

The Clarence River.

Report by Sir John Coode.

On the 12th October last year, Sir John Coode sent the following letter to the Minister for Works :—

Sir.—I have now the honor to submit my report on the Clarence River, which river I inspected in October, 1885. By the kind intervention and assistance of the Mayor of Grafton, Mr. See, I had the opportunity afforded me, either in Grafton or Sydney, of interviews with Captains Curphey, Croer and Fraser, all having long experience in the navigation of the entrance as masters of steamers; Messrs. James Freeburn and Henry Macanley, pilots; and Mr. Pegasus, late Collector of Customs at Yamba. From each of these gentlemen I received valuable information on points affecting the object of my investigations. Further facts and data, which I considered requisite, have since been supplied in accordance with a memorandum which I left with Mr. Moriarty. I have thus been enabled to study the question of the Clarence and its entrance with every advantage, and to design and lay down such works as I consider will be best adapted to remedy the existing evils.

DRAWINGS.

Accompanying this report are two illustrative drawings.

Drawing No. 1 is a general plan of the Clarence River, on a scale of 2 inches to 1 mile, extending from Tindall's Falls to the sea. It has been compiled from the following documents :—

- 1.—Tindall's Falls to Moleville Point—from the published lithographed parish maps of Turville and Eaton.
- 2.—Moleville Point to Estuary—from survey made by Navigating Lieutenant J. Gowlland, R.N., in 1870.
- 3.—Estuary and Entrance—from survey made in 1882 by Staff-commander Howard, R.N., assisted by Lieutenant P. Francis, R.N., with corrections and additions from survey made specially by Staff-commander Howard in 1886 for the purposes of this report.

Drawing No. 2 is a plan of the entrance and estuary, extending from the South Head to Freeburn Island, on a scale of 1 in. to 400 ft.; it has been compiled from the surveys of 1882 and 1886.

On both these drawings the several works which I recommend for adoption are shown in red colour.

With the limited information at my disposal as regards the commercial aspect of the question, it would be out of place for me to enlarge on the value of the present and future trade of the Clarence district. The present importance of this trade is undoubted, and renders it expedient that all reasonable means should be taken to give it the full accommodation it may require.

WINDS.

Among the points on which it became necessary to make careful inquiry, the direction and strength of the prevailing winds, and of the seas caused thereby, were perhaps the most important.

The following results are given by an examination of the records made by the Pilots at the Clar-

The following results are given by an examination of the records made by the Pilots at the Clarence Heads, and abstracted from their log-book for my use and information by Captain Howard.

Between March, 1887, and August, 1886, 5965 observations were made and recorded. It may be stated briefly that although in the totals on-shore winds from the southern quadrant exceed slightly those from the northern quadrant, yet with regard to the winds of higher velocity taken alone the proportion is equal; and further, that on-shore gales from the Southward exceed those from the Northward in the proportion of 6 to 1.

DIRECTION OF WAVES.

The conclusion thus arrived at as regards the prevailing direction of strong winds and gales is fully corroborated by the evidence given to me by the masters and pilots, who also agreed on the still more important fact that whether the wind blows from the S.E., E., or N.E., the break near the shore runs directly in from E. to W. I was also informed that south-west winds, although they are off-shore, bring in a heavy sea, the breakers caused thereby wheeling around and running in to the westward.

The run of the waves, which primarily cause the formation of the Bar being thus practically east and west, this direction must be the best for the entrance channel, for the more directly the tidal and upland waters running out of the river are brought to bear upon the Bar itself the more effective will be their power to overcome it, and to prevent any accumulation. In connection with this subject, I may mention that I was informed at Yamba that the direction of the line of deep water over the Bar after the great flood of July, 1876, was east and west; the soundings taken after the flood of January in the present year show the same result. It is right for me to state that the axis of the entrance proposed by Mr. Moriarty is on an east and west line, i.e., on the same compass bearing as that which I have just indicated as the best in this particular case.

VELOCITY OF RIVER CURRENTS.

It will hereafter be necessary to describe the Clarence River somewhat in detail. For the present it will be sufficient to state that it has a total length of about 250 miles, and a watershed of about 8700 square miles. The tidal rise at Yamba is 5 ft. at ordinary springs. The velocity of the ebb tide in the entrance, under ordinary conditions, is given on the Admiralty Chart as from 3 to 5 knots per hour, and after heavy rains at from 5 to 8 knots. The greatest velocity recorded during Captain Howard's observations in May, 1886, was 2.44 knots per hour, but on this occasion the tidal range was only 3½ feet, with a range of 5 ft. it would necessarily have been greater; and Mr. Moriarty, in his evidence given before the Legislative Assembly in 1862, refers to measurement giving 5 knots. In times of flood the velocity must considerably exceed this; and I may mention that Captain Creef informed me that about twenty years ago he was obliged to lie off the Bar for three days the "fresh" from the river being too strong to admit of his steamer, having an ordinary speed of about 11 knots, getting in against the current.

This experience can be more readily appreciated

This experience can be more readily appreciated by bearing in mind that the flood of 1876 raised the water level of the river at Yamba three feet above the level of high water of ordinary spring tides.

With such a great variation in the discharge of the river during ordinary and special conditions, it is impracticable to construct works at the mouth which, whilst ensuring a permanent channel of adequate depth when the river is in a normal state, will also allow of the escape of flood water after exceptionally heavy rains without the production in the entrance of currents of high velocity, and the creation there of disturbance to such an extent as will sometimes prove inconvenient.

After taking into account all the circumstances of the case, I am of opinion that the proper width for the entrance, or the distance between the sheltering and guiding moles will be 1400 feet. A greater width than this will not concentrate the ordinary discharge sufficiently to produce the desired effect on the Bar under normal conditions, whilst a narrower entrance would increase the velocity of floods during periods of flood to a prejudicial extent.

The works which, for the reasons given above, I have to recommend for adoption for regulating the currents at the entrance, and improving the navigable depth over the Bar, are shown more particularly on drawing No. 2. They consist of two moles or piers, which would act both as breakwaters and training works.

SOUTH BREAKWATER.

That on the south side would be a continuation of the breakwater commenced by Mr. Moriarty, the direction of the present end of which is about N.N.E. The new work would start on a curve, and would so continue until it pointed due east; in this direction it would be extended until it terminated in a depth of about 24 feet at low water, its total length being 2350 feet.

NORTH BREAKWATER.

The North breakwater would commence at a point on the sea front near Iluka, about 1200 feet S.S.W. from the present outer beacon. It would be formed on a curve of 4800 feet radius until it became tangential to a line parallel to the outer length of the southern work. Beyond the tangent point it would be formed on an east and west line, and would terminate abreast of the end of the South breakwater; the total length of this northern work being about 3650 feet.

BREAKWATER CONSTRUCTION.

As regards the construction of the Breakwaters, I consider it essential, in view of the depth in which the greater part of the works will be founded, and of their great exposure, that they should take the form of rubble mounds, deposited as *pierres perdues*, the material being conveyed over and tipped from a temporary stage, to be formed practically throughout the entire length of each work. The strong ebb currents which will sweep across the temporary end of the Northern Breakwater during construction render this course especially necessary. By keeping the stages well in advance of the end of the Breakwater mounds the surface of the sand can be coated with rubble seaward of the works proper, thereby obviating, as

seaward of the works proper, thereby obviating, as far as practicable, the scouring of the bottom which would otherwise occur. Moreover, the facilities for depositing the material which would be

derived from the adoption of a stage for each mole, taken in conjunction with the preservation of the reefs during progress, and the necessity for maintenance and upkeep for some little time after completion, and until the normal slopes have been formed by the action of the sea, are all good and sufficient reasons why staging should be provided.

The rubble for the North Breakwater would be procured from the quarries at the North and Middle Heads, and that for the South Breakwater from the quarry at the South Head.

REMOVAL OF REEF.

The most unfavourable feature of the Clarence mouth is the existence of the Rocky reef—most probably the flank of Pilot's Hill—extending to the northward, right across the entrance. It is practically divided into two parts by a narrow depression or "gutway," situated between the black and red buoys, shown on the plan. The southern or larger part is known as the "Black buoy reef."

The track used by all vessels entering or leaving the river is between the buoys referred to, the greatest depth over the rock being from 3 to 3½ fathoms. Besides being dangerous to navigation, the reefs have the further disadvantage of impeding the free flow of the tidal and river currents, thus causing the waters to "back up" in a serious degree. By their removal to the extent indicated by red cross lines much benefit will be felt and it is probable, in consequence of this removal, and notwithstanding the curtailment in width of entrance, that the velocity during floods will not be greater than at present—possibly it may be less.

The necessary operations for the blasting of these rocks should be commenced as soon as sufficient shelter is afforded by the South Breakwater to enable the work to be carried on without interruption, except on the occurrence of gales or floods.

SOUTH TRAINING BANK.

As will be seen, it is recommended that the main channel for the navigation of the river should be diverted from its present course, which runs along the southern shore, and should be confined nearly to the centre of the estuary. To accomplish this a low training bank of rubble stone should be formed, starting from about the centre of the eastern side of Freeburn Island, curving gradually southward and eastward, crossing the site of the existing channel, and terminating about 450 feet to the westward of the black buoy, now marking the southern slope of the deeper part of the Rocky reef above referred to. For the last 1200 feet of its length the bank would be fair, with an east and west line drawn through the end of the South Breakwater.

NORTH TRAINING BANK.

NORTH TRAINING BANK.

On the northern side a training bank, also of rubble stone, should be constructed as shown. It would start from the elbow in the present protecting bank, about 1200 feet south of the Engineer's office at Iluka, and would curve round south and east until fair with the line of the Northern Breakwater. Being a protection as well as a training work, it would require to be brought up considerably above high-water level. The space between its outer end and the North Breakwater would form a "wave trap," by which the range of seas due to easterly winds would be considerably reduced.

It is on record that in 1845 the end of the sand spit on the south of Iluka was nearly a mile and a quarter to the north of the Yamba shore, while in 1860 it had approached to within 800 feet of the same point. Since 1860 it has receded with various fluctuations. Mr. Moriarty has proposed to fix this spit by the construction of a training bank, as shown by green dotted line on drawing No. 2. I consider, however, that the advantages to be gained by leading the channel into the centre of the estuary—and so giving to both the ingoing and outgoing currents a direct course on to the Bar—are so great, that I am compelled to recommend that the bank at the southern end of the spit should be constructed as above described, and as shown on the drawings.

TRAINING BANK AT GOODWOOD ISLAND.

From Goodwood Island (see drawing No. 1) another training bank is shown, running generally in a S.E. direction; it would be a low work, and would serve the double purpose of causing the main stream to flow over towards the western bank, and of diverting the water from the North Arm along the eastern shore, thus assisting to maintain a fair depth in the channel in front of Iluka wharf.

PROTECTION OF ILUKA SHORE.

Near the junction of the North Arm with the main channel the river bank on the Iluka side is falling away. This, as well as the foreshore in front of the township, should be protected, as they are subject to considerable scour, especially in times of flood. A protection bank is therefore shown along this foreshore, commencing a short distance up the North Arm, and terminating at the existing bank to the south of the Engineer's office.

Between the new main channel, which will be formed upon the proposed south training bank, and the channel along the Iluka shore it is nearly certain that a shoal will be formed. This will no doubt be considerably reduced in times of flood, but in the normal state of the river it will be of service in training and confining the currents, so that full advantage would be derived from the available scour.

YAMBA CHANNEL.

As regards that part of the present main channel which runs in front of the Yamba training bank, I consider that there will be a loss of depth there, but as this channel will receive the water from the main river, which will flow between Palmer and Freeburn Islands, and also the tidal and drainage water from Wooloweyah Estuary, it is not probable that the loss will be sufficient to be detrimental to the trade carried on at the Yamba wharf.

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With the enormous scouring power available, it is not probable that any large amount of dredging will be required to form the new channels; and if, as appears probable, no material more difficult to move than sand or silt exists above the depth required it is quite possible that dredging may be entirely dispensed with.

ESTIMATE.

I estimate the cost of the works as hereinbefore described as follows:—

FOR ENTRANCE PROPER:

South Breakwater, including substantial head and light, complete	£171,400
North Breakwater	197,500
Removing North reef to a depth of 18 ft. below low water of ordinary spring tides	28,500

Total for works at entrance

WORKS BELOW FREEBURN AND GOODWOOD ISLANDS:

South training bank, 12,200 feet.....	£77,700
North training bank, 3200 feet ..	16,900
Protecting face Iluka shore, 7000 feet ..	39,500
Training bank Goodwood Island, 6800 ft.	49,300

£183,400

or a total for the whole of £580,900.

These works, if completely carried out, would, I am confident, result in the formation and maintenance of a minimum depth in the entrance of at least 18 feet at low-water; with this depth vessels could always enter and leave with safety, regardless of the state of the sea. The only times on which they might be delayed would be on the occurrence before adverted to, of exceptionally severe freshes.

In view of the very large expenditure thus involved, and in case the total amount required for the complete scheme is greater than can be appropriated for the Clarence works during the next few years, I consider it advisable to show how the river may be benefited by a portion only of the works being executed in the first instance, leaving the remainder to be added as circumstances of trade may demand, and financial considerations may admit.

As regards the most important works, viz., those at the entrance, the Breakwaters might at first be stopped at the points marked XX and YY (in red) on drawing No. 2, that is to say, 600 feet (in each case) short of their ultimate length. These reduced lengths of sheltering and guiding works, together with the deepening of the northern reef, as before named, would result in fixing the entrance and greatly improving the depth therein, so that if funds are not immediately forthcoming for the execution of the Breakwaters of the full lengths proposed, it would certainly be desirable to proceed with them on the understanding that, in the first instance, they are to be restricted to the lengths XX and YY.

The following is the relative order in point of importance which I assign to the several works in regard to their effect on the improvement of the entrance and navigation:—

1. South Breakwater, carried to a point 600 feet

entrance and navigation :—

1. South Breakwater, carried to a point 600 feet short of its ultimate length.
North do do do do.
Removal of northern reef to 18 feet below low-water.
2. Construction of low south training bank.
3. Protection of southern end of Iluka spit by construction of northern training bank.
4. Completion of North and South Breakwaters to full length.
5. Protection of Iluka foreshore.
6. Construction of low training bank at Goodwood Island.

ALTERNATIVE ESTIMATE.

The expenditure to be incurred in the first instance, if the breakwaters are stopped at XX and YY, as above indicated, would be—

South breakwater, length 1750 feet	£124,500
North do. length 3050 feet	146,000
Removal of Northern reef to 18 feet below low-water, as before	28,500

Total £299,000

On completion of these instalments of the works, and after experience of the effects thereby produced, the training banks and breakwater extensions could be carried out in sections, as would then appear to be most advisable; under any circumstances the first point to be arrived at is to fix and train the currents at the entrance in the manner proposed, allowing the internal works within the estuary to follow thereafter.

[The latter part of the report, which points out steps to be taken to improve the navigation in the tidal compartment, will be published on Saturday next.—ED.]

The Clarence River.

Report by Sir John Coode.

(CONTINUED FROM TUESDAY'S ISSUE.)

TIDAL COMPARTMENT.

HAVING thus formulated my recommendations, as far as regards the entrance, I will now, as briefly as possible, point out the steps which should be taken for the improvement of the navigation in the tidal compartment of the Clarence.

In addition to my own observations, and the information given to me on my visit to Grafton as to the general condition of the river, I have been greatly assisted by the survey made by Lieutenant Gowland in 1870, and by the detailed and highly practical description of the river written for the purpose of this investigation by Captain Howard.

COPMANHURST TO GRAFTON.

Copmanhurst is the highest point to which navigation on the Clarence can be carried without exceptional works. The rise of tide at this place is said to be 15 inches. At present the craft trading to the township do not draw more than 4 feet. Between Copmanhurst and Grafton, a distance of about 25 miles, a minimum depth of 8 to 9 feet at low-water might be obtained by comparatively slight works at the following points:—

1. "Hell's Gate," 1½ miles below Copmanhurst; present width of river channel, 100 feet; present minimum depth, 7 feet.
2. "Red Rock Crossing," 2¼ miles below Copmanhurst, a narrow artificial cutting; present minimum depth, 6 feet.
3. Shoal near junction with Orara River, 4 miles below Copmanhurst, navigable channel very narrow; present minimum depth, 6½ feet.
4. "First Falls," 5½ miles below Copmanhurst, artificial cutting through shingle; present minimum depth, 6 feet.
5. "Morgan's Flat," 8 miles below Copmanhurst, artificial cutting through shingle; present minimum depth, about 6 feet. This point can be reached at high water by vessels drawing less than 8 feet, but cannot be passed by craft drawing 6 feet.
6. "McGillveray Reach," 19 to 21 miles below Copmanhurst, several small shoal patches with minimum depth of nearly 8 feet.
7. Shoal between "Carr's Flat" and "Susan Island," artificial cutting, minimum depth, 7 feet.

The united length of the portions of these shoals having a depth less than 8 feet at low-water is about 2 miles. The depth of material to be dredged is at no point more than 3 feet, and its removal would not involve any great expenditure.

BISHOP PASSAGE.

Immediately below Grafton the river is divided into two branches by Elizabeth Island. The navigable channel known as Bishop Passage is on the north side of the Island, and has a general depth of 20 or 30 feet. A spit extending from the left bank near Bishopthorpe causes a shoal at one place where there is not more than 14 feet in the fairway. An enlarged plan, No. 1, showing this spit, is given on the left side of drawing No. 1. It will

is given on the left side of drawing No. 1. It will be seen on reference thereto that I recommend that the area crossed by red lines should be dredged, so as to give a depth of at least 12 feet at low-water in the main channel. At present the depth over the spit is in some places as little as 6 feet.

THE ELBOW.

Opposite Lawrence the river turns sharply to the eastward at the Elbow, where considerable deepening has also been carried on since 1870. An enlarged plan, No. 2, of The Elbow, The Elbow Bank, and the township of Lawrence, &c., is given on drawing No. 1, and shows the line of a channel 200 feet wide at bottom, with a depth of at least 12 feet at low-water, which I consider is the minimum depth which should be provided. From an inspection of the soundings taken in this locality by Captain Howard when making his examination of the river, it appears that a considerable portion of the deepening already carried out will be within the lines of the channel now recommended.

HUMBUG REACH.

From the mouth of the Broadwater and the end of Creer Reach the river turns sharply to the south-east; it runs practically in this direction for about 1½ miles, and then turns quickly again until its course is nearly due north. Near the most southern point of this reach the South Arm makes its lower junction with the main stream. On the hillside immediately below the junction lies the township of Maclean or Rockymouth. This length of river is known as Humbug Reach. The depth of water in fairway is from 50 to 60 feet, and the bottom is generally rocky. Immediately above the junction of the two channels some rocky shoals extend into the stream for quite 800 feet from the right bank. Captain Howard informs me that the Government are now removing some of these rocks and deepening the channel into the South Arm. Having no information as to the extent or exact locality of the removal which is being effected, I have considered it desirable to show on an enlarged plan, No. 3, drawing No. 1, my recommendation that the entire reef should be removed, as far as it affects the main channel, and where less than 12 feet is found over it at low-water. Should it be considered inexpedient to carry out the whole of the work immediately, the deepening should be commenced by opening a channel through the rock near the right bank. The eastern side of such a channel is shown by a full red line on the enlarged plan; its bottom width should be 100 feet, and its depth, 12 feet, at low-water, both as a minimum.

The small improvements in the river channel, which I have herein suggested, have been put forward solely for the improvement of the river navigation, and are based on the idea of providing at once a reasonably easy channel, with a depth of at least 12 feet to Grafton and of 8 feet to Copmanhurst at low-water of spring tides. The information available here is not sufficient to enable me to arrive at an estimate of the cost of these minor improvements.

At my request, tide gauges were fixed at six points on the river, between the Saltwater Creek and Yamba. Simultaneous observations taken at these gauges on the occasion of a spring tide show

These gauges on the occasion of a spring tide show the following tidal range at the several points:—

	Distance from Yamba. Miles.	Range. ft. in.
At Yamba.....	—	4 10
„ Freeburn Island.....	2½	2 7
„ Palmer Island.....	6½	1 11½
„ Harwood Mill.....	12	1 6
„ Rocky Mouth.....	15	1 4
„ Saltwater Creek.....	20	1 6

FLOOD RELIEF.

The question of Flood relief is so important, and in a large degree so inseparable from that of navigation, that I consider it my duty to make a few remarks thereon, although the point was not submitted for my opinion.

With the information at my disposal, it is not possible for me to determine what measures would have to be taken for the prevention of the evils which are now experienced after exceptional rain-falls. The very serious damage which is caused in the Clarence district by such floods as those of 1876 and of January last, would no doubt warrant a considerable expenditure on remedial works. The questions involved are large and important, and would require a special and exhaustive examination of the locality, as well as surveys and other observations of a costly nature, before it could be determined whether an amount of relief could be given that would be commensurate with the cost to be incurred—and if so, by what measures such relief could be provided.

Grafton appears to suffer severely at times of exceptional floods; the river bank in front is from 20 to 25 feet above high-water, and up to 1886 the highest known flood had only been level with its top; the land, however, falls to the northward, and water is admitted at the back by a small creek and at a low place at Bishopthorpe which makes an island of a great portion of the township. In July, 1876, nearly all the streets of the town were submerged for about twenty-four hours, although the water did not come over the bank in the centre or to the westward.

The data as to the flood levels at Grafton are as follows:—1857, 19½ feet above high-water; 1861, nearly as high as in 1857; 1863, February 16, as in 1857; 1876, July 17, 21 feet above high-water; 1879, June 20, 20 feet above high-water.

The flood of the 22nd-23d January in the present year is variously stated to have been from 13 inches to 3 feet higher at Grafton than in 1876.

The damage done appears to have been very serious at Copmanhurst, as also at Lawrence, and at Woodford Island.

The improvements which may be effected in the channel by giving greater freedom to the discharge of flood waters, will of course tend to mitigate the existing evils, whilst the proposed works at the entrance, by providing a fixed and uniform channel, cannot fail to be of material service in this respect.

I would suggest that steps be taken to protect such portions of the banks as are now being washed away, as a large proportion of the soft material thus removed is certain to become prejudicial to the regime of the river. I also consider it highly desirable, where dredging operations are being carried on, that the material raised should not be

desirable, where dredging operations are being carried on, that the material raised should not be dropped in any part of the river having a less depth than 5 fathoms at low water.

In conclusion, I would like to remark that it would have been much more satisfactory to me had it been possible to recommend for adoption at the Clarence River entrance work of less extent, and consequently of less cost, than those hereinbefore described, and shown upon the accompanying drawings, but it has not been practicable to do so, having regard to the object to be accomplished.

JOHN COODE,