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TAMIL NADU ARCHIVES

GOVERNMENT OF TAMIL NADU

PUBLIC WORKS DEPARTMENT

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GOVERNMENT OF MADRAS.

PUBLIC WORKS DEPARTMENT.

23rd March 1880, No. 767 W.

Buildings and Roads.
Civil Works.

Read the following paper:—

No. 104-A. From Major-General J. CROFTON, R.E., Deputy Secretary to the Government of India, Public Works Department, (Civil Works—Miscellaneous,) to the Secretary to the Government of Madras, Public Works Department, dated Fort William, 12th March 1880, No. 113 M.

In continuation of this office letter No. 314 M., dated 7th August last, I am desired to forward, for the information of the Government of Madras, a copy of a despatch from the Secretary of State, No. 5, dated 29th January 1880, with enclosure, regarding the Madras Harbour Works, and to request that, with the permission of His Grace the Governor, careful observations may be made to determine how far Mr. Parkes' assumptions are supported by facts as the works advance to completion, and that the Government of India, as well as the Secretary of State, may be informed when any fact shows that Mr. Parkes is in error in his estimate of the action of the piers in the accumulation of sand on the foreshore.

From the Secretary of State for India, to His Excellency the Right Honorable the Governor-General of India in Council, dated London, India Office, 29th January 1880, No. 5, Public Works.

I have had under consideration in Council your Excellency's letter, No. 89, dated the 15th of August last, on the subject of the Harbour Works now in progress at Madras, together with the Minutes on the same subject, by your Excellency and certain of your colleagues, which are transmitted with that letter.

2. One of the first steps taken by me on the receipt of this letter, was the communication of Sir Andrew Clarke's Report on the works to Mr. Parkes. Mr. Parkes has, as your Excellency will perceive from the enclosure to this despatch*, replied at considerable length to the objections urged against his scheme, and the conclusion to which I have been led, after carefully weighing the representations on both sides, is that to stop the works in question after allowing them to proceed so far, would be a step for which sufficient warrant has not been furnished by any new facts adduced.

* Report, dated 6th November 1879.

3. There does not seem to be more reason now than there was when the project was originally sanctioned, for doubting whether the plan of Mr. Parkes will secure, at a cost not exceeding the estimate, the kind and degree of protection which has been all along contemplated, or for considering the difficulties greater than were recognized from the beginning. And, seeing that more than half the estimated cost has already been expended, much stronger grounds than have been adduced, ought to be shown in order to justify the complete sacrifice of past outlay which would result from stoppage of operations at their present stage. Under these circumstances, I consider that no practical advantage would be gained by consulting any fresh engineering authority.

From W. PARKES, Esq., to the Under Secretary of State for India, dated 23, Abingdon Street, 6th November 1879.

Madras Harbour.

I have read and carefully considered the report of Sir Andrew Clarke on the above Harbour (herewith returned), and in accordance with your letter of the 11th October beg to submit the following observations.

2. Sir Andrew Clarke's comments on my plan may be conveniently considered under the following heads :—

1. The sand difficulty.
2. The question of entrance.
3. The question of mooring.
4. The provision of wharfs and quays.
5. The sanitary question.

The Sand Difficulty.

3. The point at issue between Sir Andrew Clarke and myself may be expressed in a very few words. My conclusion was from the first, and still is, that supplementary works will at some future time be required to prevent the advance of sand from destroying the harbour, but that the period at which this will become necessary is so distant that it need not at present be taken into account.*

4. Sir Andrew Clarke disputes the validity of the data on which I base the latter part of this conclusion, and maintains that the destruction of the harbour by the advance of sand is sufficiently imminent to justify and demand immediate preventive measures, involving extensive changes of my plan. Into the merits of his proposal for meeting the evil I am precluded by your instructions from entering.

5. I believe I shall best comply with what I understand to be the wishes of the Government by carrying out an intention which I had formed before I received Sir Andrew Clarke's report, of submitting to you a review of the whole sand question from its commencement to what I now feel justified in calling its termination. It is a subject not only of great importance to this particular undertaking, but also of much interest from a professional and scientific point of view.

6. The area of discussion is very much narrowed by Sir Andrew Clarke's admission of what I consider to be the one great principle, which is the key of the whole question. It is one for which I have contended from the first, though, in consequence of the special circumstances under which I made my original report, it is rather tacitly assumed than positively asserted therein. That principle is that the force by which the sand is disturbed and transported is that of the *waves* and not of the *currents*, and that its movements are confined to a belt bounded by the shore on one side and by a line approximating to the four-fathom contour on the other. Outside this there is no important movement. So far, Sir Andrew Clarke and myself are agreed.

7. It is important to bear in mind that Sir Andrew Clarke's report is dated February 1879, that his personal inspection took place a year earlier, and that the investigations of Lieutenant-Colonel Thomason, R.E., on the results of which he appears to place much reliance, were made in the latter part of 1877. Much had occurred since even the most recent of these dates to throw light upon the question.

8. In order that the bearing of the several stages of the review I am about to present upon the question at issue may be seen, it will be desirable to describe somewhat more in detail the conclusions which were formed as to the action of the waves upon the sand, originally from analogy and hypothetical considerations, but which, as I hope to show as I proceed, have been gradually strengthened, and are now fully confirmed by the result.

9. It is well known that the waves in the two monsoons approach the shore from different directions, approximately north-east and south-east, each obliquely transverse to the general line of the shore. The first and main movement of the particles of sand lifted from the bottom by the waves must obviously be in the same direction as that of the particles of water which have lifted them, and this must be either in the same direction as the wave itself is moving, or the exactly opposite direction, without any tendency to a diversion to the right or the left so long as the wave has an unimpeded onward movement. But when this movement is met by the shelving bottom a portion of the particles of sand-laden water are diverted right or left according to the direction of the obliquity, and thus an *alongshore* movement is communicated to the sand. At first the proportion of this movement is small, but as the rolling wave advances towards the shore into still shallower water the degree of obstruction increases, and the alongshore component of the movement increases with it, until where the wave make its final break on the beach the onward movement is completely arrested, and the final result upon the particles of sand carried by it is a transport for a certain distance *along here*.

10. It directly follows from this, *first*, that the alongshore movement is very much greater close to shore than it is further out; and *second*, that the movement in the outer part of the area of disturbance, whether great or small in itself, has a large component of transverse movement, and a small one of alongshore movement. The importance of making a distinction between these two movements arises from the fact that the alongshore movement is directly arrested by the piers, and so far as the movement in one direction in one monsoon is not balanced by that in the

* To show that this does not impose any very serious burden on posterity, I may mention that whatever the length of time may be it may be *doubled* by the extension of the South Pier seaward for a length of 1,000 feet, at a cost of 30,000*l*.

other direction in the other monsoon, the effect will be cumulative from year to year. The transverse movement on the other hand will not be interfered with by the piers, and the seasonal changes will continue to balance one another as heretofore.

11. I have to request, then, that in following the statement I am about to submit of the movements of the sand from the commencement of the works to the present time, these two principles may be kept in view, so that they may be compared with the facts as the latter are successively presented.

12. The accompanying drawing presents in one view the effects produced by the four successive south-west monsoons of 1876, 1877, 1878, and 1879. The portions of the works coloured red show the advances made in the several half years from 31st March to 30th September, the portions coloured burnt sienna the above water accumulations, and those coloured blue the portions washed away during the same intervals.

13. *Monsoon of* 1876.—The north surf bank was begun in January 1876, and by the end of March it had advanced some little distance into the sea. The sand began to accumulate on its southern side soon afterwards, and as the bank advanced the coast line followed at some distance in the rear, till both reached the positions shown by the end of September. The depth of water in which the bank was made of course increased as it advanced seaward, but the sandy bottom was much disturbed by the local action of the waves around the end of the bank, and moreover anything like accurate survey was impracticable in the surf. The depth, however, immediately in front of the bank was about 6 feet at mean tide in March, and 10 to 12 feet in September. The advance of the shore ceased in September, the erosive action of the northerly seas set in October, and, before the return of the south-west monsoon in 1877, the shore line was cut back to the extent shown.

14. There was, no doubt, a good deal of sand distance within, and possibly somewhat outside the belt of surf, besides that which resulted in the accumulation of the shore shown on the plan, but it was beyond the range of possible survey, and our knowledge of it rests upon such evidence as the unusual extension of the surf in one direction or another, the "bumping" of a masula boat in an unaccustomed place, or a discolouration of the water previously unnoticed. These facts are suggestive of some unusual disturbances, but are of too vague a character to justify any conclusion as to their nature. What is certain about the disturbances is that they had entirely disappeared before the following March, and all that remained was an advance of the line of beach in front of the town of rather more than 100 feet.

15. The triangular accumulation and its partial removal, as shown on the plan, was, however, a definite addition to our materials for estimating the *amount* of sand movement due to the alternate southerly and northerly alongshore wave action. Its *completeness* as evidence depends on the degree of reliance which may be placed on the first of the two principles enunciated in paragraph 10, and which as yet rested entirely on hypothetical considerations. My own belief was, and is, that it is a legitimate deduction from admitted principles, and that it might fairly be concluded that the amount of sand which passed the line of the pier, but would have been arrested by the pier itself had it been in existence, was so small in comparison with that actually arrested as to be properly disregarded. A calculation made upon this assumption showed that at the same annual rate of accumulation it would require 50 years for the four-fathom line to reach the sea face of the harbour, and if it were further assumed, as the plan shows, to be well within the mark, that half the accumulation under the southerly seas is removed by the northerly seas, the period would be extended to 100 years. But even if this be not admitted, and a substantial allowance be claimed for sand which passed freely, and is therefore not shown by the area of accumulation, a very considerable one might be made without so reducing the "life" of the harbour as to trench upon my contention that the means of extending it may be left to posterity. Up to 1876, however, my reliance was on a hypothesis based on abstract reasoning. I hope to show that it may now be based on *fact*.

16. *Monsoon of* 1877.—The south surf bank was commenced early in the year, but was not so far advanced when the movement of sand from the southward began as the north bank had been at the corresponding period of the previous year. The total amount of accumulation is shown on the plan. The quantity intercepted by the south bank itself is obviously less than that intercepted in the previous year by the north bank, but a considerable quantity appears to have been also intercepted by the north bank, which must, therefore, have passed the south bank. The aggregate of the two coloured areas is not very different from the one area of 1876.

17. Here we have an undoubted case of the sand passing one groyne and being intercepted by a second. If the second groyne had not existed the sand would have passed freely along the beach to the northward, and all evidence of its having passed the first groyne would have been destroyed. If, in such a case, a calculation of the "life" of the harbour had been based on the supposition that the quantity intercepted by the groyne was the whole quantity in motion, the conclusion would have been obviously false, and if the facts so far stated stood alone, they would go far to invalidate the conclusion which I drew from the amount of sand arrested in 1876, and which I assumed did represent the whole quantity in motion.

18. There are other facts, however, which materially affect the question. The results shown by the coloured areas are those of the whole six months. If we compare those of the first three months with those of the last three months we shall find a remarkable contrast. I have shown on the same drawing the shore line of the 30th June 1877, and it will be seen that while to the south of the south pier this line is in the middle of the area of accumulation, *between the piers* it nearly coincides with the line of 30th September. Thus whatever sand did pass, passed before the end of June, after that date the whole was intercepted. The cause of this is obvious. In the early part of the season the bank was but little in advance of the advancing shore line, but in June it made a considerable start, and passed the outer boundary of the shore movement. Now the north bank was, throughout the monsoon of 1876, in a state analogous to that of the south bank *after* June 1877 rather than *before* that date, so that my conclusion that the whole of the sand was, in the former year, intercepted, though based at the time on hypothetical considerations, is fully confirmed by the subsequent experience of the effect of the south bank. I may mention that since June 1877 there has been no permanent or general advance of the beach within harbour limits.

19. While these changes of the coast line were going on in consequence of the advance of the south surf bank, the "sand difficulty" was manifesting itself in another form at the north pier. After the 30th September 1876 the outer end of the bank was flattened down by the action of the northerly seas, so as to form a good foundation for the concrete blocks, and by the end of March 1877 a length of nearly 300 feet had been built, carrying the end of the pier to a point about 100 feet in advance of that at which the end of the rubble bank stood in September, and where the depth of water was about 16 feet.

20. Some disturbance of the bottom following the change in the direction of the prevailing seas was quite anticipated, though it was uncertain what form such disturbance would take. A warning from me to that effect to the Superintendent reached Madras a few days after the first symptoms of the disturbance had appeared on the 31st March. The disturbance took the form of an accumulation of sand around the end of the pier, covering the foundation and preventing blocks being placed in advance. Its result is seen in the small amount of progress made in the following six months.

21. The accumulation being entirely under water, and almost entirely under broken water, the details of its form and extent could only be very imperfectly ascertained. It appeared liable to changes, sometimes disappearing for a day or two, and then returning, but these changes could not be satisfactorily connected with any apparent causes. The sand over the rubble foundation, which was itself 2 to 5 feet above the original surface of the sand, varied from 4 to 8 feet, increasing generally as the season advanced. Its extent was not great, varying from 50 to 100 feet to seaward of the end of the block work, and to something like the same extent on either side, but in consequence of the impossibility of taking soundings through the breaking surf, the records of the most critical parts are wanting. There is a good deal of evidence of what this accumulation *was not*, but the evidence of what it *was* is very imperfect.

22. The questions to be most carefully considered were these:—1st. Was this disturbance part of an alongshore movement which would be arrested by the formation of a solid pier across its course, and thus tend to an annually increasing accumulation? 2nd. Was it an effect which would follow the advance of the pier into deeper water?

23. With reference to the first of these questions, there were some facts suggestive of a negative reply. It was not a mere extension of the ordinary surf movement, for although the waves broke heavily on this accumulation itself, there was an interval of unbroken water between it and the surf which was constantly breaking on the shore. Also it began before there was any accumulation on the coast line in April, and it continued after the erosion of the coast line began in October. It was, therefore, clearly independent of the alongshore movement on the coast, and, if so, it would be quite a gratuitous assumption that it had any alongshore component at all.

24. With reference to the second question, it seemed sufficient reply that the location of the disturbance was well within the area in which disturbance had been anticipated.

25. On the whole, therefore, the conclusion seemed safe that nothing had occurred in 1877 at variance with the second principle suggested in paragraph 10, viz., "that the movement in the outer part of the area of disturbance, whether great or small in itself, has a large component of transverse movement and a small one of alongshore movement." My confidence in this was further strengthened by the remarkable fact of the absolute arrest of the alongshore movement by the south surf bank after June.

26. Such were the circumstances which appeared to me to justify the expression of a confident expectation that the difficulties of 1877 were of a transitory kind. I was not surprised, however, that to those who examined the matter less closely my confidence should appear misplaced. In the face of the repeated predictions that "the sand difficulty" would be fatal to the success of a harbour at Madras, the assertion that an obstruction by sand which had brought the work almost to a standstill for six months was not *the* sand difficulty, was one which seemed almost to court incredulity. It was at this time that Sir Andrew Clarke's special investigations were undertaken.

27. It was not till January 1878 that the obstruction of sand in the foundations of the north pier was finally overcome. It has not, however, since reappeared in any form, and the soundings taken from time to time show that beyond the four-fathom line there is no disturbance of the bottom whatever. So far as the north pier is concerned the sand difficulty ended in 1877.

28. At the south pier the setting of concrete blocks was begun in November 1877, and by the end of March 1878 a length of 423 feet had been built, placing the end in a depth of 3¼ fathoms. During the same interval the northerly seas had cut away the coast south of the harbour for a width of 400 feet, while within harbour limits it had cut away from the northern half and added to the southern half, leaving a line parallel to that of the previous March, but 100 feet further seaward, this width of 100 feet representing the amount accumulated between March and June of 1877.

29. *Monsoon of* 1878.—The accumulation to the south of the south pier began in April, as in previous years, and by the end of June the coast line had advanced 350 feet. The works of the pier had been in abeyance during almost the whole of those three months, from causes independent of the sand difficulty. As a matter of fact, the foundations were then clear of sand, and it is possible that if the blockwork had been advanced during those three months the sand difficulty would have terminated at this stage. While the abrupt end of the pier stood in a depth of 3½ fathoms there was no apparent disturbance of the bottom, but the advancing beach on the south pushed out the foot of its slope, and before work was resumed the depth was so decreased as to establish the conditions necessary for disturbance. Then followed a state of things similar in its main features to that at the north pier in the previous year, but with some important differences which have added something to our knowledge.

30. The sand gathered around the end of the pier into a heap probably greater than that of 1877, and in September and October, when it was at its maximum, it was surveyed with tolerable precision. The result of the survey is shown by the blue contour lines on the plan of 1878.

31. The summit of the accumulation was at F, where the original depth being 21 feet, was reduced to 5½ feet. Around this summit the successive contours are arranged in irregular circles or parts of circles, and the limits of the accumulation may be approximately traced by the approach of the lines to a direction parallel with the coast.

32. The evidence presented by this accumulation supplements in a remarkable manner that presented by the similar accumulation at the north pier in the previous year. The accumulation of 1877 clearly indicated the existence of a cause independent of that which produces the surf on the shore. The times of its commencement and its cessation, and the interval of unbroken water, are proof of this. In the case of 1878 evidence on this point is imperfect. The accumulation was apparently indirectly due to the advance of the coast line. That it was not merely an extension of the shore surf disturbance, however, is proved by the fact that though there was no interval in the surf, there was a depression in the level of the sand in a position corresponding to the interval of 1877. But the weight of evidence on this point rests with the case of 1877, though the latter carries a strong presumption to that of 1878.

33. In 1877, on the other hand, direct evidence as to the disposal of the sand is entirely wanting. It might have been carried away northward beyond the range of observation. In 1878 evidence on this point is complete. The form of the accumulation is that which would naturally be assumed in a case where the motive power had spent itself. But beyond this, if any sand had been carried further to the northward, it must have been caught in the angle between the shore and the north pier as it was previous to July 1877, but none was found there.

34. On the contrary, as is clearly shown on the plan, the beach line between the piers rather retreated than advanced during the south-west monsoon. This, however, is only apparent. During the previous north-east monsoon there had been an apparent advance, due probably to a steepening of the slope under water. During the south-west monsoon it was similarly flattened again, and the line of September 1878 is almost exactly coincident with that of September 1877.

35. The accumulation at the end of the south pier in 1878 retarded the advance of the block work, though not so much as in the previous year at the north pier. The work was advanced 148 feet between June and September by sinking the blocks through the sand. The obstruction was entirely past in the following January, and by the end of March 1879 a further length of 539 feet had been set, bringing the end of the pier into a depth of rather more than 5 fathoms.

36. During the same six months the coast line was cut away south of the pier for a width of 300 feet, while between the piers it was cut away in the northern half, and accumulated to an equal extent in the southern half.

37. *Monsoon* of 1879.—The history of the sand question in this year is a very short one. "Difficulty" there has been none. Not a grain of sand has shown itself at the foundations of either pier, and the depths at the foot of the slopes of the newly made rubble banks are practically identical with those found before the work was begun, so that there has been no disturbance of the bottom. The anticipated accumulation has taken place in the angle between the shore and the south pier; but, instead of being increased by the quantity of sand, which,

according to the theory I am combating, would have passed the end of the pier if it had not been extended, it is materially less than in previous years. The accumulation of 1878 has been flattened down, and its present form is shown by the contours on the plan of 1879. What the total amount of accumulation has been is shown by a comparison of the blue contours with the original depths shown in black figures. The coast line within harbour limits has remained entirely unaltered.

38. It would, no doubt, be satisfactory if I could give a more complete explanation of the accumulations of sand which encumbered the ends of the piers in 1877 and 1878, but it should be no cause of surprise that I am unable to do so. Nothing is more complex than wave action, nothing more unaccountable than its effects. In these cases all the results were under water, and generally under broken water, so that the evidence is most fragmentary. The absence of any disturbance in the two years that the north pier, and the one year that the south pier, have been extended into deep water would certainly point to the conclusion that an abrupt obstruction standing in a critical depth of water induces special wave disturbances, but beyond this all is mere speculation. One thing however is, I think, abundantly clear, and that is that the disturbances, however troublesome and disheartening at the time, had no connection whatever with the regular and comparatively well understood alongshore movement, which continued its independent course in the still shallower water close to the shore.

39. I would beg to direct attention to a comparison of the accumulation of one south-west monsoon (1876) at the north pier, with the cumulative effect of two complete years, 1877 and 1878, each with its two monsoons, S.W. and N.E., and the one S.W. monsoon of 1879. The total effect in reference to a line parallel with the coast is not very different in the two cases.

40. Now the accumulation of 1876 is objected to as a measure of the probable "life" of the harbour on the ground that it does not represent the whole, or nearly the whole, of the sand in a state of movement alongshore. The result of 1877 is admittedly useless for this purpose, but in 1878 the arrest of sand must have been more nearly complete than in 1876; and in 1879 it was absolutely complete, yet the whole sand arrested in these three years has failed to produce an accumulation very much greater than that of the one year to which exception is taken as being only a partial arrest. This fact alone is, I think, a complete justification of my assumption of the substantial completeness of the arrest in 1876.

41. The present state of things does not give a good basis for a new calculation of the life of the harbour. A better one will be given when the coming north-east monsoon has produced its effect, when we shall have the net cumulative result of three complete years, but it is already pretty obvious that the conclusion is not likely to be less favorable than that based on the result of 1876 alone.

42. This concludes my review of "the sand difficulty," and I trust I have shown satisfactorily that it is no longer a ground for anxiety. I think that this statement of the whole case will render unnecessary any detailed examination of Sir Andrew Clarke's argument, which is only an expression of certain views which at an earlier stage were quite legitimate, but which ought now to be completely set at rest by the event. Nor does it seem necessary to enter upon any defence of the positions I took in the earlier stages of the undertaking with regard to some questions then debateable. An imputation of recklessness in drawing conclusions will be hardly entertained against me by the authorities of the India Office, and I have therefore passed over some points of which the discussion could only take the form of a defence against such a charge. I am confident that my case will not be permitted to be damaged by my reticence in these two respects.

I now proceed to the other questions raised by Sir Andrew Clarke.

The question of Entrance.

43. Sir Andrew Clarke is evidently unaware that the question of providing one or two entrances to the harbour was the subject of a full discussion in 1874, to which the few sentences in my report of 1873 were merely preliminary.

44. The then Chief Engineer of the Madras Presidency, Colonel (now Major-General) Walker, R.E., had suggested two entrances, and, although I thought it right to place my reasons for a contrary opinion on record, there was an understanding that I was to consult with nautical authorities on the subject, and report the result to the Government of Madras. At the same time the Government of Madras requested the Secretary of State to obtain the opinion of the Elder Brethren of the Trinity House on the point.

45. I applied to the Directors of the Peninsular and Oriental and the British India Companies, for the opinions of some of their commanders, and I also applied to Mr. J. J. Franklin, R.N., late Secretary of the Marine Board, Madras, who had been introduced to me by the late Sir Henry Montgomery as the best nautical authority connected with the port. The results of these applications were rendered in some measure abortive, from the fact of some of the authorities consulted having mistaken the nature of the question, and furnished their opinions on the comparative merits of a detached breakwater, a scheme for which had been lately under discussion, and a close harbour

46. The following is a *résumé* of the replies obtained:—

The Elder Brethren of the Trinity House expressed a preference for a breakwater parallel with the shore, 9,000 feet long, and did not enter into the question of one or two entrances.

Mr. Franklin gave a decided preference to the single entrance.

Captain Atkinson, Superintendent of the British India Steam Navigation Company at Calcutta, also decidedly preferred the single entrance.

Captain Gaby, Peninsular and Oriental Company, considered the harbour as shown would in great measure satisfy the requirements, and preferred it to a breakwater, but did not suggest the two entrances as an improvement.

Captain Renvoldson, Peninsular and Oriental Company, thought "Mr. Parkes' plan, with one entrance, a good one."

Captain Barlow, Peninsular and Oriental Company, was strongly in favor of a harbour rather than a breakwater, approved generally of my plan, and "did not think anything of the difficulties of ingress and egress."

Captain Stewart, Peninsular and Oriental Company, thought the enclosed harbour with single entrance superior to a breakwater, and saw no difficulties for ships to enter or depart. He suggested an extension of the northern jetty to cover the entrance.

Captain Black (the late), Superintendent, Peninsular and Oriental Company, Southampton, was decidedly in favor of a detached breakwater, but admitted the value of a harbour for landing and shipping cargoes. He did not discuss the question of one or two entrances.

Captain Henry (the late), Superintendent, Peninsular and Oriental Company, Bombay, recommended a greater area of harbour, and two entrances, but added, "If these two alterations would not interfere with the project financially, I am of opinion that they would be improvements, but should they so increase the cost of construction as to necessitate an extra charge on the shipping or trade using the port, then I am of opinion that it would be preferable to make the Harbour as you propose." (I may mention that the extra cost of the two entrances, so arranged as to give the same internal capacity and calming effect as the plan with one entrance, would be about 80,000*l.*)

47. Besides these opinions in writing, which were forwarded to the Government of Madras, I had many opportunities of obtaining valuable opinions in conversation with practical nautical men. I came to the conclusion that, while some difference of opinion did exist, the preferances on the one side or the other were not strong, and certainly not strong enough on the side of two entrances to warrant the extra cost, and interference with plans for possible future extensions.

48. I know of nothing which has occurred in the last five years to alter the conditions of the question, except the continued rapid substitution of steamers for sailing vessels in the trade, which has weakened the case in favor of the two entrances.

49. The modification of the single entrance lately proposed, unanimously approved by the nautical authorities consulted, and since sanctioned by the Government of Madras, removes some of the objections to the entrance as originally designed.

50. I may add that the rubble base for the north pier has already been deposited, and the superstructure commenced across the suggested site for the northern entrance, and that for the south pier has reached the site of the southern entrance. I hope no idea of altering the present plan will be entertained, but, if it should be, I believe the cheapest and quickest mode of making the alteration would be to finish the piers in the lines at present laid out, and then remove those portions of them where it is desired to form entrances.

Question of Mooring.

51. Sir Andrew Clarke's criticisms on my proposals for moorings, are based on grounds which are entirely obsolete. The plan of mooring appended to my Report of 1873 was put forward to meet a question raised at the time, but was never intended as a practical suggestion. I was in this difficulty at Madras. There was virtually no nautical authority with whom I could co-operate to devise a system of moorings, the then Master Attendant being a strong opponent of the whole scheme of a harbour. It was, therefore, necessary to submit such a plan as the future responsible nautical authority could amend in one of the two directions which are described in my report, but as to which of the two were preferable I knew there was a difference of opinion among seamen. I had seen reason for congratulating myself on having left this question open, for before I left India I had opportunities of consulting with the two highest nautical authorities in the country, and one preferred one alternative and the other preferred the other, each holding his opinion in a rather decided manner.

52. The question, therefore, remained in abeyance till nine months ago, when, in co-operation with the present Master Attendant, Captain Taylor, I submitted a system of moorings combining in great measure the advantages of both plans. This proposal has been approved with great unanimity, and would, I have reason to believe, have received the formal sanction of the Government of Madras before this but for the obstruction caused by the appearance of Sir

Andrew Clarke's report. It is not liable to the objections urged by practical seamen against the proposal [illegible] ever made under any circumstances by me) of mooring ships head and stern in a cyclone. It leaves ships perfectly at liberty at such times either to put to sea or to swing freely head to wind to all points of the compass within the harbour, at the option of the commander and of the Marine Authorities. I would again emphatically assert, what I have always maintained, that there ought to be nothing in the system of moorings, or in the port regulations, which could interfere with the full freedom of every commander to put to sea on the threatening of a cyclone. Whether time and experience may not induce a greater confidence in the security of the screw moorings is quite another question, and one to which the question of the advantages of the harbour for commercial purposes has but little relation.

The provision of Wharfs and Quays.

53. The absence of this from my scheme is made a prominent ground of complaint by Sir Andrew Clarke, but five years' experience of the requirements of the trade of Madras has not led me to give greater urgency to this demand. About 45,000*l.* per annum is spent upon the landing and shipping of goods. Of this, two-thirds will be saved by the simple provision of a still water shore line, and the greater part of this saving will be absorbed by the interest on the outlay for providing this. What remains will not leave much to meet the cost of deep water walls or jetties, hydraulic cranes, and other expensive appliances of a first-class port. The call for such things may come in time, but it will be some years hence, and under conditions very different from the present. What is at present wanted is quick and certain despatch, and that will be best secured by the use of large cargo boats, which can come along each side of the ship if necessary, plying to cheap shallow water jetties run out from the shore. The cost of these will be small, and self-remunerative. It is still a question whether they should be provided at the charge of Government or by private enterprise.

54. There will no doubt be an early demand for one or two deep water quay berths, with powerful cranes, for landing and shipping articles of exceptional size and weight, but special cranage fees will meet the cost of these, and the means of providing them has always been under consideration.

55. On the whole I have failed to discover that Sir Andrew Clarke has suggested any want that has not already received such consideration as its urgency seemed to demand, though I must admit that my ideas of the mode of meeting them are generally conceived on a more moderate scale than his.

The Sanitary Question.

56. This received full consideration at a very early stage of my preliminary investigation. It divides itself into two heads,—1st, the interception of all house and surface drainage from the harbour; 2nd, the prevention of pollution by the shipping within the harbour.

57. It had been my original intention to include a proposal for the first in my design, but as I was informed that my object would be effected by a plan of general town drainage then almost decided upon, I felt relieved of the necessity. This plan, however, fell through, and the interception of all drainage from the harbour was then at once admitted as a necessity, and a fair charge against the undertaking. Works for carrying out the object are now in progress.

58. With regard to the prevention of pollution by the shipping, that also is an object to be kept in view, but a necessary preliminary to devising measures for carrying it out is to obtain data on which to judge of the amount of nuisance to be dealt with. There are many worse cases than that of Madras is likely to be in which the evil is admitted, but the remedy neglected. At present I am not aware of any place that can be taken as an example of meeting the evil satisfactorily, and it may be that it will be necessary to create a precedent at Madras. But the problem is not a difficult one to solve, and its immediate solution is not urgent. I may say, however, that the ideas which have been put forward of inducing a current of water through the harbour appear to me to be chimerical. The only natural mechanical purifying power available is the tide, which will change about one-tenth of the enclosed water twice a day. Whatever this fails to effect must be provided for by stringent port regulations.

59. Before concluding this communication I wish to correct some errors as to matters of fact into which Sir Andrew Clarke has fallen.

60. In the note at the foot of the photograph, No. 2, taken 5th April 1879, it is said:—"Advance of foreshore and consequent loss of accommodation within harbour is here evident." The advance here alluded to is that immediately to the northward of the south pier, which, as explained in paragraph 36 *ante*, is balanced by a retreat to an equal extent immediately to the southward of the north pier. This is also shown in Sir Andrew Clarke's own plan (Plate III.), which gives the comparative shore lines in September 1878 and January 1879. There has, as a matter of fact, been no advance of the shore line within the harbour since June 1877.

61. In paragraph 25 Sir Andrew Clarke says, "the acreage has already been so far encroached upon that, in the opinion of some seamen, it is already a question whether some of the long steamers of the Ducal Line could, without running ashore, enter the harbour of reduced

acreage." There is no such reduction of acreage as Sir Andrew Clarke assumes, except in the extreme S.E. corner, which was affected by the accumulation of 18[illegible] a part in which no ship ever yet anchored. The effect of this accumulation on the system of moorings now before the Government will be that, out of 18 berths provided for large ships, the depth will be reduced in one from 4 to 2½ fathoms, and in another from 4 to 3 fathoms, thus making them available only for light ships. With regard to the danger of ships running ashore the four-fathom line is 2,400 feet, or more than six ships' lengths from the entrance. Three ships' lengths is generally considered sufficient to bring up in, on entering a harbour. In arranging the moorings rather more than 1,600 feet, or more than four lengths of the longest ships, is allowed to the nearest buoys.

No. 104-B. ORDER THEREON, 23rd March 1880, No. 767 W.

COMMUNICATED to the Superintendent, Madras Harbour Works, for report when and how such observations as those desired by the Government of India can best be taken.

(True Extract.)

Major, R.E.,
Ag. Under Secy. to Govt., P.W.D.

To the Superintendent, Madras Harbour Works.
" Secretary, Harbour Works Committee.
" Marine Department.

Encl. S. T. Austin.
Spare Copies

BUILDINGS AND ROADS.
CIVIL WORKS.

Cobl. of 1880 Madras.

PUBLIC WORKS.

The SUPERINTENDENT, MADRAS
HARBOUR WORKS.

&c., &c., &c.

C. O. Nos. Board Cons. No. 767. W.

MARSH.

Nos. 104-A-104-H.

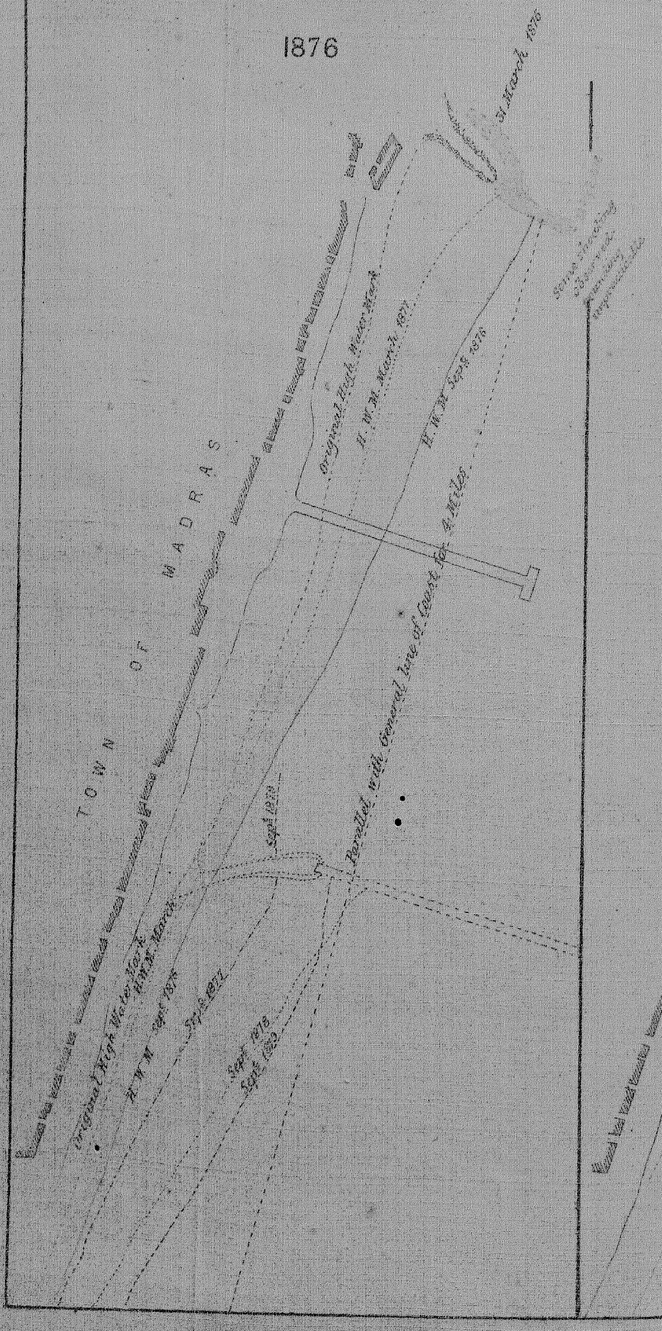
Madras Harbour Works.—Letter from the Government of India requesting that careful observations be taken for determining Mr. Parkes' assumptions relative to the —, communicated to the Superintendent, Madras Harbour Works, for report as to when and how such observations can best be taken.

OF SAND IN

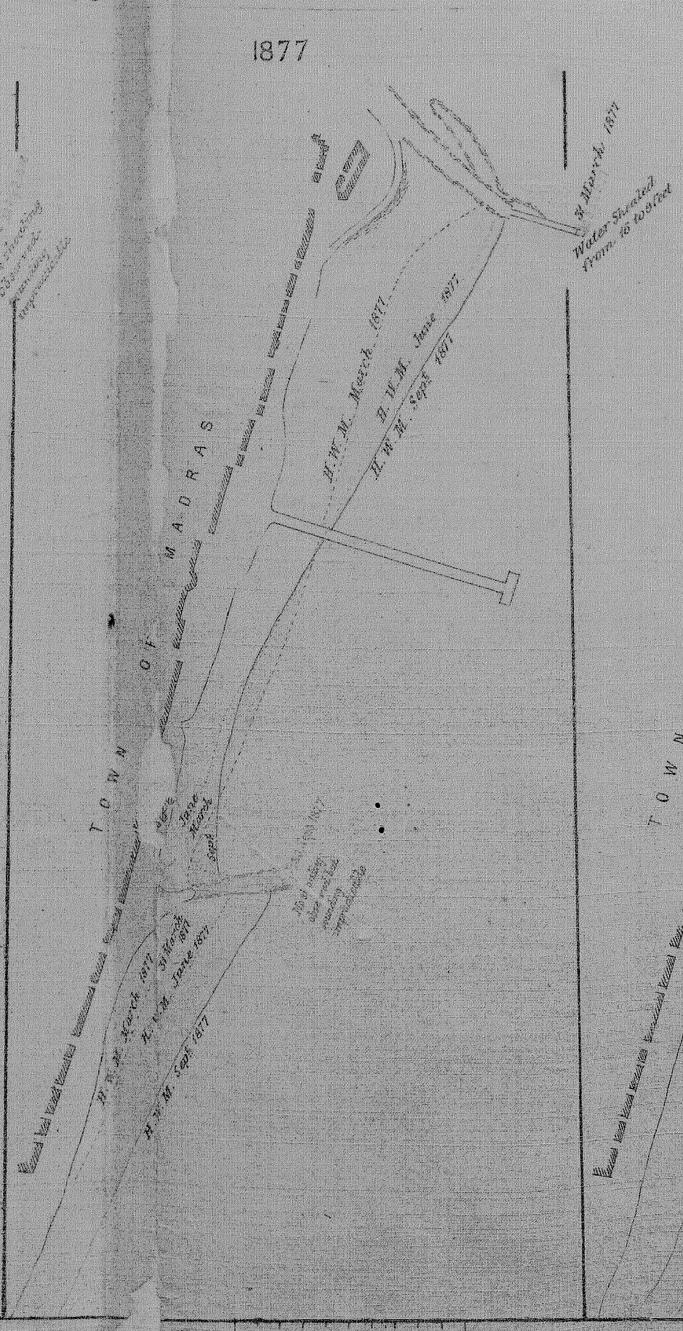
MADRAS HARBOUR WORKS

PLAN SHEWING ACCUMULATION OF SAND IN SUCCESSIVE SOUTH WEST MONSOONS.

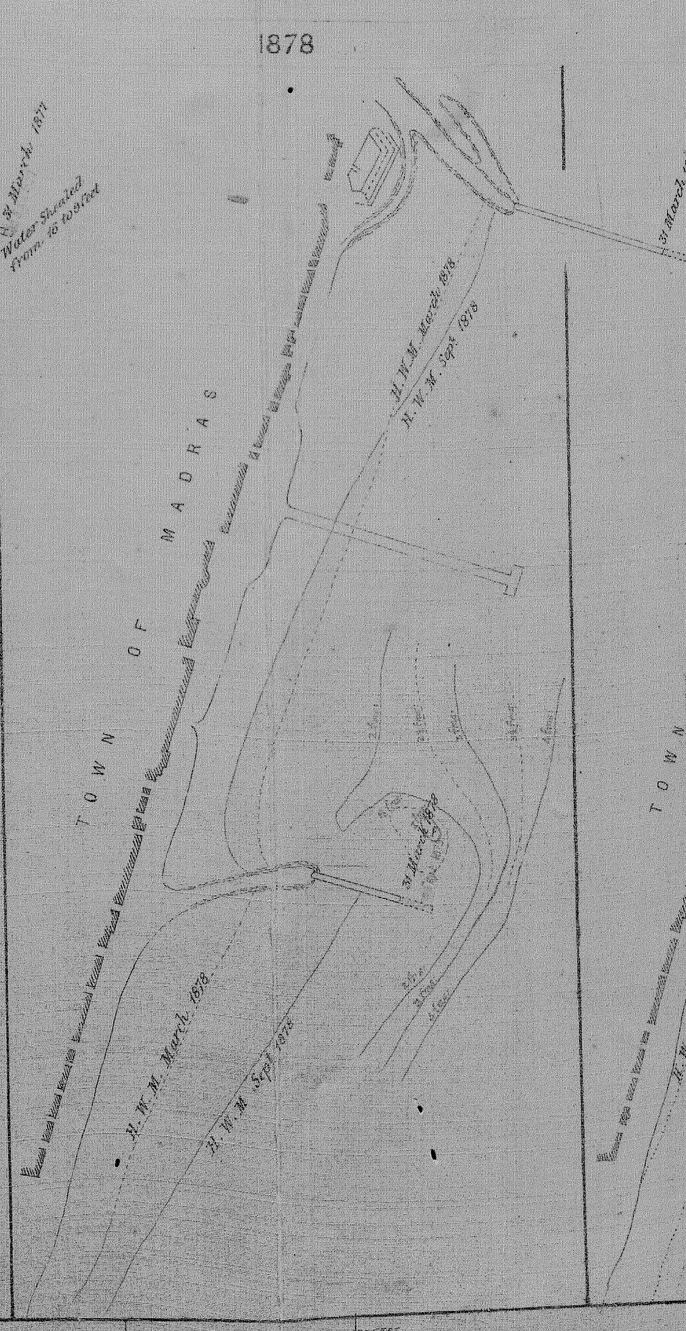
1876



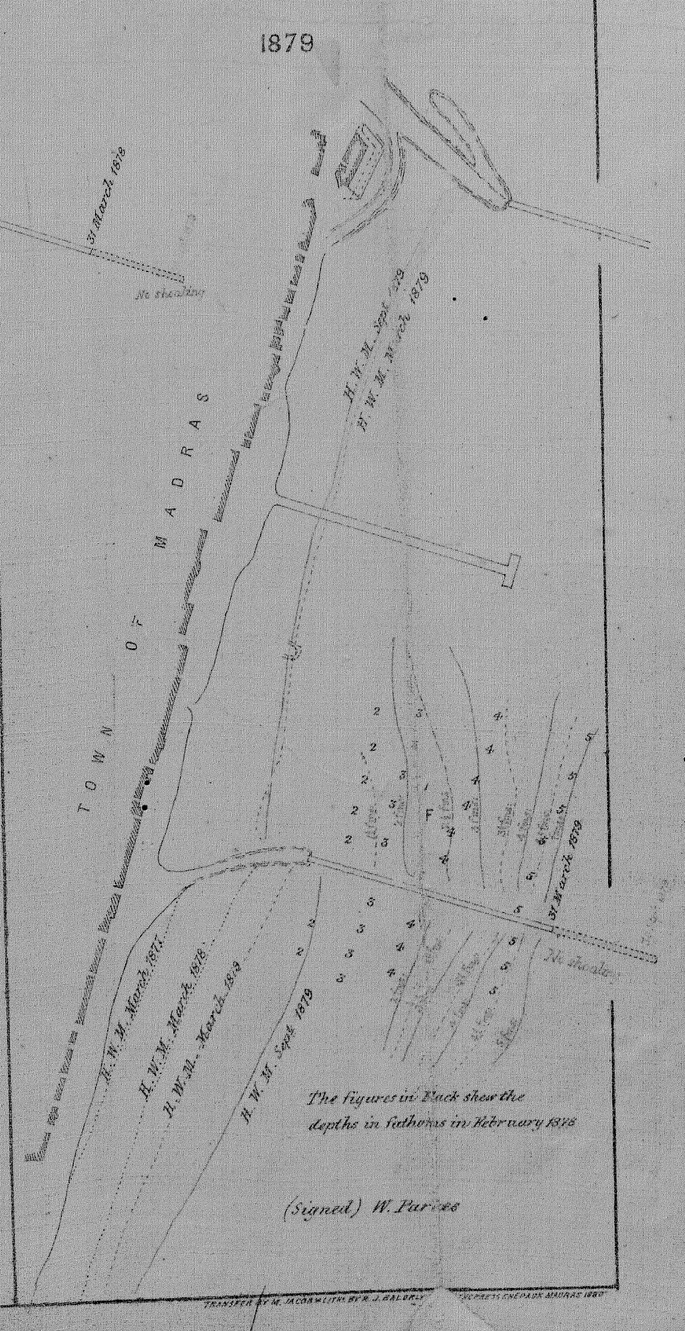
1877



1878



1879



The figures in Black shew the depths in Fathoms in February 1876

(Signed) W. Parkes

1000 0 1000 2000 FEET

TRANSFER BY M. JACOB LITH. BY R. J. BALDRY

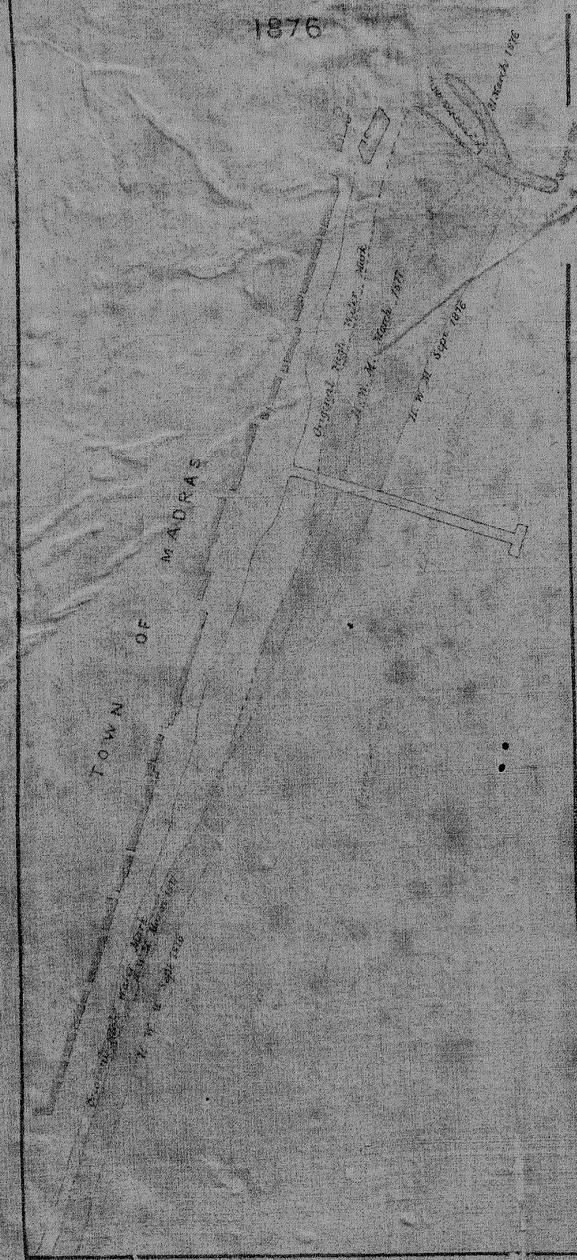
PRESS CINEPARK MADRAS 1880

Govt Litho Press Chepauk

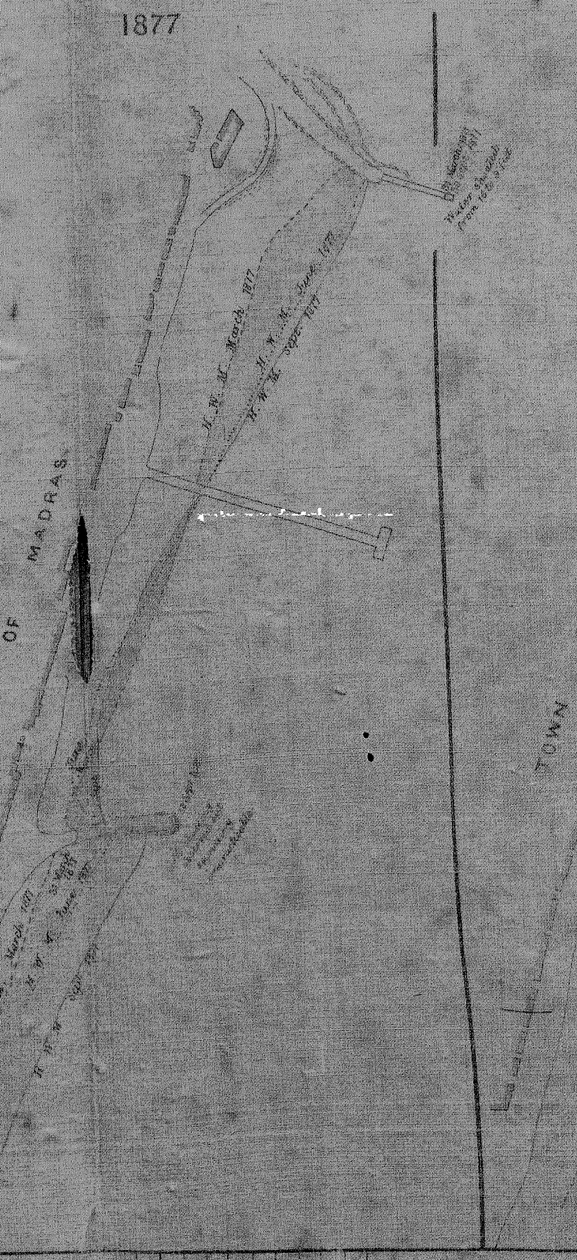
MADRAS HARBOUR WORKS.

PLAN SHEWING ACCUMULATION OF SAND IN SUCCESSIVE SOUTH WEST MONSOONS.

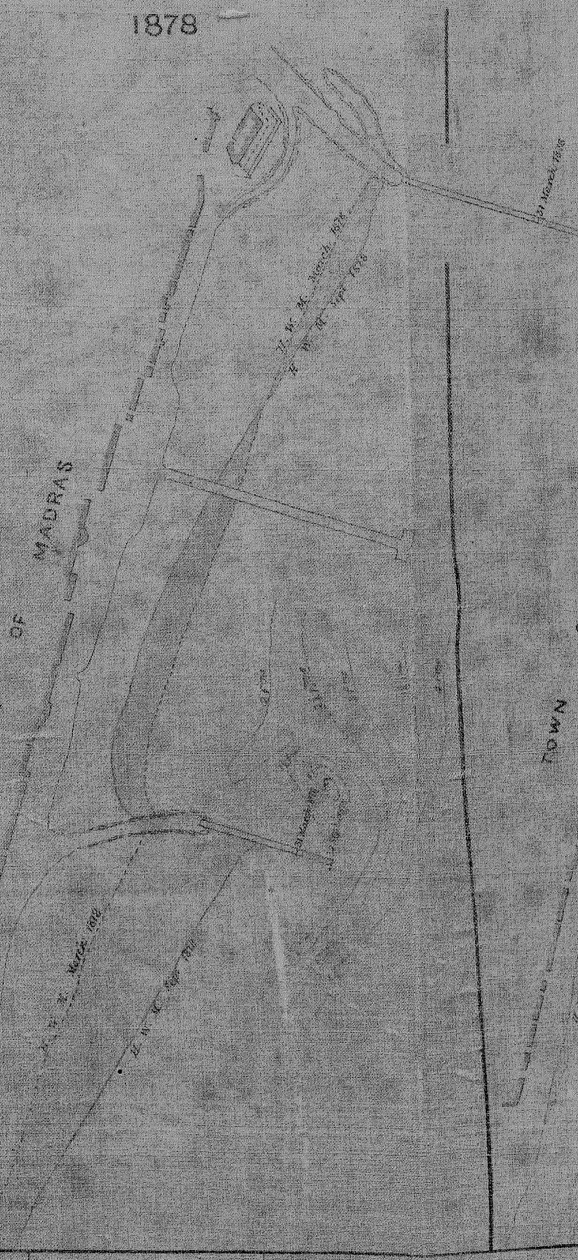
1876



1877



1878



1879

The figures in black shew the depths in fathoms in February 1878

(Sd) J. Parkes

1000 0 1000 2000 3000 4000 5000 feet

1880 12
1880
V 1

No. 113 M

All communications should be addressed to the Secretary.

GOVERNMENT OF INDIA.

PUBLIC WORKS DEPARTMENT.

Civil Works.

Miscellaneous.

To

The Secretary to the Govt. of Madras,
Public Works Department.

Fort William, 12th March 1880.

Sir,

In continuation of this office
letter No. 31 M. dated 7th August last, I am
directed to forward for the information of the
Government of Madras a copy of a despatch
from the Secretary of State No. 8 dated 29th
January 1880 with enclosure regarding the
Madras Harbour Works, and to request that
with the permission of His Grace the Governor
careful observations may be made to determine
how far Mr Parkes' assumptions are supported
by facts as the work advances to completion, and
that the Government of India as well as the
Secretary of State may be informed when any

fact

fact therein that Mr. Parkes is in error in his estimate of the action of the piers in the accumulation of sand on the foreshore. — P.W.D. 19 MARCH 80

I have the honor to be
Sir,
Your Most Obed. Servant,

Hampton Major Genl. R.E.
Deputy Secretary to the Govt. of India

Pub. No. 2243 W. 2-3-79.

(C 18-2-80)

167

9

1797

India Office,
London, 29th January 1880.

Public Works,
No. 5

To His Excellency The Right Honourable The Governor General of India in Council.

My Lord,

Para. 1. I have had under consideration in Council, your Excellency's Letter, No. 89, dated the 15th of August last, on the subject of the harbour works now in progress at Madras, together with the Minutes on the same subject, by your Excellency and certain of your colleagues, which are transmitted with that letter.

2. One of the first steps taken by me on the receipt of this letter, was the communication of Sir Andrew Clarke's Report on the works to Mr. Parkes. Mr. Parkes has, as your Excellency will perceive from the enclosure to this Despatch,* replied at considerable length to the objections urged against his scheme, and the conclusion to which I have been led, after carefully weighing the representations on both sides, is that to stop the works in question after allowing them to proceed so far, would be a step for which sufficient warrant has not been furnished by any new facts adduced.

* Report, dated 6th November 1879.

3. There does not seem to be more reason now than there was when the project was originally sanctioned, for doubting whether the plan of Mr. Parkes will secure, at a cost not exceeding the estimate, the kind and degree of protection which has been all along contemplated, or for considering the difficulties greater than were recognized from the beginning. And, seeing that more than half the estimated cost has already been expended, much stronger grounds than have been adduced, ought to be shown in order to justify the complete sacrifice of past outlay which would result from stoppage of operations at their present stage. Under these circumstances, I consider that no practical advantage would be gained by consulting any fresh engineering authority.

I have the honour to be,
My Lord,
Your Lordship's most obedient humble Servant,
(Signed) CRANBROOK.

3553. I. 224.

P.W.D.
18MAR80
No. 1009

Public Works
29th Jan 1880.

Copy
Letter to the Govt of India
No. 5 enclosure

ENCLOSURE.

MADRAS HARBOUR.

23, Abingdon Street,
6th November 1879.

Sir,

I have read and carefully considered the report of Sir Andrew Clarke on the above harbour (herewith returned), and in accordance with your letter of the 11th October beg to submit the following observations.

2. Sir Andrew Clarke's comments on my plan may be conveniently considered under the following heads:—

1. The sand difficulty.
2. The question of entrance.
3. The question of mooring.
4. The provision of wharfs and quays.
5. The sanitary question.

The Sand Difficulty.

3. The point at issue between Sir Andrew Clarke and myself may be expressed in a very few words. My conclusion was from the first, and still is, that supplementary works will at some future time be required to prevent the advance of sand from destroying the harbour, but that the period at which this will become necessary is so distant that it need not at present be taken into account.*

4. Sir Andrew Clarke disputes the validity of the data on which I base the latter part of this conclusion, and maintains that the destruction of the harbour by the advance of sand is sufficiently imminent to justify and demand immediate preventive measures, involving extensive changes of my plan. Into the merits of his proposal for meeting the evil I am precluded by your instructions from entering.

5. I believe I shall best comply with what I understand to be the wishes of the Government by carrying out an intention which I had formed before I received Sir Andrew Clarke's report, of submitting to you a review of the whole sand question from its commencement to what I now feel justified in calling its termination. It is a subject not only of great importance to this particular undertaking, but also of much interest from a professional and scientific point of view.

6. The area of discussion is very much narrowed by Sir Andrew Clarke's admission of what I consider to be the one great principle, which is the key of the whole question. It is one for which I have contended from the first, though, in consequence of the special circumstances under which I made my original report, it is rather tacitly assumed than positively asserted therein. That principle is that the force by which the sand is disturbed and transported is that of the *waves* and not of the *currents*, and that its movements are confined to a belt bounded by the shore on one side and by a line approximating to the four-fathom contour on the other. Outside this there is no important movement. So far, Sir Andrew Clarke and myself are agreed.

* To show that this does not impose any very serious burden on posterity, I may mention that whatever the length of time may be it may be *doubled* by the extension of the South Pier seaward for a length of 1,000 feet, at a cost of 80,000*l*.

7. It is important to bear in mind that Sir Andrew Clarke's report is dated February 1879, that his personal inspection took place a year earlier, and that the investigations of Lieutenant-Colonel Thomason, R.E., on the results of which he appears to place much reliance, were made in the latter part of 1877. Much had occurred since even the most recent of these dates to throw light upon the question.

8. In order that the bearing of the several stages of the review I am about to present upon the question at issue may be seen, it will be desirable to describe somewhat more in detail the conclusions which were formed as to the action of the waves upon the sand, originally from analogy and hypothetical considerations, but which, as I hope to show as I proceed, have been gradually strengthened, and are now fully confirmed by the result.

9. It is well known that the waves in the two monsoons approach the shore from different directions, approximately north-east and south-east, each obliquely transverse to the general line of the shore. The first and main movement of the particles of sand lifted from the bottom by the waves must obviously be in the same direction as that of the particles of water which have lifted them, and this must be either in the same direction as the wave itself is moving, or the exactly opposite direction, without any tendency to a diversion to the right or the left so long as the wave has an unimpeded onward movement. But when this movement is met by the shelving bottom a portion of the particles of sand-laden water are diverted right or left according to the direction of the obliquity, and thus an *alongshore* movement is communicated to the sand. At first the proportion of this movement is small, but as the rolling wave advances towards the shore into still shallower water the degree of obstruction increases, and the alongshore component of the movement increases with it, until where the wave make its final break on the beach the onward movement is completely arrested, and the final result upon the particles of sand carried by it is a transport for a certain distance *alongshore*.

10. It directly follows from this, *first*, that the alongshore movement is very much greater close to shore than it is further out; and *second*, that the movement in the outer part of the area of disturbance, whether great or small in itself, has a large component of transverse movement, and a small one of alongshore movement. The importance of making a distinction between these two movements arises from the fact that the alongshore movement is directly arrested by the piers, and so far as the movement in one direction in one monsoon is not balanced by that in the other direction in the other monsoon, the effect will be cumulative from year to year. The transverse movement on the other hand will not be interfered with by the piers, and the seasonal changes will continue to balance one another as heretofore.

11. I have to request, then, that in following the statement I am about to submit of the movements of the sand from the commencement of the works to the present time, these two principles may be kept in view, so that they may be compared with the facts as the latter are successively presented.

12. The accompanying drawing presents in one view the effects produced by the four successive south-west monsoons of 1876, 1877, 1878, and 1879. The portions of the works coloured red show the advances made in the several half years from 31st March to 30th September, the portions coloured burnt sienna the above water accumulations, and those coloured blue the portions washed away during the same intervals.

13. *Monsoon of* 1876.—The north surf bank was begun in January 1876, and by the end of March it had advanced some little distance into the sea. The sand began to accumulate on its southern side soon after-

wards, and as the bank advanced the coast line followed at some distance in the rear, till both reached the positions shown by the end of September. The depth of water in which the bank was made of course increased as it advanced seaward, but the sandy bottom was much disturbed by the local action of the waves around the end of the bank, and moreover anything like accurate survey was impracticable in the surf. The depth, however, immediately in front of the bank was about 6 feet at mean tide in March, and 10 to 12 feet in September. The advance of the shore ceased in September, the erosive action of the northerly seas set in in October, and, before the return of the south-west monsoon in 1877, the shore line was cut back to the extent shown.

14. There was, no doubt, a good deal of sand disturbance within, and possibly somewhat outside the belt of surf, besides that which resulted in the accumulation of the shore shown on the plan, but it was beyond the range of possible survey, and our knowledge of it rests upon such evidence as the unusual extension of the surf in one direction or another, the "humping" of a masula boat in an unaccustomed place, or a discolouration of the water previously unnoticed. These facts are suggestive of some unusual disturbances, but are of too vague a character to justify any conclusion as to their nature. What is certain about the disturbances is that they had entirely disappeared before the following March, and all that remained was an advance of the line of beach in front of the town of rather more than 100 feet.

15. The triangular accumulation and its partial removal, as shown on the plan, was, however, a definite addition to our materials for estimating the *amount* of sand movement due to the alternate southerly and northerly alongshore wave action. Its *completeness* as evidence depends on the degree of reliance which may be placed on the first of the two principles enunciated in para. 10, and which as yet rested entirely on hypothetical considerations. My own belief was, and is, that it is a legitimate deduction from admitted principles, and that it might fairly be concluded that the amount of sand which passed the line of the pier, but would have been arrested by the pier itself had it been in existence, was so small in comparison with that actually arrested as to be properly disregarded. A calculation made upon this assumption showed that at the same annual rate of accumulation it would require 50 years for the four-fathom line to reach the sea face of the harbour, and if it were further assumed, as the plan shows, to be well within the mark, that half the accumulation under the southerly seas is removed by the northerly seas, the period would be extended to 100 years. But even if this be not admitted, and a substantial allowance be claimed for sand which passed freely, and is therefore not shown by the area of accumulation, a very considerable one might be made without so reducing the "life" of the harbour as to trench upon my contention that the means of extending it may be left to posterity. Up to 1876, however, my reliance was on a hypothesis based on abstract reasoning. I hope to show that it may now be based on *fact*.

16. *Monsoon of* 1877.—The south surf bank was commenced early in the year, but was not so far advanced when the movement of sand from the southward began as the north bank had been at the corresponding period of the previous year. The total amount of accumulation is shown on the plan. The quantity intercepted by the south bank itself is obviously less than that intercepted in the previous year by the north bank, but a considerable quantity appears to have been also intercepted by the north bank, which must, therefore, have passed the south bank. The aggregate of the two coloured areas is not very different from the one area of 1876.

17. Here we have an undoubted case of the sand passing one groyne and being intercepted by a second. If the second groyne had not

existed the sand would have passed freely along the beach to the northward, and all evidence of its having passed the first groyne would have been destroyed. If, in such a case, a calculation of the "life" of the harbour had been based on the supposition that the quantity intercepted by the groyne was the whole quantity in motion, the conclusion would have been obviously false, and if the facts so far stated stood alone, they would go far to invalidate the conclusion which I drew from the amount of sand arrested in 1876, and which I assumed did represent the whole quantity in motion.

18. There are other facts, however, which materially affect the question. The results shown by the coloured areas are those of the whole six months. If we compare those of the first three months with those of the last three months we shall find a remarkable contrast. I have shown on the same drawing the shore line of the 30th June 1877, and it will be seen that while to the south of the south pier this line is in the middle of the area of accumulation, *between the piers* it nearly coincides with the line of 30th September. Thus whatever sand did pass, passed before the end of June, after that date the whole was intercepted. The cause of this is obvious. In the early part of the season the bank was but little in advance of the advancing shore line, but in June it made a considerable start, and passed the outer boundary of alongshore movement. Now the north bank was, throughout the monsoon of 1876, in a state analogous to that of the south bank *after* June 1877 rather than *before* that date, so that my conclusion that the whole of the sand was, in the former year, intercepted, though based at the time on hypothetical considerations, is fully confirmed by the subsequent experience of the effect of the south bank. I may mention that since June 1877 there has been no permanent or general advance of the beach within harbour limits.

19. While these changes of the coast line were going on in consequence of the advance of the south surf bank, the "sand difficulty" was manifesting itself in another form at the north pier. After the 30th September 1876 the outer end of the bank was flattened down by the action of the northerly seas, so as to form a good foundation for the concrete blocks, and by the end of March 1877 a length of nearly 300 feet had been built, carrying the end of the pier to a point about 100 feet in advance of that at which the end of the rubble bank stood in September, and where the depth of water was about 16 feet.

20. Some disturbance of the bottom following the change in the direction of the prevailing seas was quite anticipated, though it was uncertain what form such disturbance would take. A warning from me to that effect to the Superintendent reached Madras a few days after the first symtoms of the disturbance had appeared on the 31st March. The disturbance took the form of an accumulation of sand around the end of the pier, covering the foundation and preventing blocks being placed in advance. Its result is seen in the small amount of progress made in the following six months.

21. The accumulation being entirely under water, and almost entirely under broken water, the details of its form and extent could only be very imperfectly ascertained. It appeared liable to changes, sometimes disappearing for a day or two, and then returning, but these changes could not be satisfactorily connected with any apparent causes. The sand over the rubble foundation, which was itself 2 to 3 feet above the original surface of the sand, varied from 4 to 8 feet, increasing generally as the season advanced. Its extent was not great, varying from 50 to 100 feet to seaward of the end of the block work, and to something like the same extent on either side, but in consequence of the impossibility of taking soundings through the breaking surf, the records of the most critical parts are wanting. There is a good deal of

evidence of what this accumulation *was not*, but the evidence of what it *was* is very imperfect.

22. The questions to be most carefully considered were these:—1st. Was this disturbance part of an alongshore movement which would be arrested by the formation of a solid pier across its course, and thus tend to an annually increasing accumulation? 2nd. Was it an effect which would follow the advance of the pier into deeper water?

23. With reference to the first of these questions, there were some facts suggestive of a negative reply. It was not a mere extension of the ordinary surf movement, for although the waves broke heavily on this accumulation itself, there was an interval of unbroken water between it and the surf which was constantly breaking on the shore. Also it began before there was any accumulation on the coast line in April, and it continued after the erosion of the coast line began in October. It was, therefore, clearly independent of the alongshore movement on the coast, and, if so, it would be quite a gratuitous assumption that it had any alongshore component at all.

24. With reference to the second question, it seemed sufficient reply that the location of the disturbance was well within the area in which disturbance had been anticipated.

25. On the whole, therefore, the conclusion seemed safe that nothing had occurred in 1877 at variance with the second principle suggested in para. 10, viz., "that the movement in the outer part of the area of disturbance, whether great or small in itself, has a large component of transverse movement and a small one of alongshore movement." My confidence in this was further strengthened by the remarkable fact of the absolute arrest of the alongshore movement by the south surf bank after June.

26. Such were the circumstances which appeared to me to justify the expression of a confident expectation that the difficulties of 1877 were of a transitory kind. I was not surprised, however, that to those who examined the matter less closely my confidence should appear misplaced. In the face of the repeated predictions that "the sand difficulty" would be fatal to the success of a harbour at Madras, the assertion that an obstruction by sand which had brought the work almost to a standstill for six months was not *the* sand difficulty, was one which seemed almost to court incredulity. It was at this time that Sir Andrew Clarke's special investigations were undertaken.

27. It was not till January 1878 that the obstruction of sand in the foundations of the north pier was finally overcome. It has not, however, since reappeared in any form, and the soundings taken from time to time show that beyond the four-fathom line there is no disturbance of the bottom whatever. So far as the north pier is concerned the sand difficulty ended in 1877.

28. At the south pier the setting of concrete blocks was begun in November 1877, and by the end of March 1878 a length of 423 feet had been built, placing the end in a depth of 3½ fathoms. During the same interval the northerly seas had cut away the coast south of the harbour for a width of 100 feet, while within harbour limits it had cut away from the northern half and added to the southern half, leaving a line parallel to that of the previous March, but 100 feet further seaward, this width of 100 feet representing the amount accumulated between March and June of 1877.

29. *Monsoon of* 1878.—The accumulation to the south of the south pier began in April, as in previous years, and by the end of June the coast line had advanced 350 feet. The works of the pier had been in abeyance during almost the whole of those three months, from causes indepen-

dent of the sand difficulty. As a matter of fact, the foundations were then clear of sand, and it is possible that if the blockwork had been advanced during those three months the sand difficulty would have terminated at this stage. While the abrupt end of the pier stood in a depth of 3½ fathoms there was no apparent disturbance of the bottom, but the advancing beach on the south pushed out the foot of its slope, and before work was resumed the depth was so decreased as to establish the conditions necessary for disturbance. Then followed a state of things similar in its main features to that at the north pier in the previous year, but with some important differences which have added something to our knowledge.

30. The sand gathered around the end of the pier into a heap probably greater than that of 1877, and in September and October, when it was at its maximum, it was surveyed with tolerable precision. The result of the survey is shown by the blue contour lines on the plan of 1878.

31. The summit of the accumulation was at F, where the original depth being 21 feet, was reduced to 5½ feet. Around this summit the successive contours are arranged in irregular circles or parts of circles, and the limits of the accumulation may be approximately traced by the approach of the lines to a direction parallel with the coast.

32. The evidence presented by this accumulation supplements in a remarkable manner that presented by the similar accumulation at the north pier in the previous year. The accumulation of 1877 clearly indicated the existence of a cause independent of that which produces the surf on the shore. The times of its commencement and its cessation, and the interval of unbroken water, are proof of this. In the case of 1878 evidence on this point is imperfect. The accumulation was apparently indirectly due to the advance of the coast line. That it was not merely an extension of the shore surf disturbance, however, is proved by the fact that though there was no interval in the surf, there was a depression in the level of the sand in a position corresponding to the interval of 1877. But the weight of evidence on this point rests with the case of 1877, though the latter carries a strong presumption to that of 1878.

33. In 1877, on the other hand, direct evidence as to the disposal of the sand is entirely wanting. It might have been carried away northward beyond the range of observation. In 1878 evidence on this point is complete. The form of the accumulation is that which would naturally be assumed in a case where the motive power had spent itself. But beyond this, if any sand had been carried further to the northward, it must have been caught in the angle between the shore and the north pier as it was previous to July 1877, but none was found there.

34. On the contrary, as is clearly shown on the plan, the beach line between the piers rather retreated than advanced during the south-west monsoon. This, however, is only apparent. During the previous north-east monsoon there had been an apparent advance, due probably to a steepening of the slope under water. During the south-west monsoon it was simply flattened again, and the line of September 1878 is almost exactly coincident with that of September 1877.

35. The accumulation at the end of the south pier in 1878 retarded the advance of the block work, though not so much as in the previous year at the north pier. The work was advanced 148 feet between June and September by sinking the blocks through the sand. The obstruction was entirely past in the following January, and by the end of March 1879 a further length of 539 feet had been set, bringing the end of the pier into a depth of rather more than 5 fathoms.

36. During the same six months the coast line was cut away south of the pier for a width of 300 feet, while between the piers it was cut away

in the northern half, and accumulated to an equal extent in the southern half.

37. *Monsoon of* 1879.—The history of the sand question in this year is a very short one. "Difficulty" there has been none. Not a grain of sand has shown itself at the foundations of either pier, and the depths at the foot of the slopes of the newly made rubble banks are practically identical with those found before the work was begun, so that there has been no disturbance of the bottom. The anticipated accumulation has taken place in the angle between the shore and the south pier, but, instead of being increased by the quantity of sand, which, according to the theory I am combating, would have passed the end of the pier if it had not been extended, it is materially less than in previous years. The accumulation of 1878 has been flattened down, and its present form is shewn by the contours on the plan of 1879. What the total amount of accumulation has been is shown by a comparison of the blue contours with the original depths shown in black figures. The coast line within harbour limits has remained entirely unaltered.

38. It would, no doubt, be satisfactory if I could give a more complete explanation of the accumulations of sand which encumbered the ends of the piers in 1877 and 1878, but it should be no cause of surprise that I am unable to do so. Nothing is more complex than wave action, nothing more unaccountable than its effects. In these cases all the results were under water, and generally under broken water, so that the evidence is most fragmentary. The absence of any disturbance in the two years that the north pier, and the one year that the south pier, have been extended into deep water would certainly point to the conclusion that an abrupt obstruction standing in a critical depth of water induces special wave disturbances, but beyond this all is mere speculation. One thing however is, I think, abundantly clear, and that is that the disturbances, however troublesome and disheartening at the time, had no connection whatever with the regular and comparatively well understood alongshore movement, which continued its independent course in the still shallower water close to the shore.

39. I would beg to direct attention to a comparison of the accumulation of one south-west monsoon (1876) at the north pier, with the cumulative effect of two complete years, 1877 and 1878, each with its two monsoons, S.W. and N.E., and the one S.W. monsoon of 1879. The total effect in reference to a line parallel with the coast is not very different in the two cases.

40. Now the accumulation of 1876 is objected to as a measure of the probable "life" of the harbour on the ground that it does not represent the whole, or nearly the whole, of the sand in a state of movement alongshore. The result of 1877 is admittedly useless for this purpose, but in 1878 the arrest of sand must have been more nearly complete than in 1876; and in 1879 it was absolutely complete, yet the whole sand arrested in these three years has failed to produce an accumulation very much greater than that of the one year to which exception is taken as being only a partial arrest. This fact alone is, I think, a complete justification of my assumption of the substantial completeness of the arrest in 1876.

41. The present state of things does not give a good basis for a new calculation of the life of the harbour. A better one will be given when the coming north-east monsoon has produced its effect, when we shall have the net cumulative result of three complete years, but it is already pretty obvious that the conclusion is not likely to be less favourable than that based on the result of 1876 alone.

42. This concludes my review of "the sand difficulty," and I trust I have shown satisfactorily that it is no longer a ground for anxiety. I

think that this statement of the whole case will render unnecessary any detailed examination of Sir Andrew Clarke's argument, which is only an expression of certain doubts which at an earlier stage were quite legitimate, but which ought now to be completely set at rest by the event. Nor does it seem necessary to enter upon any defence of the positions I took in the earlier stages of the undertaking with regard to some questions then debateable. An imputation of recklessness in drawing conclusions will be hardly entertained against me by the authorities of the India Office, and I have therefore passed over some points of which the discussion could only take the form of a defence against such a charge. I am confident that my case will not be permitted to be damaged by my reticence in these two respects.

I now proceed to the other questions raised by Sir Andrew Clarke.

The question of Entrance.

43. Sir Andrew Clarke is evidently unaware that the question of providing one or two entrances to the harbour was the subject of a full discussion in 1874, to which the few sentences in my report of 1873 were merely preliminary.

44. The then Chief Engineer of the Madras Presidency, Colonel (now Major-General) Walker, R.E., had suggested two entrances, and, although I thought it right to place my reasons for a contrary opinion on record, there was an understanding that I was to consult with nautical authorities on the subject, and report the result to the Government of Madras. At the same time the Government of Madras requested the Secretary of State to obtain the opinion of the Elder Brethren of the Trinity House on the point.

45. I applied to the Directors of the Peninsular and Oriental and the British India Companies, for the opinions of some of their commanders, and I also applied to Mr. J. J. Franklin, R.N., late Secretary of the Marine Board, Madras, who had been introduced to me by the late Sir Henry Montgomery as the best nautical authority connected with the port. The results of those applications were rendered in some measure abortive, from the fact of some of the authorities consulted having mistaken the nature of the question, and furnished their opinions on the comparative merits of a detached breakwater, a scheme for which had been lately under discussion, and a close harbour.

46. The following is a *resumé* of the replies obtained:—

The Elder Brethren of the Trinity House expressed a preference for a breakwater parallel with the shore, 9,000 feet long, and did not enter into the question of one or two entrances.

Mr. Franklin gave a decided preference to the single entrance.

Captain Atkinson, Superintendent of the British India Steam Navigation Company at Calcutta, also decidedly preferred the single entrance.

Captain Gaby, Peninsular and Oriental Company, considered the harbour as shown would in great measure satisfy the requirements, and preferred it to a breakwater, but did not suggest the two entrances as an improvement.

Captain Donaldson, Peninsular and Oriental Company, thought "Mr. Parkes' plan, with one entrance, a good one."

Captain Barlow, Peninsular and Oriental Company, was strongly in favour of a harbour rather than a breakwater, approved generally of my plan, and "did not think anything of the difficulties of ingress and "egress."

Captain Stewart, Peninsular and Oriental Company, thought the enclosed harbour with single entrance superior to a breakwater, and saw no difficulties for ships to enter or depart. He suggested an extension of the northern jetty to cover the entrance.

Captain Black (the late), Superintendent, Peninsular and Oriental Company, Southampton, was decidedly in favour of a detached breakwater, but admitted the value of a harbour for landing and shipping cargoes. He did not discuss the question of one or two entrances.

Captain Henry (the late), Superintendent, Peninsular and Oriental Company, Bombay, recommended a greater area of harbour, and two entrances, but added, "If these two alterations would not interfere with "the project financially, I am of opinion that they would be improve-"ments, but should they so increase the cost of construction as to neces-"sitate an extra charge on the shipping or trade using the port, then I "am of opinion that it would be preferable to make the harbour as you "propose." (I may mention that the extra cost of the two entrances, so arranged as to give the same internal capacity and calming effect as the plan with one entrance, would be about 80,000*l.*)

47. Besides these opinions in writing, which were forwarded to the Government of Madras, I had many opportunities of obtaining valuable opinions in conversation with practical nautical men. I came to the conclusion that, while some difference of opinion did exist, the preferences on the one side or the other were not strong, and certainly not strong enough on the side of two entrances to warrant the extra cost, and interference with plans for possible future extensions.

48. I know of nothing which has occurred in the last five years to alter the conditions of the question, except the continued rapid substitution of steamers for sailing vessels in the trade, which has weakened the case in favour of the two entrances.

49. The modification of the single entrance lately proposed, unanimously approved by the nautical authorities consulted, and since sanctioned by the Government of Madras, removes some of the objections to the entrance as originally designed.

50. I may add that the rubble base for the north pier has already been deposited, and the superstructure commenced across the suggested site for the northern entrance, and that for the south pier has reached the site of the southern entrance. I hope no idea of altering the present plan will be entertained, but, if it should be, I believe the cheapest and quickest mode of making the alteration would be to finish the piers in the lines at present laid out, and then remove those portions of them where it is desired to form entrances.

Question of Mooring.

51. Sir Andrew Clarke's criticisms on my proposals for moorings are based on grounds which are entirely obsolete. The plan of mooring appended to my Report of 1873 was put forward to meet a question raised at the time, but was never intended as a practical suggestion. I was in this difficulty at Madras. There was virtually no nautical authority with whom I could co-operate to devise a system of moorings, the then Master Attendant being a strong opponent of the whole scheme of a harbour. It was, therefore, necessary to submit such a plan as the future responsible nautical authority could amend in one of the two directions which are described in my report, but as to which of the two were preferable I knew there was a difference of opinion among seamen. I had seen reason for congratulating myself on having left this question open, for before I left India I had opportunities of consulting with the two highest nautical authorities in the country, and one preferred one alternative and the other preferred the other, each holding his opinion in a rather decided manner.

52. The question, therefore, remained in abeyance till nine months ago, when, in co-operation with the present Master Attendant, Captain

Taylor, I submitted a system of moorings combining in great measure the advantages of both plans. This proposal has been approved with great unanimity, and would, I have reason to believe, have received the formal sanction of the Government of Madras before this but for the obstruction caused by the appearance of Sir Andrew Clarke's report. It is not liable to the objections urged by practical seamen against the proposal (certainly never made under any circumstances by me) of mooring ships head and stern in a cyclone. It leaves ships perfectly at liberty at such times either to put to sea or to swing freely head to wind to all points of the compass within the harbour, at the option of the commander and of the marine authorities. I would again emphatically assert, what I have always maintained, that there ought to be nothing in the system of moorings, or in the port regulations, which could interfere with the full freedom of every commander to put to sea on the threatening of a cyclone. Whether time and experience may not induce a greater confidence in the security of the screw moorings is quite another question, and one to which the question of the advantages of the harbour for commercial purposes has but little relation.

The provision of Wharfs and Quays.

53. The absence of this from my scheme is made a prominent ground of complaint by Sir Andrew Clarke, but five years' experience of the requirements of the trade of Madras has not led me to give greater urgency to this demand. About 45,000*l.* per annum is spent upon the landing and shipping of goods. Of this, two thirds will be saved by the simple provision of a still water shore line, and the greater part of this saving will be absorbed by the interest on the outlay for providing this. What remains will not leave much to meet the cost of deep water walls or jetties, hydraulic cranes, and other expensive appliances of a first-class port. The call for such things may come in time, but it will be some years hence, and under conditions very different from the present. What is at present wanted is quick and certain despatch, and that will be best secured by the use of large cargo boats, which can come along each side of the ship if necessary, plying to cheap shallow water jetties run out from the shore. The cost of these will be small, and self-remunerative. It is still a question whether they should be provided at the charge of Government or by private enterprise.

54. There will no doubt be an early demand for one or two deep water quay berths, with powerful cranes, for landing and shipping articles of exceptional size and weight, but special cranage fees will meet the cost of these, and the means of providing them has always been under consideration.

55. On the whole I have failed to discover that Sir Andrew Clarke has suggested any want that has not already received such consideration as its urgency seemed to demand, though I must admit that my ideas of the mode of meeting them are generally conceived on a more moderate scale than his.

The Sanitary Question.

56. This received full consideration at a very early stage of my preliminary investigation. It divides itself into two heads,—1st, the interception of all house and surface drainage from the harbour; 2nd, the prevention of pollution by the shipping within the harbour.

57. It had been my original intention to include a proposal for the first in my design, but as I was informed that my object would be effected by a plan of general town drainage then almost decided upon, I

felt relieved of the necessit . This plan, however, fell through, and the interception of all drainag from the harbour was then at once admitted as a necessity, and a fair large against the undertaking. Works for carrying out the object are ow in progress.

58. With regard to the evention of pollution by the shipping, that also is an object to be ke in view, but a necessary preliminary to devising measures for carrg it out is to obtain data on which to judge of the amount of "puisanc to be dealt with. There are many worse cases than that of Madras likely to be in which the evil is admitted, but the remedy neglected At present I am not aware of any place that can be taken as an example of meeting the evil satisfactorily, and it may be that it will be necesary to create a precedent at Madras. But the problem is not a difficu one to solve, and its immediate solution is not urgent. I may say, hever, that the ideas which have been put forward of inducing a curnt of water through the harbour appear to me to be chimerical. Tl only natural mechanical purifying power available is the tide, whichvill change about one tenth of the enclosed water twice a day. Whatever this fails to effect must be provided for by stringent port regulations.

59. Before concluding tis communication I wish to correct some errors as to matters of fact ito which Sir Andrew Clarke has fallen.

60. In the note at the fot of the photograph, No. 2, taken 5th April 1879, it is said :—"Advanc of foreshore and consequent loss of accom-"modation within harbours here evident." The advance here alluded to is that immediately to th northward of the south pier, which, as explained in para. 36 *ante*, i balanced by a retreat to an equal extent immediately to the southward of the north pier. This is also shown in Sir Andrew Clarke's own pn (Plate III.), which gives the comparative shore lines in September 878 and January 1879. There has, as a matter of fact, been no advnce of the shore line within the harbour since June 1877.

61. In para. 25 Sir Andew Clarke says, "the acreage has already "been so far encroached upn that, in the opinion of some seamen, it is "already a question whethe some of the long steamers of the Ducal "Line could, without runing ashore, enter the harbour of reduced "acreage." There is no such reduction of acreage as Sir Andrew Clarke assumes, except in the extreme S.E. corner, which was affected by the accumulation of 1878, a par in which no ship ever yet anchored. The effect of this accumulation n the system of moorings now before the Government will be that, out of 18 berths provided for large ships, the depth will be reduced in ne from 4 to 2½ fathoms, and in another from 4 to 3 fathoms, thus making them available only for light ships. With regard to the danger of ships running ashore the four-fathom line is 2,400 feet, or more than six ships' lengths from the entrance. Three ships' lengths is generally considered sufficient to bring up in, on entering a harbour. In arranging th moorings rather more than 1,600 feet, or more than four lengths of he longest ships, is allowed to the nearest buoys.

I have, &c.,
(Signed) W. Parkes.

The Under Secretary of State
for India.

No 767 P. W. Department.

PROCEEDINGS of the MADRAS GOVERNMENT.

Under date the 23rd March 80

READ the following

From,
The Government of India } (M.C. No 113 dt 12th March 80)

Communicated to the Superintendent, Madras Harbour Works for report whether such observations as those desired by the Government of India can best be taken.

Supdt. M. H. Works 3
Secy. M. H. Committee 3
Marine Supdt 4

Recd 30 17-4-80

Acted.

13.3.80

Ca 1907

Govt. of India.

PUBLIC WORKS.

84-3-80

Dated

Rec'd.

Encl.

G. O. 23 June 1880, No. 767 C.

Nos. 1064 to 1065

Madras Harbour Works

Letter from the Engr. regarding
that careful observations
be taken for determining
Mr Parkes' assumptions
relative to the ——, and
to the Engr. Madras Harbour
Works for report as to when
& how such observations can
best be taken.

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