and a nucleus outdoor staff trained in readiness for the work to commence. It is expected that the expenditure during the current financial year on these preliminary items may amount to about Rs. 1 lakh. The Government of Madras have not thought it necessary to defer this expenditure till orders are received from the Government of India on the main point under discussion in this letter.

7. *Financial consideration.*—The estimate of capital expenditure, receipts and charges, as already stated, makes no pretence of being more than a rough outline and requires careful further examination. It involves, however, if the whole scheme is accepted and the estimate proves approximately accurate, an expenditure of 203 lakhs, and the Government of Madras consider that this figure may be taken as a basis for discussion. It will also be noted that the Committee does not anticipate that the harbour can pay its way, or pay the interest on the whole capital to be expended, during the first ten years and believes that approximately 69 lakhs will have to be found by some authority as "free" money, i.e., a gift or a loan for a long period without interest.

The Governor in Council attaches for the purposes of his recommendation below considerable importance to these figures. While the expenditure they indicate is certainly not extravagant when considered with reference to the possibilities of the Cochin port, they do none the less indicate a project of a magnitude which is more suitable for execution by the Government of India than by the local Government. In fact, the Madras Government believes that there is no precedent for a local Government undertaking port works of this magnitude.

These improvements to the port of Cochin will involve a loan raised in the open market amounting approximately to Rs. 2 crores, spread over a period of five years or possibly longer. The market in this Presidency for the floatation of Government loans is at no time a very elastic one, and the Government of Madras doubt whether their borrowing resources may not be somewhat overstrained by this addition to the loans which have in any case to be raised for more purely local needs. They are therefore of opinion that in a matter which is so clearly an Imperial concern the Government of India should have recourse to the very much wider market at their disposal.

8. In this connexion I am to draw attention to the initiation by the Government of India, through the creation of a new Department of Ways and Communications, of a more forward policy on questions of transport. It is believed to be the wish of the Government of India to co-ordinate Provincial efforts in this direction with regard to the interests of India as a whole—a policy to which I need hardly say the Government of Madras have given a most cordial welcome. They observe that, doubtless as an instalment of the policy referred to, it is the intention of the Government of India to take all the main ports of India under their direct control, and I am to urge that, in pursuance of this declaration, the Government of India should now take over the port of Cochin and treat its development as a question of Imperial concern, which in the opinion of the Government of Madras it undoubtedly is. Incidentally the Government of Madras observe that it is the intention of the Government of India to declare the port of Vizagapatam a major port and to finance its improvements from Imperial funds. With the reasons which led to this decision the Government of Madras are not acquainted, but can find in the fact that the authority controlling the port of Vizagapatam is to be a railway company, no reason for preferential treatment in this respect. They presume that the distinction between major and minor ports should be based chiefly on their actual or potential importance and consider that on this basis as good a case exists for Imperial control in the case of Cochin as in the case of Vizagapatam.

9. His Excellency in Council in fact regards the declaration alluded to above as foreshadowing a policy in pursuance of which all ports which link up India with world trade will be the concern of the Government of India and will be controlled, financed and officered by that Government. If so, it is clearly desirable that a uniform policy should be pursued in the matter of the separate acts constituting the several port trusts which will control such ports, and in respect of the financial arrangements extending over a long series of years on which these ports will depend for their development. Co-ordination in these matters can, it is suggested, only attain if ports of this class are controlled by the Government of India.

10. It is perhaps unnecessary to emphasize that successful harbour development improves Imperial rather than Provincial revenues. The expansion of the trade of Cochin should bring a large addition to the customs revenue of the Imperial Government, but will not directly affect the revenue receipts of the Madras Government.

11. The above allusion to customs revenue naturally leads up to the following point peculiar to Cochin. The area included in the port of Cochin, whatever port limits may ultimately be fixed, must be divided in unequal shares between British and Native Cochin, much the larger part of the backwater and the territory immediately adjoining, including the rail head and the island of Venduruthy already alluded to, falling within Cochin State limits. This fact naturally introduces political and customs difficulties with which the Government of India are in a much better position to deal than are the local Government. It is understood moreover that the State of Cochin is shortly to be placed in direct relations with the Government of India.

As regards customs revenue a temporary arrangement has been entered into with the Cochin State by which the customs revenue of the port is equally divided between the State of Cochin and the Government of India. It is clear that whatever arrangement is finally concluded with the Cochin State on this point will require the Government of India's ratification.

12. On all the grounds urged above it appears to His Excellency in Council that the port should at once be declared a major port and its development and finance controlled by the Imperial Government. I am to urge this view on the Government of India for favourable consideration.

(viii)

Letter from the Presidency Port Officer, to the Secretary to Government, Finance (Marine) Department, dated the 28th January 1921, No. 2008/50-G.

With reference to Government Memorandum No. 1112-IV 20-1, dated the 15th December last, regarding the constitution of a Port Conservancy Board for Cochin and the possible revision of the landing and shipping dues at the port, I have the honour to report that on my recent tour at Calicut I consulted with the Collector of Malabar as requested.

2. It is understood that Government are considering the question of a Port Trust Board for Cochin and the Collector of Malabar and I agree that it will be necessary to form a Board of Trustees at an early date with power to raise loans, etc., for the development of the port. The question therefore of a Port Conservancy Board will not arise if Government are prepared to legislate for a Port Trust Board.

3. With reference to the raising of landing and shipping dues, we are of opinion that they can of course be raised, but that the

question as to the amount to which they should be raised, is a question which should be decided by the Landing and Shipping Committee or the Port Trust Board, as any arbitrary raising of the dues without consulting the merchants concerned, appears undesirable.

4. Finally we are of opinion that the Landing and Shipping Committee or Port Trust might consider the question of separating the port of Cochin from the western group of ports for the purpose of collecting its port dues in a similar manner to the action taken in the case of the port of Madras.

(ix)

Letter from J. G. BEAZLEY, Esq., I.C.S., Deputy Secretary to the Government of India, Department of Commerce, to the Secretary to the Government of Madras, Revenue (Special) (Marine) Department, dated Delhi, the 3rd March 1921, No. 1910.

I am directed to refer to your letter No. 583 IV-20-9, dated the 14th December 1920, in which, for the reasons stated, it is proposed that the port of Cochin should be declared at once as a major port and its development and finance controlled by the Government of India.

2. In reply I am to state that the Government of India have read the letter with great interest, but they regret that they cannot at present declare Cochin to be a major port. In paragraph 5 of your letter, it is admitted that the whole scheme of the development of the port hinges on the possibility of opening and keeping open by dredging a 30 feet channel through the bar. Opinions have differed on this question in the past, and the Government of Madras themselves say that certainty on the point must be arrived at before the major portion of the capital expenditure involved in the project is incurred. Certainty can be attained only by experiment, that is, by actual dredging. If the experiment is unsuccessful, it seems clear that Cochin can never be developed to a stage at which it would legitimately be declared a major port. If the experiment is successful, the whole question may require reconsideration, but until the experiment has been made the Government of India think it premature to declare the port a major port.

3. An additional reason for not declaring Cochin a major port is the fact that the only result of such action would be that nothing could be done for the development of the port for some time to come. It is understood from the enclosures to your letter that the cost of the experimental work necessary to determine

whether the bar could be kept open by dredging would amount to some seventy lakhs of rupees. There is no prospect of the Government of India being in a position to finance experimental work at Cochin to this extent in the near future. The Government of Madras refer in your letter to the difficulty of raising a loan of two crores of rupees. I am to say that there is no likelihood that the Government of India will be able to raise loan money on favourable terms for some time to come, and, in any case, their first obligations must be towards liabilities in regard to which they are already pledged, such as the improvement of railways and the discharge of temporary debt and short-term loans.

Order—No. 106, Finance (Marine), dated 26th March 1921.
Recorded.

(By order of the Governor in Council)

R. A. GRAHAM,
Secretary to Government.

II

From R. C. BRISTOW, Esq., M.INST.C.E., Harbour Engineer to Government, Madras, to the Secretary to Government, Finance (Marine) Department, Madras, dated 26th December 1921/11th January 1922, No. 74/22.

I have the honour to forward the following report on the Cochin Harbour Works.

1. It is proposed in this report to narrate the progress made at Cochin during the past 20 months under the following heads:—

- (a) A general reference to the works proposed in the Wolfe-Barry report.
- (b) The causes which led to the appointment of the *ad hoc* Committee at Cochin; the recommendations of that body and the decision of Government in reference thereto.
- (c) The experiments, investigations and works under-taken since April 1920 in regard to coast erosion, dredging and reclamation.
- (d) Conclusion.

2. (a) A general reference to the works proposed in the Wolfe-Barry report.—After 18 months' study of the general conditions

prevailing at the port, it may be said at the outset that the Wolfe-Barry report has proved to be an admirable summary of the whole subject from an engineering point of view, and that although other evidence is available now which modifies here and there the conclusions arrived at, the general principle of development recommended still holds good.

3. Messrs. Wolfe-Barry in their report on Cochin, dated 18th January 1918, deal with the following points (paragraph 16 of their report):—

(a) The preservation of the foreshores of the coastal strips or sand spits lying north and south of the entrance to the port, including—

(b) Their reinforcement by reclamations in the back-waters.

(c) The deepening and maintenance of the bar and approach channel to the port by dredging or otherwise, with special reference to the question of the suitability of the “Kalu” for this purpose.

(d) The provision of deep water areas within the back-waters, where 10 or 12 vessels can be moored to special mooring buoys.

(e) The provision of quays at Cochin, as well as on the mainland, where railway connexions can be formed.

(f) The maintenance of the tidal capacity of the back-waters.

(g) The provision of coal and oil depots.

(h) Commercial and financial questions affecting the scheme.

4. The report is illustrated by a plan, a copy of which is attached (plan No. 1) and this shows the recommendations made, which are as follows (paragraph 121 of their report):—

“Two miles of groynes and one mile of embankment at Vypeen.

“Two miles of groynes and two miles of embankment at Andikadavu.

“Dredging a channel across the bar 600 feet wide to a level of 30 feet below low water ordinary spring tides.

“Dredging an area in the backwater and providing moorings for ten or twelve ships.

“Channel and mooring buoys, tug, etc.”

5. The cost of these works was estimated by the Consulting Engineers at about Rs. 55 lakhs including for the dredger. In addition it was proposed that further dredging should be done and deep water wharves constructed as funds became available. On the arrival of the Harbour Engineer to Government in April

1920, the report was passed to him for guidance and detailed investigation.

6. (b) *The causes which led to the appointment of the ad hoc Committee for Cochin; the recommendations of that body and the decision of Government in reference thereto.*—As a result of the above recommendations by Messrs. Wolfe-Barry, the first action taken was to erect a certain number of experimental wooden groynes on the Vypeen foreshore before the monsoon burst in June 1920. These groynes will be referred to later.

7. At the same time an endeavour was made to hire from the Admiralty a powerful dredger which could start work on the bar. The Admiralty replied however that a dredger was not then available.

8. During April and May the opinions of a large number of local merchants and others were obtained with regard to the proposed development. The systems prevailing at Madras and Colombo were also investigated in particular reference to the methods of handling goods and to the nature and extent of charges levied on tonnage.

9. It was found that much difference of opinion existed on certain points. For example,—

(a) One section of the parties interested wanted wharves at Cochin, another wanted them at Ernakulam and a third did not want them at all.

(b) Land was about to be acquired at a place in Cochin which many thought absolutely unsuitable for harbour development.

(c) Other land proposed to be acquired at Ernakulam included the most expensive building sites in the town, and there was a strong movement to alter its position, which again was resisted by others.

(d) It was stated by some that the trade had reached a maximum, whilst others ridiculed the suggestion.

(e) Some merchants complained that there was not sufficient godown space and others deprecated any action being taken by Government in what they considered to be a private business matter.

10. It was realized that nothing useful could be done until these conflicting interests had been reconciled and it was therefore recommended to Government by the Harbour Engineer that exponents of opposite views should be brought together on one Committee together with representatives of Government in order that all sides of the question could be discussed. Government

therefore appointed a strong Committee of sixteen persons to report on the whole matter.

11. Meetings were held in June, July and August of 1920 and eventually, after an exhaustive study of the case, complete agreement was arrived at on all points. The report of the Committee may be referred to for details.

12. Briefly, it may be said here that the Committee recommended certain additions to the Wolfe-Barry proposals. For example, the possibilities of a reclamation scheme were brought out as a result of disputes on other points and the anticipated financial success of this reclamation and the practicability of connecting it by railway to Cochin and to the main line at Ernakulam was probably the basis upon which all parties were at length united.

13. The plan attached herewith (plan 2) shows the proposals made by the *ad hoc* Committee, and it will be noted by a comparison with plan 1 that except for the reclamation there is little difference in principle between it and the scheme prepared by Messrs. Wolfe-Barry.

14. The works recommended included the protection of the foreshores, the purchase of a dredger, the dredging at the bar, the deepening of the backwater channels, the construction of a railway viaduct, the provision of 2,000 feet of deep water jetties, the construction of godowns, power houses, etc., and the provision of power cranes.

15. The estimate for these works amounted to Rs. 203½ lakhs and a statement of revenue was forwarded showing that if Government were to put up one-third of the money, the scheme would pay for itself allowing a 33⅓ per cent increase of trade.

16. The report was despatched to Government in August 1920 and subjected to examination by the Public Works, Marine and Finance Departments. As a result of that investigation, Government at length decided—

(a) To dredge an experimental channel across the outer bar, and an inner channel north of Venduruthy.

(b) To proceed with the foreshore protection work at Vypeen and if necessary at Cochin or Andikadavu.

(c) To make a small portion of the reclamation as necessary to dispose of the dredged spoil.

The estimated cost of this work (which is shown on Plan No. 3) is Rs. 6 lakhs.

17. It was decided also that the complete scheme of the *ad hoc* Committee should be carried out subject to the success of

the experimental portions. Government orders were issued in G.O. Mis. No. 202, dated 1st June 1921.

18. (c) *The experiments, investigations and works undertaken since April 1920 in regard to coast erosion, dredging and reclamation.*—As stated in paragraph 6 above, the first work undertaken was the erection of groynes at Vypeen, this having been considered by the Consulting Engineers an essential preliminary to any scheme of improvement. These groynes were constructed to the extent and in the position shown in Drawing No. 4 attached, 2 and 3 planks deep, the bottom plank being entirely below ground level.

19. Prior to the monsoon which started on June 3rd, 1920, some of these groynes were accumulating sand and mud below low water a few inches at each groyne. Immediately the monsoon burst, however, the unsuitability of this form of protection became apparent. A heavy sea with crests about parallel with the shore line broke with great force on the shelving sand beach, dragged the sand down, undermined the upper reaches of the beach and ate its way inland with great rapidity.

20. The wooden and earth bunds which had been erected in certain places to prevent the sea outflanking the groynes appeared only to accelerate its progress, and as regards the beach the first place to erode was immediately alongside the groyne itself. In two weeks the beach level was lowered by at least 3 feet and the hasty addition of planking to the groynes only made matters worse. Making every allowance for the fact that only 12 or 13 groynes had been constructed, it was obvious that a solution would have to be looked for on other lines.

21. The first suggestion, and one which had often been recommended, was to substitute ferro-concrete groynes formed of long slabs of ferro-concrete placed lengthwise between ferro-concrete or steel H piles, the latter to be driven down firmly into the sand.

22. It was argued that the slabs would automatically lower themselves in the channels of the H piles during periods of erosion, and that fresh slabs could be added afterwards during periods of accretion. Such groynes are reported to have been successful elsewhere and it is still considered that some adaptation of the principle may be found useful in particular cases.

23. The reasons for not trying this experiment at the time were:—

(a) It could not stop the erosion during the monsoon; the groyne slabs might continue to sink and the beach to wash away

(as in the previous experiment) until the piles were so little in the ground that the whole structure would collapse.

(b) Ferro-concrete work is not yet very well understood in south-west India, and there are few men skilled at it.

(c) It would have been months before men could have been trained and the material obtained to enable the work to proceed.

(d) Meanwhile the coast was eroding rapidly and something had to be done at once.

24. As a result of daily observation on the part of the writer and one of his assistants, Mr. F. G. Dickinson, R.E., A.M.I.C.E., and aided by a number of minor experiments on the beach, it was considered that a series of stone mounds running nearly parallel to the shore in echelon fashion might prove effective, and a number of these groynes were therefore constructed as shown in drawing No. 5.

25. The engineering reasons for this decision were :—

(a) The solid obstruction parallel with the surf line would break the force of the waves and prevent dragging down of the beach.

(b) The groynes being non-continuous and of rubble stone-work would not induce a travel of wave along the face for any considerable distance.

(c) There would therefore be less likelihood of erosion on the outer toe than in the case of an ordinary sea wall.

(d) The openings between the groynes would give the water an opportunity to flow behind and deposit any sand held in suspension.

(e) Any settlement could easily be made good by adding more stones on top.

(f) Rapidity of construction.

(g) In the event of a solid wall of the sloping embankment type being necessary ultimately, the groynes would serve a useful purpose as a rubble toe to the embankment.

26. Other practical advantages of this system were :—

(a) There was abundant material and unskilled labour available.

(b) No skilled labour was necessary.

(c) Both material and labour were cheap.

27. It was realized at the time however that the placing of these stone mounds on a sand formation at low water level was attended with a certain amount of risk; for example, it was thought very probable that heavy seas would tend to demolish the mounds and that a certain amount of erosion at the outer side might lead to settlement. Nevertheless, the results of the

work during the first few months were so encouraging that it was decided to carry on until the monsoon of 1921 stopped the work.

28. Everything which was expected of these groynes has happened. Firstly they have stopped erosion, temporarily at least; secondly, they have been the cause of very considerable accretion behind them (see photograph), and thirdly, they have given rise to a certain amount of maintenance consequent upon damage by rough seas and settlement.

The enclosed tabular statement No. 6 gives approximately the amount and cost of stone used both for first cost and maintenance.

29. It is not contended that these groynes have completely solved the problem of coast erosion, and it was never expected that they would do so. The system was the best that could be thought of in the limited time available, and was the result of empiric rather than scientific observation. The result, however, has relieved all concerned of a pressing anxiety and has given time and opportunity for wider consideration of a most important question which applies more or less to the whole coast line of the Madras Presidency and which is now being investigated in detail as opportunity permits.* Meanwhile the parallel groynes are being continued northwards as far as the clay bank shown on drawing No. 7 beyond which it is not considered necessary to go, for the present at least.

30. Some particulars may be given as to the further investigation. It was realized in June 1920 that the erosion at Vypeen was only a part of a very much wider problem; that in all probability the whole coast line was undergoing change, and that it was necessary to get a broader view of the subject than was possible at Cochin. In other words, it was necessary to proceed from the general to the particular instead of *vice versa*.

31. As a commencement it was decided to obtain definite particulars as to—

(a) The state of the foreshore for 10 miles north and 10 miles south of Cochin.

(b) The monthly variation of the foreshore over a length which appeared to maintain itself fairly well, viz., the Cochin foreshore, about a mile long.

(c) The actual direction and force of the various littoral currents, combined with such other disturbing factors as the outpourings of rivers, the angles of the coast line with prevailing surf, contours of sea-bed, etc. (These particulars are required

* This involves a study of the geological formations which is being made separately.

in order to establish, if possible, why certain parts of a coast line are eroded and other parts added to, and whether there is any regular cycle of erosions and accretions.)

(d) Definite particulars as regards weather, etc. (vide two charts in opening cover of this report).

32. The first of these investigations was quickly done and repeated this year. The plan No. 7 shows roughly the conditions during July 1920 and November 1921. It will be seen that areas of erosion are roughly balanced by areas of accretion over the whole length of 20 miles.

33. As regards (b) in paragraph 31, plan No. 7-A shows the difference in the levels of the various cross-sections between July 1920 and November 1921. These sections indicate again that there is erosion in some parts of the beach and accretion in others, and that, on the whole, the difference is not yet enough to remark upon having regard to the rapidity with which local changes occur.

34. The scope covered by (c) in paragraph 31 is so wide that at least 12 months' further experience and observation will be necessary before the forces can be generally indicated, and even then it must be remembered that certain combinations of forces may not occur more than once in several years, and that anyone of these combinations may have a crucial effect on the whole question.

35. As a first step the detailed movement of forces over the Cochin foreshore is being ascertained. The foreshore has been divided into 67 sections, each 100 feet long, and the essential differences in each section are noted daily having particular regard to the direction of current, amount and direction of wind, height and time of tide, amount of erosion and accretion, etc.

36. The effect of the in-going and out-going tide from Cochin harbour is also being investigated in particular relation to its influence along the shore line north and south of Cochin. It is possible that the natural laws of erosion (or, rather, general beach movement due to prevailing winds and drift) are interfered with by the interruption in the continuity of the coast line at Cochin and by the discharge from the Cochin backwaters. It is also possible that the protrusion of the bar itself under water acts in the same way as the Madras Harbour works above water, tending to cause erosion to the leeward of the obstacle encountered by the prevailing sea drift.

37. The attached communiqué* issued by the Cochin Government on the general subject of coast erosion may be quoted here

* Printed as annexure.

as indicating the conclusions arrived at by May 1921. There is nothing particularly remarkable about these conclusions, but they do summarize the broad aspects of the question, and it is worth noting that they agree closely with many of the conclusions arrived at by the British Coast Erosion Commission and set out in their third and final report, dated 31st May 1911.

38. *Dredging*.—As already mentioned in paragraph 16 (a) above, the first dredging to be done consists of an experimental channel across the outer bar and of certain work in the harbour itself. After a careful study of the conditions at Cochin and of the engineering history of a large number of other ports, it became clear that the first thing to be done at Cochin was to improve the connexion between the gut or mouth of harbour and the vast areas of backwater lying to the south.

39. At present the tides flow to and from this area by means of various narrow, shallow and tortuous courses and the attached plan No. 8 has been prepared to show the conditions. The centres of existing channels over 6 feet in depth are shown in blue; the new channel coloured red represents the improved communication between the gut and the backwater.

40. There is nothing new in this proposal. Paragraph 102 of the Wolfe-Barry report may be quoted in this respect:—

“This backwater, according to the tidal observations we have received, is only very partially filled by the tidal wave at present, and if this channel, with its approach from the gut, were deepened, more tidal water would pass into the backwater and reciprocally the channel and deep would tend to maintain themselves, whilst the scour in the outer channel and across the bar would be correspondingly improved.”

The point, however, which has probably been overlooked to some extent hitherto, is that this improvement, if carried out before the outer bar is dredged, is likely to have a vital effect on the successful and economical maintenance of the channel during the early and relatively hazardous stages.

41. As regards the dredging on the outer bar, it is doubtful whether sufficient experiments and observations have been made hitherto as to the position of the centre line of channel and the exact point where the opening should be made through the bar. The latter is a horse-shoe shaped ridge of sand and the portion through which the opening might conceivably be made is 1,200 yards long. As the permanent opening is to be 200 yards wide and the first cut of the experimental channel only about 300 feet wide, it is quite obvious that the centre line of the cutting should be selected with the greatest care.

42. The principal requirements are—(a) the channel must be oriented so that the deep water flowing from the harbour follows its natural course if it has one; (b) the new channel where it debouches into deep water should have a lead in such a direction that the flood tide is intercepted and runs naturally up the channel; (c) the ebb tide should join the ocean currents with as little opposition of force and direction as possible; and (d) the direction should be such that navigation generally and especially dredgers engaged on maintenance work are not exposed to cross seas during the monsoon more than is unavoidable having due regard to other conditions.

43. Several series of experiments have been made to ascertain the best direction for the channel having regard to the above requirements. In deciding what form of experiments should be made, it was obvious that a common necessity would be the setting out of a proper triangulation of survey points on shore from which to take observations.

44. In May 1920, a base line on the Cochin side of the gut was laid down and permanently established with concrete blocks sunk in the ground 100 feet apart. From this base line a triangulation was carried to the Vypeen foreshore and the width of the gut accurately defined.

45. From the same base line, a traverse survey was then made round Cochin so that marks could be erected on the Cochin foreshore linked up to the principal triangulation. Plan No. 9 shows the present extent of the trigonometrical survey made. The points used in connexion with the float readings (to be described later) are marked with an asterisk.

46. The next point to consider was the nature of the floats to be used for making the experiments. It was desired to obtain the direction and velocity of water at various depths and it was necessary therefore that the submerged part of the float should offer a resistance only at that point where particulars of the current were required.

47. After certain trials the floats were made of canvas and bamboo framing about three feet cube, weighted with lead and attached by fine wire to a small conical float carrying a flag. It was found that the resistance at surface level was practically negligible in this last float, which is shown in detail on drawing No. 10.

48. It was then necessary to ascertain the point from which these floats should be started and it was thought that the best place would be the point of confluence of the streams conveying the tidal water to and from the north and south backwaters

respectively. This point is shown on the attached plan No. 11, which indicates also the centre lines of the various channels.

49. A study of a long series of actual tide readings showed that the ebb tide was strongest at the second and fourth hours, and it was decided that float experiments should therefore be made at those periods. Drawing No. 12 shows a number of typical tide charts from which it will be seen that the rate of ebb is strongest in the second and fourth hours.

50. The current readings were therefore made as follows:—

(i) On the second and fourth hours of ebb with floats submerged to 15 feet below the surface.

(ii) On the second and fourth hours of ebb with floats submerged to 25 feet below the surface.

51. The results were as follows:—

The 25 feet floats naturally followed the line of the deepest water both on the second and fourth hour of ebb. This deep water runs about west by south and west by north from the mouth of the harbour. The floats submerged to 15 feet on the second hour of ebb travelled in no particular direction, but were distributed over the whole of the fan-shaped area within the bar. The 15 feet floats on the fourth hour of the ebb, however, all travelled within a narrow zone about west by south from the harbour mouth.

52. On plotting the results of these experiments on a contoured map, it was obvious that there were two main streams making out of Cochin harbour, the first and by far the most important being that from the southern backwaters flowing west by south and west by north from the harbour mouth, and the other that from the northern backwaters flowing west by south. The effects of these two streams are clearly shown by the contour lines which indicate the “big push” and “little push” respectively made by them. [See drawing No. 13 herewith.]

53. The above float readings were taken in the months of March and April 1921. They were repeated, with exactly similar results in October 1921.

54. Having established provisionally that the channel should lead about west by south and west by north after leaving the harbour, it had to be decided what course the channel should continue over the bar and out to deep water. The first requirement was to ascertain the directions of the tidal wave and ocean currents. According to the time of high water at ports from Bombay southwards, the tidal wave travels from north to south and the inference was therefore that the mouth of the channel should lead to the northward (vide paragraph 42).

55. As, however, the tidal wave is an impulse rather than a current and it is possible for a stream to flow against it and yet be lifted by it,* floats were put in submerged to 20 feet and 25 feet in the deep water beyond the bar, to ascertain the direction of the moving current. The courses of these floats are shown on drawing No. 14, and indicate that there is no well-defined current in any direction, certainly not sufficient to justify a preference for any particular route. This being so, it is proposed to dredge a wide bell-mouthed opening to the entrance channel, so that currents to and from the harbour may be induced along whichever bend of the opening is most suitable at the time.

56. The beginning and the end of the approach channel had therefore been defined, and it remained to settle as to the remainder. In regard to this, certain conflicting requirements had to be adjusted, viz., from the point of view of navigation only, a straight channel between buoys or fixed dolphins is very desirable, whereas the best form of a channel for keeping itself clear of silt is generally stated to be one that flows in a series of reverse curves with lengths of straight channel connecting up the curves.

57. After careful consideration, and subject to such further evidence as may become available during the dredging of the experimental channel across the bar, which is expected to yield valuable information (vide special note on drawing), it is proposed to dredge the final channel as shown in drawing No. 15 coloured red. This shows practically a straight-sided channel, but retains the element of curvature which, according to general observation and specific experiment in France and elsewhere, so greatly assists the natural scour of a tidal channel. This drawing also shows the order in which the various dredging "cuts" are to be made, from which it will be seen how it is proposed to deepen and widen the channel in such a way as to provide against falling in of the sides and to give safe navigation for vessels as rapidly as possible. A slope of 3 to 1 has been allowed for on the sides. This will be subject to modification as a result of experience gained in dredging cut No. 1.

58. The alternative channel coloured yellow on the same drawing is the line recommended by Messrs. Wolfe-Barry, and it will be seen that there is little difference in the general direction of the channels. The divergence is based on evidence as to the existing principal water course which was not available when the Consulting Engineers made their report.

59. The drawing also shows, in green colour, the two experimental channels which are being made, and it may be advisable to draw attention to the concluding paragraph of the writer's report of 18th April last in which it is pointed out that it is not anticipated that these channels will keep themselves clear from silting. The point it is desired to establish beyond doubt is the rate at which silting will occur, so that it may be shown whether or not a modern suction dredger can deal with the silting at a reasonable cost.

60. It may also be noted here that in practically every port throughout the world maintenance dredging is necessary and that it is entirely unreasonable to suppose that Cochin will be an exception to the general rule. For this reason it is very desirable to obtain at once a dredger of greater capacity than the 'Manar' which, although doing excellent work, is hardly big enough to maintain the channels both inside and outside the harbour.

61. *Dredging work started in April this year.*—Dredging has been commenced on the inner bar (within the harbour). Progress at first was slow owing to difficulties with the crew and to their lack of experience in working in a tideway. Further delays arose owing to the fact that the hopper barges which were expected from Tuticorin from one cause or another failed to arrive and the vessel has had to work as a hopper dredger the whole time.

62. Nevertheless the initial difficulties have been more or less overcome and the dredger 'Manar' has shown herself to be capable of making good progress when handled properly. She has already dredged an 18 feet channel, 150 feet wide and 2,600 feet long inside the harbour, and is now being got ready to cut through the bar itself.

63. Information having been received that a modern dredger was available at the Admiralty, immediate steps were taken to secure it, if possible, in order that the work on the outer bar might be pushed forward more rapidly. At the time of writing it is not known definitely if the dredger has been allocated to the Madras Presidency, but it is known that it has been reported on by the Admiralty officers as suitable for the work at Cochin.

64. *Reclamation.*—The northern portion of the reclamation shown on drawing No. 16 has been commenced and is progressing rapidly. It had been anticipated that there would be considerable scour along the line of the retaining banks, and in order to provide for this the wall is being constructed of granite rubble on fascines (see photograph).

* See particulars of rise and fall and continuous ebb, July 27th to August 15th, 1921, on weather chart in cover.

65. This form of construction has, so far, been found suitable. There has been very little, if any, settlement to date, although this is no doubt due in part to the hard ground this particular part of the wall happens to cross.

66. It is hoped that the completion of the eastern wall of the reclamation as far as Venduruthy will be useful also as a training wall, and guide the ebb and flow from the backwaters in the required direction. Plan No. 16 shows particulars of the wall.

67. *Conclusion.*—The present state of affairs at Cochin may therefore be summed up as follows:—

The protection of the Vypeen foreshore recommended by Messrs. Sir John Wolfe-Barry and partners as the first thing to be effected has been achieved; and whether or not this particular form of defence will be improved upon later there is no longer any apprehension as to the vulnerability of this part of the coast. Further, should any other portion of the coast the penetration of which might affect the harbour regimen, be attacked seriously by erosion, it has been sufficiently well demonstrated that the shore can be protected in a similar manner.

68. The investigations in regard to currents within and without the harbour show that there is little doubt, if any, as to how the preliminary channels should be dredged; and this, with the solving of certain previously unknown quantities, tends to confirm the opinion of those including the writer, who are now confident that the bar can be opened and maintained at a reasonable cost.

69. The previous dissensions among Europeans, and between Indians and Europeans, as to what lines development should proceed on at Cochin and Ernakulam no longer exist. There is cordial agreement among all parties on the basis of the *ad hoc* Committee's report. A further sign of practical unity is the co-operation of the Cochin and Travancore States who are each putting up a third of the money required for the preliminary investigations on certain conditions.

70. Other matters which are related to the harbour development such as town planning at Cochin, the disposal of refuse, the improvement of the water-supply, and of road and railway facilities have all been discussed in their preliminary aspects. It is submitted, in conclusion, that although the results of the preliminary dredging are not yet available, so much light has been thrown on the subject during the last year, that there is good reason for an attitude of confidence, and it is considered

that these other questions may be proceeded with, at least provisionally, in the meantime.

NOTE.—It has been suggested that a reference should be made in this report to the previous dredging experiment at Cochin. This dredging was done in 1913, and consisted of a small cut through the crest of the bar, the total dredging being less than 50,000 tons, or *barely one-sixth* of the *minimum necessary to give any likelihood of complete success*. The work was not done under engineering supervision, and the position and direction of the cut was not the outcome of exact observation and experiment. A channel was not made inside the harbour to improve the scour across the bar. The spoil was dropped just outside the bar in such a position as to give the flood tide a good opportunity of carrying it back again. No attempt was made to maintain the opening when cut. In spite of all these disabilities, the channel remained open for nearly a year, and if any inference may be drawn from this experiment at all, it is encouraging rather than otherwise.

ROBERT C. BRISTOW,
Harbour Engineer to Government.

ANNEXURE. PRESS COMMUNIQUE.

COAST EROSION.

His Highness' Government have had under anxious consideration for some time past the question of the measures to be taken for the protection of the sea coast of the State against erosions that have been taking place on a large scale for several years in the neighbourhood of Andikadavu, Vypeen, Kuzhupilli and Cranganur. This question being intimately connected with that of the improvement of the Cochin Harbour, it was resolved to consider both the questions as parts of one complete scheme. Correspondence relating to this important subject began with the Government of Madras so early as 1907, but nothing really effective has till now been done towards prevention of erosions.

The Government of Madras recently appointed an expert as their Harbour Engineer in the person of Mr. R. C. Bristow, who assumed charge of his office nine months ago. Mr. Bristow has since then studied the question of erosions on the west and east coasts of the Madras Presidency, and has also made a careful survey of the west coast line for over 20 miles to the north and south of the Cochin Harbour. He has also conducted some experiments on one section of the eroded coast line in the neighbourhood of Vypeen, the result of which appears to be promising.

2. Opportunity was therefore taken to explain the situation to the representatives of the landholders whose lands have been washed away in

the three localities of Andikadavu, Vypeen and Kuzhupilli at a conference held at the Trichur Residency on the 21st May 1921, at which the Harbour Engineer, Mr. Bristow, and the Diwan Peishkar of the State were present.

3. At the conference, the representative of the landholders of each of the above three localities stated his case and indicated on plans the extent of the erosions and also suggested certain remedial measures. After all the representatives had spoken, the Harbour Engineer began by assuring the conference that the Governments concerned were fully alive to the seriousness of the situation and had devoted more time and trouble to ascertain the causes of erosion than the landholders were perhaps aware of. Afterwards he proceeded to explain that wherever fine sand—specially that rapidly dried by a hot sun—was acted upon by waves of sufficient height, the tendency was towards disruption of foreshore. But that as the sand thus removed was indestructible, it had to be re-deposited when the water was less turbulent, either in the same place or somewhere else, generally the latter. According to his observations, this process was going on both along the east and west coasts of India, but on the east coast there was a constant “feed” of sand brought down by the great rivers which discharge on that side. He also informed the conference that a survey of 20 miles on the west coast, made under his supervision last year, showed that there were places where erosion had recently occurred, places where the beach was maintaining itself and places where recent accretion was evident and that the loss due to erosion was roughly balanced by the gain by accretion. He, however, pointed out that the cycle of recurring erosions and accretions could not yet be defined, and that one could not state with certainty the exact reason why erosion should occur in one place on a long straight coast and not in another. But, in his view, the predisposing cause was probably the nature of the sea bottom close to the shore. He also laid stress on the point that, in dealing with this problem, it should be remembered that any permanent preventive work at one point invariably led to the disturbance of foreshore equilibrium in the vicinity, and that finality would only be reached when the whole coast was reinforced by protective ribs of one sort or another. In his opinion such a solution was impracticable at present not only on account of the initial capital outlay required, but because also of the sheer impossibility of maintaining such a length of work except at an absolutely prohibitive cost for staff and materials.

4. Mr. Bristow concluded his remarks by informing the conference that the Governments concerned were, in the above circumstances, driven to the expedient of maintaining by special works the most vulnerable places from a harbour point of view, pending the discovery of some simple anti-erosion method, which could be carried out by the foreshore owners themselves at comparatively small cost and with materials and labour available locally. He also explained at this stage the sequence of operations at Vypeen and stated that he did not pretend to have reached a solution there, that they were determined to save the Vypeen peninsula, that there had been accretion there since the last monsoon owing to the parallel groyne, and that even if these were washed away and all the accretion lost, there would still be other resources to fall back on. In

regard to the latter point, he described the practice of the British Admiralty in vitally important cases in England, but at the same time he drew attention to the fact that that practice was very expensive and could only be adopted as a last resort.

5. Finally, Mr. Bristow appealed to the owners to help in the solution by their own efforts and gave them a hint as to one line of investigation which could be undertaken by them with little expense. This related to the use of floating timbers for changing the character and lessening the force of a wave, and was used at Penzance on the English coast many years ago with success, but in rather different circumstances. He explained that this was the ideal solution if it could be adapted, as all the materials necessary were cocoanut trees and coir rope which nature had provided in every place where erosion was occurring. He also expressed his readiness to attend and give any help he could in the making of this experiment. The representative of the Andikadavu landholders agreed to start an experiment at once on the lines suggested.

6. The conference then terminated with an expression of satisfaction and confidence in the attitude taken by the authorities.

OFFICE OF THE DIWAN OF COCHIN,
LOCAL AND LEGISLATIVE DEPT.,
26th May 1921.
13th Edavam 1096.

T. VIJAYARAGHAVA CHARYA,
Diwan of Cochin.

III

From R. C. BRISTOW, Esq., M.INST.C.E., Harbour Engineer to the Government of Madras, Marine Department, to the Secretary to Government, Finance (Marine) Department, dated the 26th September 1923, No. 1923/23-1.

[Cochin Harbour Works—Report on result of experiment.]

In continuation of report No. 74/22, dated 26th December 1921/11th January 1922, I have now the honour to report on the result of the experimental work at Cochin as follows:—

- Part I. Investigation into the movement of foreshore material north and south of Cochin.
- ” II. Dredging of inner channel.
- ” III. Dredging of outer channel.
- ” IV. Reclamation.
- ” V. Groynes at Vypeen.
- ” VI. Proposals for dredging permanent channels.
- ” VII. Finance.
- ” VIII. General summary and recommendations.

PART I.

2. *Investigation into the movement of foreshores.*—In paragraphs 29 to 36 of my previous report above referred to, particulars were given with regard to various lines of investigation which it was necessary to pursue in order to appreciate fully the various natural forces at work. It was shown how that, to understand the situation at Cochin, it was necessary first of all to get a broader view of the conditions generally in the Presidency and particularly on the West Coast.

3. The preparation of the geological map referred to in the note to paragraph 29 of the former report was therefore proceeded with as rapidly as possible. It was not feasible of course to make an independent geological survey, but on consulting the records and obtaining existing geological maps it was found practicable to prepare a suitable plan showing the principal formations in the Presidency. The plan is an approximation in parts but is sufficiently accurate for the purpose intended.

4. Copies of this plan are attached (Nos. 1 and 2). It is of first rate importance in the consideration of any question affecting the maintenance of harbours in South India. The following points should be noted specially:—

(a) the comparatively small area of South India draining out on the western side and the resultant narrow strip of recent deposit;

(b) compare this with the conditions on the eastern side;

(c) the absence of any river worth noting between Cochin and Cape Comorin; and

(d) the obvious fact that the only recent deposit at Cochin is that brought down by the various small streams that discharge first of all into the backwater.

5. The completion of this map confirmed the conclusion, which was being gradually arrived at by observations on the foreshore, that the conditions on the West Coast, except for small local movements, were comparatively stable as compared with those on the East Coast. As will be shown later, whilst the northward travel of sand on the East Coast amounts to about one million tons per annum, that on the West Coast is certainly not greater than 12,000 tons per annum and is probably considerably less.

6. During the time the geological map was under preparation, various practical experiments were being carried out on the foreshore itself and these may be referred to briefly.

7. Submerged floats were put in the water off Vypeen and Cochin at various distances from the shore. The rate of flow on the Vypeen side was found to have a maximum of about three-

fourths of a mile per hour at Vypeen point and a minimum of one-fourth of a mile per hour in front of the parallel groynes two miles to the northward. Beyond this point there is very little movement of current. During the flood-tide there is a velocity along the shore of about three-eighths to half a mile per hour. On the Cochin side the average velocity during ebb tide is about one-fourth to half a mile per hour. During the flood it is about one-fourth to three-eighths mile per hour.

8. The minimum rate of flow necessary to secure bodily movement of sand has been found by experiment to be roughly two miles per hour. It will thus be seen that in the usual flow of water along the coast line there is no chance whatever of erosion.

9. The currents mentioned in the above paragraphs are those due to the ebb and flow of the tide at Cochin. It was found that the coastal flow was practically coincident with the rise and fall of the tide in the harbour, i.e., on the ebb tide it flows along each coast away from the harbour and during the flood tide it is drawn towards the mouth of the harbour again, the change from one direction to the other being preceded by a short period of about half an hour of slack water.

10. It may be noted further that the extreme northern limit reached by the ebb water is about $2\frac{1}{2}$ miles and the southern limit about two miles from the harbour mouth.

11. The above particulars, however, refer to the state of things along the coast during ordinary weather and not during the south-west monsoon. It was not practicable during the monsoon to put in floats, follow them in boats, and obtain their positions as required owing to the rough weather. An endeavour was made therefore to get some idea of the direction and strength of the littoral drift due to wave action during the monsoon.

12. In June 1921 a quantity of red powder of the fineness of ordinary sand was obtained by breaking up burnt tiles and spread on the Cochin beach at a point about three-fourths of a mile south of the Cochin gut. The area between high and low water marks was covered to a length of about a hundred feet and a thickness of about an inch.

13. This red material was immediately influenced by wave action which propelled it northwards, but after being carried about 30 yards it had all disappeared and could not be traced, part no doubt being kept in suspension in the water, part being dragged down below low water and part covered over by the original sand of the beach which was also in motion.

14. The experiment was repeated for several days during the monsoon and the same result obtained each time.

15. In June 1922 a similar experiment was tried, but this time the material was increased in size to pieces of about one-fourth inch gauge. These were laid out over a length of 100 feet along the shore, 30 feet in width between high and low water marks, with an average thickness of four inches. The point selected was about two miles south of the harbour entrance. The sea was rough at this place, the waves breaking in three parallel rows striking the shore nearly parallel to the general coast line. The wind was blowing gently from the south-west and the water was slightly mud-coloured.

16. The first effect of a wave breaking over the material was to wash it down the slope of the beach, the larger particles sliding and the smaller ones rolling along till the receding wave met the next on-coming wave. This meeting point was a little above ordinary low water mark.

17. Most of the material appeared to be rolled about more or less in the position it was put down in, but some of it was traced about 400 feet to the north $3\frac{1}{2}$ hours after the material was spread. No material was taken southwards beyond 10 feet of the original limit. On the next day it was not possible to find a single particle anywhere on the beach although the ground was raked over in many places.

18. Subsequently pieces of tiles of the same size as those in the last experiment were thrown on the beach. Some of these pieces were eventually traced to a distance of 3,900 feet northwards.

19. A further experiment was also tried by covering the beach in places with large quantities of shells each with some distinguishing mark on it. None of these shells, however, were ever found again, although they were searched for consistently both north and south of the harbour entrance. It is most likely they were broken up completely, or at least enough to make identification impossible.

20. The result of the above experiments may thus be summarized:—

(a) there is practically no movement of material along the foreshore due to ebb and flow of tides;

(b) foreshore movement is due to wave action only. While this may occur to a minor extent during ordinary weather it is most marked during the monsoon. The resultant movement is northwards.

21. It is however extremely difficult to estimate precisely what quantity of material passes to the north during the year. If it were possible to put down a large impenetrable groyne

across the beach and into the sea to a point where there is, say 25 feet of water, the sand would gradually be arrested on one side of the groyne as it is on the south side of the harbour at Madras and its rate of accumulation would be a measure of the annual drift.

22. Such a structure, however, carried down to a depth as would secure it from overturning during the monsoon, would cost a considerable sum, and could only be resorted to if it became absolutely essential to measure very accurately the quantity of sand moving northwards. Probably, also, several years would be required in order to get an average and reliable result.

23. Apart, however, from the general impression obtained from the above experiments it has been found possible to measure sand passing to the north in a rough and ready way.

24. It may be stated with a fair degree of certainty that the sand taken from the Cochin beach during the monsoon weather passes for a time into the backwater near the entrance to the harbour. No other alternative is practicable. It is next taken by the outgoing tide running at from 2 to 3 knots and thrown up on the Vypeen side, at the point marked X in the diagram where a small island is frequently visible for some time after the monsoon.



25. This island supplies at least part of the sand which is gradually taken northwards, and, since July 1920, has been deposited behind the parallel groynes north of Campbell's bund. The moving body of sand has been located on several occasions; its "head" and "tail" have been marked by flags each day; and the subsequent "capture" of the whole of the bank behind the parallel groynes has been plainly observed. This bank usually moves forward at a rate of about 2 feet per day.

26. The total quantity of sand which has thus been accumulated behind the parallel groynes since about September 1920 has been 21,000 cubic yards or an average of 7,000 cubic yards per annum. In view of the fact that no other areas can be found where there is the same definite tendency to silt up, it is considered quite probable that this "capture" of sand at the Vypeen groynes represents at least a considerable proportion of the quantity of sand eroded south of Cochin during the monsoon, and even supposing that a much greater quantity is deposited over various places before reaching the parallel groynes (an unlikely contingency as it cannot be traced) and that the actual quantity is even four times that above mentioned, i.e., say, 28,000 cubic

yards per annum (or roughly 42,000 tons as mentioned in paragraph 5 above) the insignificance of this quantity when compared with the million tons at Madras will be manifest.

27. Before any dredging was done on the outer bar, therefore, the opinion had been formed that any silting due to littoral drift would be so small as to be practically negligible, and, as will be shown later, this opinion was found correct.

PART II.

28. *Dredging of inner channel.* This work was started on 14th November 1921 and completed on 30th September 1922. The various materials dredged were as follows:

Soft black clay, sand, mud and shells, fine sand and oyster shells in beds several feet thick.

29. Soundings have been taken at various times and the depths in 1922 and 1923 are shown on the attached plan (No. 3) together with the latest soundings in red. It will be seen that there are small movements at the bottom, but that the total silting only amounts to 16,300 cubic yards. No maintenance work has been carried out since the channel was dredged. Its dimensions are roughly 6,000 feet long by 150 feet wide by 18 feet at L.W.O.S.T.

30. The object of this channel was to assist in training the ebb and flow of the tides in the required direction. The fact that the channel has kept itself clear shows that it has been so far successful in this respect. Moreover, the direction of flow is plainly seen from the surface to be fore and aft throughout the channel.

PART III.

31. *Dredging of outer channel.* This work was started in October 1922 and completed in May 1923. During those eight months the total quantity of silting was found to be 5,000 tons. The monsoon burst strongly on the 7th of June and by the end of the month the channel had decreased in depth from an average of 19 feet to an average of 16 feet 3 inches. The shallowest place was at the crest of the bar where the average depth was about 14 feet.

32. During the month of June the Cochin beach was under daily observation by the Executive Engineer. He states that there was local movement at various points along the beach, but there was no noticeable difference in foreshore section as a whole until after the end of the month.

33. The ebb and flow at the harbour continued more or less normal during this month (June), the period of continuous ebb not starting until 22nd of July following. These two facts indicate that the silting during June could not have been due either to littoral drift or to silting from the backwater and must have come in from the ground adjoining the channel itself.

34. Strong support of this view is derived from the fact that the worst silting in the channel took place at those points where the surface of the ground on each side was shallowest and was therefore most subject to wave action.

35. A further survey was made at the end of July and although, owing to various causes, the soundings could not be reduced very accurately, it was found that, as near as could be estimated, the quantity of silting had increased to 66,300 cubic yards. The average depth throughout was approximately 14 feet 9 inches as against 16 feet 3 inches for the previous month.

36. At the end of August the sea had calmed down sufficiently to enable a detailed survey to be made. This survey showed that the channel had widened out to about three times its original width over the greater part of its length. This was due no doubt to the continuous ebb from the backwater which lasted from 22nd July to 22nd August.

37. The total amount of silting in the channel itself was found to be about 62,000 cubic yards and in the vicinity of the crest of the bar the depth had decreased to about 10½ feet with one or two soundings at 9 feet.

38. The enclosed plan (No. 4) shows in black the soundings before the monsoon, in brown, soundings at the end of June, in blue, those at the end of July and in red, the survey at the end of August.

39. The following table shows the general characteristics of the monsoon of 1923 compared with those of 1920, 1921 and 1922. In general the monsoon may be regarded as having been a fairly severe one with an abnormal amount of wind causing rough seas, and a longer period of continuous ebb than usual:—

	1920.	1921.	1922.	1923.
Total rainfall in inches from 1st June to 30th September	90.99	68.73	79.77	111.56
Average velocity of wind in miles per day	1.25	1.77	1.71	1.84
Highest H.W. in feet	2.00	2.25	1.92	1.92
Lowest L.W. in feet				
Maximum difference in level between high and low water on the same day in feet	3.20	3.50	3.53	3.51
Number of days ships were at anchor	122	123	119	120
Days lighters were not allowed to go to sea	16 days.	16 days.	24 days.	23 days.
Longest period of continuous ebb	8 "	20 "	24 "	32 "

40. One interesting result due to the rough seas was found to be the driving in of the ridge of the bar by about 500 feet shorewards. Before the monsoon started it was noticed that the centre line of the bar was about 600 feet farther out to sea than shown on the latest chart for Cochin dated 1913. This monsoon appears to have put the ridge back to about the same position it had in 1913.

41. The result of the monsoon on the experimental cut may therefore be summarized as follows:—

(a) There was a total silting of about 62,000 cubic yards. The average depth of the channel was reduced to 15 feet but its average width had increased from 158 feet to about 450 feet.

NOTE.—62,000 cubic yards is approximately seven days' work for a powerful suction dredger to deal with.

(b) Most of the material, if not all, was driven into the cut by wave action alongside.

(c) The amount of silting was greatest where there was least depth of water alongside and where wave action had the greatest effect.

(d) The channel was subjected to a good deal of scour by the continuous ebb tides in August which resulted in a considerable widening of the cutting.

42. The engineering considerations which should govern a decision in regard to the channel may now be stated but before proceeding further it is desirable to dispose of one or two misconceptions which have arisen in regard to the experimental channel, and which have obtained a certain currency in Madras and elsewhere.

43. The first is that the experimental channel was to be regarded as a kind of small scale model of the large permanent channel, and the second, that if the "model" silted up the scheme must be regarded as a failure. The purpose of the experimental channel was, of course, an absolutely different one, as shown by paragraph No. 7 of my report of 18th April 1921 when the first estimates for the experimental channel were put forward. This paragraph may be quoted in detail:—

"As regards the channel across the bar it should perhaps be emphasized here that so far as I am aware no one has ever stated that the bar can be kept open without a reasonable amount of maintenance dredging, and the main object of this experimental work is to ascertain not whether the bar will silt up at all, but the rate at which it will silt up, so that it can be shown whether the suction dredger which it is proposed to obtain will be able to keep the bar open or not. Periodic

"surveys will therefore be made after dredging has been started, so that the amount of silting can be calculated for each month throughout the year. The dredger "Manar" will of course deal with silting as far as possible, but its capacity for this work is not comparable with that of a modern suction dredger."

This was referred to and further confirmed in paragraph 59 of my report No. 74/22 of 26th December 1921/11th January 1922, and the accuracy of this view has never been questioned.

44. Thus, the small experimental channel becomes practically a measuring tank for silting, and a means of determining where and when that silting takes place. It has very little in common with the idea of a pipe kept clear by a high pressure of running water.

45. Dealing now with the engineering considerations which govern the situation, these are six in number and may be summarized in this way.

46. (i) Whether the silting occurred gradually throughout the monsoon, or rapidly in the beginning. If the latter, then the experiment would be inconclusive, because it could not be said how much silting might have occurred subsequently. As has been shown, the silting occurred gradually throughout the monsoon and the result is therefore clear and definite under this head.

47. (ii) Whether or not the amount of silting would be increased proportionately in a wider and deeper channel. It has already been shown that as the silting comes in from the ground along each side of the channel, it follows that the same amount of material will pass into a wide as into a narrow channel.

48. (iii) Whether the total amount of silting is within the power of a dredger to deal with from the point of view of maintenance. It has been shown that the silting in a channel of the length of the experimental cut represents only about a week's work for a large suction dredger (paragraph 41). Allowing for the fact that the permanent channel will be about three times the length of the experimental, and assuming that the amount of silting will be pro rata in the additional length, which is not likely as the water is considerably deeper, the total amount comes only to 186,000 cubic yards, or less than one month's work for the dredger.

49. (iv) Whether the silting occurs in such a place and in such a manner as to lead to a blocking up, if only temporarily, of the permanent channel. It is shown in paragraph 66 post that the channel can be so designed as to preclude the possibility of this happening.

50. (v) Whether the alignment is such that the ordinary ebb tide from the backwater and the discharge of river water during the monsoon, are parallel in direction to the sides of the cutting, and do not cut across it diagonally. It has been shown that the cut has been aligned in such a way as to secure the maximum benefit from the currents, the width of the cutting having been increased three times over a considerable distance by scour during the monsoon.

51. (vi) Whether the conditions this year can be accepted as a criterion of what is likely to happen in the future. On the general question the enclosed original charts (five in number) supplied by the Admiralty show that the bar has not changed its essential characteristics since 1835. As regards the nature of this year's monsoon, the results can be compared with the definite records of the three previous monsoons, beyond which similar records do not exist. These records show that the monsoon was, if anything, more severe than the average.

52. Generally, it may be said that the experiment has been successful beyond expectation; that it has afforded very valuable information as to the manner in which the permanent channel should be dredged; and it will now be comparatively easy to design this channel in such a manner as will dispense with maintenance dredging throughout the monsoon. This will be dealt with in Part VI to follow.

PART IV.

53. *Reclamation.*—The retaining wall for the reclamation has been completed on the north-west and north-east sides and for about a quarter of a mile on the south-west side. About 60,000 tons of material have been pumped into the reclamation by the "Seetief" at a point where the water was 12 or 13 feet deep to start with over a part of the area. About one acre of reclamation has been made and this space is being used temporarily as a coal store for the dredgers.

54. The material pumped into the reclamation by the 'Seetief' is practically all coarse sand and shells. The vessel is quite powerful enough for the work, but owing to the fact that the pumps were built for mud and silt rather than coarse sand, there has been excessive wear, and delays have been serious whilst the pumps have been under repair. New pumps, however, are on order from home and it is expected that the vessel will do more continuous work in future.

55. The form of wall adopted, shown in plan No. 16 accompanying the former report, has been found quite satisfactory so

far. There has been very little settlement and practically nothing has been spent on maintenance.

PART V.

56. *Groynes at Vypeen.*—The parallel groynes have been continued to a point 1,000 yards north of the end of Campbell's bund where the width of the ground between the sea and the backwater is about 550 yards. It is not considered necessary to go beyond this point with the foreshore protection—at least for the present.

57. The reasons for, and general particulars with regard to, these groynes were given in paragraphs 24 to 29 of my previous report above quoted. Experience has only tended to confirm the view expressed in paragraph 67 of the same report, viz., that there is no longer any apprehension as to the vulnerability of the Vypeen peninsula.

58. The accretion behind the groynes has continued slowly but surely with the result that, at points where there was a depth of anything from 2 to 5 feet at low water, the land is now well above high water mark. The area of the land thus reclaimed is about 5½ acres.

59. It was noticed this year as in 1921 that the mud bank from Narrakal travelled down the coast to the south and protected the groynes very effectually during the monsoon weather. During a great part of the time, when there was a rough sea outside, the water was quite still alongside these groynes.

60. In a short time it is expected the mud bank will move back again towards Narrakal and then the sand, which has accumulated on the northern side of the gut as mentioned in paragraph 24 ante, will start moving slowly northwards. The amount of accretion behind the groynes will probably be less this year as it will have to be cast up to the existing surface above high water. Most of the sand, therefore, will proceed northwards until it finds another suitable area for depositing itself.

61. This concludes the portion of this report dealing with the carrying out of the experimental scheme.

PART VI.

62. *Proposals for dredging permanent channels.*—It will be seen from paragraph 37 above that the total amount of silting in the experimental channel was 62,000 cubic yards and that most, if not all, came in from the sides. It follows, therefore, that there is every reason to suppose that the amount of silting will be more or less constant irrespective of the width of the channel. The wider the channel, therefore, the less will be the reduction in

depth due to the silting. The permanent channel will be approximately four times the width of the experimental channel, and even if the whole of the 62,000 cubic yards of silting were concentrated over a short stretch of say 1,000 feet in the neighbourhood of the bar the depth of the channel would only be reduced from 35 feet to 33 feet, apart from the fact that a good deal of the silting is expected to be retained on the silting shelves to be referred to later.

63. It is also seen from paragraph 34 that the greater part of the silting occurred where the depth of water alongside the cut was least and where the sea bottom was therefore most subject to wave action.

64. From experience in dredging the experimental channel it is considered that dredging by any vessel during the monsoon would be rather hazardous and the results uncertain. As stated above the silting takes place from the sides when wave action is greatest and this is just the time when it would be difficult, if not impossible, for the dredger to work, observing that in addition to the heavy sea there are storms of rain and wind which would make navigation difficult.

65. The above considerations make it obvious that the channel should be designed in such a way as to preclude the necessity for dredging through the monsoon and the practical and straightforward way of doing this is to dredge the channel deeper and wider at those points where silting is most likely to take place.

66. It has hitherto been the intention to make a channel 600 feet wide by 30 feet deep at low water spring tides. It is now proposed that this channel should be dredged 600 feet wide by 32 feet deep at low water and that at those places where silting is most probable to increase the depth to 35 feet at L.W.O.S.T. and to increase the width by a hundred feet on each side, this additional width, however, being dredged not to 35 feet deep but only to 25 feet. It is confidently anticipated that these "silt shelves" will arrest the progress of much silt which would otherwise fall into the main channel and that any which might pass cross the shelf would certainly not do more than fill in the channel to a level of 30 feet at L.W.O.S.T. even at the worst places.

67. By these means it will be possible after the monsoon for the maintenance dredger to clear the material off the "silt shelves" to a depth of 25 feet as existed before, and to remove any silt in the bottom of the channel quite easily down to the previous level before the next monsoon commences; and also have ample time for assisting with the work inside the harbour.

68. The quantity of material to be dredged in such a channel amounts to 3,400,000 cubic yards and assuming that an additional dredger is purchased the channel can be dredged down to a depth of 26 feet during the first year and the remainder in the next year, that is to say, it will be quite possible for vessels to come in at high water after the execution of the first year's work. The majority of vessels trading at the port have a draught of 25 feet and under.

69. The experience of dredging by the "Manar" from October to May last, when that small bucket dredger was only stopped for a few days on account of weather during the whole period, has shown that it will be quite possible for a stationary pump dredger to work with a floating pipe-line, and as this is by far the quickest and cheapest way of doing the work this course is recommended.

70. The pipe-line would lead to the north of the channel and the material pumped would slowly be dispersed northwards by the prevailing set of the sea.

PART VII.

71. The attached plan No. 5 shows the channel dredged according to the design above described together with the other work inside the harbour considered necessary in order to allow the ships to moor up inside as a regular practice. The detailed estimates for this work are in hand. From a rough forecast, however, it will cost appreciably less than 57 lakhs, which was the amount Government previously decided in G.O. No. 157, Marine, dated 30th April 1921, was the sum the port could safely finance on the basis of the present trade.

72. It is not known exactly how this figure of 57 lakhs was arrived at but it is believed that a maximum goods tonnage of 405,000 tons was taken as the basis. This was evidently well on the safe side as the trade for last year amounted to 420,000 tons which at Re. 1 per ton produced 4.2 lakhs in landing and shipping dues alone.

73. As has already been stated on several occasions, the port is quite willing to advance the dues to Rs. 2 per ton and the basis of the finance may therefore be regarded as at least 420,000 tons at Rs. 2 per ton.

74. There are, in addition, receipts from port dues and other sources so that the total receipts may very well be taken as certainly not less than 9 or 10 lakhs.

75. Making a deduction for maintenance which will be low during the period of construction as all the plant is charged to capital cost, but will increase to about 40 per cent later, it is

PART IV.

APPENDICES.

I

CORRESPONDENCE RELATING TO PROPOSALS FOR THE
IMPROVEMENT OF THE COCHIN HARBOUR WITH REPORTS
THEREON BY G. ROBERTSON, Esq., M.I.C.E., F.S.S.E., ETC., AND
N. PARKES, Esq., M.I.C.E., 1881.

G.O. No. 2943 W., dated 27th December 1880.

READ—the following papers :—

From J. H. ASPINWALL, Esq., Chairman, Cochin Chamber of Commerce,
to the Secretary to Government, Public Works Department,
Ootacamund, dated Cochin, the 28th September 1880.

* * * * *

As one of the objects of your visit will doubtless be to inspect our
Harbour, I enclose, for your information and guidance, a copy of a letter
our Chamber addressed to Colonel Thomason, R.E., after his visit here,
which treats fully on all points connected with it and the trade of the
Port.

* * * * *

From J. H. ASPINWALL, Esq., Chairman, Cochin Chamber of Commerce, to
Col. A. THOMASON, R.E., Calcutta, dated Cochin, the 4th April 1879.

Referring to the interview which a deputation of the Members of this
Chamber had with you in November last, I have now the honour to
address you on the subject of the improvement of Cochin Harbour, and
to request that you will be pleased to submit this communication to
Government for its favourable consideration.

2. This Chamber has heard with pleasure that professional opinion is
unanimous on the point that Cochin could be converted into a first-class
Harbour at a reasonable cost; but, from your observations at the interview
referred to, I gather that, as it is essential, before any project is
sanctioned, it should be demonstrated by reliable data that the work would
be reproductive to the extent of at least 4 per cent on the proposed outlay.
I beg to forward herewith Statistics of Shipping Tonnage and Imports
and Exports for the years 1876-77 and 1877-78, which have been care-
fully compiled from official records and are perfectly trustworthy. It will
be observed that the trade of Narrakal has been included in these state-
ments, as vessels frequent that port, not because it has any traffic of its
own, but on account of its safe anchorage during the south-west monsoon,
when Cochin is inaccessible. The whole of the business done there is on
account of the mercantile community of this port, so that virtually it is
part and parcel of the trade of British Cochin, which would not be
temporarily diverted to that place if facilities for landing and shipping
during the monsoon existed here.

3. Although these statistics speak for themselves, this Chamber would
urge upon your special attention the fact that, allowing the figures
relating to Narrakal to stand separately, the proportions of the import and
export trade of Cochin alone are of sufficient magnitude to justify this
Chamber's holding out the prospect of the merchants being well able to
contribute the whole of the interest on the estimated amount required
for the Harbour.

4. The imports during the last two seasons have been as follows :—

	Cochin.	Narrakal.
	TONS.	TONS.
1876-77	73,817	19,648
1877-78	56,165	27,424
	129,982	47,072

and the exports—

1876-77	61,147	3,456
1877-78	45,629	1,518
	106,776	4,974

Aggregating—

1876-77	134,964	23,104
1877-78	101,794	28,942

As almost all the articles of export go free of duty, and it is also
probable that import duties will be either abolished or considerably
reduced, this Chamber is decidedly of opinion that both importers and
exporters would cheerfully consent to pay a tax of Rs. 1½ per ton by way
of wharfage or bunder fees, in view of the numerous advantages which
they would enjoy by the construction of the Harbour, chief among which
would be the saving in lighterage alone, and the ease and facility and the
immunity from damage with which goods could be landed and shipped
at all times of the year. This alone would give a revenue of more than
4 per cent on the proposed outlay of a quarter of a million, but, if an
additional guarantee and source of income were required the port dues
could be raised at the rate of one anna per ton, an impost which would
certainly not be appreciably felt by the shipping, considering how greatly
it would benefit by a harbour which would afford it shelter and numerous
conveniences, when other ports on the coast are unapproachable. The
Chamber has given this matter mature and careful consideration, and, so far
as the mercantile community is concerned, it has no hesitation in assert-
ing that the proposed charge of Rs. 1½ per ton will in no way cripple
or strangle the trade of the port, and it therefore respectfully begs that
due weight will be given to this suggestion by the Government in con-
sidering the claims of this port to improvement.

5. From your personal inspection of this harbour you are no doubt
satisfied that its capabilities are such that it could without difficulty accom-
modate 25 large ships, but, should any portion of the river or backwater

belonging to the neighbouring State of Native Cochin be required, this Chamber has the assurance of those in authority in that State that, no obstruction or difficulty need be anticipated, as the Government of His Highness the Raja of Cochin will be prepared to make any reasonable concessions which may be required by our Government.

6. Another matter which the Chamber would bring to your notice is the existence, in abundance, of material for works of the proposed kind at Kakanad, a place in Native Cochin in close proximity to this port. The groynes which were thrown out on this as well as the Vypeen shore some years ago, when the encroachments of the sea threatened the town, are composed of granite brought from this place. Large quantities of material of this description are available and could be conveyed by the backwater at comparatively cheap rates.

7. The Chamber would further beg to observe that, during the late famine an immense trade was carried on between the rice ports and Cochin, and almost all the towns on the line of railway and in Travancore to the south received a large share of their supplies from this port. Narrakal proved a valuable auxiliary to Cochin, as during the south-west monsoon numerous cargoes were landed there and conveyed to the famine-stricken districts. Vessels which were unable to approach any other port on the coast found shelter at Narrakal and discharged their cargoes. Had landing and shipping facilities been available at Cochin during the rainy season all those vessels which resorted to Narrakal would have come into this Harbour and landed their goods more expeditiously and cheaply.

8. The Chamber would take this opportunity of stating that the subject of extending the railway to Cochin is now engaging the serious attention of the Cochin Sirkar and the mercantile community, and arrangements are already in progress to bring the project forward in a definite and tangible shape. The proposed line will run through a thickly populated country, as may be seen from the subjoined comparative statement of the density of population in the Report of the Census of Native Cochin taken in 1876 :—

Density per square mile.				
Oude	...	...	...	463.06
Belgium	...	...	...	451.50
Cochin	...	...	...	441.51
England and Wales	...	...	...	389.30
North-West Provinces	...	...	...	378.31
Bengal	...	...	...	269.30
Madras	...	...	...	227.19
British India	...	...	...	200.70
Germany	...	...	...	193.36
France	...	...	...	178.82
Punjab	...	...	...	172.51
Bombay	...	...	...	133.40

Taking the above fact in connexion with the well-known fertility of the country and the importance of the port of Cochin as the natural outlet

for the produce of the neighbouring Native States, an enormous goods and passenger traffic may safely be calculated upon. It would be superfluous to dilate upon the numerous advantages which the railway to Cochin would secure to the country, but the Chamber would only remark that a railway in times of famine is simply invaluable. The Secretary of State for India, in his despatch of the 10th January 1878, appointing the Famine Commission, writing on this subject, observes :—"The value of railways as an assurance to the population against the worst sufferings of famine has been singularly illustrated during the past year." Without their aid it would have been wholly impossible to convey sufficient grain to the inland districts. Their resources, however, were strained to the utmost, and at one time a serious apprehension was entertained that they would be overtaken. How far it will be possible, with a due regard for financial considerations, to bring a wider range of country within their immediate reach is a question which will doubtless occupy your earnest attention at an early period. Considering the magnitude of the rice trade of this port, particularly during the prevalence of the famine, and the difficulty experienced in conveying supplies in large boats to Tirur, the nearest railway station, cheaply and expeditiously, owing to the want of water in the canals, a line from Cochin to Shoranur would be an excellent feeder in similar emergencies, especially when time and expenditure are two important considerations. The Chamber need not dwell further on this subject, as it will in due course go before the Government in a matured and definite form.

9. The Chamber would take this opportunity of thanking you for the ready and courteous attention with which you have received its representations, and, in concluding, it hopes that the claims of the Cochin Harbour to improvement will meet with the consideration they deserve at the hands of Government.

Statement showing number of vessels and their tonnage and port dues collected at Cochin and Narrakal during the following seasons.

Seasons.	Description of vessels.	Number.		Tonnage.		Port dues.			Collected.		
		Cochin.	Narrakal.	Cochin.	Narrakal.	Cochin.			Narrakal.		
				TONS.	TONS.	RS.	A.	P.	RS.	A.	P.
1876-77	Steamers	96	36	102,121	85,237	17,878	0	6			
	Ships	139	31	45,563	18,439	5,647	14	0			
	Native craft	995	2	42,846	26	4,059	1	0			
	Total	1,230	69	190,530	53,702	27,584	15	6	5,396	10	0
1877-78	Steamers	110	36	115,100	46,076	18,161	13	6			
	Ships	122	24	43,363	11,549	6,488	10	8			
	Native craft	1,260	1	50,463	13	3,263	9	0			
	Total	1,492	61	208,926	57,638	27,914	0	9			

Statement of imports and exports—Cochin and Narrakal.

Seasons.	—				Total imports.	Total exports.	Imports of rice and paddy only.
					TONS.	TONS.	TONS.
1876-77	{	Cochin	...	...	73,817	61,147	48,262
		Narrakal	...	...	18,648	8,456	14,940
		Total	...	...	93,465	64,603	63,242
1877-78	{	Cochin	...	...	56,165	45,629	49,211
		Narrakal	...	...	27,424	1,518	19,518
		Total	...	...	83,589	47,147	68,727

Letter from Col. R. H. SANKEY, R. E., Secretary to Government, Public Works Department, to J. H. ASPINWALL, Esq., Chairman, Cochin Chamber of Commerce, dated Stonehouse, Ootacamund, the 1st October 1880.

I am much obliged for your letter of the 28th ultimo, and for the courteous invitation which it contained. Should I be enabled to visit Cochin, I should be most happy to put up during my stay with you, but at the present moment my plans are little uncertain, and I half fear that I shall be unable to visit, as I had intended, the Western Coast harbours till January. In any case I will give you as early intimation as I can.

Meanwhile I should be glad to know precisely what are the proposals in connexion with the port, as I have not myself had an opportunity for visiting it, nor have I seen any report by Colonel Thomason. His scheme whatever it was went in all probability to the Supreme Government.

From what I have generally been given to understand, Cochin has in the Narrakal mud banks a costless and safe landing place throughout the south-west monsoon, while at all other times there is no serious inconvenience from the present bar so far as landing and discharging cargoes is concerned.

Having lately visited our northern ports, I had occasion to study the general conditions under which harbours could be constructed at the mouths of our rivers, and as you will see from my note attached to the G.O. of 13th August (which kindly return on perusal), I was obliged to come to unfavourable conclusions, see particularly paragraphs 29 to 39 inclusive.

Setting aside the question of a railway, which I should presume is sufficiently before Government, do you really need any large or expensive harbour works? and if so, what form should they take bearing strictly in mind the action which is inevitable at the mouths of all our rivers?

From W. T. HOLMES, Esq., Honorary Secretary, Cochin Chamber of Commerce, to the Secretary to Government, Public Works Department, Madras, dated Cochin, the 8th October 1880, No. 68.

Mr. J. H. Aspinwall has placed before the Chamber your letter to him, dated 1st instant, with a view to the Chamber addressing you direct on the subject of the proposals in connexion with the improvement of this port.

2. Your remarks and paragraphs 29 to 39 inclusive of your note attached to Government Order of 13th August have been carefully considered, and by desire of the members of the Chamber I have the honour to offer the following observations for your consideration.

3. In the month of November 1878, Col. A. Thomason, R.E., visited the port and met the members of this Chamber to confer about proposals for the improvement of the Harbour and the ability of the trade of the port to bear a charge for interest at 4 per cent per annum on the cost of the proposed improvements.

4. Owing to Colonel Thomason's short stay in Cochin and to the fact that the Chamber had no previous knowledge of his intention to visit the port, there was not time to bring before him all the information bearing on the latter point, but in conference it was understood that no engineering difficulty existed in the way of converting the port into a first-class harbour at a moderate cost.

5. The works which were under contemplation at this interview were the construction of two piers from the mouth of the backwater so as to confine the current flowing outward and direct its full force on to the bar; to construct such protective works, to prevent erosion of the sea beach north and south of these piers as might be necessary, and to construct quay walls inside the harbour, on the south side, from the present mouth to the Calvetty canal; and on the north side, on the face of Vypeen point.

6. These works were roughly estimated to cost about £250,000; and it was left with the Chamber to show that the trade of the port was able to pay interest at 4 per cent per annum on this outlay. This the Chamber did in a letter to Colonel Thomason, dated 4th April last, a copy of which Mr. Aspinwall has forwarded to you.

7. The Chamber, however, is now of opinion that, as a beginning, works of much less magnitude than those originally contemplated might suffice, and would propose the construction of the piers seawards and such protective works on the seashore to the north and south of them as may be considered necessary. These works might be expected to cost considerably less than the amount formerly estimated. Other works might be subsequently constructed as the development of the trade of the port required.

8. For any works that may be decided on there is abundance of stone within moderate distance of Cochin which would be conveyed by backwater at cheap rates from the quarries to the works.

9. In considering the question whether the proposed works, if carried out, would permanently effect their object, the Chamber inclines to the opinion that they would, and it feels some confidence in it because a

similar opinion seems to have been arrived at by professional men who have visited and inspected the port. The circumstances of this port are so widely different from those of Vizagapatam and other ports on the Madras coast, that conclusions which may be perfectly sound with reference to the latter may be found quite inapplicable here.

10. The Cochin backwater is considerably over one hundred miles, extending to the north and south of Cochin, in length; is in some parts about fifteen miles broad; is perhaps nowhere less than one-and-a-half to two miles broad throughout its greatest length; and is of great depth in many places. Into this inland sea all the rivers, some of them considerable, from the Travancore and Cochin Hills debouch (the nearest of them being fully ten miles from Cochin), and find a passage into the sea at Cochin and Paliport, but in the passage of their waters down the still backwater the silt brought down by them is wholly deposited, so that by the time they reach Cochin there is no matter borne in them, even in the height of the monsoon floods, which, depositing outside, could form a bar. In fact the water flowing out of the opening generally called the Cochin river is practically free from silt. It would appear from this that the bar at the Cochin mouth of the back water is not caused by deposit of silt brought down by the rivers, but is owing to the action of the surf endeavouring to reform the profile of the coast line broken through by the outflowing current, as pointed out by Mr. Robertson, and, if this opinion is correct, there is ground for belief that such works as are proposed would have the effect of permanently removing the bar.

11. It may here be mentioned that the depth of water on the bar at high water is $16\frac{1}{2}$ to 17 feet, and at low water $14\frac{1}{2}$ to 15 feet, and not 11 feet as stated by Mr. Robertson.

12. With reference to the facilities offered by Narrakal to shipping operations during the monsoon months, the Chamber would point out that there are serious drawbacks to those facilities, amongst which may be mentioned the inconvenience arising from the place being at so great a distance from Cochin, the cost of keeping extra staff there, the extra cost of boat-hire, the cost and inconvenience of portage across the land between the backwater and the sea, the damage done to cargo by long exposure to wet in passing between the two places and on to the ships, and, not least, the loss sustained by the pilfering by boatmen and others which cannot be checked. In these things there are reasons sufficient for a strong desire amongst merchants of this place to be independent of Narrakal as a shipping port. But as a port of safety in stormy weather, when ships might be unable to make this port, Narrakal would always be available as a temporary anchorage.

13. The Chamber notices with gratification that there is a prospect of your visiting the port, and trusts that you will find it convenient to do so at an early date.

Total exports from Cochin and Narrakal from 1870—1880.

(1)	1870-71 (2)	1871-72. (3)	1872-73. (4)	1873-74. (5)	1874-75. (6)
	TONS.	TONS.	TONS.	TONS.	TONS.
Cochin	36,054	47,512	39,905	37,460	40,321
Narrakal	2,300	2,300	2,448	2,121	1,927
Total	38,354	49,812	42,348	39,581	42,248

	1875-76. (7)	1876-77. (8)	1877-78. (9)	1878-79. (10)	1879-80. (11)
	TONS.	TONS.	TONS.	TONS.	TONS.
Cochin	39,598	58,399	44,298	37,303	35,328
Narrakal	2,689	5,106	2,835	2,332	4,898
Total	42,287	63,505	47,133	39,635	40,226

About 3,000 tons exports belonging to 1879-80 were not shipped until 1880-81 owing to want of tonnage, so do not appear in this statement.

Total imports to Cochin and Narrakal from 1870—1880.

(1)	1870-71. (2)	1871-72. (3)	1872-73. (4)	1873-74. (5)	1874-75. (6)
	TONS.	TONS.	TONS.	TONS.	TONS.
Cochin	35,354	39,951	47,876	39,229	41,814
Narrakal	500	500	164	944	1,522
Total	35,854	40,451	47,840	40,173	43,336

	1875-76. (7)	1876-77. (8)	1877-78. (9)	1878-79. (10)	1879-80. (11)
	TONS.	TONS.	TONS.	TONS.	TONS.
Cochin	43,835	73,817	56,165	70,051	31,872
Narrakal	2,972	19,648	27,424	12,680	11,869
Total	46,807	93,465	83,589	82,731	43,741

W. T. HOLMES,
Honorary Secretary.

Statement showing the number and tonnage of vessels that frequented the Port of Cochin and the amount of port dues collected thereon.

Official year.	Number and tonnage of vessels.		Amount of port dues collected.		
	NO.	TONNAGE.	Rs.	A.	P.
April to March—Official year—					
1870-71	1,463	131,482	13,608	9	3
1871-72	1,621	143,079	14,815	8	0
1872-73	1,430	162,901	19,650	0	3
1873-74	1,511	123,928	4,221	3	9
1874-75	1,842	164,747	19,739	1	0
1875-76	1,639	192,893	24,123	3	0
1876-77	1,698	204,796	27,811	9	0
1877-78	1,500	209,199	28,276	13	3
1878-79	1,484	216,065	29,868	12	6
1879-80	1,135	199,189	28,811	10	0

Total tonnage for four years from 1876-77 to 1879-80.—Tons 829,249, averaging 207,312 tons per annum.

Total port dues collected for four years from 1876-77 to 1879-80.—Rs. 1,14,768-12-9, averaging Rs. 28,692 per annum.

W. T. HOLMES,
Honorary Secretary.

Letter from Col. R. H. SANKEY, R.E., Secretary to Government, Public Works Department, to the Honorary Secretary, Chamber of Commerce, Cochin, dated Stonehouse, Ootacamund, the 12th October 1880.

I beg to acknowledge your obliging communication No. 68 of the 8th instant on the subject of the requirements of the Cochin Harbour. It will afford me great pleasure to visit Cochin and examine for myself the points advanced in your letter, but as I may not be enabled to arrange them for sometime I should be glad if you would kindly let me have even a rough plan of the works you suggest laid down on a reliable chart to allow of a general opinion being formed of the probable expense.

Thus if you could indicate generally the length of the groynes which it is now thought would suffice to sweep away the bar, their probable section, and distance apart it would not be difficult to frame some kind of approximate estimate particularly, if you can state the rate at which the material could probably be laid down at.

If the scour is such as to sweep away the bar you must bear in mind that the material composing the training groynes must as the channel is deepened by this action have a tendency to slip down the inner slopes and that then much more material will be needed than that merely required for making up a breakwater or groyne of a given section.

May I ask also what is the general character of the seas brought up by the south-west monsoon, i.e., whether they are in any way comparable with the rollers at Madras, as in that case, the material would either have to consist of stone in large masses or of concrete blocks, the expense of which I need hardly say would be considerable.

Without wishing to express at present any opinion as to the validity or otherwise of the contention in your letter against the probability of a bar re-forming with the scour it is proposed to bring upon it by the suggested groynes, I should be glad to have some good nautical opinion as to whether in the south-west monsoon ships could be safely warped up between such groynes.

I confess it seems to me at first sight that at such times an operation of the kind would be attended with considerable risk, and that steamers and vessels frequenting the port at such times would be very chary about entering a narrow canal of this kind; in fact that they would much prefer discharging their cargoes off Narrakal.

Please also if possible let me have a statement of the exports and imports for the last 20 years, with some general statement of the dues which you think the trade could bear to pay interest on the capital required for the proposed works.

From W. T. HOLMES, Esq., Honorary Secretary, Cochin Chamber of Commerce, to the Secretary to Government, Public Works Department Madras, dated Cochin, the 25th November 1880, No. 75.

I beg to acknowledge your letter of 14th October which has been laid before the Chamber, and have now the pleasure to furnish you with such of the information called for as is available.

2. As requested, a chart of the port (with latest corrected soundings on and about the bar) which is in use by the Marine Department is forwarded herewith, and there have been marked thereon the directions which, or about which, the proposed piers may be expected to take; but the Chamber feels some diffidence in offering suggestions on points which are matters for professional opinion.

3. It is of course understood that the piers will require to be extended to such a length as will enable the current to maintain an always open channel into deep water, and must be placed, with reference to each other, so as to direct as much of the force of the out-flowing current on to the bar as may be possible without exposing them to the risk of being undermined by the scour, which the confinement of the current may be expected to set up, considering that the ebb ordinarily flows at about four knots per hour and at six knots during the freshes.

4. If it is considered necessary to carry the piers out into five fathoms water, they will have to be constructed to a distance of about 2,800 yards from the river's mouth. It may, however, not be thought necessary to

carry them out so far for the following reasons:—The chart shows that in the narrowest part of the mouth of the backwater, where it is 450 yards broad, there is a depth of 42 feet, gradually shallowing to 36 feet at the point (600 yards broad) where the shore line is left and the backwater empties into the sea. Immediately the shore line is passed the current spreads out fan-like, and much of its force is lost; yet, notwithstanding, it is able to maintain a depth of 26 feet of water at a distance of 1,100 yards from the shore. It therefore seems that, if the piers were carried out just past the bar, a distance of about 1,750 yards or thereabouts, the whole volume of the current discharging into the sea at that point might be expected to form and keep open a channel of sufficient capacity right into deep water. This of course is on the supposition that the position of the bar is the limit of the disturbing action of the swell and surf on the sand of the coast.

5. In considering the distance apart at which the piers should be built, it may be noted that the chart shows that the main current is skirted, as far as the bar, by sand banks, the soundings on which are very shallow, being only 13 feet at both ends of the bar at a mean distance of 1,625 yards from the shore. If these banks may be considered as indicating about the proper line for the construction of the piers, then the south pier will run out almost due west from the light-house bastion for a distance of 1,500 yards and the north pier take a southwesterly line from Vypeen point for a distance of 1,750 yards. These directions will place them about 1,000 yards apart at the base or shore end and 650 yards at the bar, and may be expected to give a depth of about 30 feet of water where the bar now is.

6. If the triangular area thus enclosed be open to objection outweighing the economy in construction effected by building the south pier due west from the light-house bastion (though it might be useful as affording space for any swell entering between the piers to spread and disperse), then the alternative line for this pier marked on the chart may perhaps be the best, and the two piers will then be parallel at a distance apart of 650 yards.

7. Should it be considered necessary to carry the piers into five fathoms water, the south pier could be extended the required distance due west, and a direct line, as marked on the chart, be followed for the north pier.

8. As the Chamber is quite unable to express an opinion on the method of construction most fit to be adopted in the piers, it cannot furnish a probable section of them, but it would seem necessary that they should be sufficiently solid to prevent such percolation through them as might weaken the current.

9. It was thought that some information about the Madras Harbour Works would have been of assistance in the preparation of rough plans and estimates, and the Superintendent of those works was applied to for it. He obligingly replied very fully to the Chamber's enquiries; but, owing to the great depth of water in which those works have been constructed, and consequently the more massive character of them than is

required in works here, it was found impossible to frame any reliable calculations on the information furnished.

10. The Chamber is informed that for some small protective works which have been constructed on the beach the material (large boulders of gneiss rock) was obtained at two rates, viz., Rs. 2 per ton and Rs. 3½ per cubic yard. Considering that the material is obtainable in unlimited quantity and almost without quarrying at about ten miles from Cochin, and that its carriage would be by water, the Chamber is inclined to think that for large works such as proposed, arrangements for laying it down in Cochin at cheaper rates might be found practicable.

11. In the opinion of the Chamber the seas brought up by the south-west monsoon are not at all comparable to the rollers which break on the Madras coast, nor are such storms as are met with on that coast ever experienced here. The long shelving bottom perhaps explains the comparative lightness of the seas breaking on this shore.

12. It is not anticipated that there would be any special risk to ships passing in between the piers during the south-west monsoon. The process of warping would be quite unnecessary, for, as every wind that blows during that period is a fair wind for entering the port, ships once in the channel would be able to sail right in. The wind, however, at that and other times of the year when the early morning land winds do not prevail does not serve ships going out, and for use at all such times it might be desirable to keep a small tug steamer at the port.

13. The Chamber regrets that a statement of imports and exports for twenty years is not available, but one for ten years, which has been compiled by the Chamber from the official records, is attached hereto, and its figures are reliable.

14. On the subject of dues which the sea-borne trade of the port can bear, to pay interest on the required capital, the Chamber feels better qualified to express an opinion than on some of the other points raised in your letter under reply.

15. The average annual imports and exports for ten years are found to be—

		TONS.	
Cochin and Narrakal	{ Imports	...	44,513
	{ Exports	...	55,799
Total		...	100,312

16. At the present time ships of 300 to 400 tons burthen come into the inner harbour, and in discharging and loading their cargoes merchants find a saving of at least As. 12½ per ton in boat-hire as compared with the cost of discharging and loading when ships are outside (including Narrakal shipments), and on the supposition that two-thirds of the imports and exports, say, 66,875 tons, are discharged and loaded outside, the further reduction in boat hire occasioned by all ships coming inside would represent Rs. 52,940 or thereabouts annually being an average of 8 annas and 5 pies per ton on the whole trade.

17. If, however, ships were not only all able to come inside, but provision was made for them to discharge and load at quays, there would be a saving of Re. 1-1-0 per ton in boat-hire on the aforementioned two-thirds of total imports and exports, and of about As. 5 per ton on the remaining third now discharged and loaded inside, averaging 13 annas 4 pies per ton on the whole trade, and representing Rs. 83,593 annually.

18. But the full benefit which Cochin merchants would derive from the contemplated improvements is not to be measured by these savings only. Various facilities would be furnished, such as reduction of risk of damage to goods and loss by theft, greater expedition in the shipping and discharging of goods, ability to carry on shipping operations under conditions of sea and weather which now bring them to a standstill, and, not least, the avoidance of the considerable inconvenience, delay, and extra expenditure which are at present experienced in having to carry on shipping operations at Narrakal. These things have an appraisable value and were taken into consideration when the Chamber informed Colonel Thomason, in its letter of the 4th April 1879, that for harbour improvements which would include quay walls in the inner harbour, the trade of the port could afford to pay Re. 1-8-0 per ton by way of wharfage or bunder fees if necessary, a statement from which the Chamber does not recede. However as far as the Chamber understands the subject, a less tax would more than suffice to pay 4 per cent interest per annum on the supposed outlay of £ 250,000, say, As. 12 per ton in the case of harbour improvements not including quay walls, and Re. 1 per ton in the case of improvements including quay walls.

19. The facilities and quicker despatch which ships would gain under these circumstances might well be considered sufficient ground for an increase in the tonnage dues they pay to the port, and the Chamber would propose an increase of one anna per ton all round. The existing rates—

On ships from or to foreign ^{and}_{or} British ports, three annas per ton for ninety days.

Coasting steamers, 4½ annas per ton for thirty days.

Native and coasting craft employed entirely in coasting trade, 1½ annas per ton for sixty days.

20. There is attached hereto a statement of number of ships, tonnage and port dues for ten years at Cochin, which shows the average tonnage for four years, from 1876-77 to 1879-80, to have been 207,312 tons. A charge of one anna per ton on this amount would give an income of Rs. 12,957 per annum. If the tonnage of ships visiting Narrakal was taken into account, the amount would be larger, but unfortunately statements cannot be obtained in time to go with this letter.

21. The Chamber is also of opinion that a large portion of the surplus port dues collected might very justly be appropriated to this object. For the past four years they have averaged per annum at Cochin Rs. 28,692, and the expenditure against them it is believed, has not averaged Rs. 7,000 per annum. The Chamber has no idea of the manner in which the surplus

of Rs. 21,000 has been disposed of (though it is well-known that it has not been expended on the port) but ventures to propose that at least three-fourths, if not the whole of this surplus be applied to the improvement of the port.

22. Thus in one case can be raised, without any undue charge on the trade of the port, an income of Rs. 1,03,700 per annum as follows:—

	RS.
Charges on landing and shipping, say, 100,000	75,000
tons at 12 annas per ton	12,950
Increased port dues	15,750
Transfer from port dues	
Total ...	1,03,700

representing, at 4 per cent per annum interest, a capital of Rs. 25,92,500.

23. In the other case can be raised an income of Rs. 1,28,700 per annum as follows:—

	RS.
Charges on landing and shipping, say, 100,000	1,00,000
tons at Re. 1 per ton	12,950
Increased port dues	15,750
Transfer from port dues	
Total ...	1,28,700

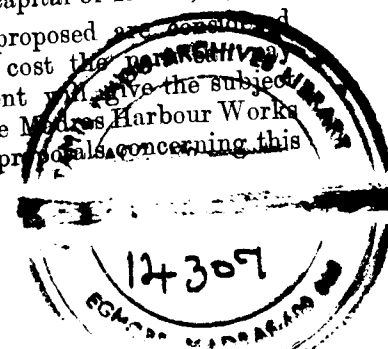
representing, at 4 per cent per annum interest, a capital of Rs. 32,17,500.

24. It may be added that a tax of even Re. 1-8-0 per ton would compare favourably with the charges on shipping operations at the neighbouring and thriving port of Alleppey; and proceeding as above, an annual income of Rs. 1,78,700 might be raised.

	RS.
Charges on landing and shipping, say 100,000	1,50,000
tons at Re. 1-8-0 per ton	12,950
Increased port dues	15,750
Transfer from port dues	
Total ...	1,78,700

representing, at 4 per cent per annum interest, a capital of Rs. 44,67,500.

25. Such being the case, and if the works proposed are practicable and can be constructed within the cost the Government interest on, the Chamber hopes that Government will give the subject favourable attention. The near completion of the Madras Harbour Works seems to afford an opportunity for taking the proposals concerning this



port into consideration for the working plant soon to be set at liberty in Madras might be made available for any works sanctioned here.

26. During the recent visit of His Grace the Duke of Buckingham and Chandos to this port, the Chamber brought the subject of this correspondence to his notice, when he was pleased to express a wish that he might have an opportunity of considering the details of the Chamber's proposals before the expiration of his term of office as Governor of this Presidency. The Chamber, therefore, respectfully requests that, if possible you will obligingly lay the proposals before His Grace at an early date.

27. The delay in replying to your letter, for which the Chamber apologizes, has been occasioned by the difficulty experienced in preparing the statement of imports and exports.

From W. T. HOLMES, Esq., Honorary Secretary, Cochin Chamber of Commerce, to the Secretary to Government, Public Works Department, Madras, dated Cochin, the 14th December 1880, No. 76.

A Notice appears in the *Madras Mail* of 11th instant that Mr. Parkes, the Consulting Engineer for the Madras Harbour Works, is to visit Beypore this month to report on the practicability of constructing a harbour there, and I am desired by the Chamber to request, that you will be so good as to obtain the sanction of Government to Mr. Parkes visiting this port also for a like purpose.

2. The Chamber trusts that nothing will be decided about the proposed works at Beypore until the proposals for harbour improvements at this place have received consideration, and the fact that this port is second in trade and importance in the Madras Presidency, whilst Beypore remains, what it always was, only a fishing village, may be deemed to give it a prior claim on the attention of Government.

3. It is open to doubt that the construction of harbour works at Beypore would ever be a remunerative undertaking, or that the produce of the Wynaad which now goes to Tellicherry and Calicut for shipment (chiefly to Tellicherry) could be diverted from those places without a railway through the Wynaad, and even that might be insufficient, for it is unlikely that curing firms established at those places will remove themselves to Beypore, and there seems to be less likelihood that they will incur the cost and risk of sending goods to Beypore for shipment when they can ship more cheaply and conveniently from their own ports.

4. Another point for consideration is the fact that there would be no produce for shipment from Beypore during the monsoon months, when it is probable the port would be quite deserted. The coffee crops usually begin to reach the coast about the end of November and are all shipped before the end of May, so that for about six months in the year the port would yield no revenue towards paying interest on capital expended in harbour construction. During the remaining months of the year shipments are now made without inconvenience from Tellicherry and Calicut,

and at less expense than they could be made from Beypore were that port converted into a harbour.

5. The construction of harbour works here might be expected to pay from the very beginning, and when this port is placed in connexion with the railway system of the Madras Presidency, of which there seems a likelihood, the existing extensive trade of the port may be expected to greatly expand. Nature having done so much for it, it is probable that this port could be converted into a first-class harbour at much less cost than only moderate works could be carried out at Beypore.

6. For these reasons the Chamber hopes that the claims of this port to first consideration will have the attention of Government before the Beypore schemes, and that Government will be pleased to allow Mr. Parkes to visit this port with a view to harbour improvements.

From J. H. TAYLOR, Esq., Lieutenant, R.N.R., Master Attendant, Administrative Department, to the Secretary to Government, Public Works Department, Madras, dated the 16th December 1880, No. 11132.

From Mr. J. H. Aspinwall, dated September 1880.

From Honorary Secretary, Cochin Chamber of Commerce, No. 68, dated 8th October 1880.

From Honorary Secretary, Cochin Chamber of Commerce, No. 75, dated 25th November 1880.

In returning the papers marginally noted, I have the honour to offer the following remarks.

2. The question of converting Cochin into a first-class harbour can only, in my opinion, be definitely settled upon the spot, for so many conflicting reports and opinions prevail on the one hand that no reliance ought to be placed upon them from a favourable point of view until the interests of Government in the other most important scale are secured.

3. I personally consider it impossible to make Cochin a first-class harbour: nature has not done enough for it. A second-class one it may already be considered during the fine season, at which period I believe nearly all trade operations are conducted.

4. I will recapitulate my chief reasons for this opinion. In the first place, independently of the bar obstruction, more than a sea mile of about 18 feet of water has to be approached and passed over from the open sea with its heavy ground swell.

5. Now the least depths that would justify a large ship in approaching the coast and making a narrow harbour mouth is, I consider, five fathoms or 30 feet, and I know no instance where so small an allowance even as that obtains at present. The removal of the bar, which is only from 2 to 4 feet less than the entire passage would not remedy this crushing defect. The Cochin Chamber put the present depth on the bar at 16 feet, but I have known it 14.

6. On the subject of removing the bar by a natural process, I would observe that the sand-spits on either side of the entrance to Cochin come up nearly to the surface to some portions, and above it in others. The contemplated walls would do very little more than guide the stream as it

is now guided, and though the bar is found much diminished after a good scour during the heavy rains of the south-west monsoon, yet it speedily reforms during the fine season and the regular return of ebb and flow. If the contemplated walls are to take the usual harbour form and, after reaching the bar, converge to a narrow opening, I see no reason to doubt that the stream thus narrowed would soon represent the only deep portion, the sides silting up as is evidenced at the Vizagapatam backwater and other places. I have marked on the chart in blue pencil the points mentioned above from A to B. Then as regards a first-class harbour, the passage between Cochin and Vypeen, where the deepest water is situated, is only 1,100 feet across, so that a first-class steamer of, say, 350 feet, even if very tightly moored in the centre, would require the whole width to swing in safety, so that only one tier could be moored in line, and pilots now experience great difficulty in avoiding collision while bringing ships in under canvas, which would be increased if a large class of ships had to be provided for. One tug, in my opinion, would be a necessity.

7. The space inside the backwater after Vypeen is passed is also extremely limited. I have drawn a blue pencil mark about where the harbour would practically end, C to D. The remainder water-space, though having holes or swatches here and there, is too shallow for use, and the holes have no leads into them. The hundreds of miles of backwater spoken of by the Chamber can, I therefore suppose, only be meant for boat traffic. The chart sent with your letter is old—1858.

8. About the section of the walls being weaker than those at Madras, I am of opinion that the Madras system of blocks cannot be used at Cochin. The sand is now near the surface and a rubble base would have no sufficient depth. The method used at Alexandria and Port Said, where large blocks are thrown in to find their own slop, would, I imagine, answer better.

9. No reliable data as to the comparative force of the sea on the East Coast and West Coasts exist, except in one instance of the small Calicut Pier, which has stood some years in the present position, the portion close to the shore having alone suffered from surf, but I am confident some of the seas we have had in Madras during the same period would have destroyed it entirely. I should have been very glad if I could have conscientiously endorsed the hopeful and confident character of the correspondence forwarded with your letter, but the points I have raised demand, in my judgment, careful consideration. Colonel Thomason does not seem to have viewed Cochin or any other Madras Harbour from a nautical point of view. If you adhere to the proposal to visit the West Coast in January in the *Margaret Northcote* with me, many subjects of great interest to Government will receive the attention that has not been properly given to them hitherto.

Order thereon, No. 2943 W., 27th December 1880.

The Right Hon'ble the Governor in Council is of opinion that no action should be taken in regard to the proposed improvements to the Harbour of Cochin until, after personal inspection by the Chief Engineer

and Master Attendant, Madras, a joint report by those officers shall have been laid before Government and considered.

2. Arrangements will therefore be made for such inspection at an early date.

3. Meanwhile the Government of India will be requested to obtain the opinion of Captain A. D. Taylor, Superintendent, Marine Survey of India, on the general question. It is understood that Captain A. D. Taylor is intimately acquainted with the port, and his observations, accompanied by the latest chart, will doubtless be valuable.

4. The Government of India have already been requested by telegram on the 18th December to forward any report and plans which Colonel Thomason, R. E., may have laid before them in connexion with his recent examination of the harbour.

G.O. No. 222 W., dated 26th January 1881.

Read—the following paper:—

From W. T. HOLMES, Esq., Honorary Secretary, Chamber of Commerce, Cochin, to the Secretary to Government, Public Works Department, Madras, dated Cochin, the 20th January 1881, No. 81.

The Chamber has had under consideration the letter from Captain J. H. Taylor, Master Attendant, Madras, dated 16th December 1880, attached to Proceedings of Government, dated 27th December 1880, No. 2943 W., and I am desired to make the following representations in answer to his remarks on the Chamber's application for harbour improvements.

2. The Chamber concurs in the opinion that the question of converting Cochin into a first-class harbour can only be settled on the spot; and is sanguine that no person coming to the study of the question with a practical and unbiassed mind can fail to be impressed with the facilities offering for such conversion. It may be Captain Taylor's opinion that it is an impossibility; but other equally competent judges who have visited the port and considered the question have formed an opposite opinion, and the weight of professional judgment is, so far, the Chamber considers, strongly against Captain Taylor. Amongst Commanders of vessels visiting the port, there is but one view of the facility with which the conversion could be effected, and Captain Taylor's opinion is the only conflicting one that has come to the Chamber's knowledge.

3. In the third paragraph of his letter Captain Taylor seems to imply that, as a second-class port, the harbour meets all requirements of trade during the season, and that during the monsoon months there are no trading operations requiring harbour facilities. If this were the state of the case, it is probable that it would be familiar to the merchants of the port, and, knowing it, they would hardly propose to Government a measure for additional taxation on their trade to pay for work which they felt to be unnecessary. It is, of course, true that the bulk of trade is done between the months of October and May, both months inclusive, but a reference to

the statistics of imports and exports at Narrakal, already furnished to Government, will show that the monsoon trade of this port (the trade of Narrakal is only the monsoon trade of Cochin) is a rapidly growing one. The imports rose from 500 tons in 1870-71 to 11,869 tons in 1879-80, and the exports from 2,300 tons in 1870-71 to 4,898 tons in 1879-80. It was owing to there being no facilities for monsoon trade that none existed prior to 1870-71, and that it has not greatly exceeded the rapid advance already made since that date is because the port of Narrakal has not furnished all the facilities required.

4. From the tenor of his remarks in paragraphs 4 and 5 of his letter, Captain Taylor would seem to have missed the purport of the Chamber's proposals, which are not only to remove the bar but to carry out a deep channel into deep water by pier walls built out into five fathoms water if necessary; in fact to provide a channel of 30 feet deep into the same depth of water which Captain Taylor admits would justify a large ship in approaching the coast. The Chamber's proposals for effecting this and its reasons for believing that they would be effective are set forth in paragraphs 3, 4, 5, and 7 of its letter, dated 25th November last.

5. The time when Captain Taylor knew the depth of water on the bar to be only 14 feet was probably when the Cruz Milagre gap was open. It has not been so low since.

6. Captain Taylor's remarks against the possibility of removing the bar and other obstructions by a natural process as contained in paragraph 6 of his letter are, in the Chamber's opinion, altogether erroneous. It is not the case that the sand spits on either side of the entrance to the backwater come so near to the surface that the contemplated walls would do little more than guide the current as it now flows; and it is difficult to understand how, with the chart of the port, before him and it may be supposed, some personal knowledge of the port, he has fallen into such an inaccurate statement.

7. Near the shore line the water on the spits is shallow; and at a little distance to the west of Vypeen point a small sand bank is visible at low water for about one month after the monsoon, formed, probably by the action of the monsoon floods on the littoral sand laden current. This bank disappears with the subsidence of the floods, and for the rest of the year there is no sand appearing above the surface of the water. Between the site of this sand bank and the Vypeen point there is a broad channel with, at present, a depth of 12 feet of water (during the monsoon floods it is more) through which sweeps a powerful current northwards. The sand spits as they proceed seawards gradually fall into deeper water until, where they join the bar, there is about as much water on them as on the bar. A reference to the chart shows a depth of water on the N. spit ranging from 4 feet at its shore end to 17 feet near the bar, and on the S. spit of from 4 feet near the shore to 11 and 12 feet near the bar.

8. Now, considering that the bar is about 1,700 yards from the mouth of the backwater, it must be admitted that, before it is reached, there is room between the top of the spits and the surface of the water for a very considerable portion of the current to pass without going near the bar at all, and, as a matter of fact, which is open to ocular demonstration every

day, much more of the current passes over the spits and through the channel round Vypeen point than crosses the bar.

9. The construction of the proposed walls, which, it may be remarked, are not intended to take the usual harbour form, but, as before stated, to direct the current, would, therefore, very materially alter the course of the current, bringing the whole of it into a channel in which but a small portion of it now flows; and there is reason to believe that this confinement of the current would effectually remove the obstructions which Captain Taylor considers "crushing defects," from the fact that, where the outflowing current is now confined, it maintains a depth of from 36 to 42 feet of water.

10. With reference to the statement, that the breadth of the passage between Cochin and Vypeen at the point of deepest water is only 1,100 feet, the Chamber begs to remark that, according to the Government chart now in use at the port, it is 1,350 feet across, and the channel has not narrowed since the chart was drawn; but there is no reason to suppose that, as a matter of necessity, a steamer of 350 feet length would be anchored in this particular portion of the harbour and be left to swing with the tide to the obstruction of navigation. Vessels would be moored stem and stern as in other places, it may be presumed.

11. Not having before it the chart on which Captain Taylor has drawn his blue pencil lines, the Chamber cannot judge what he considers to be the limited space within the backwater, but has no hesitation in affirming that there is at the present time ready space of sufficiently deep water for mooring several vessels of considerable size.

12. If a line be drawn eastward from Builder's point parallel with the Cochin shore, and terminating in a line with the corner at the end of the yards, there will be enclosed a space, inside the backwater, of 1,000 yards long by 400 yards broad, all deep water, with the exception of a small piece in the north-east corner. Supposing that every vessel visiting the port is 350 feet long and requires a length of 550 feet for a mooring, there could be accommodated within these limits eight such vessels moored in double tier, leaving ample room for passage on both sides and a space of 600 feet by 1,200 feet for ships to be turned in so that they might be berthed with their stems seaward. If, instead of confining the moorings to space actually within the backwater, they be extended down the passage between Cochin and Vypeen, where ships often now anchor, and the whole of which would become available under the Chamber's proposals, there would be a length of 1,650 yards which would accommodate sixteen ships of 350 feet moored in double tier, and leave a space of over 500 feet by 1,200 feet as a turning station. It is a mistake, however, to suppose that every vessel visiting the port would be 350 feet in length, or that there would ever be so many vessels of such size in port at once (it is probably not found so in Madras); and allowing for a large proportion of vessels of smaller size, the space pointed out would afford accommodation for a large number of ships.

13. Should more space be required with the development of trade or for other reasons, it can be obtained by the construction of training walls

and the operation of dredging further into the backwater, which operations were contemplated by Colonel Thomason, R.E., in his estimate of probable cost; and there is somewhere a powerful dredger, purchased a few years ago for use at this port at a cost of £20,000, which has never done a day's work in the port. This plan of extending the harbour accommodation might be made doubly profitable; for, besides providing accommodation for more shipping, the depositing of the mud, dredged up, behind the training walls would reclaim an area of the backwater that would be of great value for yards and would be eagerly taken up by the mercantile community.

14. Captain Taylor is also in error in his remark, "the hundreds of miles of backwater spoken of by the Chamber," for the Chamber has not made any such statement. The Chamber has stated that the backwater is over one hundred miles in length, and this reference to its length was not made with a view to make it appear that the whole of it is available for shipping, but, in a consideration of the silt question, to show that it collects all the silt brought down by the rivers and of which none passes into the sea. But many parts of the backwater are very deep particularly the wider ones, and over it is conducted on immense traffic. It furnishes water communication from British territory right through the Native States of Cochin and Travancore, and bears much of the produce of those two States to British Cochin for shipment.

15. With reference to the comparative force of the sea on the east and west coasts of South India, the Chamber is of opinion that the case of the Calicut pier, mentioned in the 9th paragraph of Captain Taylor's letter, is about as good data as need be required, but it may be supplemented by an allusion to the Alleppey pier, a construction of wooden piles without bolt or nail, the superstructure being secured by chain and rope lashings only.

16. Captain Taylor expresses an opinion that Colonel Thomason did not view the Cochin harbour from a nautical point of view. The Chamber, however, believes he viewed it from a practical point of view, and more does not seem necessary.

17. The Cochin backwater will afford facility for any extent of harbour development, if steps be taken to keep open a deep entrance channel, and the Chamber is satisfied that there is not such a favourable site within the Madras Presidency, or one that holds out so fair a prospect of success and reasonable return on capital expended.

18. The Chamber begs to express its obligation to Government for having sanctioned an early inspection of the port, but it regrets to observe that Captain Taylor has already committed himself to the opinion that it is impossible to make Cochin a first-class harbour for reasons which are now shown to be fallacious.

Order thereon, No. 222 W., 26th January 1881.

Communicated for the information of Captain Taylor, R.N.R., who will take into consideration the arguments in favour of a harbour at Cochin as now advanced by the Chamber of Commerce, and state his views thereon after visiting the port in company with the Chief Engineer.

(True Extract.)

R. H. SANKEY, Colonel, R.E.,
Secretary to Government, P.W.D.

G.O. No. 911 W., dated 4th April 1881.

Read—the following paper:—

From W. T. HOLMES, Esq., Honorary Secretary, Chamber of Commerce, Cochin, to the Secretary to Government, Public Works Department, Madras, dated Cochin, the 19th February 1881, No. 87.

Referring to the meeting which the members of this Chamber had with you and Captain Taylor, R.N.R., on Saturday, the 5th instant, I now, by desire, have the honour to offer the following observations on the various points which you left for further consideration by the Chamber.

2. The first in order is the question whether the floods in the backwater bring down such silt as, depositing outside the entrance, now forms the bar. The Chamber has already expressed a very decided opinion that no such silt is discharged from the backwater, and its opinion on this point was not in any degree shaken by the opposite views expressed at the meeting referred to.

3. At the meeting there were produced by the Chamber two bottles of floodwater taken from the mouth of backwater on the 4th December last. Between that date and the 20th November preceding there had been a fall of upwards of 8 inches of rain over the district between Cochin, Alleppey, and the Travancore hills, and the rivers from the hills being in heavy flood, there was being discharged from the mouth of the backwater an usual monsoon flood.

4. The samples of water which were drawn in the presence of the Master Attendant of the Port were as bright and clear as water can be. A few particles of substance were contained in them, but not sufficient to form the thinnest film over the bottoms of the bottles, or when shaken up to at all cloud or discolour the water. The taste of the water was but slightly brackish, a fact which may be noted as a proof of its being floodwater, for in the absence of floods the backwater becomes salt to a distance of 30 to 35 miles from Cochin.

5. The appearance of this water was not considered by you as at all confirmatory of the Chamber's statement, because (1) you deemed it probable that the silt, being heavy, might not be held in suspension by the waters, but by the strength of the current might be rolled along the

bottom of the backwater, and (2) because inside the backwater you had observed along the shore obstructions placed with a view to causing reclamations by the deposit of silt.

6. In reply to the first objection the Chamber begs to observe that such rivers as the Hoogly, Gōdāvari, Cauvery, Indus, and perhaps all other rivers that are known to bear down silt, and, in consequence, to have bars at their mouths, run during flood time in turbid streams which discolour the sea for considerable distances from shore. In like manner run the rivers which discharge into the Cochin backwater.

7. But the Cochin backwater ranges from 2 to 15 miles in width, and over these broad areas, some of which are from 30 to 50 feet deep, the current is necessarily slow, and in passing them the floodwaters deposit all their silt. If, however, it can be urged that the current over such places is so strong as to roll heavy silt from the bottoms of such deep pools and over steep banks, it must be admitted that it is also strong enough to keep in suspension lighter particles of silt, in which case the floodwaters discharged from the mouth of the Cochin backwater ought to present the appearance of the floods from the rivers which have been referred to. The fact that they do not present such appearance is proof, in the Chamber's opinion, that the objection of rolling silt on the bottom of the backwater is untenable.

8. With reference to the second objection, it may be mentioned that during the monsoon months there is of necessity a wash from the lands on the margin of the backwater, and where there are no protective works there must be some attrition of the shore, regulated by the strength of the current. During flood-tide, too, a certain amount of sand is rolled in from the sea along the shores. These are the materials which form the reclamations referred to, sided by mud, excavated by hand from the bottom of other parts of the backwater. In this view, which the Chamber believes to be the correct one, the reclamations lend support to the statement that no silt is discharged from the mouth of the Cochin backwater which, by depositing outside, forms the bar.

9. The next point to be considered is the objection that the construction of the works proposed by the Chamber would not alter the direction and strength of present forces, and that, therefore, the bar must re-form, the time required for it to do so being regulated by the length of the breakwaters.

10. The Chamber is not prepared to allow that, with groynes thrown out to the length and depth contemplated, the present forces will remain unaltered. The bar is now formed and re-formed by sand forced into mechanical suspension in the water owing to the action of the surf on the coast, and then being carried by the littoral current across the backwater's mouth where, meeting with opposing currents, the sand is at once deposited. This being so, the groynes once prolonged beyond the effect of the surf on the bottom, the re-forming action becomes, at any rate for a time, impossible.

Mr. Robertson says, page 31 of his report:—"Were the current to be kept together in full strength till it got into such a depth of water that the action of the waves was not sufficiently powerful to stir up the bottom there would be no decided bar."

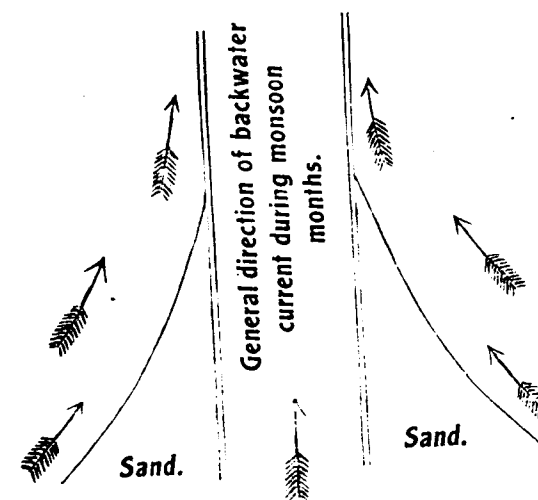
11. If it be urged that the littoral currents would still bring up the sand and deposit it north and south of the groynes, increasing the breadth of the beach until the profile of the coast extended to the sea end of the groynes, and would there re-form a bar, the Chamber submits that such action must be the work of a great length of time; that the coasts north and south would have to be eroded to an unprecedented extent before the materials could be obtained for such an extensive filling in; and these coasts are protected for some distance by the small groynes already in existence. Again, the bottom of the sea is nothing but mud, and could lend no material for the purpose.

12. The same action around the Madras Harbour Works has been estimated, the Chamber believes, to require about two hundred years; and at Cochin, where there is a slower littoral current and the proposed groynes longer, an equal time may be necessary, even though the depth of water be less.

13. Moreover, supposing this filling in to have taken place, the profile of the coast would then be altogether different to what it now is, for it would exhibit two tolerably sharp curves along the contour of which the littoral currents would be forced to sweep, and the sand which they would carry would be deposited, not in a line running at nearly right angles to the scour in and out of the river, but into lines which, with the assistance of that scour, would form for a long distance prolongations of the groynes, and thus assist and not obstruct the endeavours to form a good harbour.

14. The common belief that the mud banks of Narrakal and Alleppey have been the work of rivers depositing their silt at these places is, the Chamber thinks, erroneous; as far as Alleppey is concerned, it has no river near it.

15. It is a well-known fact that the bottom of most of the Cochin extensive backwaters is a deep bed of mud, similar in every respect to the mud composing the banks at Alleppey and Narrakal. It is also a pretty well ascertained fact that the strip of sand which separates the backwaters from the sea was a long distance further to the west than it now is, and that



the sea has encroached. Nothing, therefore, is more likely than that the mud banks of those two places were once bottoms of backwaters.

16. Some stress was laid on what was said to be a fact that in no part of the world had bars to rivers been got rid of. But the Chamber does not consider this to be an overwhelming argument against the proposed

works for Cochin for in the case of this port the circumstances to be dealt with are not such as are met with in other parts of the world. Cochin is an exception in many ways to everything met with elsewhere—

First.—Cochin has no river strictly speaking, but only an opening from the backwaters to the sea.

Second.—The extent of backwater which has to be filled and emptied every tide is altogether unprecedented, thereby giving an impetus to the ebb and flood unknown elsewhere.

Third.—No ascertainable silt is deposited.

Fourth.—The bottom of the sea is mud, not sand.

Fifth.—Cochin has both to the north and south a safe anchoring ground in smooth water for vessels in case of weather so bad as to make it unwise to risk an entry into the harbour.

Sixth.—The wind during bad weather is invariably fair for ships entering the harbour.

Seventh.—Cyclones are absolutely unknown.

17. The Chamber, in its letter of 25th November 1880, No. 75, paragraph 16, estimated that about one-third of the trade of the port is conducted inside the mouth of the backwater, and allowed for the less lighterage such trade has to bear in the average of the lighterage paid on the whole trade of the port. The one-third includes both British and native trade, whether carried in British or native craft. The native craft, being of small tonnage, is able to come close in shore, and so to a large extent incurs much reduced lighterage, but the number of such vessels is rapidly diminishing owing to their inability to compete with the coasting steamers, and it is only a matter of a few years when the native carrying trade between all ports visited by steamers will practically have ceased to exist. The following figures warrant this anticipation.

Native vessels frequenting the port of Cochin :—

	No.	Tonnage.	Port dues.
1876-77	863	45,224	4,234
1877-78	736	34,815	3,263
1878-79	741	35,010	3,282
1879-80	496	25,060	2,347

These vessels never venture to sea during monsoon weather, say, for five months in the year.

18. The Chamber is having prepared a statement of the value of the trade carried by this class of vessels during the past two years as compared with the total value of the trade of the port, which, when completed, will be forwarded to you.

19. A meeting of native merchants was convened by the Chamber on the 11th instant, when the Chamber's proposals to Government were formally laid before them for expression of their opinion thereon. To the most influential of the body the proposals had been fully explained some days previously, and they were requested to give them every publicity in

the bazaar. At the meeting the following resolution was passed, and a certified copy of the proceedings is attached hereto :—

“Having had explained to us the details of the scheme for the improvement of the Cochin Harbour which has been prepared by the Chamber of Commerce, we are of opinion that the proposals are in the interests of the native mercantile community and merit their support. We fully endorse the views expressed by the Chamber in their communications to Government on the subject of the dues which the trade of the port can bear to pay interest on the cost of the proposed works, and are confident that the interests of the native mercantile community in this matter can be safely left in the hands of the Chamber of Commerce.”

20. In considering the claims of the respective interests, Europeans and Native, on Government in connexion with the proposals for harbour improvement, it should be borne in mind that only few of the principal native merchants of Cochin reside and carry on business in British territory. The majority are subjects of the Native State of Cochin, and whilst enjoying all the advantages of a British port for their sea-borne trade, the opportunities for trade opened out by British enterprise, and, in fact, owing their whole prosperity as traders to their contiguity to a body of British merchants, contribute but little to the Imperial Revenues of India. On these grounds, if their views had been antagonistic to the proposals put forward for the improvement of the port, the Chamber would have been prepared to urge the prior claims of the interests of British subjects over those of a foreign State on the consideration of the British Government. Native merchants, however, have recognized that their interests are identical with those of British merchants in the Chamber's proposals.

21. The extra charge of one anna per ton proposed to be levied on vessels visiting the port ought to be specially assigned to the port, even though there be no change in the grouping of western ports. All that the Chamber has to propose is that the earnings of the port be applied to its improvement, and arrangements to effect this would seem a matter of account and not difficult.

22. In the present system of grouping the ports on this coast it does not follow that the amount of port dues collected in Cochin represents more than its proper earnings. Coasting vessels do not always pay their port dues in Cochin. Having paid the dues here once, the next time they become payable the vessel may be at any one of the other ports of the group, and there they are levied. Each port has its chance.

23. Whether the trade of the port can provide not only interest on the cost of construction, but also cost of maintenance of works and allowances to establishment, the Chamber cannot say, not having an estimate of the capital required. The Chamber has shown, on an average of the trade of the port for ten years, about what the port can now provide, and there is reason to believe that such improvements as have been proposed would increase the trade and also the revenue. On the figures which have been furnished it is for Government to decide, after obtaining estimate of cost, whether the trade can bear all the charges referred to.

24. But supposing the estimated revenue falls short of the required sum, the Chamber would urge that, as the proposals they have made merit the attention of Government from an imperial point of view, Imperial Revenues should be charged with the deficiency, which it is anticipated cannot be large.

25. The Chamber in putting its views before Government do so in what is believed to be the interests of the port and the whole mercantile community, but at the same time cannot fail to notice the fact that the harbour improvements advocated, while benefitting the local trade, would also be of essential importance to the whole of South India, connected with it as the port is likely soon to be by rail.

26. In case of war with a naval power such a land-locked harbour, centrically situated between Bombay and Trincomalee, would be of inestimable value as a harbour of refuge where ships could repair and refit, and as a resort for our ships of war; and its nearness to Aden, being about two days nearer than Bombay by homeward bound steamer routes during monsoon months, points it out as a port possessing every capability for becoming of very considerable importance.

27. The Chamber had not had an opportunity of perusing Mr. Robertson's report on the port prior to your visit, and the copy kindly lent by Captain Taylor has been read with considerable interest. The favourable opinion of such an authority the Chamber trusts, will have great weight with Government, and lead them, before deciding against the Chamber's schemes, to appoint a practical expert to inspect and report, if further report is thought necessary. If Mr. Parkes or Mr. Thorowgood of the Madras Harbour Works could be deputed to this duty, he would be able to make an approximate estimate of cost, and his practical experience would enable him to put a true value on the objections raised and the arguments used to overrule them. He would be able to properly estimate the great advantages of the port and suggest the best means of making the most of them.

28. Steps are being taken to obtain the views of Commanders of vessels visiting the port on the points on which a nautical opinion is desired, and the opinions which may be received will be forwarded to you.

Proceedings of a Meeting of European and Native Merchants of Cochin held in the Office of the Municipal Commissioners of Cochin on the 11th February 1881 to consider the interests of Native Mercantile Community in the proposals made to Government by the Local Chamber of Commerce for the improvement of the Harbour of Cochin.

Present:

G. BRUNTON, Esq., IN THE CHAIR.

J. H. Aspinwall, Esq.
W. T. Holmes, Esq.
G. A. Jung, Esq.
O. M. Raphaels, Esq.

J. R. Oughterson, Esq.
Veerjee Kanjee, Esq. (Mooljee Jatta & Co.)

Hassary Deevjee, Esq. (Samjee Padomsee & Co.)
Hadjee Moosah Haji Hamed Esq.
Damjee Ramjee, Esq. (Damjee Ookah & Co.)
Maljee Kasavajee, Esq.,
Vishnoo Kasava Sampla, Esq.
Jenardina Govinda Goket, Esq. (Vishnoo Denaka Devada).
Pundaling Ramjee, Esq.

Harri, Vasoodeva Preboo, Esq.
Leckmena Babajee, Esq.
Opendra Shetty Ganapathy, Esq.
Ramachandra Maha Deva, Esq.
T. V. Peechoo Putter, Esq.
Dharsee Ketsee, Esq.
C. A. Perreira, Esq.
P. Vieyra, Esq.
G. Lafrenais, Esq.

The Chairman explained the details of the Chamber's proposals for harbour improvements, and invited any gentleman wishing for further information to inquire for it; after some discussion it was proposed, in behalf of the Native mercantile community, by Mr. Hadjee Moosah Haji Hamed, and seconded by Mr. Veerjee Kanjee, that—

“ Having had explained to us the details of the scheme for the improvement of Cochin Harbour which has been prepared by the Chamber of Commerce, we are of opinion that the proposals are in the interests of the Native mercantile community and merit their support. We fully endorse the views expressed by the Chamber in their communications to Government on the subject of the dues which the trade of the port can bear to pay interest on the cost of the proposed works, and are confident that the interests of the Native mercantile community in this matter can be safely left in the hands of the Chamber of Commerce.”

The resolution on being put to the meeting was carried unanimously.

G. BRUNTON,
Chairman.

Report on the Cochin Harbour.

In compliance with the decision of Government conveyed in G.O. of 27th December 1880, No. 2943 W., we, the undersigned, inspected the Cochin Harbour on the 4th and 5th instant, and on the latter date had the advantage of a very complete discussion of the several points at issue with the Chamber of Commerce, several of the leading native merchants being also present on the occasion.

2. Prior to our arrival the Chamber of Commerce had submitted their letter, No. 81,* dated 20th January 1881, combating the views put forward by the Master Attendant in his letter of the 16th December 1880, No. 11132, printed with the previously quoted Government Order, and again they have in a still later communication explained very fully their views in the Honorary Secretary's letter, No. 87, dated 17th instant dealing with some of the most important points discussed in the conference of the 5th instant.

3. Unfortunately Commander A. D. Taylor, whose presence was specially desired by Government, and whose advice would have been

* G.O. No. 222 W., dated 26th January 1881.

most useful to us, was unavoidably detained in Calcutta. He has, however, telegraphed to the Master Attendant expressing general concurrence with his views regarding the Cochin Harbour.

4. On the whole, we believe that we have obtained a sufficient knowledge of the locality, and of the views of those who are most interested in the question of a harbour, to indicate the points on which future discussion must hinge, and thus at least narrow the issues in a way that will enable Government to obtain the opinion of experts like Commander A. D. Taylor in this country, and, if necessary, of professional men in England, before committing themselves to a final decision.

5. The previous printed reports, as also that by Mr. George Robertson in 1871, will have already sufficiently explained the physical features of the present port of Cochin and its exceptionally large backwater; we shall therefore, at once proceed to state the facts that have come under our notice as bearing upon the question of the proposed harbour, and the inferences we have drawn therefrom.

6. On the morning of the 4th February 1881 we found two vessels anchored, as stated to us by the Port Officer, at not a less distance than $1\frac{1}{4}$ miles west of the bar, which again, was not less than 1,300 yards in a direct westerly direction from Light-house point.

7. Our own small steamer, the *Margaret Northcote*, anchored 1 mile west of the bar apparently just at the limit of the 5 fathom contour, as the soundings taken in proceeding inwards towards the bar clearly indicated.

8. The buoys at north and south ends of the bar showed it to be 385 yards in length, the water shoaling sensibly beyond this limit on either side. At half tide the minimum depth of water was found by us to be 14 feet or somewhat less than 13 feet at low water.

9. The last monsoon being of more than usual strength the bar seems to have been forced back 20 yards closer to the shore than during the previous year, when it was 1,500 yards west of light-house point, and seems to have had a minimum depth in it of 16 feet.

10. Mr. Robertson, it will be observed, found only 11 feet on the bar, but as the Cruz Milagré gap was then open, this may be considered as less than what may be fairly calculated on in ordinary seasons; but it must be borne in mind that very extensive reclamations have for a long time been in progress in the Cochin backwater, and as the area over which the flood tide has to spread is thus being gradually though probably not as yet very sensibly, contracted, the volume of water poured out at the mouth has a tendency to be decreased, and with this decrement, both the velocity and scouring power must diminish. It must also be borne in mind that the whole of the backwaters being within native territory, the influence of the Madras Government in limiting or controlling the reclamations can at best be only indirect. These facts must have weight in deciding on any harbour scheme that may be devised.

11. Immediately on the bar we found the material brought up by a diver to consist of rather coarse sand and shells, but there is nothing here or in any of the surrounding country to indicate that laterite or any kind of rock underlies the bar at a depth that would call for removal. Outside

to seaward there would appear to be mud in a very fine state of comminution not unlike that found at Narrakal to the north. This may, as supposed by the Chamber of Commerce, have anciently been a backwater though there is every reason to suppose that it also consists or has been added to by the continued though yearly small deposits of silt carried over the bar in the height of the monsoon.

12. North and south of the general run of the deep channel between the actual mouth and the bar, the shoals, though necessarily varying somewhat in contour from time to time, continue pretty constant in extent and position, and so far as we are able to judge, there is apparently no tendency for the effluent water to take any other direction or establish a new channel. The narrow channel adverted to by the Chamber of Commerce as passing in front of the long groyne at Vypeen point, and stated to be sometimes used for boats, is, we find, merely trifling excavation due to the swirl of the ebb water at the spot, and only to extend a few yards. Its existence can have no bearing on the question of a harbour.

13. There are seven long and one short groynes at intervals along the beach on the south side of the mouth (the Cochin side), and one long and nine short groynes on the Vypeen side. With the exception of the long one above mentioned (which rather requires looking after as it is not in good repair) they seem to have done the work fairly in correcting encroachment, but call for no remark in reference to the object of our immediate inquiry.

14. The pot-hole shown on all charts to exist within the immediate limits of the mouth, ranging from 28 to 49 feet in depth still appears to exist in much the same form as in previous years, though possibly the actual line of deep channel here may vary a little. Holes of this character, due no doubt to down or reflex currents which are found to exist in all cases of obstruction like a bar to the effluent water (in bridge, piers, etc.), are apparently very constant in all similar cases along the coast. Mr. Robertson notices the deep pot-hole which was found at the Cruz Milagré Gap while there was a bar outside with only 2 feet of water on it. Numberless other similar instances can be adduced, and we are satisfied that no arguments based on such facts, as the existence of holes of this character, can have any bearing on the feasibility or otherwise of forming a harbour. They are directly produced by the bar in front, and were this latter removed there would, in our opinion, be no down or reflex currents tending to form such holes, which consequently would in that case fill up to the uniform level of the bed throughout.

15. We now come to deal with the proposals put forward for the formation of a first-class harbour, and in regard to this we may at once say that the chief result of the conference held at Cochin on the 5th instant, has been recognition of all concerned, as to the necessity which exists for carrying out any breakwaters that may be constructed, (with a view to confining the ebb stream and sweeping away the bar) into a depth of 5 fathoms, it being clear that under no other conditions could it be expected that the harbour should prove of use to vessels of large draught during the south-west monsoon or whenever there was any swell. In regard to this point it is only necessary to refer to the statement contained in paragraph

4 of letter No. 81, from the Honorary Secretary, Chamber of Commerce, dated 20th January 1881, where it is observed that their proposals "provide a channel of 30 feet deep into the same depth of water".

16. The reasons which have led to this decision have already been sufficiently dwelt on in the letter from the Master Attendant of the 16th December, and need not be recapitulated; but it must be observed that the acceptance of the principle, alters materially the question regarding which we have been called on to offer our opinion; as the extra expense due to the additional two miles of breakwater (one mile on north and the same at least south) which on the suggested plan would have to be carried out, so as to reach the five fathom contour line, renders it hopeless to expect that the funds derivable solely from local imposts could possibly suffice to defray the $4\frac{1}{2}$ per cent on capital outlay as required by the Government of India for including the work under the head "Productive."

17. In the absence of a complete estimate an opinion of this kind can of course be only accepted for what it is worth, but we have no reason to think that the Chamber of Commerce themselves would be indisposed to accept this view, as in their correspondence they have dwelt on the necessity of economising on the outlay proposed for their original scheme, embracing certainly not half the work now seen to be essential, in order to bring it within the local means.

18. From 50 to 60 lakhs would in our opinion be the least which such works would in all probability cost, and if to this be added the usual indirect charges for interest of money while the work is under construction, etc., as ordered by Government to be shown in all like cases, we feel we are not in any way over-stating the matter when we affirm that 70 lakhs is the least amount which the works would cost; and as the local imposts would have to meet not only the interest charge $4\frac{1}{2}$ per cent on this but also provide means for covering such extra charges for maintenance, establishment, etc., as may be necessary, for the future, there is no hope of this being done in the manner suggested by the Chamber of Commerce, solely from local resources.

19. But as it is quite open to the Government to deal with the work as one of sufficient Provincial or even Imperial importance, a view that the Chamber of Commerce have strongly pressed we feel it right to point out certain considerations which under this aspect of the question seem to us to call for attention, before it would in our opinion be desirable to frame any estimate.

20. In this sense we will consider the scheme in its present form to consist of the construction of two long breakwaters running parallel to each other or nearly so, say 400 to 450 yards apart, into 30 feet depth of water, so as to concentrate such scouring power as may exist in the ebb tide, with a view to the removal of the present bar, and to maintaining this depth throughout the year.

21. The difficulties we have felt to exist in regard to any scheme of this character are—

(1) The construction of breakwaters on this plan would neither change the volume nor the velocity of the stream which now issues

through the mouth, in spite of which the present bar has been formed. The natural and inevitable tendency would therefore, we consider, be to the reconstruction of the bar, and gradual reproduction of much the same condition of matters as now exists only a little further out to sea.

(2) The removal of the bar were such ultimately possible, would allow of rollers, entering the new mouth during the south-west monsoon, to advance unchecked right up to the easternmost extremity of the harbour so formed; and we are thus of opinion that the entrance of any vessels at such periods between the pier heads would be an extremely hazardous and even dangerous proceeding; excepting during ebb tide with steamers or sailing vessels assisted by steam tugs. This condition would seriously diminish the value of the harbour as one of refuge. Again all shipping inside the harbour as proposed would be exposed to the full force of these rollers, and the anchorage or wharfage be in consequence rendered extremely inconvenient, if not unsafe.

(3) From the manner in which the breakwaters are proposed to be carried out we consider that no future dredging of any practical value would be possible.

22. In dealing with the first of the above difficulties, it may be as well at once to say that too much stress has been laid by the Chamber of Commerce, on the supposed formation of the bar as being directly caused by the deposit of silt brought down by the river.

23. No weight has ever been laid by us on this point which only incidentally cropped up in reference to Vizagapatam (the Government Order connected with which was communicated to the Chamber of Commerce for general information only prior to our visit), the conditions of which are different, as it has a river often necessarily charged with silt discharging through the mouth.

24. No doubt the great Cochin backwater does act as a very complete settling bed for silt as urged by the Chamber of Commerce, but it cannot do so wholly, and we are unable to admit the argument employed by them as to the formation of the present reclamations inside the backwater, being due to sand carried in from the sea as stated with the flood tide. The ebb tide assisted by river freshes especially during the monsoon, must of necessity be a much more powerful agent for moving all matters in suspension (as being greater in volume and velocity) than the flood tide, and to suppose that more material is carried into the backwater, than is discharged from it, is opposed to all physical laws.

25. It is not, however, necessary to pursue this subject further. So far as the actual formation of the bar at Cochin is concerned, this factor may be entirely omitted, as the existence of this, like every other bar here and elsewhere in all parts of the world, is mainly, if not entirely due to the action of the surf.

Mr. Robertson observes with reference to this that "the surf is always striving to restore the natural profile of conservancy of the shore. After the current has flowed out to sea for nearly a mile, it is no longer able to resist and keep down the ever working and powerful efforts of the waves to re-form the profile of the coast, by continuing the beach line which has been broken through by the outgoing current."

26. In a paper by Mr. I. J. Mann, C.E., it is shown that while this statement would meet with very general acceptance of all professional men, the explanation of the causes leading to the establishment of bars has been various. It is, however, needless to advert to more than one of the various authorities on this subject, viz., Mr. D. Stevenson, who attributes the formation of all such bars solely to the action of the sea. "The waves" he observes, as is well known, throw up "a girdle of light or heavy material. . . round every bay and headland of our (English) coast, and the entrances to rivers form no exception. The effect of this constant action of the sea is to form a continuous line of beach across the mouths of our tidal rivers and inlets." He does not appear to attach any importance to river currents as agents in the production of bars observing that "a bar would be formed *although the outgoing current held not one particle of matter in suspension.*"

27. It only requires a glance at any good chart, exhibiting in detail the debouchures of all our rivers along both east and west coasts on this Presidency to show that, wherever the shore is made up of sand or easily moved material, and is unconfined by rock or other obstruction, the tendency always is for the rivers on approaching the coast to turn suddenly to the north, and often not for miles find an exit to the sea. This as is well known is due to the superior power of the south-west monsoon which by induced sea currents, driving the sand before it below the surface, and by the wind acting on all exposed sand above, advances the sand-spit at the mouth further and further northward till a certain point is reached, when the river bursts out again south and the advance northward recommences.

28. In Mangalore we have lately been able to show that the movement northward of the river mouth due to this action, has apparently been pretty steady at the rate of 300 feet per annum during the last 54 years. But without multiplying instances it will probably suffice to note, as now clearly established—

First.—that whether the effluent stream contains material in suspension or not, the tendency is for a bar to be formed, wherever the forces of the surf on one side and the stream on the other sufficiently neutralize each other;

Second.—that the sand forming such bar is carried chiefly from south to north across the line of the normal direction of the debouching river. The contention of the Chamber of Commerce, in paragraph 13 of their letter No. 87 of the 19th instant, that "the currents and deposits at the ends of the proposed groynes would thus assist and not obstruct the endeavours to form a good harbour" is therefore in our opinion not borne out by the facts as now explained.

29. It may, of course, be fairly contended that there is a certain depth below the surface at which the wave action is nil, and there is no sensible amount of sand in movement at such depth. This is practically the contention of the Chamber of Commerce, and it is at first sight supported by the following observation of Mr. Robertson to warrant consideration, viz., that "were the current kept together in full strength till it got into such a depth of water that the action of the waves was not sufficiently powerful to stir up the bottom, there would be no decided bar."

30. Mr. Robertson does not, it will be noted, say at what depth of water such action may be expected to cease, and in the plan he proposes for a harbour at Cochin, he evidently considers that the groynes suggested would not reach this undisturbed depth, as he observes that "a little dredging or raking" will be needed to preserve the depth of channel. (In connexion with this remark it may be parenthetically observed that Mr. Robertson considered that the effect of the works suggested by himself would only secure a depth of from 20 to 21 feet at low water, which it is unnecessary to say would be wholly insufficient for a first-class harbour).

31. Without a series of very carefully conducted experiments, it would be impossible to decide this point in a manner sufficiently conclusive to satisfy every one, but in the paper before adverted to by Mr. Mann, there is a good deal of evidence to show that wave action is felt at depths hitherto apparently unsuspected.

32. Without overburthening our report with quotations, it may be sufficient to say that among the evidence adduced, it seems that on the banks of the Newfoundland the agitation during storms has been known to affect the bottom at a depth of over 80 fathoms; at St. Jean de Luz in the Bay of Biscay over 160 fathoms; and at Land End the lobster traps are frequently filled with coarse sand and shingle during heavy ground swells in depths of 30 fathoms. Sir G. Airey mentions also that ground swells frequently break in a depth of 100 fathoms.

33. We do not wish it for a moment to be understood that looking to the general character of the seasons on the west coast, and the immunity which it appears to enjoy from cyclones, that disturbance may be expected at depths such as these; but accepting the fact that the south-west monsoon sets in at times with considerable abruptness and strength, we are not prepared to say that on such occasions the sea bottom is not agitated at five fathoms in depth. In fact we incline to the opinion that unless there be some very direct proof to the contrary, such may be accepted as almost certain to be the case, especially considering the very shelving character of the west coast, which in this respect differs materially from that found near Madras, and most of the east coast, and that it would therefore behove Government to hesitate in adopting a scheme which, perhaps a single season of an unusually heavy monsoon, might render nugatory.

34. Dredging, as we shall presently show, is not apparently available for deepening channels situated like the one proposed with mouth open to the sea and exposed to swell; consequently if it be desired to give a prolonged life to the harbour with works of this character, it would be desirable not to stop the groynes in 5 fathoms, but to run them out another half a mile into $7\frac{1}{2}$ fathoms (which is the same as that adopted for the Madras Harbour) as the best available expedient.

35. We now beg to turn to the second set of difficulties which has presented itself to us, viz., those which would probably be felt by every master of a vessel, approaching a harbour of the proposed character during the south-west monsoon, or in fact at any time when there was a heavy sea and wind.

36. It will be remembered that the essence of the proposed scheme is to preserve an uniform section of channel into deep water, so as to maintain, as far as possible, intact the scouring power of the effluent water, and keep the whole as clear as possible of deposits. However the direction of the groynes might be varied, this must in the main be the guiding principle so as to sustain the validity of the grounds on which the scheme is based.

37. But if this be so, there must be an exposed mouth and a long channel up which the seas must sweep with uninterrupted swing, till they gradually die away or become dispersed by the shoals of the backwater, at the extreme east end of the harbour. Mr. Robertson clearly indicates this difficulty, when he observes that "it must be remembered that in reducing a bar we take away a kind of breakwater in front of an entrance and introduce a bigger wave."

38. A strong opinion has already been expressed by the Master Attendant on this point, and statements have reached us of the extreme difficulties and dangers which comparatively small craft have experienced in approaching the present mouth of the port in the monsoon, though having plenty of sea room to work in and able by their small draught to double sharp round to south-east end of the channel, after passing through the mouth and bring up in a perfectly sheltered anchorage, none of which advantages would be open to large vessels entering the harbour under the proposed scheme.

39. As directly bearing on this point, we would now quote the following observations from a report by Commander A. Dundas Taylor in reference to the proposed ship canal between Ceylon and India, dated 28th July 1871, viz., "To examine the sea approaches and thus to determine the accessibility of a port, is a first essential, and comes within the province of the Marine Surveyor. A glance at the plan which exhibits the sites of all proposed schemes (for Pamban) will explain how unreasonable would be the tax upon a Master Mariner's skill, in seamanship and navigation, when attempting to enter either of the openings, which were submitted to the consideration of the Parliamentary Committee. . . . I am convinced that mishaps would have attended any attempt to shoot the canal's mouth when the monsoon swell and current accompanied the steamer."

40. It is needless to say that the dangers thus foreseen with reference to Pamban, would have equally to be counted on and disposed of, in dealing with any harbour scheme for Cochin.

41. The third and last difficulty as to the impossibility of carrying out satisfactorily dredging operations, in a channel exposed to heavy swell, is more easily disposed of. No dredge so far as we are aware has yet been devised for working satisfactorily in such positions. With all the adjustments that it may be possible to make, any sudden jerky movements in the vessel must communicate themselves to the bucket ladder, and produce strains which would very soon break up the strongest framing of this character. On a few quite still days, aggregating say, six weeks in the year, a dredger like the *Albuquerque* might work, but it must be obvious that this would go but a small way to meet the requirements of the case.

The *Albuquerque* dredge with her side anchors and cables would moreover by herself take up 800 feet in width of the channel when at work and thus seriously impede traffic.

42. After the foregoing exposition of our views, which owing to the very able manner in which the Chamber of Commerce have stated their case, we have found it desirable to detail at greater length than might under other circumstances have appeared necessary, it is needless to say that personally we feel ourselves unable to recommend the scheme put forward by that body, and that consequently it is at least at this stage unnecessary to go into any of the engineering details.

43. It does not, however, necessarily follow that the rejection of this particular scheme would invalidate all others. We are given generally to understand for instance that Mr. Parkes is under the impression from the papers sent him by the Chamber of Commerce, that a plan by which the bar might be sheltered and then removed by dredging, somewhat in the same way as in his Kurrachee harbour, might be feasible; and although it would probably take some time to mature a scheme of this nature, we are not prepared to say that with abundant means at disposal, a harbour based on this principle might not have a good deal to recommend it. The general principle whether applied in the form of a detached breakwater entirely shielding the bar from the action of the surf or otherwise, has certainly more to recommend it than the one we have been considering, though the latter might under certain conditions be either wholly or in part incorporated with it.

44. All we are now concerned with however is whether with this new light on the subject, it would be desirable to have the details of the scheme worked out by Mr. Parkes.

45. It can hardly be questioned that the cost of constructing such a breakwater out to sea as would admit of the bar being entirely sheltered, and of the whole of the stuff being dredged out (this would be by far the cheapest part of the operations) must if anything be greater than what we have before named as likely to be required in the scheme we have been obliged to condemn.

46. The question again therefore arises as to whether any provincial or imperial subsidy can be looked for in aid of the local resources, which would certainly be insufficient for the execution of a project of the kind. The Chamber of Commerce urge strongly their claims for a subsidy of this character, and in the late minute by the Honorable Sir Andrew Clarke, the necessity of creating a certain number of harbours of refuge along our shores, to meet the exigencies of war has been seriously pressed on the attention of the Government of India. It appears to us, however, that it would be exceedingly difficult to render an open place like Cochin defensible against an enemy's vessels, which stealing insufficiently close at night could easily injure the place without running much risk themselves. Trincomalee is in fact so far as we are aware the only harbour between Bombay and Calcutta which naturally lends itself to such an object, and which would be at once perfectly secure and easy of access.

47. We can only therefore say that if the Government, after weighing what we have advanced, still consider these claims sufficiently well

founded, and there be any probability that they will be recognized by the Government of India, it would be difficult to find a more able professional Harbour Engineer for drawing up a complete scheme, and framing an estimate of the probable cost, than Mr. Parkes.

48. There would in our opinion be no sufficient object gained in going minutely into a discussion of ways and means for meeting interest on outlay, at this stage of the enquiry especially as under the proposals put forward by the Chamber of Commerce in the letters printed with G.O. No. 2943-W., dated 27th December 1880, there are several points involving not a little complexity, regarding which our information is incomplete.

49. We took advantage of our visit to Cochin to inspect the singular mud bank at Narrakal, situated some six miles to the north, and which for the last few years has been used by the merchants for shipping and landing goods throughout the monsoon.

50. There is backwater all the way to within a quarter of a mile of Narrakal, where the Cochin Government have cut a boat canal across the sand-spit separating it from the sea, and constructed covered passage with tramway from this close up to the beach, as also a small landing pier. The very serviceable condition of this latter work after three years wear and tear, shows that at least in that period there have been no heavy seas at this point.

51. The bank consisting of the very finest mud (of a greenish-black colour and very unctuous to the touch) seems so far as can be ascertained to extend about three miles along the shore from south to north, and four and half miles out to sea. It has not apparently shifted its position as seems to have been the case with other similar banks notably that which though known to have been at Alleppey some twenty years ago, has apparently moved seven miles south to Porcad, and is still believed to be progressing gradually to the south.

52. The effect of the bank on the portion of sea covering it is singular, as at the first burst of the monsoon there is said to be the same surf as in other parts of the coast; the water is discoloured and dark with the churned up mud. But after this stage has passed this seems to settle down and becomes clear like the rest of the neighbouring sea. Some persons consider the surface has an oily look at this time, and others that air bubbles, stems and branches of apparently submerged trees rise to the surface, etc., but of none of these statements is there any distinct proof.

53. What, however, appears certain is, that the full characteristics of this tract in providing a perfectly quiet anchorage during the monsoon are not fully developed till the monsoon has sufficiently advanced to render the water in the backwater on the land side quite fresh, and that during this period the water on the bank out to sea is also so fresh, as to lead to the conclusion that such water at this time rises from the bottom under pressure.

54. The effects, however, are that the monsoon swell gradually subsides over the outer limits of the bank and vessels are thus enabled to run into comparatively quite still water at the height of the monsoon, thus providing Cochin with an unrivalled harbour during this period. So far as can be

ascertained, no surf breaks along the margins of the bank; the seas merely die away.

55. There can of course be no question that there are a number of serious drawbacks to trade conducted in this manner, and that merchants suffer considerably by losses of goods exposed in the canal boats, and by fraud and carelessness on the part of the boatmen, but the fact remains that they are able to carry on trade at this period when all other West Coast ports (except Porcad) are closed.

56. As considerable interest attaches to the conditions under which the mud banks alluded to exist on the coast, it is to be hoped that Mr. W. King, Assistant Superintendent, Geological Survey of India, who joined us, and secured some specimens of the mud for analysis, may be enabled to follow up the enquiry.

57. A chart giving general information about the Cochin anchorage and port, and also showing sufficiently the proposed scheme for a first-class harbour accompanies this report for facility of reference.

R. H. SANKEY, Colonel, R.E.,
Chief Engineer, Public Works Department.

J. H. TAYLOR Lieutenant, R.N.R.,
Master Attendant.

MADRAS,
29th February 1881.

From W. T. HOLMES, Esq., Honorary Secretary, Chamber of Commerce,
Cochin, to the Secretary to Government, Public Works Department,
dated Cochin, the 17th March 1881, No. 88.

Since addressing you on the nineteenth ultimo the Chamber has had the port inspected by Mr. Parkes, M.I.C.E., Chief Engineer of the Madras Harbour Works, and I have the honour to forward a copy of his report for the information of Government.

2. It will be observed that Mr. Parkes is of opinion that the bar can be permanently removed and the port converted into a first-class harbour; but the works he considers necessary to accomplish this will be more extensive and costly than hitherto estimated. Such works, however, Mr. Parkes informed the Chamber in conference, would give Cochin a harbour equal to that of Bombay, and capable of indefinite extension at the moderate cost of dredging within the backwater.

3. The cost of the works proposed is estimated at 81 lakhs of rupees, and it is scarcely necessary to remark that this is much beyond the ability of the existing trade of the port to provide four and a half per cent interest on. But the facilities which a first-class harbour and railway communication would provide might certainly be expected to increase the trade of the port from year to year, which would be attended by an increased revenue on harbour works.

4. There may, however, be imperial interests involved in the conversion of this port into a first-class harbour which may induce the Government of

India to expend, without immediate expectation of interest thereon, that portion of the cost for which the present trade of this port cannot provide and the Chamber begs leave to mention what appear to it a few of the more important of those interests.

5. It is generally understood here that the Government of India are desirous to have a first-class harbour or harbour of refuge on this coast between Bombay and Ceylon, and that Marma Goa and Carwar have been recommended as suitable sites. The cost of harbour works at either of those places would be considerable, and neither place has yet a trade that could return any appreciable revenue on the outlay. A railway to connect the port with the railway system of India would also have to be constructed either as a State work or under a State guarantee.

6. Against Marma Goa there is the special objection that it is not in British territory.

7. The Chamber begs to urge in favour of the selection of the port of Cochin, as the site for such a harbour, that it is more centrally situated between Bombay and Ceylon than either of the ports named; that it is already a port of considerable trade, being fifth in importance in India and second in the Madras Presidency, and able to pay about two per cent interest on Mr. Parkes' estimate of the cost of the required works; that it is probable it will soon be connected with the railway system of India at a very moderate liability by way of guaranteed interest to the British Government, and that the total cost of harbour works here might not impose on Government a greater liability than would the harbour and railway works at either of the other places mentioned. The nearness by railway of this port to the principal Military stations in the Madras Presidency and also its nearness to Aden would seem points of importance in connection with movements of troops.

8. Mr. Parkes, when in conference with the Chamber, expressed a wish that his report and suggestions might be submitted for the opinion of another Marine Engineer; for whilst there is no doubt that the Cochin bar can be permanently removed, it is possible that another competent authority might be of opinion that this could be accomplished by less extensive and costly works than now projected. The Chamber does not see its way to making such a reference, and feels that it must now leave any further proceedings in the matter deemed necessary in the hands of Government. In what it conceives to be the interest of the port the Chamber has ventured to urge the subject on the attention of Government and trusts that it will be accorded due consideration.

From N. PARKES, Esq., M.I.C.E., to the Honorary Secretary, Chamber of Commerce, Cochin, dated Cochin, the 11th March 1881.

Having now carefully perused the documents referring to the proposed improvement of the Harbour of Cochin which you have laid before me, having received much valuable information on the subject from various gentlemen on the spot, and having made such personal inspection as was possible during my short stay, I beg now to lay before you, for the

information of the Members of the Chamber of Commerce, the conclusions at which I have arrived.

Your questions to me are substantially the following:—

1. Can improvements commensurate with the cost be made for a sum not exceeding £250,000 for such improvements of the entrance as would enable the class of ships at present frequenting the port to come at all seasons to the inner harbour when fully loaded instead of lying in the roads or at Narrakal as at present?

2. Is Cochin capable of being made into a first-class port accessible to the largest ships at all times, and, if so, by what means and at what cost?

With regard to the first question, I feel compelled after much consideration and with very great reluctance to give a negative answer. I think that such works as could be carried out for the sum named would be in any case ineffectual and probably injurious. Works to be really efficient must be carried out on a much larger scale, but if so carried out they would render Cochin such a port as is contemplated in the second question, to which therefore my reply is affirmative.

Proposals appear to have been considered by the Chamber for carrying out piers from Cochin and Vypeen respectively so as to concentrate the scour on the bar.

This it is correctly supposed would form for itself a channel between the piers equal in sectional area to that existing in the present entrance; as far as their ends, and for some distance beyond. It is further supposed that, if this distance beyond the piers be such as to reach the depth of water in which the wave will not act upon the bottom so as to heap up another bar similar to the present one, there will be such a continuous depth throughout as the scour may produce.

The piers described in paragraph 5 of your letter to the Secretary to Government, Public Works Department, of 25th November 1880, appear to be laid down upon this principle, and they terminate in a depth of 24 feet. Their cost would, as I estimate, be about 50 lakhs of rupees.

I agree in very much of the principles upon which these lines were laid down, but there are some important respects in which I think the plan requires to be modified and supplemented, and these will further increase the cost.

In the first place, the process of obtaining the increased depth by scour in the face of the waves is a hazardous one. A large quantity of material would be disturbed and driven out beyond the piers; some of it would be deposited in the eddies near their unfinished ends, and would form new material for the waves to act upon and nuclei for new accumulation. It would also consist of heavier and coarser material than that of which the bar is now composed, and would therefore, under the influence of the waves, remain at least temporarily at a higher level. From this cause the navigable depth over the bar would be temporarily reduced, and the contour of the depth within which the wave has injurious action would be permanently pushed out to sea. These anticipated difficulties may at first sight appear hypothetical, but they are suggested by the experience of my own practice both at Karachi and at Madras. At the former place the attempt to

remove the bar by scour in the face of the sea produced a great aggravation of the evils. Another objection to the lines as laid down is that there is no room for the wave to spend itself between the piers so that the seas entering between their ends would be propelled in almost full force to the ships' berths. At present the seas are broken by the bar and the shallow water on either side and this advantage would be lost.

To avoid these two evils it would be necessary to start the piers from the shore at a much greater distance apart and they should be kept at such a distance from the existing navigable channel that any disturbance or accumulation that may take place around their advancing ends may not affect the channel. They should begin to approach one another only when they have arrived in the depth of water in which the bottom is not affected by the wave. Thus there would be no disturbance of the existing bottom in the navigable channel by the increased scour. It may appear to be throwing away a natural advantage not to effect the required deepening by natural scour, but the cost of dredging it would be under three lakhs of rupees—a small sum for avoiding the evils consequent on an excess of scour.

A more important source of economy would be sacrificed by carrying the lines of the piers away from the landspits which, more especially on the south side, lie parallel with the channel and placing them in deepest water north and south; but I can see no alternative to surrendering the advantage. To do so, however, would necessarily increase the cost of the piers by about 8 to 10 lakhs.

Then comes the question of the depth in which they are to terminate. I think 24 feet is too near the outside limit of wave action to be thoroughly safe, but a more imperative reason for a greater depth is that required for navigation. Twenty-four feet, with two feet rise of tide, is sufficient in smooth water, but it is not enough where a ship is liable to a lift and drop of five or six feet by the waves. I think 27 feet is the least that should be allowed for the ends of the piers.

In order to carry out the principles here laid down, therefore, I would propose to remove the north pier to a distance of 900 yards northward from the shore of the channel and the south pier 1,100 yards southward, giving with the width of the channel itself a total width between them of 2,700 yards; that they be carried out parallel to one another in a due westerly direction to a depth of 24 feet, and then curving towards one another, terminate in 27 feet with a distance between them of 900 yards or double that of the channel between Cochin and Vypeen. Having a uniform depth of 27 feet, the new entrance would have also nearly double the sectional area of the Vypeen channel, there would be consequently only half the velocity of current, and no disturbance of the bottom.

The piers as I have described them, one 10,600 feet and the other 11,330 feet or each over two miles in length, together with the dredging of the channel, I estimate to cost 81 lakhs of rupees. Their execution would make Cochin a first-class port, and utilize the fine anchorage 3,000 yards long by 250 yards and upwards wide, with more than 24 feet depth. Thirty steamers of the largest size could be moored in the space in a single row of fifteen on either side with ample width between them for passage, and in some parts there is room for double rows. Besides this,

there is practically unlimited space of shallower water, the depth of which could be increased to any required extent by dredging. It would likewise be in direct communication with an immense extent of inland navigation by means of the backwater.

These advantages already exist, but they are unavailable by reason of their inaccessibility from the sea.

It is no part of my duty to express any opinion as to whether the acquisition of such a harbour is ever likely to justify the outlay required for this; but it is at any rate desirable that the capabilities of the place should be known. It is unfortunate that from the nature of the case it is impossible to recommend a plan for a smaller measure of improvement at or proportionally smaller cost. The swell from every direction between south-west and north-west must be reduced before the bar can be even lowered, and that can only be done by breakwaters two miles from shore.

Order thereon No. 911 W., dated 4th April 1881.

The Government are compelled to accept the unanimous opinion of the Chief Engineer, Public Works Department, the Master Attendant, and Mr. Parkes that no permanent improvement to the Harbour of Cochin is attainable except at a cost, the interest of which could not possibly be met by the trade of the port, even allowing for the increase that might reasonably be expected.

2. Nor do the Government consider that such a work could justifiably be undertaken from Provincial Funds, or recommended to the Government of India for execution as a productive work.

3. It is for the Government of India to decide whether the construction of a first-class harbour at this port is of sufficient importance from an Imperial point of view to justify its construction without reference to financial results, and the papers will therefore be forwarded to that Government for consideration.

(True extract)

C. C. RAWSON, Captain, R.E.,
Acting Under Secretary to Government,
Public Works Department.

Report to the Government of India on Cochin Harbour, by George Robertson, Fellow of the Royal Society of Edinburgh; Member of the Institution of Civil Engineers; past President of the Royal Scottish Society of Arts.

From February 23rd to March 2nd I was engaged in examining Cochin and its vicinity. Mr. Dalrymple, the Master Attendant at Madras, who takes a great interest in the prosperity of Cochin, Captain Maiden,

the Master Attendant, and Mr. Grimes, the Assistant Engineer of the range, were with me. The Government of Madras had instructed Captain Castor, formerly Master Attendant at Cochin, but now at Cocanada, to meet me here. His experience and information were of great assistance to me. I had interviews likewise with Mr. Brunton, C.E., and with others, who knew the place well.

There are three main points to be considered at Cochin—(1st) the question about closing the Cruz Milagre gap, (2nd) the improvement of the bar at the entrance to the harbour, (3rd) the best method of resisting the encroachments of the sea.

(1) Cochin Harbour is part of the large backwater already described under the head of internal water communication. The outlet at Cochin was the only outlet to the sea till 1862, with the exception of the extreme north one, near Paliport. In that year the sea, which has for long been encroaching on this part of the coast, burst through at Cruz Milagre, about one and a half miles to the north of Cochin. At first the gap might have been stopped as easily as Captain Castor promptly stopped a neighbouring one in 1868. Now, however, the Cruz Milagre gap is 720 feet wide, and has 27 feet in the deepest point, with a strong current through it.

Since the survey of 1858, made before the gap opened, the ship channel at Cochin entrance has gone to the north, the sides are more irregular, the bar is 200 yards nearer shore, and double the width, and there appears to be 2 feet less water on it. The current through the entrance has also a more decided tendency to escape towards the north. Part of the changes above alluded to may fairly be put down to the effect of the gap, though the encroachment of the sea in shortening the entrance at Cochin some 600 feet on the north side, and 1,000 feet on the south side has probably had much more effect than the gap. There is such an immense body of water in the backwater to the south, that the escape of water at the gap has, comparatively, a trivial effect on the scour at Cochin. The scour at the gap loses its effect very soon, and a short distance out to sea there is only 2 feet of water on its bar. Still, however, as matters may get much worse, and as it is desirable to do what is possible to increase the scour at Cochin, I think the gap should be closed, or, at least, if not closed fixed in its position. By comparing the sections of Cruz Milagre with the sections of the gap at Mangalore, it will be found that the depth at the former, though twice as much at one place, is really, on the average, not greater than at the Goorpoor gap. On each side of the deep part there is a considerable extent of shallow water. Before closing the gap, I think it would be well worth while to try to shallow it, by adopting a somewhat similar course to that recommended for Mangalore. A groyne of piles and brushwood should be projected from the north-east angle of the gap taking care, by carrying the groyne well into the bank, and for some distance along it to act as a training wall, that the current does not outflank the groyne. The Cruz Milagre gap is not quite so favourable for being thus recessed from the stream as the one at Mangalore, because it enters from a tidal backwater, filled every tide, equally or nearly so, and not from a decided river, like the Goorpoor, pouring down, during the monsoon, flood waters right into the gap. The advantage, in the latter case, of recessing the gap from the main current, will be more apparent;

still, I think it worth while to try to shallow Cruz Milagre; and there are plenty of materials on the spot, which have been collected for some time with the view of closing the gap.

It has been proposed to close it by an embankment of a series of modussils, or timber frames, brushwood, grass, straw, sand, clay, stones, and sand-bags. The frames are to be put together on the banks, and floated on rafts to their places, 10 feet apart across the channel, and to be sunk firmly into the bed by a forward and backward movement, and secured to each other and the banks by spars. The clear space between the uprights to be closed in by a double wall (so to speak) of interlaced bamboos; these walls can be sunk easily in still water at the changes of the tide, and they can be kept in their places by a few stones, or by a few light posts and cross pieces; only they should not be raised to a height of more than six feet at a time, and the space between them filled in by brushwood, sunk by stones or sand-bags." This description is extracted from the specification, which goes into other details as well. I think it will be found a very difficult and elaborate way of stopping the gap, though it may do in the Tanjore District, in rivers where the current is all one way, and where, perhaps, there is not 27 feet of water. I prefer the more simple method, of heavy bags of clay, or sand even, thrown down in broad successive layers, backed on one or both sides, with stone thrown down in corresponding layers, as described for Mangalore. If it be determined to close the gap at once, without endeavouring to shallow it first, there is little fear at Cruz Milagre of the lands being covered by flood water. The gap is a pot hole caused by the rush of the stream in and out. There is only 10 to 12 feet of water in the backwater, and on the seaside there is on the bar only 2 feet of water a short distance out. Any diminution of stream in the gap will allow the surf to push the bar in, to shallow the opening. At present no groyne should be put on the seaside, but groynes will be useful hereafter to widen the strip of sand between the sea and the backwater. Cocoanut trees ought to be planted at Cruz Milagre and on the site of the other partial or temporary gaps. All extensive reclamations in the backwater, especially in the neighbourhood of Cochin, should be interdicted, for they have just the same effect as gaps in diminishing the amount of tidal water passing through the harbour mouth.

It occurs to me that it would be worth while to notice at what point the tidal water coming from the Paliport end meets that from Cruz Milagre; for, if the tide comes in pretty strongly from Paliport towards Cruz Milagre, it might be advisable to put a bund with a lock in it, across the backwater, at the narrowest point, near Paliport. This would give the Cochin mouth a larger area to fill with tidal water, and thus cause a greater scour in and out. The effect of a bund in this position during the rains would, however, require to be carefully considered.

(2) Before considering how the depth of water on Cochin bar can be increased, it may be as well to make some remarks on the cause of the bar.

Cochin backwater, especially the southern part of it, is a magnificent reservoir for tidal water, the greater part of which has its entrance and exit through the harbour mouth. Though the rise of the tide is seldom

more than from 1 to 3 feet, yet the tidal water keeps a depth of from 40 to 50 feet in the entrance. Whenever the stream leaves the "fauces terræ" at Vypeen point, it is discharged on to the shallow exposed sea coast, but is still able to keep up a considerable depth for some distance out, although the water has now begun to spread out sideways and escape, especially towards the north. Meanwhile the surf is always striving to restore the natural profile of conservancy of the shore. After the current has flowed out to sea for nearly a mile, it is no longer able to resist and keep down the ever working and powerful efforts of the waves to re-form the profile of the coast by continuing the beach line which has been broken through by the outgoing current. Were the current to be kept together in full strength till it got into such a depth of water that the action of the waves was not sufficiently powerful to stir up the bottom, there would be no decided bar. The same result would happen were the current to discharge under shelter from the waves, as, for instance, into a land-locked estuary.

At Cochin the surf has sufficient power on the bottom, in 15 or 16 feet of water, to overcome the levelling efforts of the current, as at present existing, and throw up a bar with only 11 feet of water upon it.

All that has been said of the outgoing current applies also, though with less effect, and inversely, to the ingoing current.

To strengthen the current, and confine it till it arrives into deeper water, where the waves act with less effect on the bottom, is evidently the way to treat the harbour at Cochin.

With this method of treatment in view, it is instructive to examine the various surveys. In the survey of 1835, when the current was kept longer together by more projecting "fauces terræ" and by hard sandbanks, which prevented the stream from spreading, there was 16 to 17 feet on the bar. Since then the "fauces terræ" have been gradually eaten away by encroachments of the sea, and the survey of 1852 shows that a bar was beginning to form, with only 13 feet on it. In 1858 the bar had completely formed, but was very narrow. After that, the Cruz Milagre gap took place, and the following survey, in 1869, shows the bar nearer shore, broader, and with 2 feet less water on it.

These surveys illustrate the true theory of the formation of bars at river mouths, more beautifully than any set of surveys with which I am acquainted; for, it seldom happens that the "fauces terræ" of a river are so much eaten away, and the results of their diminution so plain.

I propose to restore artificially the "fauces terræ" and to carry them much farther to sea than they ever were when there was 16 to 17 feet of water on the bar, by projecting long groynes on each side of the harbour entrance. These are laid down on the plan. The south groyne to start from the light-house, and to run out for 3,000 feet. The north groyne to commence at Vypeen point, and to run out for 2,300 feet. I should wish to project this groyne a little further; but it will be noticed, that the deep water into which it would immediately get, would make a prolongation very expensive. The current will thus be kept together, and concentrated on the bar, and in a direction more nearly approaching, than at present, the general direction of the harbour mouth. The south groyne, in projecting beyond the north one, not merely helps to direct the stream,

but also gives considerable shelter to the harbour entrance, from some of the strongest winds. It must be remembered, that in reducing a bar, we take away a kind of breakwater in front of an entrance, and introduce a bigger wave, so that some shelter is desirable. These groynes assisted after very unusually heavy gales by a little dredging or raking, will, I believe, keep a constant depth, at low water of springs, of 20 to 21 feet in the approach to Cochin; making it the finest close harbour in India.

Before any works are decided upon, it will be necessary to make borings over the bar, to ascertain that there is no rock just under the sand. There is not likely to be any, but it is as well to be certain.

It will probably be necessary to gain a portion of the proposed depth by dredging, because a current which is sufficient to keep down a bar, may not be sufficient to remove it after it is once formed. It requires a strong stream to excavate. I expect, however, that as the training walls are pushed forward, the greater part of the deepening will be done by the increasing current. Something may be done by raking, to help the efforts of the ebb current, but that is never so satisfactory as dredging, as the stuff is only shifted and not removed. At Cochin the flood tide would bring back a certain amount of what the ebb tide shifted. The ebb tide has always the benefit, however, of whatever land water happens to be in the backwater.

It is much better to start the south groyne from somewhere near the light-house, than to take it from the harbour entrance, and run it parallel with the groyne on the north side. In the first place, a much greater distance to sea is gained by the same length of groyne, and, secondly, because two parallel piers would conduct the waves right into the harbour entrance and cause such a swell as to prevent vessels lying there. The south groyne I propose will, to a great extent, conduct the waves into an angle out of the way and breach them, thus reducing the swell in the entrance.

The best section for these training walls, and the method in which they should be constructed, are matters for future consideration. A great deal will depend upon the character and side of the stone which can be obtained. I was told that stone could be got from the other side of the backwater, some 12 miles off. The site is not one for anything vertical or of solid masonry, because considerable settlement may be expected. In my opinion the very best way to form the groynes would be with large concrete blocks, as in the breakwater at Port Said. They might be blinded with rubble, or backed with it, as is proposed to be done at Alexandria.

Concrete blocks made with portland cement are being used at Karachi; and Mr. Parkes informs me that the cost of current expenses in making each block is about £12, but this does not include anything for plants, preliminary works, or superintendence. Each block weighs about 27 tons, and contains 432 cubic feet. The cost is, therefore, at the rate of 7½ rupees per cubic yard, or rather under 4½ rupees per ton. It will not be necessary to use such heavy blocks at Cochin, where no part of either of the groynes will be in more than 15 feet of water, at high water.

Taking this price for portland cement concrete, and allowing 20 per cent for plant, superintendence, etc., I estimate the proposed works at 7½ lakhs of rupees.

This appears a large sum to be spent on one harbour in India but it is nothing to what is spent on many a less important harbour in England and elsewhere.

Though I don't think it necessary that the blocks need be so large as at Karachi, yet it is not very likely that stone will be got in large enough blocks to stand the sea, like blocks of concrete. If it be decided, therefore, not to try concrete, resource must be had to rubble.

The groynes may be made in two ways with rubble. Either a great mass of simple rubble allowed to take its own slopes from the action of the sea, as in the outlying breakwater at Portland or pitched to given slopes above low water, as at Granton and many other places.

According to the first plan, a great quantity of rubble is used, which, at Cochin, I was informed, will cost 4 rupees a cubic yard. According to the second plan, there would be less rubble, but more skilled work in the pitching. So that, on the whole, I don't think that either plan would be cheaper than concrete; unless, by quarrying on a large scale, rubble can be obtained at a cheaper rate than the above.

The blocks may be made with cement, sand, and broken stone, in proper proportions, mixed either by hand or in Messent's machines (first used at the Tyne piers); or they may be made by building up blocks of rubble with Portland cement mortar.

Portland cement costs, at Karachi, 84 s. per ton, and the casks are used as fuel. I think it might be made in India. It is an artificial cement, composed of chalk, lime, and alluvial clay from creeks in the Medway. The manufacture of it requires care, but is not difficult. It would be worth while trying experiments with coral lime and alluvial clay from some of the Indian rivers. If portland cement could be cheaply made in India, the expense of executing marine or hydraulic work in that country would be greatly reduced. Every part of the coast supplies sand; and at Port Said the concrete blocks have been made of Theil lime and sand alone.

It is possible that there may be some good natural cements in India, like Roman cement, which would do for the manufacture of concrete blocks.

The groynes should be 20 feet wide at the top, with a height of 5 feet above high water; so that heavy waves may pass over them, and yet the shelter behind be considerable.

(3) The measures to be adopted for preventing the erosion of the beach to the north and south of the harbour entrance.

This is a subject about which there has been an immense deal of discussion, both as to facts and as to principles. The papers and reports about the groynes and revetments at Cochin occupy a prominent position in the literature of that place. Into the minutiae of the "battle of the groynes" it is not my intention to plunge. Many of the groynes have acted very well in protecting the shore; and those erected by Captain Castor some years ago were, doubtless, the means of saving part of the town from

inundation. I would rather treat of the principles involved in groynes and revetments.

In a place like Cochin, a groyne on the sea shore acts in two ways. It catches any sand which may be travelling along, acted upon by a littoral current or otherwise; and it recesses a small piece of shore between it and the next groyne from the current, and permits some of the sand which is washed up by the waves, to lie at rest, and in time to collect in considerable quantities. In one of the reports on Cochin, the existence of a littoral current, sufficiently close in shore to have any effect in accumulating deposit against groynes, is denied. Now, it is quite true, that the currents out at sea may be so diminished by the friction of passing over a long shallow shore, that by the time the land is reached, there may be very little apparent current left. But they have their effect nevertheless at the water's edge. If the lines of surf waves be examined it will be found that they never roll in exactly on to, and parallel with, the shore, but always a little obliquely to it, touching the shore at one point first, and pushing the sand along in one direction, as the breaker shoots along the shore, that direction, being influenced by the direction of the current out at sea, and quite independent of the local wind. The oblique action of the surf roller is particularly well seen on the coast of India, where there are long stretches of straight coast, with few indentations to interfere with the normal direction given by the ocean current, which, during the year, runs for the most part to the north. When I was on the Malabar coast, the rollers always, so to speak, approached the shore with their right shoulders forward. On the Coromandel coast, on the other side of India, the rollers neared the shore with the left shoulders forward; in each case pushing slightly northward towards the head of the great bay on that side of India. This is exemplified in the sketch drawn on the plan of Cochin. A nearly calm day is the best for watching the obliquity of the lines of surf waves to the shore, and the way they approach the high water line. The general tendency of the surf at Cochin is to push the sand, which is awash at the edge of the sea, towards the north. Groynes, therefore, are useful, even though there may be no observable current just at the shore line, for they arrest this travelling sand. Besides, there is at Cochin a strong tidal current at the shore, for some distance on each side of the harbour entrance, owing to the water rushing into and out from the backwater. True, it acts both ways, and of itself may not tend to lodge sand much more on one side of a groyne than on the other. It is, however, desirable to recess the beach by groynes, so as to protect it, in short lengths, from the erosive action of these tidal currents.

In considering the action of a revetment (and by that I mean a pitched slope more than anything in the nature of a wall), it is to be remembered that groynes, after all, are put merely for the purpose of forming a revetment in front of a piece of beach, the revetment being of sand, or shingle, as the case may be. Groynes lead to revetments, revetments never lead to groynes. The revetment is the final object aimed at. Where important places have to be guarded, such as near the light-house, the sides of the harbour channel, and at Vypeen point, there ought to be revetments between the groynes. Indeed, to a certain extent, this is being done. There is an amount of uncertainty in the action of the groynes, which

renders it desirable to fix and secure any important places. With particular winds, it often happens that the sand between two groynes is scooped out in a few tides.

In a long line of coast, and especially where it is intended not only to protect land, but to regain what is lost, it is proper to throw out groynes, the intervals depending on the length of the groynes, the exposure, and other circumstances, so that no general rule can be given. I would advise an extension of the line of short groynes all along the shore towards Cruz Milagre and at the site of the gap after it is closed. I fully expect, however, that the proposed long groynes for training the current on to the bar, will have a wonderful effect, not merely in resisting the encroachments of the sea, but in restoring the coast towards its former line, say that of 1858. It is difficult to believe that the coast line for 1835, on the north side of the harbour entrance, is correct, for it shows a direction quite different from the general trend of the coast at Cochin.

In the shipping area of the inner harbour, Captain Castor thinks there is room at present for fifty ships of large size, say, 700 tons, if properly moored in tiers; but any amount of area can be got by dredging. Cochin dockwater can be converted into the largest close harbour in the world by edging the shallow places. The rise and fall of tide is so small, that the dockwater is practically a wet dock, of greater area than all the docks Great Britain put together.

I have already mentioned that the bar will have to be dredged to a certain extent, to get the full depth upon it, which the scour will be able to maintain when the proposed groynes are built; a little dredging will probably also be required after unusually heavy gales. But as the edging will not be continuous, it occurred to me that a combination might be made of a dredger and a tug-steamer. If the harbour at Cochin is to be used during the monsoons, a tug-steamer will be necessary, as the stream then is, for the most part, always outward, and sailing vessels could not get in unless it happened to be blowing half a gale of wind from the east. Even in fine weather, a tug would often be useful. At present, vessels sometimes pay as much as 300 or 400 rupees to be towed out by steamers frequenting the port.

I find, however, that the idea of combining a dredger with a tug is not new; for Messrs. W. Simons Company of Renfrew, the principal manufacturers of dredging plant in this country, inform me that they have a patent for it, and are making one at present for the Canadian Government. They state, that the cost of one of their patent screw-dredgers, such as would be useful at Cochin, is £8,600 delivered on the Clyde: the vessel to draw 10 feet of water, to have compound engines of 50 nominal horse-power, with a central-bucket well, and ladder to dredge in 21 feet at low water. He should be capable of raising from 100 to 150 tons of sand per hour and would be designed and fitted as a tug-steamer having a speed of 7 or 8 miles per hour. The patent screw dredger is provided with rudder, masts, spars and canvas for wind propulsion, like a full rigged screw-steamer, the lower masts being constructed in combination with the shear legs for lifting the bucket ladder, so as to leave clear spaces centrally for the dredging apparatus. The craft could quite safely steam out to India,

via., the Suez Canal. I think such a vessel would be of great value at Cochin. When not required either at the bar or for towing purposes, she might be employed in deepening and extending the accommodation for vessels inside the harbour.

It is hardly necessary to remark, that dry docks, or repairing slips, can be made at Cochin whenever required, or rather whenever funds are forthcoming, for something of the kind would be of great use at present. While I was at Cochin, the large vessel which had been injured at Calicut was being careened over for examination—a troublesome, dangerous, and imperfect operation, in comparison with the ease with which repairs can be executed in a dry dock, or on a slip.

On the future importance of Cochin as the great western outlet for the trade of Southern India, viewed in connection with the Suez Canal, and the probable development of Railway and internal water communication, it is hardly my province to dwell.

During the last ten years, the average annual tonnage of vessels visiting the port of Cochin has been—

Steamers ...	...	Inwards	25,816	Outwards	25,816
Foreign ships ...	...	"	42,423	"	41,731
Native craft ...	...	"	43,371	"	41,934
The value of exports has averaged Rs. 70,26,325.					
" imports " Rs. 49,36,873.					

Report to the Government of India on Narrakal by George Robertson, Fellow of the Royal Society of Edinburgh; Member of the Institution of Civil Engineers; past President of the Royal Scottish Society of Arts.

On the 28th February I visited the remarkable mud bank of Narrakal in the pearl fishery steamer "Margaret Northcote." The Diwan of Cochin was on board, and also the Master Attendants of Madras, Cocanada, Cochin and Tuticorin; so that nautical advice was not wanting. This curious and valuable anchorage was fully reported on and surveyed by Captain Castor, when he was at Cochin. From his reports, and from what others told me, there cannot be the slightest doubt as to the tranquillizing effects of the mud during stormy weather, and the value of Narrakal as a natural harbour of refuge during the monsoon.

We sent a diver down for specimens of the mud, which is of a dark green colour, and of a peculiarly greasy character. It has been analysed at Madras. When we were at Narrakal, though there was a considerable swell on the sea, yet the weather was too fine to develop the peculiarities of the bank. There was, however, sufficient surf on the coast elsewhere to show the marked difference at Narrakal, where, for some miles, the surf ceased, and there was not a ripple at the water's edge.

The whole phenomena connected with the mud banks, both here and at Alleppey, are well worthy of careful scientific investigation. There are many places on the coast of India, where the presence of mud has a quieting effect on the surf, but none so remarkable as these two spots;

oth of them, be it remarked, in the vicinity of the same backwater, and ar from any great silt-bearing river.

Several theories have been raised in connection with these mud banks; but I consider that, at present, there are not sufficient scientific data upon which to found a true theory as to the origin of the banks, and the connection that is supposed to exist between them and the adjoining backwater.

The special point upon which the Government of India have asked my opinion in connection with Narrakal and Alleppey, is the possibility of taking advantage of such localities, and opening out communications between them and the backwaters.

With regard to taking advantage of the localities, as two natural harbours of refuge in the vicinity of the close harbour of Cochin, I consider the banks most valuable additions to that port, and amongst the most potent reasons for its improvement. No other harbour in the world has such adjuncts. But, with regard to opening out direct communication between Narrakal and the backwater, I consider it would not be prudent to attempt it. It would manifestly be unwise to shut the Cruz Milagre Gap, for the purpose of improving Cochin, and at the same time to open another gap close by. In the long shallow coast at Narrakal, even though there is little surf, it would not be possible unless by incessant dredging to keep open the mouth of a canal, without a current through it of tidal water. It would not be safe, in the present absence of scientific data, to throw a current of water into the centre of the Narrakal mud bank. So far as is known, that bank is stationary; but at Alleppey the bank there shifts, and has gone four miles to the south in ten years. The in-going stream also, during flood tide, would fill the backwater with mud. The banks are too valuable to try experiments with. The six feet line at no place here comes nearer shore than 900 yards in very soft mud, and in one place Captain Custor's chart shows it to be a mile from shore. Any canal, therefore, would require to be carried out between long protecting groynes, or it would be filled up almost every tide. I do not recommend the trial. A scouring current might be injurious to the mud bank; and if a lock were put on the canal, the difficulty of keeping the entrance clear of mud would be great.

At Narrakal there already exists a small canal of 985 yards in length, from within 80 yards of the high water line to the Cochin backwater. This canal can be widened and deepened in connexion with any general improvement of the internal water communication, so as to admit large cargo boats, or even steamers. The canal is very close to the southern boundary of the smooth water at Narrakal, but it is at the point where the six feet line comes nearest to the shore. Boats landing goods have to be dragged on shore for a long way through slush. A jetty would be an advantage, but it would require to be a very long one, three times as long as the pier at Calicut, to be of much use.

The three fathom anchorage is two and a quarter miles from shore.



Latitude 9° 58' 07" North

II

G.O. No. 308, MARINE, DATED 15TH JULY 1903.

READ—again the following papers :—

G.O. No. 150, Marine, dated 4th March 1902.

ABSTRACT.—Directing that the Right Hon'ble the Secretary of State for India be addressed on the subject of the formation of a suitable harbour on the West Coast of the Madras Presidency, and requested to obtain the opinion of the Consulting Engineer to the India Office on the several points specified in connexion therewith.

READ—also the following papers :—

Despatch from the Secretary of State for India, to His Excellency the Right Hon'ble the Governor in Council, Fort St. George, dated India Office, London, the 27th March 1903, No. 3-Public Works.

With reference to your Excellency's Despatch, dated the 4th of March 1902, No. 7 (Marine), regarding

Cochin Harbour : Report by Messrs. Coode, Son & Matthews on proposals for improvement.

* Letter to Messrs. Coode, Son & Matthews, dated 23rd June 1902.

Letter from Messrs. Coode, Son & Matthews, dated 25th June 1902.

Letter to Messrs. Coode, Son & Matthews, dated 19th August 1902.

Letter from Messrs. Coode, Son & Matthews, dated 20th August 1902.

Letter to Messrs. Coode, Son & Matthews, dated 25th August 1902.

Letter from Messrs. Coode, Son & Matthews, dated 25th August 1902.

Report by Messrs. Coode, Son & Matthews, dated 23rd February 1903, and drawing.

ing the formation of a suitable harbour on the West Coast of the Madras Presidency, I forward, for your information, a copy of correspondence* with Messrs. Coode, Son & Matthews on the subject, with the report of that firm on the questions raised in the proceedings which accompanied your Excellency's Despatch.

ENCLOSURES.

No. 1.

India Office to Messrs. Coode, Son & Matthews.

P.W. No. 548.

India Office,

Gentlemen,

23rd June 1902.

I am directed by the Secretary of State for India to acquaint you that a scheme for the formation of a harbour at Cochin in the Madras Presidency has recently been submitted to him by the Government of Madras with a view to its being professionally examined in this country.

Lord George Hamilton would be obliged if you would furnish him with a report on the proposals of the Government of Madras as stated in the enclosures to their despatch of the 4th March 1902, No. 7 (Marine), a copy of which accompanies this letter.

I am, etc.,
HARDWICK.

Messrs. Coode, Son & Matthews.

No. 2.

Messrs. Coode, Son & Matthews to India Office.

Westminster Chambers, 9, Victoria Street,
London, S.W., 25th June 1902.

Sir,

We beg to acknowledge the receipt of your letter, dated 23rd instant, P.W. No. 548, forwarding papers in connection with a project for the improvement of the harbour at Cochin in the Madras Presidency, and requesting us to furnish a report on the subject, which we will do with the least possible delay.

We assume that by undertaking this work we should not be interfering with professional business which would otherwise have been placed with Sir Alexander Rendel.

We have, etc.,
COODE, SON & MATTHEWS.

The Under Secretary of State for India.

No. 3.

India Office to Messrs. Coode, Son & Matthews.

P.W. No. 1211.

India Office,
19th August 1902.

Gentlemen,

With reference to your letter, dated the 25th of June last, regarding the preparation of a report on a project for improving the harbour at Cochin, I am directed by the Secretary of State for India in Council to inform you that the assumption which you make in the second paragraph of your letter is correct, and to request that you will be so good as to proceed as speedily as possible with the preparation of the report.

I am, etc.,
A. GODLEY.

Messrs. Coode, Son & Matthews.

No. 4.

Messrs. Coode, Son & Matthews to India Office.

Westminster Chambers, 9, Victoria Street,
London, S.W., 20th August 1902.

[Cochin Harbour.]

Sir,

We have to acknowledge the receipt of, and to thank you for, your letter of 19th instant, instructing us to prepare a report on the proposed improvement of the harbour at Cochin. We hope, at an early date, to proceed with the consideration of this matter.

It will be requisite hereafter that we should see Mr. deWinton, who is home on leave. We assume we are at liberty to communicate with him accordingly.

We have, etc.,
COODE, SON & MATTHEWS.

The Under Secretary of State for India.

No. 5.

India Office to Messrs. Coode, Son & Matthews.

P.W. No. 1591.

India Office,
25th August 1902.

Gentlemen,

I am directed by the Secretary of State for India in Council to acknowledge the receipt of your letter of the 20th instant regarding the preparation of a report on the proposed improvement of the harbour of Cochin, and to inform you that you are at liberty to communicate with Mr. deWinton on the subject.

I am, etc.,
HORACE WALPOLE.

Messrs. Coode, Son & Matthews.

No. 6.

Messrs. Coode, Son & Matthews to India Office.

Westminster Chambers, 9, Victoria Street,
London, S.W., 25th August 1902.

Sir,

We have to thank you for the intimation you have been good enough to convey in your letter of to-day's date relative to our communicating with Mr. deWinton with regard to the report we have been instructed to prepare on the proposed improvement of the harbour of Cochin.

We have, etc.,
COODE, SON & MATTHEWS.

The Under Secretary of State for India.

[Cochin Harbour.]

Report by Messrs. Coode, Son & Matthews, dated 23rd February 1903.

Sir,

With further reference to your letters*, as enumerated in the margin,

* P.W. No. 548, dated 23rd June 1902. we regret we were unable, for unavoidable reasons, to arrange an interview with Mr. deWinton before 13th ultimo, when he was good enough to call here, and to furnish certain information of a general character bearing upon this investigation.

2. The only useful plan of the locality which is available for reference is chart No. 65, a copy of which was forwarded with the papers accompanying your instructions. Upon referring to this chart it will be observed that there is an enclosed, submerged area, or backwater, east and south of Cochin, of enormous extent. Although the rise of tide is only from $1\frac{1}{2}$ to 3 feet, nevertheless, the vast expanse of backwater, supplemented in rainy seasons by the outflow from numerous rivers which discharge therein, is sufficient to create and maintain a depth of from 40 to 50 feet where the scour is concentrated, immediately in the entrance. Seaward of this last-named point, the out-going currents spread laterally, the only controlling influence being submerged sandbanks which reach for a distance of nearly a mile from the shore. At this spot, where the out-going currents meet the onshore seas, a bar is created in the position indicated on the chart. It will be observed from the foregoing, and from an examination of the chart, a duplicate copy of which we have coloured in gradations of blue tint to indicate the locality of the deep water, that the forces in operation, both with regard to scour and deposit, are on an unusually large scale.

3. To overcome the difficulties which are now experienced in consequence of the existence of the bar and the shoal water adjacent thereto, it has been proposed that a channel, 500 feet in width and 30 feet in depth at low water of ordinary spring tides, should be dredged from the anchorage, through the bar and up the backwater to the site suggested for the proposed wharves. It is also contemplated to erect two wharves, each of 1,000 feet in length, for the landing and shipment of goods, and to purchase a powerful pump dredger.

4. We gather that it is desired we should report upon the following points in connection with the foregoing proposals:—

- (1) As to the feasibility of the suggested dredging.
- (2) The best type of dredger to employ.
- (3) Capital cost.
- (4) Cost of maintenance.
- (5) In what seaway could the dredger work.
- (6) Whether it could, besides dredging the channel, maintain the latter at the requisite depth when dredged.

5. As previously stated, the only data available on which to base an opinion with regard to the foregoing subjects are those given on the Admiralty chart, and in the general statements with reference to the direction of wind, the condition of the weather, and the state of the bar, from the years 1897 to 1901, inclusive. There is no information as to the character of the sand, whether it is of such a nature as can be dealt with by a pump dredger, nor as to the extent to which mud exists, the latter being an important feature, as the system of pump hopper dredging is not suitable for the removal of material of this description. Moreover, there are no reliable particulars as to the extent to which the depth on the bar fluctuates during the two monsoons, nor as to the movements of the out-lying sandbanks, due to sea action.

6. With regard to the last-named features, we may observe that in consequence of our connexion, as Consulting Engineers, with the harbour works at Colombo, we are generally conversant with the periods and duration of the south-west and north-east monsoons, and are therefore in a position to judge, generally, of the extent to which wave action occurs at Cochin, and of the probable effect which the disturbances caused thereby would have on a channel such as proposed after the same had been formed.

7. As far as an opinion can be expressed from the particulars available in the documents transmitted to us, taken in conjunction with our knowledge of the monsoons and their action, we have no hesitation in stating that if the channel is dredged as contemplated, from the anchorage to the entrance to the backwater, which forms the most essential feature of the proposed undertaking, the operations in connexion therewith being largely conducted during the north-east monsoon when fine weather prevails, on the occurrence of the following south-west monsoon, in consequence of wave disturbance, such deepened and improved channel would, to a large extent, be filled by sand, drawn from the vast supplies in the sea-bed and in the banks lying on either side of the proposed deep-water track.

8. We do not consider, if the channel is formed, that it could be maintained to a sufficient extent to be of practical utility for the navigation of deep-draft vessels, certainly not during the occurrence of south-west monsoons, when the channel for a length of nearly two miles would lie open to the disturbing action of the sea.

9. In our opinion, the only mode of effectually treating such an entrance as that at Cochin, having regard to the physical conditions which prevail there, would be to construct a sheltering and training mole on either side of the entrance, the cost of which, having regard to the extent to which trade is carried on at the port, would, we take it, be altogether prohibitory.

10. In this last-named connexion, we may observe that the partial execution of such moles would, to some extent, increase the depth on the bar. Whether such improvement would produce results equivalent to the required expenditure, could only be determined after a careful engineering survey and inspection has been made, and reliable figures procured with regard to the cost at which suitable material could be obtained for the construction of the moles.

11. With reference to the financial position, as given in document No. 150, Marine, dated 4th March 1902, the following may be taken as generally summarizing this aspect of the question :—

	Rs.	£
Estimated revenue <i>per annum</i> ...	1,30,000 =	8,666
Proposed loan, repayable in 30 years.	15,00,000 =	100,000 (say)
Annual payment of principal and interest.	86,748 =	5,783
Sum available for working expenses.	43,252 =	2,883

12. Taking the cost of the dredger, delivered, as 50,000*l.*, and the loan at 100,000*l.*, the sum of 50,000*l.*, would be available for dredging and buoying the channel, the formation of which would entail the removal of 2,700,000 tons of sand and silt. We do not regard this estimate as sufficient, especially bearing in mind the delays from unfavourable weather, in consequence of the work having to be undertaken in so exposed a position.

13. With reference to the sum which would be available to cover the working expenses of the dredger in maintaining the channel, provided it were practicable to form it for the full depth throughout its entire length, viz., Rs. 43,252, as given in the document No. 150, Marine, which equals 2,883*l. per annum*; we consider this sum altogether insufficient to cover wages of the crew, fuel, stores, renewals, overhauling and repairs, which would necessitate an annual expenditure of not less than 10,000*l.* for a dredger of the size contemplated.

14. Having regard to the general views which we have expressed above, we have to report on the six points you have remitted to us for opinion, to the following effect :—

(1) We do not consider the dredging of the channel and its maintenance to be feasible in such an exposed position, having regard to the duration of the south-west monsoons, when maintenance dredging would, under general conditions, be impracticable from excessive wave action.

(2) The best type of dredger to employ would unquestionably be a pump hopper dredger adapted for self-loading and depositing at sea.

(3) The cost of such a dredger might be taken at the sum named in the document No. 150, Marine, i.e., 50,000*l.*

(4) The annual cost of maintenance of such a vessel, viz., wages of crew, coal, stores, repairs and renewals, but exclusive of interest on first cost and depreciation, would be fully 10,000*l. per annum*.

(5) Such a vessel as that referred to would work in a wave disturbance of say from 4 to 5 feet.

(6) We are of opinion that the channel could not be adequately maintained for the reasons we have stated.

15. If it is desired that any action should be taken with regard to the construction of training and sheltering moles on either side of the entrance, with a view to the improvement of the existing depth over the bar, and subsequently maintaining such improvement, it would be requisite that an extensive engineering survey should be made, with soundings, sections, current observations, borings and other particulars, so that the local conditions may be fully understood prior to framing a design for the

same. The cost of such an investigation, including a report, design and estimate thereon, but exclusive of local labour, boat hire, provision of boring tools and craft in connexion therewith, may be taken at about 1,400*l.*, on the understanding that an engineer experienced in this class of work is sent out from England, provided such an officer is not available in the works department of the Madras Government. Whether the trade requirements of Cochin are sufficient to justify such an expenditure having regard to the comparatively limited extent to which the depth on the bar might be increased by such works we have no means of judging.

16. What we have in view with reference to this last-named suggestion, is the possible deepening of the bar, say, by 3 or 4 feet, and a reduction in the extent of the fluctuations that now occur. If such improvements would be of real value to the port, it might be considered desirable that an investigation of the character alluded to should be undertaken, the works, of course, being arranged so that they could be extended hereafter as the trade of the port develops.

17. We beg to return the documents received by us in connexion with the foregoing, as follows :—

G.O. No. 150, dated 4th March 1902.

No. 35, being a chart showing the proposed channel and works.

Three enclosures giving particulars of currents, state of bar, etc.

We have, etc.,
COODE, SON & MATTHEWS.

The Under Secretary of State for India.

Memorandum from the Public Works Department, dated 6th May 1903, No. 319-D.

Order—No. 303, Marine, dated 13th July 1903.

Recorded.

2. The report by Messrs. Coode, Son & Matthews received from the Secretary of State for India with the despatch above read shows that the proposals for the improvement of the port of Cochin are impracticable, and that the cost of constructing a sheltered harbour at that port would be altogether prohibitory. The Government are therefore reluctantly compelled to abandon the scheme until time and circumstances reveal a practicable means of improving the harbour.

(True extract)

G. S. FORBES,
Acting Chief Secretary.

To the Presidency Port Officer.
" Collector of Malabar.
" Chamber of Commerce, Cochin.
" Secretary, United Planters' Association of Southern India.
" Public Works Department. (Railway Branch).
" " "
" Political Department.
" Revenue "
" Copy to Chamber of Commerce, Madras.

III

G.O. No. 861 W., DATED 29th APRIL 1913.

READ—the following papers :—

(i)

G.O. No. 1356 W., dated 30th September 1912.

ABSTRACT.—An estimate amounting to Rs. 25,000 being the cost of the special establishment and plant required for the Cochin Harbour Investigation sanctioned with remarks.

(ii)

Note by Mr. J. R. Bell on the Port of Cochin and the prospects of making the harbour accessible for sea-going steam-ships.

SECTION I.—PRELIMINARY.

It may allay future misapprehensions if I begin by enunciating the scope of my personal investigations before developing such conclusions as I now can offer.

2. *Breakwaters*.—Throughout close on half a century many successive phases of this harbour problem have been pushed by the Government of Madras to the extent of often enlisting the sympathy and (in the Albuquerque episode) the financial support of the Secretary of State. Just here without further historical retrospect, it may suffice to recall that the penultimate reference in 1903 to the Secretary of State elucidated a distinctly adverse opinion from the harbour works advisers to the Admiralty,—the pre-eminent firm of which Sir William Matthews, Past Pres. I.C.E., is now head.

3. Summarised, that opinion affirmed that no *satisfactory entrance of the desired class can be made and maintained* without extending a pair of breakwaters to deep water; and allowed, as I read it, that the available data,—while insufficient for accurately forecasting the details of those structures or perhaps wholly their ultimate adequacy,—amply suffice to show experts that *the cost of the breakwaters must be, in any case, prohibitive*.

4. It is safe to say that the above conclusion as to cost is accepted by all competent reasonable opinion and that unless breakwaters can be dispensed with, this part of the case may be regarded as definitely closed.

5. I largely base that view on the records of the Chamber of Commerce. These show that after the failure, in 1877, of the “Albuquerque” dredger the Chamber advanced a project by Mr. Brunton for extending two parallel breakwaters into 24 feet of water. Early in 1881 Colonel Sankey noted (1) that the Brunton project ought anyhow to extend to the 30-ft. line, (2) that he questioned, even so, its efficiency, and (3) that it would assuredly

cost some 40 lakhs. To this the Chamber demurred with much vigour and procured an independent opinion on the case from Mr. Parkes, who had built the very successful Manora Breakwater at Karachi. Mr. Parkes replied (a) that Mr. Brunton's (24 feet) project would cost 50 lakhs, (b) that its parallel alignment was wrong because, in order to dissipate inevitably heavy internal seas, the alignment must be bell-mouthed from 900 yards (? feet) at the entrance to 2,700 at the shore end, (c) that the entrance must extend into at least 27 feet of water, and (d) that then the cost, exclusive of internal facilities, would touch 81 lakhs. That indeed is now a moderate estimate.

6. *Dredging*.—Allowing that all idea of breakwaters (especially now that 33 feet, not 30, has to be aimed at) may be regarded as impracticable,—we come to the question of how far dredging alone has been commended. A brief history of this alternative may be summarised as follows.

7. After it became clear that the closure of the Cruz Milagre Gap had not materially benefited this bar the Government procured a new bucket dredger, the “Albuquerque” intended to deepen the bar by 2 feet, i.e., from 13 or 14 to 15 or 16 feet. When tested on the bar during March 1877 in a normal ground swell with a heave of 1½ feet she failed quite hopelessly and was promptly withdrawn to sheltered waters.

8. In 1888 Mr. Brunton advanced his new design of a “sluice-dredger” which would squirt clean surface water against the crest of the bar so that (clearly only during the ebb) the agitated sand would be carried off seawards. The Government, in my view very properly, declined to entertain that proposal and matters rested till the reference to Sir William Matthews' firm was made.

9. Since those days suction dredging on a very large scale has attained many notable developments, especially in the United States where the Government is doing wonders to improve minor harbours. In this connexion I quote, without however wholly endorsing, the remarks of an eminent fellow member of the American Society recorded so lately as last November in a discussion on Pacific Coast Harbours. Mr. LeConte said: “It may be stated that the day for extending jetties (i.e., breakwaters) out into deep water in order to maintain depth on the bar is gone for ever. The annual interest on cost of deep water extensions will pay for the necessary dredging five times over.” I demur to so vigorous an assertion because, for reasons to be presently given, such dredging in India has cost hitherto quite thrice the rate Mr. LeConte seems to figure on.

10. Apart from American experience of dredging very notable results have been attained at Natal, initiated indeed by the father of Mr. Browning (Chief Engineer to the Cochin Darbar) whose interest in Dredging is well known to all concerned with this case. Mr. Campbell, a comparatively junior Engineer of the Madras Public Works Department, whose primary duties I take to be directly connected with work of more immediate urgency, has also made a study of this question and is now prosecuting private enquiries at home into the type of dredger that Messrs. Simons recommend for Cochin. I myself have been called into council because I have many years' intimacy with this method more

particularly as applied, on my advice as their Consulting Engineer, by the Chittagong Port Commissioners.

11. *Backwater problems.*—Allowing that all question of breakwaters has been laid definitively aside and that dredging now offers the only fair prospect of improving this entrance, we come to issues of far more pressing interest to the various administrations concerned, viz., to the paramount Government of Madras and the Native States of Travancore and Cochin.

12. *Reclamations.*—In the first place some 99 per cent of the backwaters and lowlands belong to the two Darbars who are naturally eager to extend their revenues by their traditional methods of reclaiming shoals from the backwaters and cultivating them by what is known locally as kole irrigation. The two States admit doubtless that such reclamations must not be so urged as to materially accelerate the inherent deterioration of the Cochin Bar by inordinately reducing the tidal-scour prism: while the paramount power agrees that reasonable facilities for thus improving their revenues shall not be withheld from the feudatories. When the observations now being taken are completed, there is little question that this matter will be satisfactorily and equitably settled.

13. *Erosions.*—In the second place still more serious dangers to the facilities and even existence of this port are threatened by sea-littoral erosions establishing fresh outlets from the backwaters. Here the Native States are obviously less concerned than this Government with the prospective fate of Cochin as a port. Consequently Madras has had to bear the brunt of creating littoral protective works although these actually stand on,—and purport, if successful, to incidentally conserve,—Native land. Ever since 1862, when the Cruz Milagre Gap first opened in our days, the Madras Government has been engaged with this problem which is mainly responsible for the successive appointment of Public Works officers in charge of operations at Cochin, from Mr. O'Shaughnessy to Mr. Campbell, and for the expenditure of considerable sums on dams, groynes, revetments and other measures connected with cases of erosion.

14. I judge from the scanty allusions to erosion in the papers originally sent me and from, for instance, Mr. Campbell's report dealing almost only with improving the bar, that the erosions are now assumed to be completely under control. That may be why more stress is laid in the instructions to Mr. Sneyd, the officer now in charge of the surveys, on backwater data and on borings in the bar than on the prospects and consequences of erosions and new inlets. Nevertheless, I propose below to offer some remarks on this subject by way of *obiter dicta*.

15. *Personal.*—The first papers in this case reached me from Madras through the Government of Bengal on the 17th January along with an enquiry if I could and would undertake it. Allusion was made in the covering letter to a suggestion that the expert employed ought to see for himself not only the place but the action of the bar in May and June. To make a long story short, it was at once arranged by wire that I should come forthwith to Madras, whence after discussing the case and some additional papers with the Honourable Member, the Honorary Secretary, the Presidency Port authorities and Mr. Sneyd (who met me with lands and samples of borings), I proceeded to Cochin to formulate my views on

the subject of extending, if need be, the scope of the enquiries which Mr. Sneyd has already in hand. That is in fact the main object of the following report.

16. Arrived at Cochin on January 27th,—I spent my time till February 6th examining local conditions and consulting the opinions of the Chamber of Commerce, both individually and *en bloc*, as well as several of the oldest inhabitants not excluding leaders of the Portuguese and Eurasian communities. Among professional men I have derived very great help from Captain Hand (who had just finished an excellent new survey of the port in, to my mind, an amazingly short time), from Lieutenant Clarke, the Port Officer, and from Mr. Sneyd, whose home training as a Harbour Engineer very specially fits him for this charge. I also interviewed, more than once, Captain Winckler, a notable retired Master Mariner, a native of, and at one time Port Officer at, Cochin. Among senior Engineers Mr. Browning kindly came from Trichur, Mr. O'Reilly, Executive Engineer from Cannanore and finally the Chief Engineer from Madras, the Superintending Engineer from Coimbatore and Mr. Bastow, Chief Engineer from Travancore. These favoured me with consultations, allowed me to assist at their official inspections and, at a final conference, drew up notes of further instructions for completing the whole case. A typed copy of my own private notes is appended.

17. It seems right to say here that the stress laid by the Chamber of Commerce on seeing the place in May and June is apparently not based on any notable change in the bar at that period. That, especially against the ebb tide, the sea is then so heavy as to "trip" on the bar and makes the working of barges quite dangerous is a fact of which ocular demonstration is superfluous. It were nevertheless well that Mr. Sneyd should put this action on record by means of photography accompanied by a return showing the amount of hindrance to cargo working actually incurred.

18. Most of the following statements regarding physical facts come from secondary sources which I am not in a position to verify. Also it may be that in some cases I have misapprehended the authorities I rely on. Consequently, in matters relating to local conditions and indeed all statements not explicitly based on my own knowledge,—I would beg the Public Works Department to kindly verify the alleged facts, names of places, etc.

19. In concluding this preamble I wish to offer warm thanks to all, whether named or unnamed above, for the kindly and capable help which enabled me to get through so much work in the time with so little fatigue.

SECTION II.—THE BACKWATERS.

20. *Drainage area.*—Mr. O'Shaughnessy—*vide* Government Proceedings of 21st December 1869—allows that these backwaters drain and partly cover some 5,000 square miles of low country in addition to an undefined hill-tract area. I am told that the rainfall touches 120 inches over the lowlands and some 250 on the uplands. Whether 5,000 miles includes the Periyar Delta is not clear. In this connexion Mr. G.

Robertson, Harbour expert, allowed in 1871 that the southern backwaters affect Cochin far more than do the northern and said that what I will call a minor Tidal Node turns back all tidal if not also all upland discharges northward so as to wholly avoid the Cochin outlet. Mr. Smith and Colonel Ellis on the other hand incline to allow that a considerable side channel from the Periyar spills towards Cochin in high floods. That is not inconsistent with the existence of the "node" which Mr. Browning and Mr. Sneyd, so far as the dry season is concerned, have verified. The facts regarding the node's position and action in the rains should be fully investigated as part of Mr. Sneyd's new instructions.

21. *Detritus*.—It is steadfastly believed locally that the enormous denudation of gneissic sand and jungle-humus which the above drainage areas cannot fail to discharge is all trapped within the backwaters and that none ever reaches the Cochin gut. My present attitude towards this allegation is one of technical agnosticism. I find it equally difficult to either credit the alleged facts or to discredit those who assert them. From a wide intimacy with other (e.g., Himalayan) rivers I confidently assert that the persistence of great depth in the "pot hole" of the Cochin Gut is not incompatible with the passage of huge volumes of heavy detritus while the river is in flood. I think it a *sine qua non* that the facts of this part of the case shall be investigated scientifically not only in the winter but throughout the whole year.

22. *Gaugings*.—It was agreed in our conference of 5th February that, subject of course to Government sanction, the rises and falls whether tidal or fluvial, the velocities, sectional areas, salinities and siltages must now be determined for all stages and seasons through at least a whole year. It was also agreed that the gauge datums must be absolutely unimpeachable because in these cases a very slight error in levels can vitiate the whole thing. I think that the help of the G. T. Survey should here be evoked. I forgot to say at the conference that the distances (both up and down and there and back) to which the currents carry floats, such as whitewashed cocoanuts, should be frequently determined at each gauge station. *Prima facie* I suspect that the effective tidal compartment rarely extends farther than 12 or 15 miles from Cochin.

23. *Gauge stations*.—The conference suggested that the station at the head of Vembanaud lake, being mainly of interest to Revenue authorities, should be worked by Travancore officials under occasional supervision by Mr. Sneyd. Mr. Bastow has kindly agreed to this arrangement. That reduces the work of the survey staff on the southern backwater to two stations, one at the outlet from the lake and one at a point marked on the plan where practically the whole of the southern backwater is shown concentrated in one throat. Mr. Sneyd, if our views are accepted, will also have, in one sense, two northern stations. The upper of these is not, strictly speaking, a gauge-station being concerned with observing any seasonal variations in the locus of the node. The location of the lower station is a point of some difficulty. There is no single throat in the northern system of channels and it seems likely we shall have to gauge all three main waterways where crossed by a line extended, roughly, W.N.W. from Ernakulam railway station to some point on Vypeen. I attach special importance to this part of the investigation for two reasons. First, the

steepness of the Cochin shore of the gut half suggests that the northern discharge is heavier than is generally supposed—and secondly a question may yet arise of diverting the channel now immediately east of Vypeen and driving its discharge around between Candle Island and Bolghotty.

24. *Gauging the gut*.—The Cochin gut offers a normal example of not uncommon phenomena. The various backwater discharges have for ages been so oriented that they concentrate in the Gut and scour a deep "poy hole" from which they presently diverge over the bar. Just here it is noteworthy that where a few weeks ago, Captain Hand, R.I.M., indubitably found maximum depths of 60 feet,—Lieutenant Channer in 1883 found 55 feet and earlier (according to Colonel Sankey's report of 1881) the charted maximum was only 48 feet. These figures give room for the supposition that the gut-scour deepens *pari passu* with the rise of the bar outside in the ratio of quite 4 or 5 to 1. If that is so, I foresee no small risk of the Cochin shore at the gut being some day undermined.

25. I hold it absolutely necessary to regularly gauge the velocity, salinity and siltage in the gut at all depths, in all stages and seasons but I anticipate much difficulty over deep silt gauging. The coarse materials found on the bar, whether they come in from the sea or run out from the land, are sure to crawl so close along the bottom that ordinary silt traps will fail to secure proper samples. I have heard of lobster pots being used in such cases but don't know any details. It would be a comfort to find, as we may, that variations between 48 and 60 feet depths are more seasonal than secular. It seems likely that each of the charts under reference was perhaps only sounded once in the course of each survey possibly under differing seasonal conditions.

SECTION III.—THE EROSIONS.

26. *Secular changes*.—I do not fully share the more extreme anxieties to which sea erosions have given rise, although I confess they are more than sufficiently alarming. It seems to me axiomatic that the land as a whole is encroaching on the sea along this coast. If not what becomes of the denudation from hills scoured by over twenty feet of annual rainfall? All of it cannot well land in the backwaters which seem to mainly accumulate light manurial silts while the heavier stuffs pass on. It seems certain that monsoon gales produce waves in the wider backwaters, but I do not gather that these, as in the Sunderbund channels, throw up sandy beaches. Whether they actually do so in the Vembanaud lake should be recorded.

27. *Hypotheses*.—I rather lean to Mr. Browning's ingenious view that certain rivers throw out submerged deltas in the sea and that these by dint of outside littoral currents, extend "Bills" which are inevitably followed by "Bights" running more or less parallel with the shore. The Bills perhaps tend in the long run to segregate new backwaters from the sea. Such theories unfortunately are of more academic interest than practical value. No one generation, or even century, is likely to see the whole process completed and I only mention this idea by way of explaining hypothetically the present situation immediately north of the Cochin entrance.

28. *The Vypeen divide.*—Whatever connexion exists between the discharge from the Periyar at Manambam, the original mud-flat anchorage off Narrakal and the gradual southward extension of that vast flat, it seems certain that the extension has cut off Narrakal from the sea and has moved down the anchorage to Malipuram. The flat constitutes, *ex hypothesi*, a Bill and it is undoubtedly succeeded by a Bight which, at least ever since 1835, has continuously worn away the Vypeen seashore. We don't seem to have any express technical term to describe a comparatively narrow width of spit which segregates the sea from an adjacent backwater. For convenience I will here call it the Vypeen divide. According to Mr. O'Shaughnessy's map, made in 1869, this divide has worn away from over a mile wide in 1835 to a bare 100 yards and is now mainly a mere *super-bar*. The 1835 shore line was presumably defined by Lieutenant Robertson, R.N., who recorded 15 to 17 feet of water (perhaps according to the tide rise) on Cochin bar.

29. *Foreshore protection.*—For quite fifty years the Cochin sea face and the Vypeen Divide has been under more or less continuous treatment. The primary objective at Cochin is to conserve urban British property, while at Vypeen, where practically all the land is agricultural and owned by the Cochin Darbar, the main object is to keep the sea out of the contiguous backwater. At Cochin Mr. O'Shaughnessy's dictum of 1869 still holds good—"There is nothing unusual in the rapid disappearance and equally rapid reappearance of the (*super-bar*) sand." That is quite reassuring at Cochin where the gains overbalance the losses. How far the favourable balance was justly attributable in the sixties to Colonel Walker's revetment near the lighthouse, or in the seventies to Colonel Farewell's groyne A (which he credited with widening a mile long of beach of 100 yards in one season), or always to natural causes, can no more be now determined than the future persistence of existing conditions can be guaranteed.

30. At Vypeen, where the losses prevail, the dual persistence of Nature's successive attacks and the efforts of groyne adherents are equally notable and equally difficult to explain. As the originator of the Bell Bund method, I can speak of River erosions with some authority and I suspect that in some ways the case of Sea erosion is analogous. The cases differ because in vagrant rivers the attacks are concentrated (often within one month of the year), are exceedingly virulent while they last, and are invariably delivered longitudinally, in-parallel to the bank. On the contrary, sea erosions, while infinitely less virulent, persist through the whole monsoon season, attack the shore in a more or less obliquely, transverse direction and exercise coincidentally, a vertical component by alternate rising-fore-wash and then falling-back-wash. Consequently it does not quite follow that a treatment may not succeed in this case although it may fail as badly as I have seen every sort of groyne protection fail in the Punjab rivers.

31. The truth, more or less common to both cases, seems to be that groynes and similarly light defences only suit instances where Nature occupies a semi-neutral attitude and is ready on small provocation to adopt either of two alternative courses. Where Nature is approximately neutral, groynes can undoubtedly help her to, so to speak, make up her mind. When

nature and art act together, their unanimity and progress are wonderful, whereas in the contrary case, the Groyner's art is always useless and not uncommonly harmful.

32. Mr. O'Shaughnessy, who seems to have closely observed the groynes of his day in and after the monsoon, puts his conclusion, with regard to Vypeen in the sixties, very clearly and moderately. He does not admit the existence of littoral currents apart from tidal ebb-spread over the bar. He allows that in calm weather the groynes of his day "have apparently a satisfactory effect but in rough weather "the coast gets cut away as fast if not faster than where there are no groynes." In the case of swift rivers I go farther and find that the effect of every sort of groyne-work when seriously attacked is invariably harmful and ultimately intensifies the ills it was meant to repel.

33. The following may be quoted as a very characteristic episode. Early in 1869 a special "harbour committee" of two Railway Engineers from Madras and a Master Attendant reported that "at the time of their visit" in January the action of the existing groynes was "most satisfactory." Thereupon the Government Order allowed that "it would appear all apprehension of further serious encroachment of the sea at present is removed . . . and therefore work on the groynes may be stopped." By December of same year Mr. O'Shaughnessy reported that the groynes were all useless or worse and recommended reverting to Colonel Walker's method of revetment. In reply, the Government, appalled not improbably at the cost, deferred action for Mr. Robertson the Harbour Expert's opinion; but Mr. Robertson, when he came, declined to be drawn into "the battle of the groynes." The subsequent history is one of successive groyne projects, some stone and others timber, some high and some low, some long, others short, and so on, interspersed with occasional attempts at revetting between groynes, and with repeated allegations that each last failure was due to easily remediable defects of design.

34. For reasons partly indicated above, my river experience is obviously of little use here. I can plainly foresee that, for instance, Mr. Browning's proposed new groyning would cost quite a lakh a mile of shore and that revetment like that north of Madras may easily cost three lakhs a mile. Moreover, I don't see my way to recommend either, or indeed as yet anything at all. This season is anyhow too far gone to introduce any new scheme. So far as I see, stone revetments have failed here mainly because they have no backing and huge voids between the boulders allow forewash and backwash to drag the sand all over the place. As stated in conference I am sure we have here had more than enough of starting fresh hares on *ad captandum* designs and want better information about the actual conditions and their seasonal changes. Marine surveys, sounded only once after a long term of years, may or may not give us the information we need. If practicable, we want sections taken (by the level and staff) at brief time intervals and different stages, extending on fixed alignments as far into the sea as tenth-parts of a foot can be read. We want these both at Cochin and at Vypeen, both where and when accretion is gaining and while erosion is rife, but whether and if so how this can be done in bad weather remains to be determined by actual experiment.

35. *Irruptions of the sea.*—I doubt whether sea breaches are quite so deleterious to the Cochin entrance as is commonly supposed. It is doubtful if the Cruz Milagre gap which was 900 feet wide, some 22 feet deep, and remained open some seven or eight years, did any serious harm to the bar. After some pottering with side groynes in echelon, the gap was ultimately closed, on peremptory instructions from Government by a sand-bag dam that was built in a month's time. It is certain that this closure did not materially improve the Cochin bar. Mr. G. Robertson, in admitting the fact, thought it due to most of the bar-scouring force coming from the southward. He says explicitly that, if the Cruz Milagre breach had occurred as far south as it was actually north (about $1\frac{1}{2}$ sea miles) from the entrance, the Cochin bar would have shoaled to half its then depth. I cannot subscribe to so sweeping a statement as that. As already suggested, the permanence of the Cochin bar depends for the most part on the converging orientation of the deeper backwater channels. It is possible but not likely that a breach may so occur as to seriously tap the Cochin tidal prism. If that ever happens I wish to leave it on record that we ought to be prepared with projects, for so damming the backwater nearest to the breach as to isolate its tidal reach from the main backwater. An instruction to this effect with regard to Vypeen and also perhaps to the erosive danger point which exists, Mr. Browning tells me, some few miles south of Cochin might well be added to the instructions finally given for these extended investigations.

36. To conclude this section of my note, I venture to say that although I regard the risks due to erosions as far less imminent than some have supposed, I consider it absolutely futile to embark in any serious undertaking on the bar at Cochin until after it is perfectly clear that all possible risks from erosion are absolutely under control.

SECTION IV.—THE BAR AND THE HARBOUR.

37. *Hydrography.*—There is nothing abnormal about the Cochin river's embouchure. After collecting the backwater streams in a gut it fans out into a semi-circular bar, which has, roughly speaking, a radius of about a mile and therefore a periphery of three miles. The actual shape of the bar on plan differs somewhat from a semi circle because wave-action, coming slightly from the southward of west, shifts stuff off the left shoulder of the normal semi-circle and transfers it to the right (northern) shoulder. The mean depth on the bar is conditioned by the volume and velocity of the ebb tides which distribute their discharge over the bar's entire periphery. All additions to the bar accrue on its seaward face. Consequently the radius and length of the bar are ever very slowly increasing and for that, if for no other reason, the depth grows proportionately shallower.

38. *Bar strata.*—So far as the borings have gone they show about seven or eight feet of coarse sand and shells overlying stiffish black clay. If this condition continues throughout we may safely predicate that this bar has never been deeper than the 21 or 22 below datum feet to which the clay must have been originally scoured out. The borings in hand were restricted to the particular alignment on which Mr. Campbell proposed to start dredging operations, but I have asked that the borings (or prickings

if they prove easier) shall be taken all over the middle 90 degrees of the semi-circular periphery. At present I am neither prepared to accept nor disapprove of the alignment now in question. The sand so far found is well suited to dredging operations and so indeed, with proper adjuncts is the clay underneath. I see no room to suppose that there is anything harder than this clay under any part of the bar, but this, like other points, has got to be established before any overt action can be taken.

39. *Dredging problem factors.*—It will clear the air to say at once that this bar can only be treated by a hopper dredger which carries away her spoil in her hold. The idea of landing it through pipes is, here, utterly illusory. So is that of delivering it by relays of dump-scows while the dredger keeps on digging. Dump-scows can no more live alongside a dredger on this bar, in even moderate weather, than iron barges can live alongside ships in the offing. Neither can we predicate that the hopper-dredger can carry her spoil into the backwater for reclamation work. She would have to contend with strong tides in narrow water and would assuredly lose time in connecting her discharge to a shore-pipe. I take it therefore that much, if not all, of the bar-spoil has got to be dumped, or perhaps better pumped overboard, at sea—where and how far from the working-ground remains to be determined.

40. The daily outturn of work will obviously depend on the size of the hopper-hold, the distance to the dumping ground and the speed of the ship. As, however, a bigger boat needs more propelling power she can utilize comparably larger pumps and it follows from this and other less obvious considerations that while dredging the same stuff and steaming at the same speed to the same dump-ground a, say, 2,400-ton hopper (the size I here incline to recommend) will deal with her full load in exactly the same time as would a boat of half her size. So far therefore, *caeteris paribus*, the day's work varies directly with the tonnage of the vessel. Within limits, the first cost of the bigger boat is less,—her hull is more durable and she costs far less per ton to work because much same superior staff is needed for either dredger whether larger or smaller.

41. The *quality* of stuff to be dredged affects the outturn very materially, but to a smaller economical extent than may be generally supposed. At Chittagong, for example, we at times encounter stuff, of very "volatile" nature in water, that takes five hours of dredging to fill the hopper-hold once. At the other end of the scale some stuffs settle so readily that the hopper can be filled in one hour. Here, however, it were wrong to imagine that we get five times the former outturn. We have to reckon with the time spent in travelling and dumping, which we may fairly take at three hours per load. On this basis, while the most volatile silts I know of yield one load (*ex hypothesi* 2,400 tons) in eight working hours, the best we can expect would yield two loads in the same time. In short, five times better stuff gives only twice as good outturn. Eight hours is quite a fair day's work for a single crew. The rest of the day goes in raising steam, proceeding to and from the work and the anchorage and in making things snug at night. Speaking of the crew I note that in this climate the whole lot must be accommodated in deck-houses and sheltered by standing awnings.

42. The time actually spent over travelling to and from the dump-ground depends on the normal speed of the ship, as conditioned by the state of the engines and the cleanness of the hull. In this case the vessel would have to be docked twice a year, presumably at Bombay, where also she will need a triennial overhaul, most likely, being Government property, in and at the convenience of the Government dockyard. I need not dwell on further delays entailed by accidents of sorts. These things help to make Indian dredging work very costly, but the main factor consists in the necessary employment of high-paid Europeans who are inevitably more concerned to avoid mishaps than to push on the work. Resort for repairs, etc., to Bombay or Colombo involves, for example, the entertainment of an officer with a ship master's certificate. We have not yet hit on any quite satisfactory way of paying our dredging staffs, as a contractor would, by piece-work.

43. *Dredging duty.*—By long-established custom a dredging-ton is reckoned at 20 cubic feet of hopper capacity, representing, we may take it in this case, some $12\frac{1}{2}$ cubic feet of solid measurement. On that criterion 2,400 tons will equate 30,000 solid cubic feet and a channel dug through this bar to 30 feet below low water with 600 feet bed-width and six-to-one slopes (which is now the steepest angle of repose in the gut) would measure some 54,000,000 cubic feet. On reflection I now hold that 33 feet depth and 900 feet bed-width are needed and expect these changes to double the aforesaid quantity. Even 54,000,000 cubic feet at 60,000 per working day (on the hopelessly impractical assumption that no fresh deposit whatsoever accrued in the time) would take 900 working days to shift. As we have nowhere yet succeeded, so far as I know, in getting more, in round figures, than 180 days' work per annum, in comparatively sheltered waters, I doubt here if, allowing for the monsoon, we can count on more than 150 days. On that showing the lesser suggested channel would occupy one 2,400-ton dredger for four years and obviously the bigger channel twice as long, apart from clearing re-siltages.

44. I have gone at some length into details of my experience with dredger working because I wish both Government and the Chamber of Commerce, to verify my statements and recognize that I am not merely offering these deprecatory forecasts *ex cathedra*.

45. *The entrance.*—From a Harbour Engineer's point of view a main merit of merely dredging consists in the fact, that unlike fixed training-walls, dredging does not irrevocably commit us to any foreordained alignment. If the dredged alignment proves wrong, we can abandon or change it without serious harm. As already indicated, I need a great deal more information before feeling justified in recommending any action whatever, and, in my view, nothing but extended experience can prove where the line of least resistance can be found. Messrs. Parkes, Mathews and Campbell concur in recommending an entrance running direct out to seaward, but Mr. Browning, some time ago, favoured and Captain Hand still favours an alignment which starts outward due west from the Gut and then turns towards the north. It may be that dredging, while in progress, will show that the second or possibly some third alternative alone befits the conditions which will assuredly develop as the operations progress.

46. I base my new view that the entrance should aim at a depth of 33 and a bed-width of 900 feet on the following considerations. I suggest extra width because the sea, from May onwards, will assuredly run swiftly up the middle of the deep entrance while dragging on its flanks and breaking along its side slopes. The breakers will surely pull down large masses of sand, etc., which will assuredly, as elsewhere, create lumps and patches in the fairway. Assuming we want a safe passage for ship drawing 24 feet in a sea with a "heave" of quite 4 or 5 feet. I hold that 33 feet dredged depth will not leave too much room for such patches and lumps as I anticipate. These will develop exactly at the time when the dredger would find most difficulty in tackling them. I am not here immediately concerned with asking whence the bar sands originate. That point will be duly investigated, but the fact in any case remains that, wherever they come from, they necessarily come during the monsoon. Personally I do not believe that any monsoon bar-dredging can be done.

47. *The harbour.*—Mr. Campbell is quite right where he allows that deepening the entrance is calculated to accelerate the force of the tidal waves. It also will vastly increase the influx of ground swell, a point I have just dwelt on. Both actions are liable to lessen the present safety of the anchorage within the port. They may even tend to endanger Ernakulam itself. The waves can only begin to dissipate their activities well within the gut where the main backwater channels, as viewed with one's back to the sea, widen out. When Captain Hand's new chart has been lithographed, the Marine Department should be called on to show where, with or without dredging out fresh anchorages, it will be safe to lay down double moorings for ships. The idea of moorings where the ships must keep always under steam in the monsoon and where the working of barges may be difficult does not commend itself to my judgment. So far, even assuming we can bring the ships in, I see no finality about where they are to lay. The bar project is, to my mind, as yet so exceedingly nebulous, and harbour proposals so obviously for primary discussion in the Marine Department that as yet these are well outside the sphere of immediate examination from the engineering point of view.

SECTION V.—SUMMARY.

48. In conclusion, I may here perhaps revise and reiterate the gist of my *ad interim* conclusion as already outlined in conversations with the Honourable the Chief Engineer and with the Chamber of Commerce :—

I. It is absolutely necessary on every account that the peculiarities of the backwaters should forthwith be exhaustively explored and recorded.

II. The treatment and segregation of the various erosions, both where active at Vypeen and where threatened at other points, have got to be set on a definitive basis. Until the Government can feel absolutely assured that they possess the means of infallibly dealing with any possible sea-breaches it is idle to regard costly improvements on the bar as within the sphere of practical polity.

III. It is right to go on investigating the bar and its conditions although not to spend money on bar-works. I have told the Chamber that

the ultimate feasibility of dredging the bar to admit sea-going steamers at all seasons can only be established by crucial and costly experiment. If the authorities concerned, e.g., the Government, the Cochin Darbar and the merchants are prepared to stake 15 lakhs, say 5 lakhs apiece, on the sheer preliminary of employing, in the first instance, one 2,400 ton hopper dredger on this bar—well and good. If not, I see no prospect of making any valid progress. Such success as one dredger can show would at best mean that a second and not improbably a third dredger would be needed to keep down the bar in perpetuity. With 15 lakhs, £100,000, we can I think pay for a dredger *plus* the capitalized value of working and amortising the prime cost. If she fails to show that a deep-sea entrance can be established it will be of little use, in my judgment, for her to only give us say two or three feet more depth than at present. As a hopper dredger she could be of but little use to either Darbar for effecting reclamations. She would need to be fitted up with costly shore-pumping gear and most likely her draught will be too great for employment in that way. I doubt if she would sell second hand for more than £10,000 if so much.

IV. Lastly there is much room to fear that deepening the entrance, if successfully effected, may greatly lessen the present security of the inner harbour and marginal villages and towns. It is up to the Marine Department to show where they would propose to moor big ships inside. I am not now prepared to suggest any comprehensive inner harbour scheme in sequel to a very hypothetical entrance.

15th February 1913.

JAS. R. BELL.

Order—No. 861 W., dated 29th April 1913.
Recorded.

2. The investigations ordered in G.O. No. 1356 W., dated 30th September 1912 read above, should be continued for another year from the date of expiry of the present sanction on the lines described by Mr. Bell in his report. The Superintending Engineer, IV Circle, will submit a revised estimate of the cost of the investigation and he is informed that, pending submission of, and sanction to, that estimate the employment of the present staff may be continued.

(True extract)

C. A. SMITH,
Secretary to Government.

To the Superintending Engineer, IV Circle.
" Marine Department.

" Political Department.

" Resident in Travancore and Cochin (through the Political Department).

Copy to the Financial Department.

" Accountant-General (Order only).

" Chamber of Commerce, Cochin.

" Collector of Malabar.

IV

G.O. No. 1267 W., DATED 7TH JULY 1915.

READ—the following papers:—

(i)

From the Supg. Engr., IV Circle, dated 3rd September 1914,
No. 1667 W./611 P.

From the Supg. Engr., IV Circle, dated 21st September 1914,
No. 799 W./611 P.

(ii)

Letter from J. M. PARKER, Esq., Superintending Engineer, IV Circle, to the Chief Engineer, Public Works Department, dated Coimbatore, the 21st December 1914, No. 1083 W./611 P.

With reference to your Memorandum No. 1249/Wks.-B.-3. of 25th September 1914, I have the honour to forward herewith the final report on the Cochin harbour investigations prepared by Mr. Campbell, Executive Engineer, West Coast Division, together with the charts, plans, etc., drawn up by him. The investigations were carried out strictly on the lines laid down, and the report and its appendix deal fully with them and with the conclusions deduced from the results obtained. The main object of the investigation was to ascertain beyond reasonable doubt whether the conditions prevailing at the Cochin bar and entrance are or are not favourable to the opening of a channel through the bar of sufficient depth to admit of the passage of ocean-going vessels, and specially by a study of the natural forces at work to ascertain whether such a passage would remain open or whether following the ordinary laws governing the formation of sand-bars it would close. I need not recapitulate Mr. Campbell's arguments—*vide* his final report and the appendix thereto—paragraphs 6, 7, 8 and 10—by which he endeavours to prove that the conditions of the Cochin bar are in every way favourable to the proposals, but I am myself convinced that his arguments backed as they are by the results of the observations made during the last two years are in the main sound, and that it is beyond reasonable doubt established that the Cochin bar can be opened and kept open with very little artificial assistance to a depth sufficient at all stages of tide to pass ocean-going vessels into a harbour within the lagoon. Once this point is accepted the question of the suitability of Cochin as a port settles itself, for no one who has visited the place can fail to be impressed with the extraordinary natural advantages which it possesses. The back-water is a vast lagoon which only requires dredging and laying out to form a harbour for any number of vessels which may ride secure at anchor there. On the economic aspect of the scheme I have nothing to say as it is entirely outside the scope of the investigation which forms the subject of Mr. Campbell's report. As regards the future, the first step towards the realization of the scheme of Cochin as a harbour has already been taken. In the proceedings of Government in the Marine Department in their Order No. 366, Marine of 24th October 1914 (communicated with the Chief Engineer, Public Works Department's Memorandum No. 8458-C. of 3rd

November 1914), the proposal to hire the dredger "Jinga" to dredge open the Cochin bar was agreed to. As stated in paragraph 6 of Mr. Campbell's report this part of the work though actually the first and most important step in the history of the harbour will be a very small item compared with the work to follow, viz., the formation of the harbour itself. After completion of its work on the bar which will not, it is considered, extend over more than two to three months, the dredger should be employed at once in deepening the lagoon near the entrance to form anchorages, so that the harbour may become operative with the least possible delay. As regards further operations I do not attempt to formulate any proposals or even to review the scheme sketched out by Mr. Campbell. I consider the formation of the harbour proper to be far too large and vital a question to be left to amateurs, so to speak, and in view of the vast interests which the success of the scheme would involve, I have no hesitation in recommending that from the start first-class expert knowledge should be brought to bear on the matter, and that a comprehensive scheme based on the best advice obtainable should be drawn up.

ENCLOSURE.

Final report on the Cochin Harbour investigation from December 1912 to March 1914.

This investigation was originally sanctioned for a period of six months in G.O. No. 1356 W., dated 30th September 1912, but subsequently on the receipt of the late Mr. J. R. Bell's report, dated 15th February 1913, a continuation of the investigation up till the 31st March 1914 was sanctioned in G.O. No. 1696 W., dated 26th August 1913.

In June 1913 the Chief Engineer called for a report on the results obtained from the investigation up to that time, and I accordingly submitted the same. I may state that this report, dated 18th June 1913 and published in G.O. No. 1693 W., referred to above, is equally applicable to the investigation as subsequently continued up to the 31st March 1914, when it was finally closed, all observations taken later than the date of the report merely proving confirmatory of those taken previously, and in no way revealing new features nor giving me any reasons for modifying my previous statements. I do not, therefore, propose to go again over the ground covered by the report (a copy of which I am attaching as an appendix), but shall confine myself to a description of the principal observations as carried out by the investigation party, to a statement regarding the establishment and expenditure, and to making certain recommendations regarding our future procedure for the improvement of the harbour.

The following is a list of the observations and works carried out:—

I. Borings and probings on the Cochin bar and in its vicinity for ascertaining the nature of the material to be removed in dredging a channel through it.

Boring work was at first attempted with a derrick on a raft built on two big cargo boats, but the arrangement was found to be unsatisfactory

as the raft oscillated with the waves and the boring pipe could not be maintained in a vertical position. Subsequently a large tripod derrick was constructed out of bamboos and placed on the bed of the sea. This was found to act very well and 13 boreholes were completed by this means varying from 40 to 46 feet below M.S.L. The depth of water in which the derrick stood varied from 12 to 22 feet. Besides recording and plotting the sections on paper, samples of the borings have been kept in graduated boxes with glass lids to them which at once show the different strata passed through by the boring tool. At the site of the proposed channel it was found that there was on the top of the bar a thickness of 10 feet of sand lying on a bed of mud, the depth of which was not found although the borehole was taken down over 40 feet below M.S.L. In a borehole made on the same line 80 feet to the westward or seaward of the bar no sand was discovered but only the pure mud of which the bed of the sea is here composed. On the eastward side of the bar, that is to say towards the harbour the sand was found to increase in thickness to 15 feet, lying as usual on mud.

In addition to the borings 16 probings were made; I do not consider however that these are reliable, as the person in making them has to judge entirely by feel as to what material the probing rod is passing through. I tested one probing by making a proper bore-hole in the same place and found it very much out. However as the boreholes have given us all the important information we require, accurate results from the probings are not essential to our purpose.

II. Periodical soundings on the bar in order to note any fluctuations it may be subject to.

The lines on which these were taken were first plotted on the chart and the position of their starting and finishing points bore to certain fixed marks ashore (the rifle butt, the lighthouse, and the boundary pillars on Vypeen) ascertained by means of a station pointer. When soundings were to be taken, two boats proceeded to sea and by means of a sextant the one picked up the finishing point of the line and the other the commencement, the first boat remained anchored while the second rowed straight towards it taking soundings at regular intervals. The result of these soundings taken once a fortnight, was to show that the variations of the bar were very small throughout the year.

III. Littoral current observations off the coast on either side of the harbour entrance for the purpose of ascertaining the direction of sand-travel and the character of the currents on the bar.

Floats constructed from empty oil-drums weighted with stone and sufficiently submerged to prevent their being influenced by the wind, were dropped into the sea off the shore if the tide was flowing, and at the harbour mouth if it was ebbing. The point at which the float was launched and picked up was found by observations with a sextant. The float was usually allowed to travel for about an hour. The course of the float was plotted immediately on plans previously prepared. These observations have confirmed the natural supposition that the littoral currents in the vicinity of the harbour mouth are purely tidal and consequently reverse twice every twenty-four hours. Excepting that issuing

from the harbour, there is no current from the coast to the bar and therefore no sand can be taken there from the foreshore.

The ebb-current issuing from the harbour if it has a burden of sand or silt does not drop it at any particular point, but as its strength is gradually absorbed in the ocean, distributes it over the floor of the sea, and consequently its power to raise the bar or fill a channel dredged through it is negligible.

Occasionally the bar is raised temporarily from 6 inches to 1 foot by the floods during the monsoon which weaken the force of the flood-tide and roll the sand from the harbour on to the bar; as soon however as the tidal action is again operative the small ridge, so raised, is levelled off.

IV. Observations of sand within the harbour in order to discover whether it is deposited there by fluvial or marine agency.

Samples of the material comprising the bed of the harbour were obtained by lowering a heavy lead weighing about 13 lb. and having a hollow on its lower side filled with soap to which the mud or sand, as the case might be, attached itself. The facts that the sand closely resembles that of the foreshore, to which it is connected without a break, and that it is entirely different in appearance from that of the river from which it is separated by long stretches of mud, conclusively demonstrates that it is of marine origin and is brought in on the flood tide.

I may here state, that the bed of the sea being pure mud and containing practically no sand, and the only other sources from which sand is obtainable in any quantity having been eliminated, we are driven to the conclusion, that as a channel through a bar can only be naturally closed with sand, the chances of our cut through the Cochin bar being filled up are very remote.

V. Cross-sections have been regularly taken and plotted of the Vypeen foreshore for the purposes of observing its fluctuations, and the effect of the protective works that have been constructed there. I may explain that Vypeen derives its importance from the fact that it is a narrow spit of alluvial soil only 200 feet wide in places and two feet above high water springs, which divides the backwaters forming the Cochin harbour from the sea. Since time immemorial this spit has been getting narrower owing to the erosion of its sea face. Finally in 1913, when a breach was imminent, the present protective works were hastily commenced, as there were well-founded fears that if a breach were to occur, the current due to the ebb and flow of the tide, being no longer concentrated at one entrance, the bar would silt up to the detriment of the port. These protective works, which took the form of stone-faced bunds, were in the first place of a tentative nature and, though they managed to hold their own, required a considerable amount of repairs and strengthening. Improvements to these are still in progress and there can be no doubt that ultimately they will sufficiently be strong to resist all attacks of the sea.

VI. The collection of data necessary for computing the cubic contents of the tidal compartment, and for constructing a tidal diagram of the backwaters discharging through the Cochin opening.

Levels were taken from the bench mark at the Port office, Cochin, down to Alleppey, 40 miles south and 11 miles north to Iyempalli.

Automatic gauges were fixed at Cochin, Ramanthuruthi Island, Edacchi, Tannirmukum, and Aryad on the south branch of the backwaters, and in addition ordinary gauges were fixed at Iyempalli, Narrakal, Ochanthuruthi in the northern branch of the backwater and at Perumanur, Arukutti, Panavallia, and Pallipuram in the southern branch. Iyempalli is roughly the position of the nodal point of the tides entering the backwater at Munambam and Cochin.

The readings for constructing a tidal diagram were made on the 20th and 21st May 1913 between 6 a.m. and 6 p.m. both days. The whole of the investigation party was employed in reading the fixed gauges over a period of 14 hours. From the tidal diagram the tidal compartment was calculated by dividing the backwaters up into 10 blocks according to the stations at which readings were taken. The areas of these were taken off the survey maps by means of planimeter and multiplied by the mean of the extreme range of the tide as observed at each end of the block. The result showed that the cubic contents of the tidal prism is 2,780,000,000 cubic feet for a tide of 2 feet 3 inches at Cochin, which gives an average discharge of 154,000 cubic feet per second through the Cochin opening and a velocity of 3.34 feet per second. One of the immediate results of these observations was to show that those backwaters more than 20 miles distant from Cochin do not form part of the tidal compartment. It must not, however, be assumed that the indiscriminate reclamation of the Vembanad lake and other backwaters, not forming a portion of the tidal compartment, can therefore be carried on indefinitely without deleteriously affecting Cochin harbour. In the monsoon these backwaters act as flood-moderators and although a very considerable amount of judicious reclamation may be done, care must be taken that they are not encroached upon to such an extent that the current of the flood-waters discharging through the harbour during the monsoon is increased.

VII. Cross sections have been regularly taken of the Cochin gut, but were not found to differ materially at any time.

VIII. Silt observations made in the Cochin gut showed that more silt was brought into the harbour during the monsoon than was discharged.

IX. Diagrams have been prepared from the charts of 1833, 1852, 1883 and 1913 showing (a) the mutations in the levels of the Cochin bar and gut, and (b) of the foreshore and sand-banks near the harbour entrance.

X. Discharge observations were made of the left branch of the Alwaye river. It was thought that something might be done to increase the tidal currents during the monsoon by diverting the floods from the Alwaye river down the right branch of its estuary which discharges through the Manambam opening. It was found however that such a scheme is not practicable as at the junction of the branches the whole country becomes inundated in flood time and regulators, by obstructing the flow of the water, would nearly increase the flood and do little or no good.

2. The working of the investigation party was somewhat hampered by the fact that there were many changes in the officers and subordinates in charge of it, as the following list shows :—

From 8th December 1912 to March 1913 Mr. Sneyd, Assistant Engineer, on Rs. 500 per mensem was in charge.

From March 1913 to 22nd April 1913 it became a section of the Shoranur subdivision, with Overseer P. Subrahmanya Ayyar, Overseer, on Rs. 150 in direct charge.

From 22nd April 1913 to 30th May 1913 T. P. Anantarama Ayyar, Overseer, on Rs. 100 was in charge.

From 31st May to 16th August it was again made a separate subdivision ; Mr. Wernigg, Assistant Engineer, on Rs. 375 held charge.

From 16th August to 3rd November 1913, it again became a section of the Shoranur subdivision with Mr. V. David, sub-Overseer, on Rs. 45 in direct charge.

From 3rd November to 16th November Mr. Wernigg was in independent charge.

From 14th November to 31st March 1914 it was once more a section of the Shoranur subdivision and in direct charge of Mr. David.

3. The cost of the investigation was covered by an estimate amounting to Rs. 58,770 sanctioned in G.O. No. 1695 W., dated 25th August 1913. The actual expenditure has however been only Rs. 35,300 and thus a saving of Rs. 23,470 has been effected ; this saving has been chiefly due to the fact that the cost of establishment and tide gauges amounted to considerably less than was anticipated.

4. As regards the improvement of the harbour, the first work to be undertaken is that of dredging a deep channel through the bar by which ships can enter the harbour at all seasons of the year. It is therefore apparent that if further progress is to be made a decision must be come to as to the type of machine we shall employ for this work. I may state that I have given this subject considerable attention for sometime past and that in 1912 with a view to making enquiries regarding the purchase of a second-hand dredger I addressed the Conservancy Boards of various ports in the British Empire where I knew dredging operations were, or had lately been, in progress. Amongst others, I wrote to the Chief Engineer of the Bombay Port Trust who replied to the effect that his dredging operations were shortly coming to a close and that two very powerful dredgers, the "Kalu" and the "Jinga", built by Messrs. Simons and Co. of Renfrew and each capable of dredging over 5,000 tons an hour would then be for sale. On further enquiries, however, I learnt that these dredgers bring up the dirt in such huge volume and at such a high speed that they can only discharge through a pipe-line, no hopper barge being able to withstand the force and rapidity with which the material is delivered. As I questioned the possibility of our being able to maintain a pipe-line on the bar I dismissed the idea of purchasing one of these dredgers from my mind, and thought no more about it until it was recalled by Mr. Rutherford when as Chief Engineer of the Government dredger "Manar," he was lately engaged in cutting an experimental channel through the Cochin bar. This gentleman who has worked for a long time on the "Jinga" at Bombay and is therefore in a position to

speaking with authority regarding her capabilities and those of the pipe-line, most strongly recommended her employment on the Cochin bar and emphatically stated that the pipe-line would withstand any sea that is met with there during the fine weather previous to the approach of the monsoon. There will of course be the remote chance that a heavy swell may come and break our pipe-line, but even this contingency, unless it is of frequent occurrence, will mean nothing worse than a delay caused by the time occupied in replacing it. As, however, it would only take the "Jinga" twenty eight-hour-working days to dredge a channel 25 feet deep and 600 feet wide at the bottom, I consider that the slight risk we should be taking of having the pipe-line damaged is amply warranted. In this connexion, I may state that I have just returned from visiting Cochin in company with Mr. Thomas McMurray, a Director of Messrs. Simons & Co., with which firm I had previously been in correspondence regarding our requirements at Cochin. I may explain that Mr. McMurray who is travelling in the East in connexion with the dredgers his firm have supplied to different places in India and Burma, wished to study the conditions at Cochin first-hand. It is of considerable interest that this gentleman, whose opinions on matters concerned with dredging have every right to carry weight, frankly told me that although it might possibly be to the financial interests of his firm to recommend the purchase of a new dredger, yet he was too much of an engineer to do so, if we could purchase the "Jinga" for a reasonable sum, and use her on the bar, as the saving of time and money effected would be so great that there was no justification for buying a new but less powerful dredger. Mr. McMurray further informed me that when in Bombay lately he had for his own satisfaction made a survey of the "Jinga" and found she was in excellent order excepting that the pump was rather worn and would have to be renewed after a year or two's more work ; this would cost £1,200, but she would then have 15 years work in her. As she cost £60,000 five years ago, and as the Bombay Port Trust are asking only £23,000 for her now she is a very cheap purchase. As regards the pipe-line, Mr. McMurray states that although the Bombay pipes are in bad repair they would last one season that is to say, long enough for us to dredge the bar. I may here explain that the discharge pipe is 3' 9" in diameter, and is in 80 feet sections, each section being supported on either side by a cylindrical pontoon. The section thus complete with its floats weighs 12 tons empty ; the sections are connected to one another by universal joints. I may state that when I discarded the idea of using a pipe-line on the bar, I was unaware of the great weight of the sections comprising it or I should certainly have given the matter further consideration. I am now in agreement with Mr. Rutherford that with such heavy pipes, if we work in the right months of the year there is little or no danger of our pipe-line being broken by the waves. Mr. Clapton of the Port department who spent four months on the bar making the marine survey the season before last, also concurs in this opinion.

I recommend that the channel follow approximately the line of best water over the bar, as shown on Commander Hand's chart of 1913, for the reasons that not only is the bar narrower there than on any other line, but it will receive fuller advantage of the flood-tide which approaches from the

south-west and which will assist in maintaining the depth of the channel, further as will be seen from the chart, the landfall south of the bar being considerably better than that north of it, the further south we have entrance to the channel within reasonable limits, the better. When working on the bar the "Jinga" would be fitted with a pipe-line 2,000 feet long which would discharge the material dredged on the north side of the channel. It is not advisable that the dredgings should be dumped on the south side as the set of the flood tide and of the waves during the monsoon is in a north-westerly direction, and will tend to move it northwards, if anywhere. Mr. McMurray informs me that the sand and mud so discharged would deposit in a mass below the mouth of the pipe and that very little would be carried away on the current, consequently we should build up a mud-bank which would act as a training groyne and would assist in concentrating the current through our dredged channel. There would be no risk of the mud so dredged being carried back into the channel, as, from our observations, we find that no currents pass from north to south across the bar.

5. As the dredging of the bar by the "Jinga" or for that matter by any other dredger must from its very nature have a slight element of uncertainty in it, I would suggest that if possible we should come to an agreement with the Bombay Port Trust by which we might hire the "Jinga" and its appurtenances for two months, after the close of the monsoon, with the option of purchasing her, should she prove satisfactory, the amount paid in hire to be deducted from the purchase money. The best time to commence work is in the middle of November after the freshets have ceased and before the afternoon sea-breezes have commenced. From the 1st November to 15th January perfectly calm weather is the rule at Cochin. If however we are to take full advantage of these months we must have everything in readiness to commence work. I would therefore recommend that the discharge-pipes are brought down to Cochin in October and kept in readiness for the arrival of the dredger in November. The channel to be dredged will have to be accurately buoyed, and arrangements made for coal for the dredger, etc. With respect to the dredger itself, it must be first carefully inspected and a report made regarding any fittings that may be wanting, as it is quite possible that we may find that certain extra accessories, such as wire-rope and anchors are required for working her at Cochin. Then we have to arrange for a crew and as both the Dredge-master and the Chief Engineer will probably come from Europe we cannot leave this till the last moment. Further everything points to the fact that if we are not going to waste a season, we should lose no time in considering definitely the financial side of the case and deciding the lines on which we are going to work.

6. In regard to further improvements to the harbour we must not forget that if we get the "Jinga," the opening of the bar will be a mere incident in its work, and that if all goes well she will be available for employment inside the harbour in less than a couple of months after her arrival. I may here state that for dredging in the smooth waters of a harbour and discharging the material through a pipe-line for reclamation purposes, the "Jinga" is not to be improved upon. That there is plenty of work for it inside the harbour is obvious from a glance at the

soundings shown on the chart, for Cochin harbour though it covers a large area can afford an anchorage to only six steamers at present, even if double moorings are used, and a considerable amount of deepening will have to be done before it can accommodate many more large vessels. I propose therefore as soon as the bar has been opened to dredge a large deep water basin immediately within the harbour entrance. This will have a minimum depth of 28 feet and will form the main anchorage. The material dredged will be discharged through a pipe line into the sea in front of Vypeen where it will be of great use in securing the foreshore, for it will take many years of erosion such as goes on at present before the large quantities of sand and clay so deposited would be removed. Even when it does go, in the course of time, it will only travel north and augment the Narrakal Point, in the same way that all sand and mud eroded from the Vypeen foreshore does at present.

7. Having excavated our deep water basin, which would not occupy the "Jinga" more than nine months we shall have a harbour with shipping facilities to all intents and purposes, equal to those of Colombo. If further improvements are required, as without doubt they will be, they should take the form of land reclamation within the harbour. For in view of the fact that the shores of the harbour are already occupied the reclamation of some of the shallower portions of the backwater is most necessary, in order to obtain the land required for wharves, quays, storehouses, railway lines, etc. As however reclamation cannot be satisfactorily carried out unless the necessary retaining walls or banks, forming the enclosures for the reception of the material dredged are ready, before dredging is commenced, it is by no means too early to prepare a scheme for erecting the same. The type of wharf to be adopted must first be decided. Personally I am of the opinion that, as there is ample space available in the harbour, massive quay walls with deep water alongside of them are not necessary, and that it will be both quicker and more economical to enclose the areas to be reclaimed with light reinforced concrete walls or rubble banks requiring no great depth of foundation but from which screw pile wharves, like those at Calcutta and Rangoon, can be built out into water having a depth of 28 feet at low water springs. The breadth of the wharves must be such that the natural angle of repose of the ground lying beneath them is not exceeded or the retaining wall at the back will be undermined. As a start reclamation may be commenced by raising the western portion of Candle Island which, although it lies below high tide level, is under paddy cultivation and is at present let by Government to Messrs. Aspinwall & Co. of Cochin on a lease terminable at six months' notice. We could also by means of our dredger extend the island a 1,000 feet to the west and so obtain 2,000 feet of frontage on the south side of the island. This would be sufficient to accommodate four steamers and could be further extended as required. The railway can be carried across from its present terminus, on screw pile bridges and rubble banks to the island and so to the wharves, thus effecting a great saving in time and money in the landing and shipping of passengers and cargo. This programme of work, modest as it is, is I think all that is required to commence with, and has the advantage of being capable of enlargement to any extent that altering circumstances may require.

8. As regards the physical effect of dredging and reclamation within the harbour, I would point out that the Cochin harbour is a lagoon for seven months of the year, with its entrance kept open by the tidal scour, and that for the remaining five months, it is purely an estuary for the discharge of river water. Our dredging operations must therefore be directed to assisting the discharge of flood waters during the monsoon and the propagation of the tidal wave during the dry season. Only therefore where existing shoals indicate that there is no great scour should reclamation be carried on, and even then care should be taken to interfere as little as possible with the waterways; if, however, the natural channels, as indicated by the soundings shown on the chart are enlarged, and the deep water basin is excavated, as proposed, within the harbour entrance, any reclamation of shoal water will be fully compensated for by the increased facility for the passage of water.

9. I have in the foregoing assumed that the "Jinga" will be acquired, but in the event of this course being thought undesirable and a new dredger having to be bought, I strongly recommend the purchase of one of Messrs. Simons & Co.'s drag-suction hopper dredger similar to that they supplied for clearing the bar at Lyttleton, New Zealand. I may explain that a dredger of this type has its suction pipe fitted with a large scoop trailing behind the vessel. This scoop is pressed into the mud or sand by the forward movement of the dredger, with the consequence that the material brought up is very compact and contains a minimum amount of water. Another advantage of this type of vessel over ordinary suction dredgers is that it requires no mooring, and dredges by moving backwards and forwards over the ground, thus effecting a great saving of time. It can also work in comparatively rough water as there is practically no jar on the trailing suction pipe when the vessel rises and falls. I visited Messrs. Simons & Co. at Renfrew in 1912, and it was then that Mr. Brown, the Managing Director recommended this type of dredger for the Cochin harbour. Mr. McMurray informed me that since my visit they had supplied a similar one for use on the shoals at the mouth of the Rangoon river. The cost of one of their dredgers, capable of dredging about 1,500 tons an hour, is £53,000; it could also be used for reclamation purposes inside the harbour, but of course a small dredger like the "Canterbury" can hardly stand comparison with the "Jinga", the latter being able to turn out three to four times the amount of work that the former can.

10. One final word. If there is any doubt as to the value of the "Jinga" I think it will be dissipated when I state that an English firm found it worth while to buy her sister ship the "Kalu" (which is exactly the same age) and to take her back to Europe for work. It appears to me therefore that if we sit down quietly and allow the "Jinga" to go elsewhere and then proceed to buy an inferior dredger at double the price, with an avoidable delay of two years, while she is being built, it will be one of the most remarkable incidents in the annals of harbour engineering.

11. The following is a list of plans that accompany this report:—

- (1) Plan showing the proposed improvements to Cochin harbour.
- (2) Plan showing position of bore holes on Cochin harbour.
- (3) Diagram showing the depth of sand on the Cochin harbour.

(4) Diagram showing changes of sand banks and land at the Cochin harbour entrance.

(5) Longitudinal section showing the changes in different years in Cochin Bar and Gut.

(6) Tidal diagram of Cochin backwater on 20th May 1913.

(7) Tidal diagram of Cochin backwater on 21st May 1913.

(8) Map of Cochin backwater showing position of tide gauges.

(9) Thirty-six diagrams showing the result of the littoral current observations in the vicinity of the Cochin harbour entrance.

(10) One tracing showing the different soils met with in the borings on the bar.

A. H. S. CAMPBELL,

Executive Engineer, West Coast Division.

15th June 1915.

SUB-ENCLOSURES.

(1)

APPENDIX TO FINAL REPORT ON COCHIN HARBOUR, No. 1010-S.E.,
DATED 16TH JUNE 1914.

Report on the results obtained from the investigation of the Cochin harbour and bar from December 1912 to June 1913.

The primary purpose of the works of investigation, recommended in my report, dated 16th August 1912, and on which action has been taken, was to gauge as nearly as practicable the physical forces that we know are maintaining the present régime of the harbour and bar, and by co-ordinating the results to estimate the character and extent of the physical changes that have taken place in the past and are in progress at the present time. Having arrived at this point we could then proceed to our ultimate object, which is to anticipate with some degree of accuracy, the feasibility and effect of dredging a channel through the bar of sufficient depth to admit ships to the harbour, and the probability of being able to maintain such a channel, when made, at a reasonable cost.

2. In making these proposals I had only my personal observations and the chart of 1883 on which to base them. Since then, however, the discovery of the charts of 1835, 1852, 1858 and the making of a new chart this year have supplied us at once with many invaluable and incontrovertible facts concerning the régime of the harbour and bar that could not possibly have been obtained by any other means, and which, had they been at my disposal when writing my report, would have caused me to considerably modify the extent of the investigation that I recommended. I may state that, in my opinion, the knowledge acquired from charts, taken in conjunction with that obtained from the hydrographical observations made during the last six months, affords us such definite information on the points with which we are chiefly concerned as to render further investigation unnecessary.

3. From a study of the charts we see how the sub-aqueous features of the harbour and the bar have been developing into their present form during the past 80 years. So gradual and regular has been this development, with the entire absence of any violent changes as to warrant us in concluding that the régime of the harbour entrance and the bar is governed by constant and well established forces. It is with the influence that these forces will exert on our channel that we are concerned; all other points of investigation, however interesting from a scientific aspect, are of no practical importance to us.

4. *Tidal and fluvial scour.*—There has been a prevailing impression amongst Engineers who have studied the question that the silting upon the bar, small though it is, has been due to the reclamation of land with if the backwaters which, by encroaching on the tidal compartment, has weakened the tidal current that keeps the bar open. The charts show that this is not the case and that the scour is sufficiently strong to increase the depth of water in the Cochin gut, where it is confined, from 44 feet in 1835 to 62 feet in 1913, in fact so steep is the slope on the south side of the gut that there is every possibility of the angle of repose being exceeded, if the scouring continues, and a serious landslip occurring at no very distant date. I may here state that the tidal prism has been carefully computed (see sheet No. 15) and the discharge found to be 154,000 cubic feet per second for a rise of 2.3 feet at Cochin. This is a very large discharge for a 1,500 feet opening, but is probably doubled when the spring tides which have an extreme range of 3 feet 6 inches, are in force, and during the monsoon, when the floods from the Periyar river come down.

Conclusion I.—No measures are necessary for improving the tidal compartment.

5. The question may well be asked "How do you reconcile the foregoing statement with the fact that the tidal currents have consistently weakened during the last 80 years, as is evidenced by the gradual silting up of the bar?" Here again a comparison of the charts (see sheet No. 6) gives us an irrefutable answer, by showing how the land and sand banks on either side of the harbour entrance, extending out to the bar, have been eroded. These act as training groynes and serve to concentrate the tidal currents on the bar and prevent their dissipation at the harbour entrance. Their deterioration must therefore be accompanied with a concomitant silting up of the bar. Had the land and the sand banks attached to it been protected with rubble groynes, in my opinion, the depth of water on the bar would have been, as in the Gut, greater to-day than it was 80 years ago. It will be noticed that the erosion on the north side of the harbour mouth is much greater than that on the south side. This is due to the fact that protective measures were undertaken first on the south side, the result being that the tidal currents effecting their escape from the confinement of the Gut, take the northerly direction, with the consequence that there is much greater erosive scour on the littoral north of the harbour entrance than the south. This can only be remedied by the construction of a groyne of rip-rap at Vypeen, sufficiently long to bring the north side of the harbour entrance level with that of the south. The groyne might then be continued to the eastern limit of the 6 feet contour and another on the south side of the harbour similarly constructed.

Such groynes located as shown on sheet No. 1 would be cheap to build costing only Rs. 30 per foot run, and would be of the same section as those at present protecting the Vypeen foreshore which stand excellently in 11 feet of water. Besides concentrating the tidal currents these groynes would prove very effective in protecting the harbour entrance and reducing the ground swell.

Conclusion II.—Works should be undertaken without delay to conserve the existing sandbanks on the other side of the harbour entrance and to assist them in concentrating the tidal currents on the bar, by means of two rubble groynes as shown in sheet No. 1. These groynes need not be taken out into more than 6 feet depth of water. That on the north side of the entrance should be commenced first, and brought up level with the existing groyne, protecting the light-house on the south side of the harbour and then both groynes advanced equally towards the bar, until the limit of the 6 feet contour is reached.

6. There is yet one other very important point on which we can gain information from the study of the charts. I refer to the place at which the bar is silting up. In my report of August 1912 I estimated that this was going on at the rate of one foot in 10 years: the charts show that it has been 7 feet in 78 years, thus proving I was not far out in my reckoning. The permanent silting up has in the past been so very regular and gradual that there is no reason to anticipate that it will exceed the rate of 1 inch a year, on the average, when a channel has been dredged through the bar, which will have the effect of concentrating and accelerating the tidal currents.

Conclusion III.—There is no reason to suppose that a channel dredged through the Cochin Bar will silt up on an average of more than one inch a year.

7. We will now consider the results of our hydrographical observations in the vicinity of the harbour entrance and bar, under the following heads:—

- Littoral currents.
- Observations of sand within the harbour.
- Soundings on the bar.
- Borings on the bar.

8. *Littoral currents.*—These have been taken with a view to ascertaining whether sand from the foreshore was carried by their agency on to the bar. The results (*vide* sheets No. 18 to No. 25) have clearly demonstrated that these currents are purely tidal, flowing from the harbour mouth southwards and northwards along the coast when the tide is ebbing and in the reverse direction into the harbour when it is flowing but in no case crossing the bar, thus showing that no sand can be taken thither by the littoral currents.

Conclusion IV.—No sand is carried on to the bar by the littoral currents, which are purely tidal.

9. *Observations of sand within the backwater.*—These were made for the purpose of finding out whether the sand of which the bottom of the Cochin Harbour is composed is of alluvial or marine origin and whether

the sand from the Periyar river is likely to affect a channel through the bar. I believe that we have proved beyond doubt that the sand in the harbour is of marine origin and is brought into the harbour on the flood tide. By taking samples from the bottom of the harbour we were able to define the limits of the sand and mud (*vide* on sheet No. 7). Now had it been of fluvial origin, the sand area in the harbour would not have been circumscribed with mud as is found to be the case, but would have continued unbroken from the point where the Periyar enters the backwaters down to the harbour mouth. Moreover, the sand found in the harbour contains marine shells, and closely resembles that of the Vypeen foreshore while it is very dissimilar from that found in the Periyar river—*vide* samples. Further we find the period of the greatest erosion of the Vypeen foreshore between 1835 and 1858 (*vide* sheet No. 6) synchronises with that during which the greatest amount of sand was being deposited within the harbour, thus showing that the sand as it is eroded at Vypeen is carried into the harbour by the flood tide and deposited.

Conclusion V.—The sand within the harbour has its origin not in the Periyar river but in the sandbanks at the harbour entrance and the Vypeen foreshore from which it is transported in the harbour by the flood tides.

10. *Soundings on the bar.*—These have merely confirmed the information previously gathered from Port officers and others whose duties have brought to their notice the fluctuations of the bar, namely, that after a freshet in the Periyar river and at the end of the monsoon, the bar is found to be temporarily raised a few inches but that as soon as the ordinary tidal currents are again established, the bar is reduced to its normal height. The temporary raising of the bar is easily accounted for by the increased velocity of the ebb current eroding a certain amount of sand within the harbour and transporting it on to the bar and is the reflex action of the scour in the gut. This action does not produce any permanent raising of the bar beyond one foot in 10 years and there is no reason to anticipate that it will adversely affect a channel through the bar. I would point out that an examination of the charts shows the line of deepest water across the bar has not materially shifted during the last eight years. If therefore we adopt the same line for our channel, it is most improbable that there will be any tendency for it to take any other course than that dredged for it.

Conclusion VI.—The height of the bar during the year, does not fluctuate to any appreciable extent, and the line of deepest water across the bar may be considered as permanent.

11. *Borings on the bar.*—In my report of August 1912 I stated that in my opinion the amount of sand that was available for increasing the bar and for filling up any channel dredged through it would be found to be very limited in quantity. The borings have proved the correctness of my supposition and that in fact there is less sand than I anticipated. The bar has been found to be a ridge of sand resting on the mud floor of the sea, and can be easily dealt with by a suction dredger, while the facts of the quantity of sand being limited and the floor of the sea being mud are

most favourable to the construction and maintenance of a channel through the bar. Bars are invariably formed of sand and not mud, the particles of which the latter is composed being too light when in suspension to settle on any bar.

I will here give a couple of quotations from Mr. Wheeler's "Tidal Rivers" in support of my contention that a channel dredged through the Cochin Bar would not silt up appreciably :—

"In a tidal river, where the current is continually being reversed, the particles of matter brought down in suspension from the upper reaches of a river are too light to form a bar, but remain diffused amongst the tidal water until deposited in the sea. The material of which tidal bars are formed consists of shingle or sand, the particles of which are too large and too heavy to remain in suspension.

"Bars having been once formed and subsequently maintained by the action set up by their shape, if removed by dredging, are not liable to be re-formed, unless in situations where there is strong littoral drift and the ebb current is not sufficient to keep this out of the channel."

Conclusion VII.—Sand and shingle being the only material that can be deposited on a bar and these being very limited in quantity at Cochin, there are no means by which a channel through the bar could be materially filled up. The sand composing the bar and the mud underlying it are suitable for suction dredging.

12. I believe an impression prevails that the conditions at Cochin somewhat resemble those of Durban, and that therefore we may expect to meet with similar difficulties when dredging our bar. I would therefore take this opportunity of stating that I have made careful enquiries of two gentlemen residing at Cochin who were able to enlighten me on the subject, namely, Mr. Lokie of Messrs. Peirce, Leslie & Co. and Mr. L. B. Clarke, the Port Officer, the former gentleman having lived several years at Durban, and the latter having visited that port in the course of his naval career. On being questioned they both agreed on the following most important points in which Cochin has the advantage of Durban :—

(1) The tidal compartment at Cochin, and consequent tidal scour, is incomparably greater than that of Durban.

(2) The bed of the sea at Durban is composed of sand the quantity of which is unlimited thus necessitating the construction of long training groynes for carrying the channel into such a depth of water that a bar could not be formed across it by the action of the waves. Further, owing to the amount of travelling sand the amount of dredging was necessarily very great.

Conclusion VIII.—The condition for dredging and maintaining a channel at Cochin is much more favourable than those of Durban.

13. Fears have been expressed that the dredging of the bar by facilitating the entrance of waves into the harbour, will be the cause of damage to the foreshore at Ernakulam. In order to show that such fears are without foundation I do not think I can do better than quote from

Mr. Shield's Harbour Construction, which is a standard work on the subject. He writes:—

Reduction of waves.—In the case of an harbour which opens out quickly within the pier heads, waves running straight in do not disturb the tranquillity of the water to such an extent as might be supposed because immediately they pass the entrance they rapidly expand, and their height is thereby at once reduced.

The late Mr. Thomas Stevenson, C.E., has given us a formula for calculating the reductive power of harbours, by which is meant their power to reduce the height of waves after passing within the entrance.

The formula is as follows:—

$$X = H \frac{\sqrt{b}}{\sqrt{B}} - \left(H + H \frac{\sqrt{b}}{\sqrt{B}} \right) \frac{\sqrt{D}}{50}$$

where H = height of wave at entrance, in feet.

b = breadth of entrance, in feet.

B = breadth of harbour at place of observation, in feet.

D = distance from mouth of harbour to place of observation, in feet.

X = reduced height of wave at place of observation, in feet.

This formula has been accepted as very approximately correct, numerous experiments having proved its accuracy. At Cochin the gut 1,500 feet wide represents the pier heads: this opens out at once into the main harbour over 6,000 feet wide. Therefore assuming that a wave 6 feet high entered the gut it would according to the above formula be absorbed as soon as it passes the gut, as indeed is found to be the case with waves that enter now.

Conclusion IX.—There are no grounds for supposing that the dredging of the bar will be, indirectly, the cause of damage to the foreshore of the harbour.

14. With regard to the depth to which the channel should be dredged, I attach a copy of letter No. 4/727, dated 24th May 1913, from the Port Officer, Cochin, giving his views on the subject, to which I think considerable weight should be given. From this it will be seen that a channel 22 feet deep will be of use.

The following are the quantities to be dredged from various depths of for a bottom width of 600 feet with side slopes 6 to 1:—

Depth.	Quantity in c.ft.
22 feet	14,976,000
25 "	24,528,000
30 "	63,518,000

On these figures, a suction dredger of the "Canterbury" type as recommended by Messrs. Simons & Co., dredging at a rate of 64,000 c. ft. a day, the minimum it should do, would dredge a 22 feet channel in 240 days which means that steamers would be coming in at the end of the first season's working.

I am of the opinion that not much good is to be gained by experimental dredging with the "Manar", when there can be no doubt that a channel will keep open. In the first place, a bucket dredger is a most unsatisfactory machine to work in the rough water on a bar and if we once commit ourselves to this form of experiment we shall have to carry it through to its conclusion, or the money spent on it will be wasted. This will take years to do, and means discarding the whole of the convincing information we have already acquired. It must not be forgotten that it takes at least two years to build a dredger of the "Canterbury" type after the order has been placed. It will take a couple of seasons for the "Manar" to dredge any channel worth considering, and then the channel will have to be observed for another couple of seasons to see if it fills, and eventually if the result is satisfactory, as no doubt it will be, a suction dredger will be ordered, taking another two years to build so that there will be no prospect of commencing work in earnest for another six years.

Finally, I may state that we have ample data at our disposal to warrant the purchase of a suction dredger, seeing that the results of our investigation and study of the harbour have not revealed a single feature that is adverse to the maintenance of a channel through the bar, excepting perhaps the erosion of the Vypeen shore and the sandbanks attached to it, which can easily be remedied.

Plans as per the accompanying list are herewith sent.

A. H. S. CAMPBELL,
Executive Engineer, West Coast Division.

(2)

Letter from Lieut. L. B. CLARKE, R.N.R., Port Officer, Cochin, to the Executive Engineer, West Coast Division, dated the 24th May 1913, No. 4/727.

With reference to your No. 1248, dated 21st May 1913, I have the honour to inform you that, in my opinion, assuming the average draft of steamers using this port to be 22 feet, a channel dredged through the bar to a universal depth of 22 feet L.W.O.S.T. would be useful to such steamers wishing to use the channel in the fine weather. This would I think allow steamers drawing 22 feet and less to use the channel at almost any state of the tide: and at the top of high water would in very fine weather allow of steamers drawing as much as 24 feet to use the channel.

In the south-west monsoon a vessel drawing 22 feet would probably require a channel dredged to a depth of 30 or 32 feet or possibly more. Of course, a great deal would depend on the state of the swell and as to what depth of water a vessel would require, but personally I do not think I should care to take a vessel out of or into Cochin Inner Harbour in ordinary monsoon weather without about 10 feet of water under her bottom.

With reference to your last paragraph, I think quite a number of vessels could use the channel in fine weather when it had been dredged to a depth of 20 feet throughout.

It is to be understood that the above depth of 22 feet of the channel to be dredged refers only to what I consider would be a fairly useful minimum working depth but should the Cochin Harbour Scheme develop, as I hope it will, the ultimate depth of the channel should, I think be, at least 30 to 35 feet L.W.O.S.T.

(3)

Letter from Commander W. B. HUDDLESTON, R.I.M., Presidency Port Officer, Madras, to the Superintending Engineer, IV Circle, dated the 9th September 1914, No. 2008/1/333 P.W.

With reference to your letter No. 1667-M./611 P., dated 3rd September 1914, I have the honour to state that my report on the working of the "Manar" will be submitted to Government when the result of my observations is completed. I am not aware in this connexion that I am called upon to submit reports on the subject to you.

(iii)

Memorandum No. 1249-Wks. B-14-7, dated 31st May 1915.

Mr. Allan Campbell is informed that with effect from the 10th June 1915 he will be posted for duty in connexion with the Cochin Harbour. He should as soon as possible proceed to Bombay with Commander Huddleston, the Presidency Port Officer, to inspect the Bombay Port Trust dredger "Jinga." Commander Huddleston will explain to the Presidency Port Officer at Bombay the conditions under which the "Jinga" would have to work at Cochin. If it is found that the dredger is suitable for the purpose and is in good working order and can be hired at a reasonable figure, Mr. Campbell should at once begin to prepare a complete estimate for a season's working of the dredger. An agreement will have to be made with the Bombay Port Trust for hiring the dredger and Mr. Campbell will be empowered to negotiate for her hire on the basis that, if she proves a success, this Government will purchase her, if the price asked for is not unreasonable and in that event, the amount paid for her hire will be taken as part of the purchase-money. A crew to work the dredger and the cost of putting the pipe line in order and getting it down to Cochin should also be taken into consideration. All this will have to be done at Bombay. Mr. Campbell will also have to include in his estimate, a season's working expenses of the dredger and her return to Bombay.

2. Separate orders will issue in the Marine Department in regard to the deputation of the Presidency Port Officer, Commander Huddleston, to Bombay along with Mr. Campbell for the purpose of inspecting the "Jinga" and negotiating with the harbour authorities there.

S. B. MURRAY,

Joint Secretary to Government.

To A. Campbell, Esq., Executive Engineer,
West Coast Division.

Copy to the Superintending Engineer, IV Circle.
" " Presidency Port Officer.

(iv)

Letter from Commander W. B. HUDDLESTON, R.I.M., Presidency Port Officer, Madras, to the Chief Secretary to Government, dated the 19th June 1915, No. 2008/181 G.

In accordance with permission granted in an Order from Government, No. 193, Marine, dated 7th June 1915, I have the honour to report that I proceeded to Bombay on Saturday the 12th instant, arriving at that place on the 14th instant.

On interviewing Sir Frederick Sprott, Chairman of the Port Trust, on arrival, I was informed that the Government of India had just agreed to purchase both the dredgers, "Jinga" and "Kalu", and that in the event of trials proving satisfactory, the dredgers would be bought outright by Government for £52,000.

Under these circumstances, beyond making enquiries with regard to the suitability or otherwise of this type of dredger for work on the Cochin Bar, I was unable to take further action in the matter—beyond being verbally assured by Sir Frederick Sprott that in the event of either of the dredgers being returned as unsuitable—the Government of Madras would be given the first option of their services.

The result of my enquiries were that these dredgers were very suitable for work at Cochin.

I left Bombay on Wednesday evening and returned to Madras this morning, 18th instant.

(v)

Letter from A. H. S. CAMPBELL, Esq., Special Officer, Cochin Harbour Works, to the Chief Engineer, Public Works Department (through the Superintending Engineer, IV Circle), dated the 24th June 1915.

With reference to the Government's Memorandum No. 1249-Wks. B/14-7, dated 31st May 1915, I have the honour to report as follows on my visit to Bombay.

2. I arrived in Bombay on the morning of the 12th instant and at eleven o'clock called at the office of the Bombay Port Trust where I interviewed Mr. A. C. Fosbery, the acting Chief Engineer. In answer to my enquiries, he informed me that I had arrived just too late to purchase the "Jinga", as the day previously a telegram had been received from the Government of India accepting the terms on which the Bombay Port Trust were prepared to part with her. It appears that both the "Jinga" and the "Kalu" are being acquired by the Government of India for use in the Persian Gulf in connection with the military operations. The news that I had been thus fore-stalled was as unexpected as it was unpleasant; however, I continued to prosecute my enquiries in the hope that the Government of India will not require the services of the dredgers for any great length of time and that we may ultimately acquire one.

3. I may here mention that the statement contained in my final report on the Cochin Harbour Investigation that the "Kalu" had been sold, was, I find based on wrong information. It appears that the Melbourne Port Trust Authorities have been endeavouring for the last two years to purchase the "Kalu", at a lower figure than that demanded by the Bombay

Port Trust, but have not succeeded. They sent over their own Engineer to examine the dredger, and he, I am told, was quite satisfied with her. The Melbourne people were however still haggling over the price when the Government of India stepped in and took both the dredgers. I understand that the Hong-Kong Port Authorities were also corresponding with a view to purchasing one of the dredgers, and were on the point of sending over an Engineer to see it when all negotiations were abruptly closed by the Government of India's action. I record these facts as they may prove of interest to us, in case we should ourselves ever have occasion to require a purchaser for either the "Jinga" or the "Kalu."

4. After leaving Mr. Fosbery I called on Sir Frederick Sprott, the Chairman of the Bombay Port Trust, from whom I learned that, in the event of their purchasing the dredgers, the Government of India will pay £27,000 for the "Kalu" and £25,000 for the "Jinga". These prices which include the pontoons and "ball and socket" joints for 1,200 feet of floating pipe line, are I consider by no means excessive. As the pipe itself is worn out it is being renewed locally. Messrs. Simons & Co. of Renfrew have been instructed by cable to send out the necessary crew for working the dredger. The Government of India are to be allowed to have the dredgers on trial for one month on a rent of Rs. 150 a day from the date of their arrival at the site of the work in the Persian Gulf, all working expenses, of course, being paid by the hirers. If at the expiry of that period the dredgers are not returned they are to be purchased outright for the abovenamed sums.

On enquiring whether, in the event of the Government of India, returning the dredgers at the end of a month's trial, the Port Trust would permit us to have them on the same terms, I was informed that while the Port Trust was prepared to sell us either of or both the dredgers at the same price at which they were under offer to the Government of India, they would not entertain the question of hiring one of them to us for any period, however short, as the risk of the dredger sustaining damage was too great. It was further explained that the Port Trust had been actuated solely by patriotic motives when they conceded to the Government of India's request to hire the dredgers. As the question of hiring one of the dredgers is of considerable importance to us, I continued to press the point, and suggested that we might be charged a higher rate than the Government of India was paying. I was, however, given to understand that the matter was not open to discussion and that if we wanted the use of the dredger we should have to buy her outright. I may state, that, should it prove inconvenient for us to pay the full price of the dredger at once, I think, the Bombay Port Trust would be prepared to accept payment in instalments spread over three years: an arrangement which would probably be better suited to the somewhat limited means that are likely to be available at first for the development of Cochin harbour.

I should explain, that it appears our chance of ultimately having the opportunity of acquiring one of the dredgers is by no means so remote as might appear at first sight. It is, in fact, dependent on one of the three following possible eventualities:—

(i) The return of the dredgers to the Bombay Port Trust after the month's trial.

- (ii) The completion of the work for which they are required.
- (iii) The cessation of military operations against Turkey.

As it is extremely probable that one of these things will occur I do not think we have any reason to give up all hope of ever seeing either the "Jinga" or the "Kalu" at Cochin. In fact, if fortune favours us, the present turn of events may prove in the end to be greatly to our advantage; for supposing that the Government of India only requires the dredgers for a short time, which is quite possible, we may expect at the end of that period to get one of the dredgers at a lower price than that now asked by the Bombay Port Trust. In the meantime the Government of India is putting the pipe-line in order, turning the suction-pipe of the "Jinga" so that the worn side is uppermost, and generally over-hauling the dredgers. They are also bringing out all the necessary European staff for working the dredgers from England, so that should we be able to acquire one of the dredgers immediately after the Government is finished with her, she should be in full working order and completely staffed, a fact which in itself will save us a great deal of time and expense. In order, however, that we may not miss the opportunity of buying one of the dredgers, should it occur, it is very necessary that we should keep in touch with the Royal Indian Marine, in whose charge they are at present, and also with the Bombay Port Trust to whom they may be returned.

5. I remained a week in Bombay, as I did not wish to leave without having obtained the fullest information regarding the dredgers. During this time I took the opportunity of daily visiting and studying the Bombay Port Trust works, completed and in progress, where, thanks to the extreme kindness and courtesy of the Port Trust Engineers, I had every facility afforded me for prosecuting my enquiries, and I gathered much information that should be useful in the event of the Cochin harbour scheme maturing. I also availed myself of the opportunity of questioning several Engineers, independently, regarding the feasibility of using a floating pipe-line on the bar at Cochin. Everyone I asked including Mr. Fosbery, the Acting Chief Engineer, and Mr. Wales, the Executive Engineer, in charge of the Port Trust's dredging operations, assured me that there was no danger at all of the line being broken by the swell. They pointed out that the pipe line had been used successfully through four monsoons in Bombay harbour where a much worse sea is encountered than that on the Cochin Bar during the fine weather. Apparently it is not a swell but a short choppy sea that may occasionally cause trouble with the pipe-line. It is quite obvious, however, that people are not going to pay £80 for each "ball and socket" joint if it will not enable the pipe line to sustain the rise and fall due to an ordinary swell without getting broken. The conclusion I came to, after having consulted the Port Trust Engineers, and examined the "ball and socket" joints, the pipes and pontoons, personally, was that we have no reason at all to anticipate trouble with the pipe line if we only use it on the Cochin Bar during the months of October, November, December and January.

6. I think the following information regarding the dredgers, and taken from the records kept by the Bombay Port Trust may be of interest:—

The dredgers "Jinga" and "Kalu" were built in 1908 by Messrs. William Simons & Co. (Limited) of Renfrew. They were designed

to be capable of dredging 2,000 cubic yards of soft clay and mud per hour from a depth of 30 feet and discharging the material so dredged to a distance of 4,500 lineal feet on shore. The dredging depth was subsequently increased to 40 feet. Their dimensions are as follows:—

Length on main deck...	205 feet.
Breadth moulded ...	42 "
Depth ...	13 "
Mean draft with 150 tons of coal in bunkers and 820 tons of water in tank about ...	8 "
Gross tonnage...	891 tons.
Register " ...	401 "

The dredging pump is a 39-inch centrifugal pump driven by a set of triple expansion inverted direct acting surface condensing engines.

The dredger is propelled by two sets of compound surface condensing engines sufficient to propel the vessel at a speed of about 7 knots an hour. Either of these engines can work the cutter, if it is required, which I do not anticipate will be the case at Cochin.

The boilers are four in number, of the marine cylindrical horizontal multitubular type with a working pressure of 180 lb. per sq. in. and provided with a Howden's forced draught. This forced draught I may mention should form an essential part of any dredger required for use in the tropics, as by obviating the necessity of continually opening the furnace doors, the stokeholes remain quite cool, whereas otherwise, owing to the vessel being always stationary, the heat becomes insupportable.

Both the "Jinga" and the "Kalu" have their pumping engines fitted with Aspinall's patent marine engine governor which has the effect of preventing the machinery from racing when the load is taken off it suddenly. The governors were fitted after the dredgers had been in work some time and actual practice had shown the necessity for them.

The cutter is of rotary pattern constructed of steel. Both suction and discharge pipes are of 39 inches diameter. The floating pipe line consisted originally of 39 inches diameter steel pipes 80 feet long on two floaters of 54 inches diameter each 70 feet long. It was found necessary when working to have some shorter floating pipes, so six floating pipes of 30 feet length were obtained. Naturally the actual length of floating pipe used by the dredgers when working varied considerably. On one occasion the "Jinga" was pumping through 2,700 feet of floating pipe line, but it appears that above this length it became difficult to work in a strong tide.

The shore pipes at first used were in 20 feet lengths but subsequently 61 lengths of 30 feet were obtained. Some short lengths of 10 feet, 5 feet and 2 feet were made in the Port Trust's workshops as well as two telescopic pipes which were found very useful when connecting up two long lengths of pipes. An experiment to ascertain the velocity of flow in the pipes gave the following result:—

Length of floating pipe line ...	2,700 feet.
" pipe connecting shore, and floating pipe ...	40 "
" shore pipe line ...	1,625 "
Total length of pipe ...	4,365 "

Time taken for mud to travel from the dredger to the discharge 6½ minutes. Velocity nearly 700 feet per minute.

7. *Cost of the dredgers.*—The original net cost of the dredger was £56,500 each, but improvements such as fitting electric light, extra winches, lengthening the ladder to 40 feet, etc., together with the Consulting Engineers' fee of Rs. 45,724 brought the total cost of the two dredgers up to Rs. 19,99,146 or roughly 10 lakhs each.

In the same way the total cost of the two pipe lines each consisting of 2,000 R.ft. of floating and 2,500 R.ft. of shore pipe amounted in all to Rs. 9,29,519 or approximately 4½ lakhs each.

When the pipes were first supplied they were fitted with rubber joints, subsequently these were replaced with those of the "ball and socket" type which appear to have given very good results.

The dredgers have only worked for four years from June 1909 to July 1913. The Port Trust Engineers contend that, owing to the improvements they have made to the dredgers, they are better machines now than when they were purchased. I may state that the claim is fully supported by the Port Trust's records which show that the outturn of work increased very considerably, and the break-downs diminished, the longer the dredgers were in use. This is to a great extent accounted for by the fact that the dredgers, being the most powerful built up-to-date of their type, were to a certain extent experimental and it was only natural that certain defects should show themselves in working. As a matter of fact any trouble that was experienced was entirely connected with the centrifugal pumps, and not with the more delicate machinery. The pump shafts of both dredgers broke, owing to their being of too weak a section and had to be replaced by shafts of 13½ inches diameter with a 13½" to 11½" cone after which there was no trouble. The cast-iron outer casing of pump on the "Kalu" was broken and that of the "Jinga" cracked by large stones getting into pump. The casing of the "Kalu's" pump had to be renewed while that of the "Jinga" has been fortified with steel bands. As, however, there is no possibility of our meeting with stone or rock of any kind on the Cochin Bar we shall not be troubled on this account.

As regards the working capacity of the dredgers, the "Jinga" dredged on the average 302 brass an hour while working during the first two years and 424 brass an hour during the last year. I would point out that if the "Jinga" maintained this rate at Cochin, she would dredge a channel 25 feet deep below L.W.S. and 600 feet wide in 74 working days. The "Kalu" averaged 150 brass an hour during the first year and 346 brass an hour during the last year. The difference in to 100 cubic feet so that 424 brass is about 3,400 tons. The difference in the output of the "Jinga" and the "Kalu" was explained to me by the Port Trust Engineer as being entirely due to personality of the dredger masters; he on the "Jinga" having pressed his dredger much more than him on the "Kalu." The Engineers further stated that "Kalu" has all the capacity of the "Jinga" and is an appreciably better dredger as it has not been worked so hard. Actual figures show the "Jinga" to have dredged 50 per cent more material than the "Kalu" during the four years that they were at work. Obviously therefore if we have the choice we should take the "Kalu" in preference to the "Jinga."

8. With regard to the working expenses of the "Jinga" and the "Kalu," I find that for the year 1912-13 they were as follows:—

	"Jinga."	"Kalu."	Approximate estimate for working expenses of one dredger at Cochin.
	Rs.	Rs.	Rs.
Wages ...	40,858	42,329	44,000
Stores ...	21,476	16,220	18,000
Coal ...	1,13,218	59,251	1,00,000
Repairs ...	84,575	41,800	40,000
Sundries ...	1,528	3,422	3,000
Pipe line ...	25,195	22,027	25,000
Total ...	2,46,647	1,84,652	2,30,000

In my approximate estimate I have allowed for 500 tons of Natal coal a month at Rs. 25 per ton which should be sufficient. The coal bill of the "Jinga" for the year shown above was considerably in excess of that for any other year, and therefore need not be accepted as the average. Repairs of course include dry-docking. Although the pipe line will only be about one-third of the length of that used in Bombay, the expenditure under the head will be practically the same the first year as the pipe will have to be brought to Cochin in sections and rivetted together there. I enclose a copy of one of the pay bills of the "Jinga" in order to show exactly the composition of the crew and the rates of pay. Of course should we use only the dredger for three months on the bar, and then decide to wait and see what happened before proceeding to dredge out the interior of the harbour and make reclamations, the working expenses during the first year would be lessened to a great extent but not quite proportionately to the time in which the dredger would lie idle as it would still have to be kept-up, and we could not very well dispense with the crew.

The total outlay in the first year, if we bought the dredger outright would be approximately 4 lakhs for the dredger and pipe line *plus* Rs. 2,30,000 working expenses or Rs. 6,30,000 in all. Besides opening the bar the dredger could in the 12 months do a great deal of valuable work inside the harbour by deepening it and reclaiming land where necessary.

Finally, I may mention that in 1912 when I called on Messrs. Simons & Co. at Renfrew and discussed the question of a dredger for Cochin, I came to the conclusion that a drag-suction dredger would be best suited for our requirements, but after seeing the Bombay dredgers I have changed my opinion and think that a dredger of the same type as the "Jinga" and "Kalu" would serve Cochin far better than any other. After all, the dredging of the bar should only form a very small item in the work at Cochin the bulk of which should be the reclamation of the backwater where possible in order to form sites for warehouses, railway sidings, etc.

ENCLOSURE.

BOMBAY PORT TRUST.

Pay sheet of workmen employed on dredger "Jinga" during the month of April 1913.

Numbers.	Designation	Names.	Number of days.	Rate.	Amount due.	Provident Fund.	Income-tax.	Other deductions.	Nett.	Amount paid.	Amount unpaid.	Numbers.
					Rs. A. P.				Rs. A. P.			
1	Deck syrang ...	.....	30	45	45 0 0	...	...	...	54 8 4	...	...	...
	Overtime.	54	40	40 0 0	...	...	...	...	48 7 4	...	...	...
2	Pontoon do. ...	.....	30	30	30 0 0	...	...	...	36 10 3	...	...	...
	Overtime.	54	30	30 0 0	...	...	...	...	30 8 5	...	...	...
3	Wynch tyndal.	.....	30	25	25 0 0	...	...	...	29 1 4	...	...	...
	Overtime.	54	30	25 0 0	...	...	...	...	30 8 5	...	...	...
4	Wynchman ...	.....	30	25	25 0 0	...	...	...	29 1 4	...	...	...
	Overtime.	54	30	25 0 0	...	...	...	...	30 8 5	...	...	...
5	Do. ...	.....	30	25	25 0 0	...	...	...	29 1 4	...	...	...
	Overtime.	54	30	25 0 0	...	...	...	...	30 8 5	...	...	...
6	Do. ...	.....	30	25	25 0 0	...	...	...	29 1 4	...	...	...
	Overtime.	54	30	25 0 0	...	...	...	...	30 8 5	...	...	...
7	Do. ...	.....	30	25	25 0 0	...	...	...	29 1 4	...	...	...
	Overtime.	54	30	25 0 0	...	...	...	...	30 8 5	...	...	...
8	Pontoon kha-lasee.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
9	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
10	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
11	Do.	.....	29	17	17 6 5	...	...	...	21 0 7	...	...	...
	Overtime.	54	29	17 6 5	...	...	...	...	21 0 7	...	...	...
12	Do.	.....	27	16	16 3 2	...	...	...	19 10 7	...	...	...
	Overtime.	54	27	16 3 2	...	...	...	...	19 10 7	...	...	...
13	Do.	.....	5	3	3 7 5	...	...	...	21 12 11	...	...	...
	Overtime.	54	5	3 7 5	...	...	...	...	21 12 11	...	...	...
14	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
15	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
16	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
17	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
18	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
19	Do.	.....	9	5	5 6 5	...	...	...	6 9 9	...	...	...
	Overtime.	54	9	5 6 5	...	...	...	...	6 9 9	...	...	...
20	Do.	.....	11	1	1 3 4	...	...	...	...	...	...	...
	Overtime.	54	11	1 3 4	...	...	...	...	...	...	...	...
21	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...
22	Do.	.....	30	18	18 0 0	...	...	...	21 12 11	...	...	...
	Overtime.	54	30	18 0 0	...	...	...	...	21 12 11	...	...	...

Pay sheet of workmen employed on dredger "Jinga" during the month of April 1913—cont:

Numbers.	Designation.	Names.	Number of days.	Rate.	Amount due.	Provident Fund.	Income-tax.	Other deductions.	Nett.	Amount paid.	Amount unpaid.	Numbers.
					RS. A. P.		RS. A. P.		RS. A. P.			
23	Pontoon	...	30	...	18 0 0	...	...	...	...	...	...	...
24	Do.	Overtime.	5 1/2	...	3 12 11	...	...	...	21 12 11	...	...	...
25	Deck khalsee	...	30	18	18 0 0	...	...	...	21 12 11	...	...	...
26	Do.	Overtime.	5 1/2	...	3 15 8	...	...	...	21 15 8	...	...	...
27	Do.	...	30	...	18 0 0	...	...	...	21 12 11	...	...	...
28	Do.	Overtime.	5 1/2	...	3 15 8	...	...	...	21 15 8	...	...	...
29	Do.	...	30	...	18 0 0	...	...	...	21 12 11	...	...	...
30	Do.	Overtime.	5 1/2	...	3 12 11	...	...	...	21 12 11	...	...	...
31	Do.	...	30	...	18 0 0	...	...	...	21 12 11	...	...	...
32	Do.	Overtime.	5 1/2	...	3 12 11	...	...	...	21 12 11	...	...	...
33	Engine driver.	...	30	60	60 0 0	...	...	...	21 12 11	...	...	...
34	Fireman	...	30	40	40 0 0	...	...	...	21 12 11	...	...	...
35	Fireman	Overtime.	10	...	15 6 2	...	...	...	55 6 2	...	...	...
36	Greaser	...	30	22	22 0 0	...	...	...	24 9 10	...	...	...
37	Do.	Overtime.	10	...	8 7 5	...	...	...	30 7 5	...	...	...
38	Fireman	...	30	...	22 0 0	...	...	...	30 7 5	...	...	...
39	Do.	Overtime.	30	20	20 0 0	...	...	...	27 4 11	...	...	...
40	Do.	...	30	...	20 0 0	...	...	...	25 6 2	...	...	...
41	Do.	Overtime.	7	...	5 6 2	...	...	...	25 6 2	...	...	...
42	Do.	...	30	...	20 0 0	...	...	...	25 12 4	...	...	...
43	Do.	Overtime.	7	...	5 6 2	...	...	...	25 6 2	...	...	...
44	Do.	...	30	...	20 0 0	...	...	...	25 6 2	...	...	...
45	Do.	Overtime.	7	...	5 12 4	...	...	...	25 12 4	...	...	...
46	Do.	...	30	...	20 0 0	...	...	...	25 12 4	...	...	...
47	Do.	Overtime.	7	...	5 6 2	...	...	...	25 6 2	...	...	...
		...	30	...	20 0 0	...	...	...	25 12 4	...	...	...

Pay sheet of workmen employed on dredger "Jinga" during the month of April 1913—cont.

Numbers.	Designation.	Names.	Number of days.	Rate.	Amount due.	Provident Fund.	Income tax.	Other deductions.	Nett.	Amount paid.	Amount unpaid.	Numbers.
					RS. A. P.		RS. A. P.		RS. A. P.			
48	Coal trimmer.	...	30	15	15 0 0	...	...	...	19 0 7	...	...	...
49	Do.	Overtime.	7	...	4 0 7	...	...	...	19 0 7	...	...	...
50	Do.	...	30	...	15 0 0	...	...	...	19 0 7	...	...	...
51	Do.	Overtime.	7	...	4 0 7	...	...	...	14 0 5	...	...	...
52	Do.	...	22	...	11 0 0	...	...	...	4 8 1	...	...	...
53	Cook	Overtime.	5 1/2	...	3 8 0	...	...	...	25 0 0	...	...	...
54	Butler	...	30	25	25 0 0	...	...	...	20 0 0	...	...	...
55	Topaz	...	30	20	20 0 0	...	...	...	15 0 0	...	...	...
56	Stooker bhan-dari.	...	30	15	15 0 0	...	...	...	14 0 0	...	...	...
57	Deck	...	30	14	14 0 0	...	...	...	8 0 0	...	...	...
58	" mate "	...	30	8	8 0 0	...	...	...	62 1 7	...	...	...
59	Timekeeper	...	30	5 1/2	51 0 0	...	...	...	1,495 10 8	...	...	...
		L.A. 15 per cent.	...	...	8 1 7	...	...	...	...	...	...	...
		Total	...	...	...	...	...	...	...	...	...	...
1	Dredging master.	...	30	51 1/2	512 0 0	...	...	...	609 15 3	...	...	...
2	Chief Engineer.	Overtime.	5 1/2	...	113 3 8	...	...	...	690 7 9	...	...	...
3	Second Engr.	...	30	...	512 0 0	...	...	...	442 5 4	...	...	...
4	Third Engr.	Overtime.	10	325	328 0 0	...	...	...	366 13 2	...	...	...
5	Pontoon master.	...	30	272	272 0 0	...	...	...	154 3 8	...	...	...
		Overtime.	10	...	104 9 10	...	...	...	...	...	...	...
		Total	31 1/2	5 per day.	157 8 0	...	...	...	2,363 13 2	...	...	...

(vi)

Endorsement by the Superintending Engineer, IV Circle, No. 617
W/614-D., dated 1st July 1915.

Forwarded.

J. M. PARKER,
Superintending Engineer, IV Circle.

Order No. 1267 W., dated 7th July 1915.

Mr. A. H. S. Campbell, Temporary Engineer on Rs. 850 per mensem,
is informed that his services are no longer required in the Public Works

Department of the Madras Government. He should proceed immediately to Calicut and hand over all papers, etc., connected with the Cochin harbour to the Executive Engineer, West Coast Division. His services will be terminated with effect from the date on which he hands over charge to the Executive Engineer, West Coast Division, on which date, the Superintending Engineer, IV Circle, should arrange to pay Mr. Campbell a month's salary in lieu of a month's notice.

(True extract)

S. B. MURRAY,
Joint Secretary to Govt., P.W.D.,
General, Buildings, Roads and Railways.

To the Superintending Engineer, IV Circle,
the Accountant-General,
A. H. S. Campbell, Esq.,
the Marine Department, with copy of Mr. Campbell's report and notes.

Copy to the Executive Engineer, West Coast Division.

(V)

REPORT BY SIR JOHN WOLFE-BARRY, LYSTER & PARTNERS ON THE PROPOSALS FOR THE IMPROVEMENT AND DEVELOPMENT OF THE HARBOUR, TO THE UNDER SECRETARY OF STATE, INDIA OFFICE, DARTMOUTH HOUSE, 2, QUEEN ANNE'S GATE, WESTMINSTER, LONDON, S.W.1. DATED 18th JANUARY 1918.

1. Following the instructions sent us by your direction in the letter from Mr. H. A. Haines of 22nd December 1916 (P.W. 2715), we now have the honour to inform you that the investigations at Cochin, which were undertaken on our behalf by Mr. L. H. Savile, were completed on 7th May last, after which Mr. Savile returned to this country and conferred with us, and we now beg to submit our report on the improvement of that port.

PRELIMINARY INSTRUCTIONS AND CONFERENCES.

2. As regards the scope of our report, only general instructions were given in the letters from the India Office, but Mr. Savile had a conference at Ootacamund, on 25th April 1917, with some of the principal officials of the Madras Government, as well as the Diwan of Cochin, when a memorandum of the points to be considered was drawn up. Subsequently, on 3rd May, he had an interview with the members of the Cochin Chamber of Commerce, who also recorded their views of the requirements of the port.

3. The principal points to be considered were also defined in a memorandum by the Hon'ble Mr. A. Butterworth, dated 19th February 1916, which with a covering letter, dated 13th March 1917, was forwarded by the Hon'ble Mr. J. P. Bedford to Mr. Savile.

4. Mr. Savile succeeded in obtaining from the Government of Madras, as well as locally, a considerable amount of information in regard to the physical conditions of the port, including surveys for the years 1858, 1893 and 1912-13, but in respect of other important matters, particularly the

erosion of the foreshore north and south of the port, there has been a lack of systematic records, which makes it difficult to draw precise conclusions as to the variation in the condition of the areas affected, as well as the effect of the remedial works which have been carried out.

SCOPE OF REPORT.

5. In submitting our views on the improvement of the port we have endeavoured not only to cover all the points raised in these documents, but also to put forward a comprehensive scheme of improvement commensurate with the prospective development of its trade and graduated to suit the increase in its revenues which may be looked for as a result of improved physical conditions.

6. We have also endeavoured, following the suggestion made at the conference on 25th April, to recommend a scheme devised in the best interests of the port and province independently of any political questions which may be involved, as we believe that this is the only way in which the best physical and commercial results can be obtained.

7. We do not propose to enter into any geographical and topographical description of the port and its surroundings, or to investigate at any length the physical forces at work. The former features, though exceptional, are thoroughly understood by the Government of India, having been set out in the reports which have already dealt with the locality; and the latter, though applying to somewhat peculiar conditions, may be regarded generally as normal to the western coast line of India. Geographical etc., description.

8. They may be briefly cited as a small tidal range varying from 3 feet to 1½ feet, the prevalence of a south-west monsoon for some four months in the year, viz., from June to September inclusive, during which heavy seas break on the shore line and a current from south to north sets in along the coast. Physical forces.

9. The effect of the tidal range is to partly fill and empty the great area of backwater lying behind the coastal strip, and in so doing to scour out a deep channel at the Cochin gut where the connexion between the open sea and the backwater has been formed.

10. This action is accentuated by the outflowing volume from the rivers which drain into the backwater and which at certain times of the year deliver very large quantities of water into this area.

11. The strip of coast which divides the backwater from the sea is furnished on its sea face with a sandy beach or foreshore, and this belt of sand, as is observable in all similar cases, advances or recedes accordingly as the winds blow from off or on to the shore.

12. During the south-west monsoon the heavy seas breaking on the foreshore tend to denude it of its protecting sand covering, and as this action is continuous throughout a considerable portion of the monsoon period, there is considerable risk of the coastal strip being breached in weak places.

13. These heavy seas from the south-west, acting in combination with the current, also cause a general drift of material along the coast from south to north.

ARRANGEMENT OF REPORT.

14. The order in which we propose to consider the various points is that which their importance, and the sequence in which the works connected with them will have to be taken in hand, demands.

15. Our report is accompanied by a map of the locality, which will render it self-contained and make the remarks and recommendations it comprises readily comprehensible.

16. The following are the points which have to be considered, arranged in the order in which it is proposed to deal with them:—

(a) The preservation of the foreshores of the coastal strips or sand spits lying north and south of the entrance to the port, including

(b) Their reinforcement by reclamations in the backwaters.

(c) The deepening and maintenance of the bar and approach channel to the port by dredging or otherwise, with a special reference to the question of the suitability of the "Kalu" for this purpose.

(d) The provision of deep-water areas within the backwaters, where 10 or 12 vessels can be moored to special mooring buoys.

(e) The provision of quays at Cochin, as well as on the mainland, where railway connexions can be formed.

(f) The maintenance of the tidal capacity of the backwaters.

(g) The provision of coal and oil depots.

(h) Commercial and financial questions affecting the scheme.

PRESERVATION OF THE COASTAL STRIPS.

17. Commencing with (a), the preservation of the foreshores of the spits north and south of Cochin: it has been recognized by all those who have interested themselves in the welfare and improvement of the port that it was essential to its maintenance that these spits should be preserved against encroachments of the sea, as otherwise, owing to the substratum being alluvial, serious breaches of the spits might be caused such as would lead to a deterioration of the main channel between the sea and backwater at Cochin, upon which the access to the Port of Cochin depends.

18. This view we entirely endorse, and for this reason we have placed the question of the maintenance of the foreshores in the forefront of our report, as it is not only the first point to be considered, but, as will be seen later, the improvement works in connexion with the main channel must also be designed and constructed consistently with this essential condition.

19. So far as can be judged from the charts available, no general depression or erosion of the bed of the sea in the neighbourhood is observable, but, on the contrary, the bar is said to have shoaled, and the denuding action appears to be limited to the higher contours fringing the coast line.

20. There has been in the past a great difference of opinion as to how this protection to the foreshores would best be afforded; and the works which have been proposed, as well as those which have been carried out, have been of very different character and design.

21. Although erosion has been going on at the beaches north and south of the entrance channel, that on the north side has been apparently most serious, and some 55 years ago the sea broke through at Cruz Milagre, a point rather more than a mile to the north of Vypeen. Erosion of foreshores.

22. The erosion on the south side of Cochin, though considerable and progressive, has not apparently been considered sufficiently serious, so far, as to require remedial works.

WORKS ON FORESHORE NORTH OF VYPEEN.

23. It is evident from the plan showing the lines of foreshore for the 27 years between 1883 and 1910 that the erosion of the foreshore to the north of Vypeen has been steady and serious throughout that period. Groynes and bund.

24. Attempts have been made to arrest the encroachment of the sea, by groynes in the first instance, and more recently by a "bund" or bank raised about 12 feet 6 inches above Admiralty datum level, presumably low water ordinary spring tides, and having a paved slope on either face.

25. The groynes, which were first constructed, extend along a length of foreshore of about 3,600 feet from the entrance channel at Vaipin. They are placed at varying distances apart and their length also varies from about 120 feet to 450 feet.

26. Although we have no detail drawings or particular description of these structures, we understand that they consist of stone mounds running at right angles to the coast line, and that they are raised to a considerable height above the foreshore level.

27. This type of structure does not, according to modern experience and practice, give the best results in accumulating sand.

28. From the plan referred to above, showing the successive lines of foreshore between 1883 and 1910, it is evident, however, that these works have had a considerable effect in delaying, if not arresting, the rate of erosion as the "foreshore line" of 1883 had up to 1910 only advanced shorewards 450 feet to 500 feet abreast of the groynes, whereas further to the north, where there are no groynes and where the "bund" has since been constructed, it had advanced about 700 feet between these dates. Effect of works on erosion.

29. From the sections of the foreshore abreast of the "bund" for 1916 and 1917, which we have received, it is evident, on the contrary, that this work has done nothing to arrest the erosion, and we understand that this view is confirmed by the fact that it has been necessary recently to add to the protection which it affords by forming a rubble apron along its toe.

NECESSITY FOR PROPERLY CONSTRUCTED GROYNES.

30. This is in accordance with experience in other places, which indicates that where there is lateral drift of the beach sand due to wave and current action, a work of this class parallel to the coast line tends rather to promote erosion, and that the best means to protect a foreshore is to accumulate sand or shingle by properly constructed groynes connected with an embankment or wall at their land end.

31. The most successful groynes are those which are only slightly raised above the foreshore at first and are so constructed that they can be gradually raised and extended as the sand accumulates.

32. This system interferes as little as may be with the natural travel of the sand and promotes a more regular and general raising and protection of the coast line.

33. The construction of such a system of groynes connected by a suitable embankment at their shore end to prevent their being outflanked by the sea is therefore, in our judgment, the first step to be taken in connexion with improvement works at Cochin.

34. The extent to which these should be constructed along the coast from Vypeen must depend, of course, upon the local conditions when they are undertaken, but we understand that the heavy wave action which causes the erosion during the monsoon months is at present neutralized at a point about two miles north of Vypeen by the presence there of a considerable admixture of mud with the sea water, which has the effect of flattening out the waves and preventing their erosive breaking action.

35. As the narrow portion of the spit only extends for this distance, it would probably be sufficient if the protective groynes in the first instance only covered this length of foreshore, any extension of them northwards being left for future consideration.

RECLAMATIONS NORTH OF VYPEEN.

36. At the same time, we think it would be well if reclamation was carried out on the backwater side of the spit along this length, so as to increase its width so far as may be reasonably practicable.

37. For reasons which will be stated later, when the question of providing moorings and wharves in the backwaters is dealt with, reclamations of this character and extent would not, in our judgment, interfere with the maintenance of the tidal capacity of the backwaters, which is so necessary in the interest of the approach to the port.

38. It would also be desirable in addition to the above remedies against sea encroachment to endeavour to raise the level of this spit as far as possible.

39. If, as we believe would be found to be the case, a good sand beach was formed by the groynes, a certain amount of sand would be blown inland during the monsoon, and its accumulation in the form of dunes would be promoted by the planting of marram grass or other indigenous vegetation suitable for the purpose.

EROSION OF FORESHORE SOUTH OF COCHIN.

40. Coming to the erosion on the foreshore on the south or Cochin side of the channel, we have not been able to obtain any specific information in the form of sections or "foreshore lines," such as have been furnished in regard to the foreshore north of Vypeen.

41. We are informed, however, that erosion is also proceeding here, and it is evident from the plans submitted that the sandspit dividing the

sea from the backwater is very narrow and low, so that with progressive erosion it can only be a matter of time before a breach occurs.

REMEDIAL WORKS.

42. The same class of treatment as we have already prescribed for the Vypeen foreshore would, we believe, produce equally satisfactory results in this case.

43. In this suggestion we include a reasonably wide strip of reclamation which will not, we think, have any detrimental effect on the capacity of the backwater, as well as the raising, if possible, of the level of the spit by trapping the blown sand.

44. There can be no doubt from the evidence before us that, from the point of priority, if for financial or other reasons it is necessary to consider this, the work north of Vypeen is the most urgently needed, but, subject to this consideration, we would suggest that the sooner the work on the south side of Cochin is taken in hand, the less will be the expenditure and difficulty likely to be incurred in the carrying out of the work. We offer no remarks as to the extent of this latter work which is desirable, as we have not sufficient local information to allow of our doing so, but it is evident from Mr. Savile's report that the erosion is taking place along a considerable length of the coast. No doubt the groyne work and reclamation could be undertaken in such a manner as to cover the most urgent needs first, and at the same time to spread the expenditure over a suitable time commensurate with financial requirements.

BAR.

45. This disposes of the first two points, (a) and (b), set out in our preliminary list of matters requiring consideration, and we propose to deal next with (c), the deepening of the bar and approach channel, on the success of which the commercial progress of the port mainly depends.

46. It has been stated in the reports describing the physical conditions of the port, that the bar has shoaled of recent years, and, if the charts for 1858, 1883 and 1912-13 be compared, this would certainly appear to be the case in a moderate degree, assuming, as seems probable, that the surveys were all carried out under precisely similar conditions, at the same season of the year, and to the same datum. The ruling depth on the bar in 1858 and 1883 was 13 feet at L.W.O.S.T., whereas in 1912-13 it may be taken at 10 feet.

47. A conclusion has been drawn in Captain A. Campbell's report of 7th November 1912 that a continuous rate of bar shoaling of one foot in every ten years has prevailed for some centuries, and on this he bases the theory that the bar was originally the same depth as the Cochin Gut at present, and that the shoaling is due to silting up of the backwater. He goes on to suggest that to restore the former depths it would be necessary to enlarge and deepen the backwater sufficiently to restore the *status quo* and so keep the bar at the required depth.

Evidence of charts.

Capt. A. Campbell's report.

Extent of works proposed.

Raising level of spit.

48. So far as the charts referred to above are concerned, we do not think that there is any justification for the conclusion as to a continuous rate of silting, such as is suggested by Captain Campbell, and we cannot subscribe to his inference as to the original depth of the bar. In the three charts quoted, we find practically no shoaling in the 25 years between 1858 and 1883, and, although the chart of 1912-13 does show a shoaling of about 3 feet, there is no proof of steady or continuous shoaling over the full period of 54 years which the three charts cover.

49. Most bars, such as this, show variations of depth from time to time which, having regard to the vastness of the forces affecting them, the variability at different seasons and periods of those forces, and the difficulty of measuring the changes, it is practically impossible to account for satisfactorily.

50. That the shoaling was due to the "warping up" of the backwaters is, we think, open to the strongest doubt; indeed, the depths in the Cochin gut in the three surveys, 1858, 1883, and 1912-13, present strong evidence in exactly the contrary direction.

51. If the depths in this gut and the contours be carefully examined, it will be seen that there was a marked improvement in the sectional area and depth of the channel as between 1858 and 1883, and a still further improvement, though not so marked, as between 1883 and 1912-13. In fact, the investigations which we have made into this question show that the efficiency of the gut as a channel was increased as between 1858 and 1883 by about 15 per cent and as between 1858 and 1912-13 by 22.5 per cent.

52. This gut channel is, of course, equally dependent with the bar for its maintenance upon the tidal and fluvial flow into and out of the backwater, and inasmuch as its condition has improved so greatly in 54 years that it shows at the latter date a maximum depth of 62 feet and improved sectional area, where it formerly showed only 52 feet and greatly reduced section, we fail to see how it can be held from the evidence of the charts that there is any proof of the deterioration of the backwater.

53. The cause for the shoaling on the bar in 1912-13 will probably best be understood by examination of the contours of the channel on its inner face.

54. There is a marked difference in the position of the two-fathom line in the charts 1912-13 as compared with the earlier surveys. At the later date, this contour shows a much wider spread channel than in the former surveys, indicating not that there was any reduction of volume of outflow over the bar, but that for some reason, which without more information it is difficult to trace, there was greater dispersion of the currents as they approached the bar. Possibly this was due to the fact, which is observable from other data furnished to us, viz., that since 1883 the bar has progressed seaward to the extent of about 800 feet.

55. We believe that there is an earlier chart (1835) alluded to by Captain Campbell which shows a bar with 17 feet depth, but this has not been forwarded to us; and we understand from Mr. Savile that it is not

considered reliable. In any case, without an opportunity of examining it carefully it would be unwise to comment upon it.

56. For these reasons we do not deem it expedient to base any important conclusions upon the reduction in depths on the bar which is observable between the charts of 1883 and 1912-13. Neither chart shows a satisfactory state of the bar from the point of view of the requirements of the port, and the really important question is, how and to what extent can the depth be improved?

57. The bar at Cochin presents no special features as compared with similar formations in like positions. It may be described as a shoal which is the natural terminal formation of a channel furrowed across the foreshore by tidal and fluvial currents, the bottom of which (channel) must necessarily gradually rise with the dispersal and slackening of the flow due to the falling slope of the shore.

58. The most effective method of removing such a barrier, if that were the only point to be considered, would be by constructing moles or breakwaters on either side of the channel in such a manner and to such an extent as to preserve the continuity of contraction and depth beyond the limits of the gut and so to prevent the dispersal and slackening of the currents on which the channel depends for its maintenance.

59. Such a course is not possible in the present case for two reasons:—

(1) Because the projection of such works to the required depth into the sea would arrest the travel of the sand along the coast and tend to promote a breach through the coastal spit on the leeward side, and

(2) Because the cost of such works would impose a prohibitive burden on the finances of the port at the outset.

DREDGING.

60. The other alternative is that to which most of, if not all, the authorities have looked for improvement, viz., dredging.

61. The difficulties connected with dredging are mainly concerned with the maintenance of the depth of any channel, which may be formed in the calm months of the year during the stormy period of the monsoon, and the effect upon the foreshores on either side of excavating a deep and wide trench along the axis of the present channel.

62. In regard to the first of these points, there can be no doubt that the effect of a prolonged period of onshore gales accompanied by heavy seas must tend to level up the plateau of banks offlying the port to a uniform surface, and to restore what, but for the effect of the inflow and outflow through the gut, would be a continuous and uniformly shelving shore in this position.

63. The counteracting effect, which enables the channel to be maintained during this period, is the current set up by the volume of water flowing into and out of the backwater; and if it be correct, as has been stated and as might naturally be expected, that the bar shoals during the monsoon, it is apparent that the current is unequal to maintaining as great depths in the channel during stormy weather as in the calm months.

Conclusions from variation of bar depth.

Cause of bar formation.

Moles or breakwaters.

Effect of monsoon.

General instability of bars.

Cochin gut.

Table of 1835.

64. We are firmly of opinion therefore that, if such a channel as is proposed to commence with, viz., 600 feet in width and 30 feet below low water, were formed by dredging before the monsoon and left undredged during that period, it would be practically obliterated at the end of that time.

Dredging of
1914.

65. This view is confirmed by the evidence of the sections which were taken through the comparatively small trial channel which was dredged before the monsoon period in 1914. These show that, after the dredging was completed in April, there was steady shoaling throughout the monsoon period and that by October the channel had shoaled to its original depth.

DREDGER "KALU."

66. Holding this opinion, therefore, we cannot recommend any reliance being placed upon the pipe line dredger "Kalu" for forming and maintaining such a channel, more especially as we understand that Messrs. Simons' representative, Mr. McMurray, after investigations on the spot, has decided that she could not dredge in this channel during the monsoon.

67. It is further uncertain whether it would be possible to employ her with advantage on this work, even during the calm months of the year, as with her limited length of discharge pipe, viz., 1,000 feet, there would be the risk, in working in a channel 600 feet wide, of the material deposited, as it must be, so near one side of a channel with long flat slopes, finding its way back into the deepened area. This is a matter, however, which if necessary would best be determined by experiment.

EFFECT OF DREDGING UPON FORESHORES ON EITHER SIDE OF CHANNEL.

68. Before dealing with the type of dredger which we consider best adapted to the needs and circumstances of the case, it is desirable to revert to the second of the two difficulties which formed the introduction to this section of the report, viz., "The effect upon the foreshore on either side of cutting a deep and wide trench along the axis of the present channel."

69. The importance of preserving and reinforcing these foreshores has been explained in the earlier paragraphs of this report dealing with the postulates (a) and (b) of the preliminary list of points for consideration.

70. It will be readily understood therefore that, if the effect of dredging is to create long flat slopes on either side of the deepened area, there will be great danger, in forming a channel 600 feet wide with a depth in places of more than 20 feet below the present level of the adjoining banks, that a very considerable area of these banks may be permanently lowered.

71. The effect of this would be in the first place, to greatly increase the amount and cost of the dredging, and in the second place, and this perhaps is the most important point, to reduce the general level of the foreshore in the vicinity, and, by so doing, to increase the force and effect of the seas breaking on the beach, as well as to hinder the accumulation of sand by the groyne.

72. We therefore consider it essential that all dredging work should be preceded by the deposit on either side of the channel of a continuous, low, rubble stone mound which, as the deepening work proceeded, would gradually subside and ultimately revet or face the sides of the newly formed channel, and thus prevent them from falling in or any lowering of the contiguous banks taking place.

Revetment of
dredged
channel
necessary.

73. By correctly estimating and limiting the deposit of stone to the quantity required for this purpose, the upper edge of the revetment would be left coincident with the adjoining bank, and thus no interference with the normal sand movement would arise from this form of work.

74. It would also avoid the undesirable enlargement of sectional area of channel resulting from a dredged channel with unrestricted slopes, and so give the current a better scouring value than it would otherwise possess.

75. It would probably be desirable to increase the size and weight of the rubble stones as the work proceeded seaward, as it would there be exposed to somewhat greater wave action, but we do not consider that, with this precaution, there would be any risk of displacement of the stone as the top of the revetment would at its outer end lie at a considerable and gradually increasing depth below low water level.

TYPE OF DREDGER.

76. From the borings which have been taken in the channel and on the bar it appears that there is a considerable depth of sand on the crest of the bar and along the inner length of the channel, but that the outer portion consists mainly of alluvial deposit.

Material
forming bar.

77. There should be no difficulty in dealing with the sand by the ordinary type of suction dredger, and, as the vessel will have to work during the monsoon, it should be constructed with hoppers.

78. For the removal of the mud a "drag" would have to be fitted at the nozzle of the pipe, which could be shipped or unshipped as occasion required.

79. To deal with the quantity of material to be removed, say, to the level of 30 feet below low water, the dredger should have a hopper capacity of not less than from 2,000 to 2,500 tons, and be able to fill herself with sand or mud in about one hour.

80. The exact form and type of this dredger would require to be carefully considered in order that she might be specially adapted to the work required of her, more particularly for dealing with the shallow bar at which she would have to commence work. The cost, too, of such a boat would be excessive at the present time.

81. We do not anticipate that the maintenance of the channel outside the monsoon period will involve any serious proportion of the dredger's time. Considerable deposit will without doubt occur during the monsoon, which will probably occupy the full time of the dredger; but at other times she will be available for dredging the sites of the mooring and wharf berths which are to be formed inside the backwater.

Maintenance
of dredged
channel.

MOORING BERTHS, WHARVES AND MAINTENANCE OF TIDAL
CAPACITY OF BACKWATER.

82. We think it well to deal with this feature of our report, (d) in our preliminary list, jointly with (e) and (f), as the formation of mooring berths, wharves and the maintenance of the tidal capacity of the backwater are all matters which may be considered as interdependent.

83. We conclude that the provision of mooring berths for ten or twelve vessels which is asked for may be regarded as a temporary requirement, preliminary to the establishment of substantially constructed wharves at Cochin as well as on the other side of the backwater convenient to the railway.

84. If this view be correct, economy would certainly suggest that the mooring berths should be formed in one position only, so that the dredging at the outset of more than one approach channel would be avoided.

85. We consider that the best place for these buoys, to which vessels would, we presume, be moored fore and aft, is in the comparatively deep channel which flanks the eastern or inner shore of the Cochin promontory.

86. They would necessitate, inclusive of the approach channel, the deepening by dredging of a length of about one and a half miles of channel by an average amount of, say, 13 feet, so as to give 27 feet at low water, which we think would afford ample depth at the outset for the type of vessels frequenting the port.

87. The width of the mooring area would have to be sufficient to allow of vessels swinging when going to sea, and 600 feet should be sufficient for this purpose if, as we assume, this manoeuvre were carried out by a ship whilst moored at one end and under the control of a tug.

88. A large proportion of this work could probably be performed by the "Kalu" whilst the other dredger was engaged in deepening the channel, provided that the tidal currents in the vicinity are not likely to cause the deposit of the dredged material in inconvenient positions.

89. The suggestion that this material might be deposited on the fore-shore north of Vypeen, with a view of protecting it from erosion, is not one to which we attach any value, as we understand that it consists of light mud. If, however, any sand were so dredged this would certainly be of value for the purpose.

90. The position described is well sheltered, and it has the double advantage that it could be utilized in connexion with permanent wharves constructed hereafter along this shore, as well as that it would promote the propagation of the tidal wave into the remoter portion of the backwater to the south. Once established it might fairly be anticipated that there would be an increase of the tidal currents through this deep, and so its maintenance would not involve any serious amount of dredging.

91. The conveyance of goods by barges to and from the railway at Ernakulam would for the time being put that place at somewhat of a disadvantage with Cochin, but on the other hand the length of transport

would be reduced to about one-third of what it is at present, and its trading facilities would thus be vastly improved.

92. The best position for the wharves to be ultimately constructed at Ernakulam has been carefully considered, and in connexion therewith the scheme of wharves at Candle Island and the railway connexions therewith proposed by Captain A. Campbell has been studied. We do not, however, think that his scheme offers the most satisfactory solution of the problem.

93. The area which he proposes to dredge is in the nature of a *cul de sac*, as the water in the areas to the north and east of it shallows rapidly.

94. This means that the maintenance of the depth in the dredged area would doubtless involve a considerable amount of dredging from time to time.

95. The wharf which he proposes is only some 1,800 feet in length, and there is no room for any substantial extension without interfering with the propagation of the tidal wave. To obtain this length he has to create a very undesirable extension of Candle Island, which will in a measure block the passage of the tidal wave into the northern portion of the backwater.

96. Finally the railway extension involves the construction of a viaduct nearly a mile in length, whilst the wisdom of placing so important a trade centre on an island, isolated from the locality which it is intended to serve, and difficult of access by the population who will be employed there, and for whose benefit it is primarily required, may well be questioned. With a deepened bar channel and increased wave disturbance in the neck of the harbour, the proposal is also open to the criticism that its position in the monsoon period will be too exposed.

97. Captain Campbell's reports on the harbour of Cochin contain so much valuable information, and we feel so greatly indebted to him for his able analysis of the features and circumstances affecting the régime of the port, that we regret that, although in other matters we have derived so much assistance from him, we are unable to agree with all his conclusions or to follow him in this particular recommendation.

98. It is without doubt a difficult point to solve satisfactorily, and we have been guided in the solution we recommend by three main considerations, viz. :—

- (1) Suitability of location ;
 - (2) Ready maintenance of the deep water alongside the wharves ;
- and
- (3) The improvement of the tidal volume in the backwater by forming the deep in such a position as to induce improved propagation of the tidal wave.

99. The position which seems to us the most suitable from these various points of view is the shore line to the south of the Government buildings at Ernakulam, which borders a deep channel running between it and the Island of Vendurthi.

100. This site is convenient to the town and could no doubt be readily linked up to the existing railway, whilst there is plenty of room for extension of the wharves.

Captain
Campbell's
proposals.

Considera-
tions
affecting
selection of
site.

deposit of
dredged
material on
Vypeen
shore.

Ernakulam.

101. The channel is a natural formation, due no doubt to the currents passing with the tidal oscillation into and out of the vast backwater lying to the south.

Improved
propagation
of tidal wave.

102. This backwater, according to the tidal observations we have received, is only very partially filled by the tidal wave at present, and if this channel, with its approach from the gut, were deepened, more tidal water would pass into the backwater and reciprocally the channel and deep would tend to maintain themselves whilst the scour in the outer channel and across the bar would be correspondingly improved.

103. The Island of Vendurti forms a most satisfactory shelter from both wind and waves, whilst the site is sufficiently far removed from the gut to permit of the full expansion and degradation before reaching this point of such increased wave action as may result from the deepening of the outer bar channel.

PROVISION OF COAL AND OIL DEPOTS.

104. Coming to point (g) in our preliminary list, it will be obvious that "the provision of coal and oil depots," and presumably with them suitable berthing for ships, involves only a slight modification of the problem already discussed, and that mainly in the nature of the equipment which is required at the wharves.

105. Given suitable sites on the land for such depots, and we assume that such must exist in the neighbourhood of the positions which we have selected for wharves, the construction and proper equipment of suitable berths present no difficulties.

106. The exact nature and position of the accommodation cannot, however, be defined without further investigation on the spot into the opportunities afforded by various sites, as well as the precise requirements under each head.

COMMERCIAL AND FINANCIAL QUESTIONS.

107. The final consideration to be dealt with comes under head (h), viz., "commercial and financial questions affecting the scheme."

108. Fully treated, this section of our report should comprise estimates of the works recommended, combined with a statement showing how the necessary capital expenditure could be guaranteed by the surplus revenue of the port, supplemented if necessary by such assistance from the Madras Government as the circumstances seemed to warrant.

109. The conditions under which our investigations have been made do not, unfortunately, permit of such a complete review of the case being made.

110. There was so little information available at the outset in regard to the physical regime of the port and the coast, and the features which they present are so exceptional, that the enquiries which Mr. Savile conducted were necessarily mainly directed to the points which would enable us to determine generally what works were possible and desirable in order to effect the improvements demanded.

111. The nature of these works could only be settled after Mr. Savile's return, when all this information had been laid before us and duly analysed.

112. It will be understood therefore that, though the information we have received has been sufficient to enable us to prescribe generally the character of the works required, further investigations would be required on the spot before they could be designed in sufficient detail to enable their cost to be ascertained with accuracy.

113. This particularly applies to such works as the groynes and embankments, more particularly on the Vypeen shore, as well as the wharves within the backwater.

114. Under these circumstances, we can only deal in a general way with the financial aspect of the scheme.

115. Mr. Browning, the Engineer to the State, has given some attention to this matter, and in his report of 7th October 1900 he states that the annual sum of 3 lakhs could be relied upon from the port at the outset.

Mr. Browning's estimate of available revenue.

116. The report of the Cochin Chamber of Commerce for the year 1914-15, of which we have received a copy, though not in sufficient detail to allow of our estimating closely the economy to be effected by and the additional revenue to be anticipated from the proposed works, enables us at all events to test in a general way Mr. Browning's estimate, with the result that we feel justified in stating that his expectations are reasonably confirmed by the investigation.

117. Another document (G.O. No. 546, dated 14th October 1913), which has only come to hand since the above paragraphs were written, throws fresh light on this point, and indicates that a saving of 12 annas per ton may be anticipated from such an improved method of dealing with the trade of the port as the works now recommended provide for.

118. Applying this rate to the volume of trade in the year 1913-14, which it is estimated was equivalent to 475,000 tons, we obtain a saving of Rs. 3,57,500.

119. The excessive cost at present prices of the dredger recommended for the work, and the doubt as to how prices will stand after the war, make it advisable to exclude from the approximate figure which we put forward for the preliminary works the cost of this appliance and to treat it as a separate item.

120. The capital cost of this dredger would we assume form a direct charge against the undertaking, so that the cost of dredging may be estimated independently of that item and included in the figure for the preliminary works.

121. The following is a list of these works recommended in the foregoing:—

Two miles of groynes and one mile of embankment at Vypeen.

Two miles of groynes and two miles of embankment at Andikadavu.

Dredging a channel across the bar 600 feet wide to a level of 30 feet below low water ordinary spring tides.

Dredging an area in the backwater and providing moorings for ten or twelve ships.

Channel and mooring buoys, tug, etc.

122. The nearest approximation to the cost of these works which can be made with the information at present available is 25 lakhs.

123. As stated before, the cost of the dredger if constructed after the war is problematical.

124. At pre-war prices dredgers of 2,000 and 2,500 tons would cost about 13 and 15 lakhs, respectively, but at present prices these figures would have to be increased to about 26 and 30 lakhs, respectively.

125. Even, however, at this latter figure the total capital cost of these preliminary works, including the dredger, would only reach 55 lakhs, on which the Rs. 3,57,500 of revenue referred to above would pay 5 per cent interest and provide for amortization of the amount within 20 years.

126. As we pointed out at the commencement of this report, it is essential that the reinforcement of the coastal strips, particularly that north of Vypeen, should be thoroughly well established before the dredging of the bar channel is undertaken, and as the preliminary investigations necessary for the proper design of the works involved, as well as their construction, and the subsequent consolidation of the foreshore, will necessarily occupy considerable time, the construction of the dredger might be delayed until more definite information is forthcoming as to future prices in the shipbuilding industry.

127. The works tabulated above, though in the nature of preliminary improvements, to be supplemented later by the construction of wharves and further dredging at Ernakulam, should, if carried out, certainly give a fresh impetus to the trade of the port, which would not only enable it to effect great economies, but also to add considerably to its revenue.

128. It should thus be able to meet the increased expenditure in maintenance which would mainly arise from the dredging necessary to keep the approach channel and mooring area in proper condition, as well as to make provision for further capital outlay on the gradual construction of wharves in addition to the development and equipment of the port generally on modern lines.

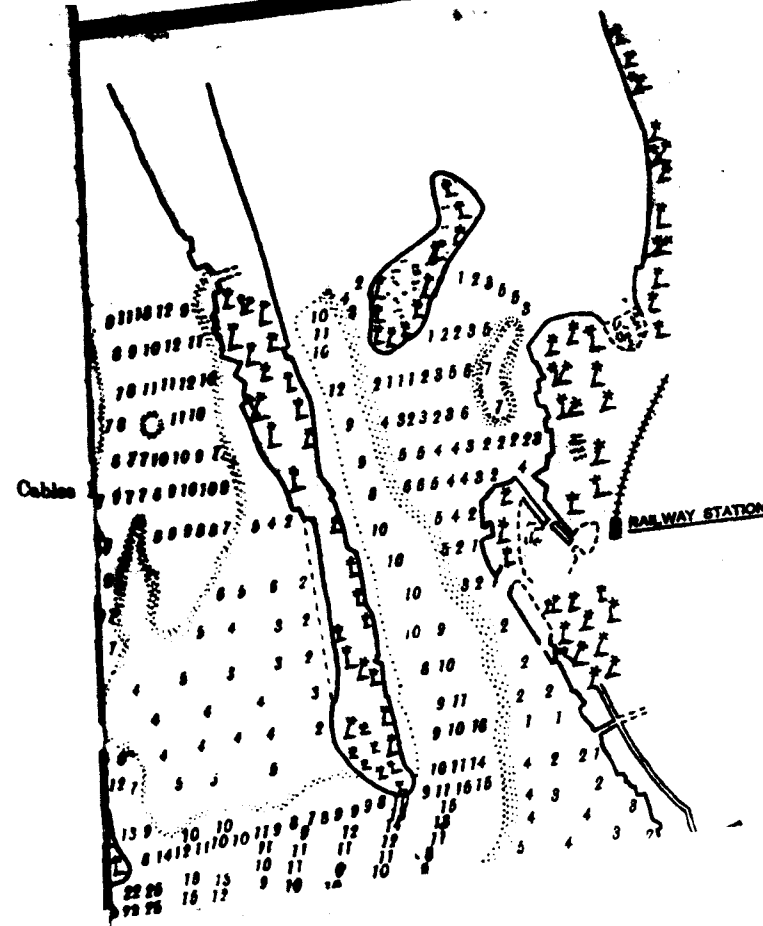
129. Under such a scheme it appears to us that the steady progress and advancement of the port would be assured and the prosperity of this part of India would be materially advanced.

Postscript, 28th January 1918.

Since the above report was completed and the first proof printed we have received from Mr. Savile, in Bombay, a "copy of letter from the Port Officer, Cochin, to the Presidency Port Officer, Madras, through the Collector of Malabar, Calicut, No. 12/2129, dated 18th October 1917."

This letter gives replies to a list of questions which Mr. Savile at our request addressed to the Secretary, Public Works Department, Government of Madras, on 4th July 1917.

There are only two points which materially affect the views we have expressed in the above report, and which, therefore, require to be dealt with afresh.



The first of these concerns the revenue which would be available to meet the capital charges entailed by the improvement works.

On this point the letter states: "The . . . would be borne by landing and shipping dues. The Chamber of Commerce has signified its willingness to pay up to Rs. 2 per ton, if necessary, therefore the maximum revenue would be:—

" Proportionate share of port dues, viz. two-thirds available balance	Rs. 58,570
" Landing and shipping dues 498,820 tons at Rs. 2	9,86,640
	10,40,210

It will be obvious from this statement that the estimates given in paragraphs 118 and 125 of the report are fully justified.

The second point is that the dredging for the mooring basins should be carried to 30 feet below low water.

In paragraph 86 of the report we had allowed for a depth of 27 feet only and the provision of the extra 3 feet will add some 3 lakhs to the estimate of lakhs 55 in paragraph 125.

In view, however, of the available revenue quoted above being so much greater than we anticipated this small increase of capital cost does not appear to be important.

A.G.L.

VI

EXTRACTS FROM REPORT OF SIR GEORGE BUCHANAN, 1919.

I have read the report by Sir John Wolfe-Barry and Partners, . . . but it cannot be called a detailed project on which Government or a public body would embark on expenditure. The works proposed comprise—

- (a) two miles of groynes and one mile of embankment at Vypeen,
- (b) two miles of groynes and one mile of embankment at Andikadava,
- (c) dredging a channel across the bar 600 feet wide to a level of 30 feet below L.W.O.S.
- (d) dredging an area in the backwater and providing moorings for ten or twelve ships, and
- (e) provision of channel and mooring buoys, tug, etc. It is stated that the nearest approximation to the cost of the works, which can be made with the information available, is 25 lakhs.

As a matter of interest I have examined the plans, and charts, and inspected the port, and the following remarks may be taken for what they are worth:—

(a) the groynes and embankments carried out at Vypeen by Mr. A. Campbell, Executive Engineer, are in such good condition and doing their work so satisfactorily that I cannot see any object whatever in spending

money in that locality especially as there is a large reserve of stone available on the spot to repair any breaches in the apron which may occur in the next few years.

(b) I did not go to Andikadavu, and as the report states that the writers themselves had been unable to obtain any specific information in the form of sections, or foreshore lines but "are informed that erosion is proceeding," it is evident that their proposals are premature, and that proper plans and sections must be prepared before any opinion can be formed; I understand that Andikadavu is some eight miles south of the entrance to Cochin port, and it is open to question whether the possible effect of a breach in that locality is not very much overestimated.

(c) I must confess that the proposal to deposit, on either side of the dredged channel, a continuous low rubble stone mound, causes me grave misgivings, as I am afraid that after a heavy monsoon the stone would be washed into the channel, where its removal would be exceedingly difficult. I cannot call to my mind any similar work elsewhere, and I cannot subscribe to the opinion expressed in paragraph 64 of the report to the effect that a channel dredged before the monsoon and left undredged during that period would be practically obliterated at the end of that time. I attach no importance to the fact that when the bucket dredger "Manar" made a small experimental cut, the hole filled up during the monsoon, and I believe a properly dredged channel would, with a certain amount of periodical dredging, maintain itself; at all events the experiment should be tried before adopting the highly dangerous expedient of dumping rubble at the edge of the channel.

(d) The report gives no details in respect to the dredger, which is the crux of the whole scheme, but merely observes that the exact form and type would require to be carefully considered in order that she might be specially adapted to the work required of her.

In my judgment there are no insuperable difficulties in dredging a channel through the bar, and making a port at Cochin, but to enable a reasonable and complete project to be placed before Government the following action is, I suggest, necessary:—

(a) First and foremost a scientific examination of ways and means from the financial and commercial aspect.

(b) It is a matter for consideration, whether the works at present contemplated are not of prohibitive cost for the port of British Cochin alone, and whether the second part of the scheme, namely, the extension of the channel to Ernakulam and building of wharves there, should not at all events be considered in greater detail than has been the case. A port without any hinterland has not much prospect of large development . . . I therefore consider that although the necessities of British Cochin may warrant the early extension of Part I of the scheme, i.e., dredging of bar, and mooring berths, section 2, i.e., the extension to Ernakulam, should be properly considered before section No. 1 is put in hand.

(c) Assuming that the considerations under (a) and (b) have been worked out in detail, and it has been settled definitely that the scheme is justified, then a proper project accompanied by detailed plans and estimates can be prepared, and I should recommend the appointment as Port Engineer of a comparatively young engineer with port experience who would,

subject to supervision, be entrusted with the whole-time work of making the port.

(d) I need hardly say that everything depends on getting the right kind of dredger . . . A modern dredger for sea work is an exceedingly costly machine, and it is impossible to be too careful in its selection and design.

VII

NOTE BY MR. W. HUTTON, CHIEF ENGINEER, PUBLIC WORKS DEPARTMENT, 1919.

It will at once suggest itself that the formation of these rubble mounds on each side of the site of the channel to be dredged is a detail of the channel work which can best be determined by the practical experiment of using the new dredger, which is to be obtained, to dredge a short length of channel before the monsoon and then observe the action of the monsoon on the dredged channel. If this short length of channel be filled up during the monsoon months, then it would be necessary to adopt the plan of rubble mounds or some other system. Neither Sir John Wolfe-Barry, Lyster and Partners nor Sir George Buchanan rest their opinion in this matter on any similar problem successfully dealt with elsewhere, and both their opinions can only be correctly judged by the experiment I have indicated. But I must confess that, in this matter, I am inclined to agree with Sir George Buchanan for a reason that neither he nor the firm refer to. If the rubble mounds settle down so as to relevel the channel which they can only do in a partial way, then when the channel has to be re-dredged periodically or continuously, as the case may be, the presence of this rubble stone in the bed of the channel would interfere with the process of dredging. Some of the stone is bound to find its way as far as the bed of the channel. Surely it seems preferable to retain a sandy or mud bottom to the channel rather than artificially cause obstructions in the form of rubble stone.

The other criticisms of Sir George Buchanan refer to the provision of groynes to protect the sea north and south of Cochin. The firm propose two miles of groynes to the north and two miles to the south of Cochin. Sir George Buchanan does not consider these groynes necessary, as the existing groynes to the north are doing their work satisfactorily and are in good condition. The Public Works Department have, since the firm sent in their report, obtained a plan of the correct type of groyne from Mr. Savile and have prepared an estimate for the two miles to the north, the cost being Rs. 90,000. In constructing groynes to protect a foreshore and arrest the travel of the sand drift, it is not necessary to construct a whole series of groynes included in an estimate before observing their action. We can construct a few and then decide by observation whether their construction promises to fulfil the original intention. Consequently I again advocate the practical test of trying whether the groynes will be useful or not before deciding finally for or against the construction of four miles of them. In this matter of criticising the firm's proposal to construct groynes it seems to me that Sir George Buchanan is unnecessarily giving

this minor item in the firm's scheme undue importance probably for want of more important points to criticise.

Another criticism of Sir George Buchanan is that the firm do not give any details of the dredger. Again, I think Sir George Buchanan's statement is unacceptable, because the report of the firm is not a detailed report accompanied by plans and estimates, but a general report laying down the main lines on which detailed plans and estimates should be drawn up. The firm give sufficient information of the dredger for a general report.

Sir George Buchanan's demi-official letter is valuable in this way that he approves the general principle of the scheme and contents himself, ineffectually, I submit, with criticisms of relatively unimportant details. He states that "in his judgment there are no insuperable difficulties in dredging a channel through the bar and making a port of Cochin." This is, I think, everyone's opinion, and the case is to my mind on a par with the Madras harbour northern entrance question. For very many years expert after expert, before and after the construction of the harbour, advocated an entrance on the north side . . . and, after many years, the first entrance constructed on the east side was closed and an entrance to the north was constructed and found to be a success. Similarly with Cochin the crux of the problem is to dredge a channel through the bar and dredge an area in the backwater where steamers can lie close to the shore of British Cochin. I submit that the general report of Messrs. Wolfe-Barry, Lyster and Partners should be accepted as the basis for detailed plans and estimates, which should be drawn up by an engineer of experience and not by a comparatively young engineer with port experience as recommended by Sir George Buchanan. Such an engineer might be from 35 to 40 years old.

