REPORTS

THE ENGINEER-IN-CHIEF.

I.—VISIT TO THE PROVINCES OF CANTERBURY AND OTAGO.

II.—TAIERI RIVER.

III.—TIMARU HARBOUR WORKS.

IV.—OAMARU HARBOUR WORKS.

PRESENTED TO BOTH HOUSES OF THE GENERAL ASSEMBLY, BY COMMAND OF HIS EXCELLENCY.

WELLINGTON.

1871.

REPORTS OF THE ENGINEER-IN-CHIEF.

I.—VISIT TO THE PROVINCES OF CANTERBURY AND OTAGO.

No. 1.

Mr. J. Carruthers to the Hon. W. Gisborne.

Sir,— Public Works Office, Wellington, 2nd November, 1871.

I have the honor to submit the following general report on my visit to Otago and Canterbury.

On the 31st of August I left Wellington for the Bluff, where I arrived on the 5th of September. Mr. Blair, District Engineer, joined me at Dunedin, and accompanied me throughout the Province of Otago.

The objects of my visit were to make myself acquainted with the country, to ascertain what prices obtained, and to examine the general direction of the lines which have been laid out.

I have little to remark on the lines from Winton to Kingston, and from Invercargill to Dunedin; beyond that the best general direction has been selected for them. As to details, it would have been impossible for me to have examined them, even if I had had time, as the engineers who laid out the line have been, in every case, so sparing of marks on the ground that it will be necessary to resurvey the lines before they can be used even as base lines.

Clutha River.

I fully agree with Mr. Brunton (see his Report on line from Mataura to Clutha) that steps should be taken to guard against the Clutha River cutting away the isthmus on which Balclutha is situated. It will probably cost very little to prevent this happening; but it will have to be attended to before the bridge over the Clutha is begun.

Chain Hills Tunnel.

At both ends of the tunnel through the Chain Hills, near Dunedin, careful surveys are required in order to place the line in the best position. These can be done by the staff at present engaged, and will cost only the chainbearers' wages. They should be undertaken at once.

I had no time to examine the branch line to Tuapeka.

Dunedin to Moeraki.

From Dunedin to Moeraki no line has yet been proposed; but as it is more than likely that it will be eventually built, I took the occasion of my stay at Moeraki to make a reconnoissance of part of the country. There will be no difficulty in making a line from Moeraki to Waikouaiti. I have requested Mr. Blair to make a reconnoissance from Waikouaiti to Dunedin, when he could do so without detriment to his other work, and without incurring expense.

Moeraki Jetty.

At Moeraki I examined the proposed site for the jetty. I cannot at all agree with Mr. Miller in his remarks as to the direction of the present jetty (*vide* his report on line from Moeraki to Waitaki). It appears to me to have been very well chosen; and I consider the proposed jetty to be placed as nearly in the same direction as can be done, with due regard to reaching deep water with a short length of jetty and of connecting with the railway.

Moeraki Branch.

A branch line has been laid out to connect the Port of Moeraki with the main line. This will be a work of great expense. The soil is very liable to slip, and there will be difficulty in keeping up the slopes of open cuttings, which latter are moreover very heavy. There is also a tunnel of 220 yards in length, through what Mr. Miller describes as "one moving mass of saponaceous clay." This is estimated at £10 per lineal yard, but I have no doubt it would cost not less than £35 or £40. The Caversham Tunnel, requiring no lining, and through a remarkably easy material, is costing £10 a yard, and it cannot be expected that a lined tunnel through swelling clay could be built for the same. The lining alone would cost more than twice Mr. Miller's estimate for the whole. Instead of incurring this great expense I would recommend the use of gradients of 1 in 25, with curves of about 10 chains, which would avoid the tunnel and heavy cuttings, and would be quite sufficient for the trade of Moeraki. A 10-ton engine would be able to take twenty tons net at each trip, and would make the single trip in quarter of an hour or twenty minutes.

Moeraki to Waitaki.

Although for the present the terminus of the line is at Moeraki, it must be taken into consideration that at some future time it will be extended to Dunedin. It therefore becomes desirable to keep the gradients as flat as possible, as hereafter the traffic between Christchurch and Dunedin will pass over them.

Between Christchurch and Oamaru there is no steep gradient; between Oamaru and Moeraki there is one gradient close to Oamaru of 1 in 50, and another near Herbert of the same, which cannot be avoided without great expense. One in fifty may therefore be taken as the ruling gradient, which it is desirable not to increase, but which may be used whenever anything is saved by doing so.

I think economy in first cost has not been sufficiently studied in the line as laid out. There are three tunnels at and near Hampden; and I think that by changing the line from the crossing of the Wainakarua River to the junction with the Moeraki branch they may be all avoided. The tunnels are estimated to cost only £7 and £10 per lineal yard; but as they will have to be lined throughout, and as heavy timbering would be required during construction, the cost may safely be put down at three times that amount. Should it appear that these tunnels can only be avoided by zig-zags, it would be better to employ even that objectionable expedient than to sink capital in making a road better than the requirements of the country call for.

From the Wainakarua to Herbert, the work will be expensive; and again, near Oamaru, the country becomes difficult. At both these points the ruling gradient of 1 in 50 occurs.

From Oamaru northward, as far as my visit extended, viz. to the Styx River, north of Christchurch, no engineering difficulties occur except the crossing of the river. These latter are all very similar in character, having a great discharge, and velocity sufficient to carry shingle to the sea.

Waitaki River.

It is proposed to cross the Waitaki River on iron girders of 33-feet span, supported on wooden piles driven into the shingle. I would earnestly recommend a change in the plan.

The river bed consists of wide shingle bottoms, dry at low water, with one or two deeper channels where the water is about twelve feet deep. By excavating the shingle by hand as far as possible, that is to the surface level of low water, the piles may be driven to a depth of fifteen feet below this, or in other words to only three feet below the bed of the river, for wooden piles cannot be depended on to drive more than fifteen feet. Of course the piles actually coming in the deep water channels could be driven fifteen feet below the bottom of the river, and would be safe, as, indeed, the whole structure would be if the deep channels never shifted. The channels are, however, notoriously unstable, and it may be regarded as certain that they will eventually leave their present position and take up another where the piles are only fifteen feet below the surface, or three below the bottom of the river. A pier, of which the piles are only three feet in the ground, would not be safe for the passage of railway trains.

It becomes, therefore, desirable to adopt some other plan of pier. Iron piles might be substituted for wooden ones, as suggested by Messrs. Blackett and Bray, maintaining the same spans as at present. They might, I think, be driven to a safe depth, and, at any rate, the expense of a trial would be very small. This would certainly be the cheapest plan of bridge which could well be adopted.

At present the Waitaki is supposed to bring down no drift timber, and short spans of thirty-three feet are therefore not very objectionable. There is no doubt, however, that hereafter timber will be planted along the banks of the river (partly with a view of confining them within their present channels) and in a perdurable bridge, constructed entirely of iron, it would be, I think, desirable to take into consideration the likelihood of accidents arising from this cause. Assuming that drift wood will hereafter come down the river, the spans ought to be about seventy feet, which would require more expensive piers. As a temporary measure, a wooden superstructure would be cheaper than iron, and more easily constructed. Full plans and estimates ought to be made of the most likely plans, and the best selected. These I will take an early opportunity of preparing.

The above remarks on the Waitaki River, apply equally to the other large Canterbury rivers.

I have &c.,
JOHN CARRUTHERS,
Engineer-in-Chief.

The Hon. the Minister for Public Works, Wellington.

No. 2.

Mr. MILLAR to Mr. CARRUTHERS.

SIR,— Wellington, 8th November, 1871.

My attention has been directed to strictures contained in a paragraph of your report just laid upon the Table of the House of Representatives, *re* the Moeraki and Waitaki Railway, upon the prices estimated by me for *semi-tunnels* at Hampden, &c., *i.e.* £7 and £10 per lineal yard.

Were this underground portion of the line *tunnel* in the strict professional acceptation of the term, I quite coincide with you, and you would, moreover, be justified in stating that they could not be constructed at the prices quoted.

When, however, I explain they are not tunnels, being but little more than mere sewers, just under the surface of the street, and opened therefrom, requiring no heavy timbering, and lined with but three rings of brickwork and occasional counterforts—the cost of bricks on the spot not being more than 25s. to 30s. per thousand, an abundant supply of brick-earth, and timber for burning, being in the locality—you will agree with me that the price named is ample, seeing that the excavation and filling in has been allowed for, in the cubical quantities under the head of earthwork—*vide* first item of my approximate estimate.

With this explanation I rest satisfied that you will kindly do me the justice of attaching a note of explanation to your report, prior to its being printed.

I have, &c.,
J. MILLAR, F.S.A.

John Carruthers, Esq., C.E., Engineer-in-Chief.

No. 3.

Mr. CARRUTHERS to Mr. MILLAR.

SIR,— Public Works Office, Wellington, 14th November, 1871.

I have the honor to acknowledge the receipt of your letter of the 8th instant, in which you offer explanations relative to your report on the Moeraki and Waitaki Railway, and in reply, to state, without expressing any opinion thereon, that your explanations will be laid before the General Assembly, as you request.

I have, &c.,
JOHN CARRUTHERS,
Engineer-in-Chief.

J. Millar, Esq., Wellington.

II.—TAIERI RIVER.

Mr. J. CARRUTHERS to the Hon. W. GISBORNE.

SIR,— Dunedin, 5th October, 1871.

I have the honor to acknowledge the receipt of your instructions contained in Mr Blackett's telegram to me of the 7th ultimo, "to examine the Taieri River in reference to the gradual but continual rise of its bed in the Taieri Plains;" also of a memorandum on this subject written by Captain T. Fraser, in which it is stated "that a great physical change has taken place, which threatens to endanger that portion of the Clutha Railway which is to cross the Taieri Swamp." I therefore visited the river with a view of ascertaining by inquiry and observation whether any such danger exists.

The Taieri is a mountain torrent from its source to the Gorge at Outram, and has throughout this distance a velocity great enough to enable it to carry shingle; from Outram to the sea it is a sluggish tidal river, with a velocity enabling it to carry only silt. About fifty miles above Outram it passes through the Taieri Lake, where its velocity being checked, it deposits all the shingle and sand it had hitherto carried, the lake acting as a silt trap, allowing only the finest silt in suspension to pass. The upper part of the river, where its degrading power is greatest, being thus cut off, it carries to the Gorge at Outram less deposits than ordinary torrents of its size.

At Outram a further check in its velocity occurs, and any shingle which may have been collected and not ground into silt in its downward course from the lake is deposited there. It is almost impossible to find by inquiry whether the bed of the river is being raised by any such deposit. The rise, if any, must be very small, but it would seem great to any casual observer, who would naturally notice where material had been deposited, but would not see where, in other places, it had been cut away. A comparison with similar torrents elsewhere is of more value. The rivers of Italy have been embanked for centuries, so that the silt they carry having been prevented from spreading over the plains, the latter have not been raised or altered, and any elevation of the beds of the rivers becomes apparent by their rising above the plains. In this manner it has been found that, in several centuries, some of the smaller torrential rivers have risen, at the points where they reach the level ground at the foot of the mountains, to the extent of several feet, the larger ones remaining quite fixed. It is very unlikely that the Taieri will rise more than this (say about two feet in a century) and the small size of the shingle at Outram makes it still less likely.

Below Outram, the character of the river entirely changes; instead of rushing with great velocity, carrying and grinding up shingle in its course, it winds through a level alluvial plain, where it assumes the ordinary character of such a river—namely, the level of its bed becomes almost absolutely fixed, while its course becomes very variable.

Any deposit of silt in its bed, would, as a mathematical necessity, cause an increase in its velocity, which would at once cut away the obstruction and restore the old level. There is no instance of such a river having its bed raised by deposit of silt. Notwithstanding the vast quantities of *detritus* brought down by alluvial rivers like the Nile, Ganges, &c., and their small velocities when near the sea, the average level of their beds has remained fixed for centuries. Although the level of such rivers is permanent, the course is very variable. The soft alluvium through which they pass offers but slight hindrance to the cutting away of the banks, so that the river never keeps absolutely to the same channel. As a rule, these changes are not very rapid; fields are cut away in one place and formed in another, but on the whole it requires a good many years to cause a great change. Sometimes however, in floods, a new channel is cut by the flood water in a very short time, and this is more likely in ploughed land than where the grass and shrubs are left growing.

There is plenty of evidence in the shape of lagoons to show that the course of the Taieri has varied very much through the plains, and there is no reason to suppose it will be more permanent for the future. In floods it spreads over the whole plain, the flood water taking a direct course to the Waipori Lake, instead of following the windings of the main river, and it is quite possible that this flood channel may eventually become the main channel of the river. This may never happen, and even if it did it would probably not affect the Clutha Railway, which would be left to the east of the new river course.

It has been supposed that the gold diggings have affected the bed of the river. I think this is true only to a slight extent. Nearly all the diggings are placed above the Taieri Lake, and any shingle or heavy material brought into the river is deposited there. Any diggings below the lake, by increasing the shingle and heavy silt brought into the river, would tend to raise the river bed as far as Outram. At present these are few in number, and the effect produced must be inappreciable; but should they increase in number and extent, their influence would be great and injurious.

The Waipori River has, I think, no effect on the Taieri; the large quantity of heavy silt which comes down it is all deposited in the Waipori Lake. As this is a very shallow lake, it will in a comparatively short time get filled up, so as to lose its value as a silt trap.

When the Taieri is in flood, much of the silt which it holds in suspension is deposited in the overflowed plains which are thus being gradually warped up (and at I think a higher rate than the bed at Outram can be rising). This effect is increased by the diggings; but if it were not for the beneficial influence of the Taieri Lake, or if extensive diggings were opened below the lake, there would be great risk of sand being spread over the plains instead of silt—of course to their destruction as farming land.

The inquiries which I made of settlers living on the banks of the river, tend to show that no perceptible rising of the bed has taken place. They all agree that although, when the river is low, fine silt is deposited, it is at once removed when the river rises. As far as I could ascertain, the fords of the river are not materially changed. It is, of course, very difficult or even impossible for any one to know, without levelled cross sections, whether any rise in the bed of a river is taking place; and even with them, unless they were very numerous, it would not be much better. The course of the river is never quite the same for two years running, and the deposit of a bank at any known spot would naturally lead to the opinion that the river was silting up, although at other points it would be deepening, but, being out of sight, would escape notice.

In conclusion, I am of opinion—1st, That the bed of the Taieri is rising at and above Outram, but slowly, and that for the rest of its course the level of the bed is quite permanent. 2nd, That although there is a possibility of the river taking a new course from Outram to the Lake Waipori, it would probably not injure the Clutha Railway by doing so, and is altogether too remote a contingency to make it desirable to incur any extra expense in laying out the railway in order to meet it.

I have, &c.,

The Hon. the Minister for Public Works, Wellington.

JOHN CARRUTHERS.
Engineer-in-Chief.

III.—TIMARU HARBOUR WORKS.

Mr. CARRUTHERS to the CHAIRMAN, Timaru and Gladstone Board of Works.

SIR,— Timaru, 29th October, 1871.

I have the honor, in accordance with instructions, to submit the following report on the Roadstead of Timaru.

In November, 1865, and in September, 1868, the late Mr. Balfour wrote two valuable reports on the same subject; these, together with his plan of the roadstead and a very elaborate survey made by Lieutenant Woolcombe, have been placed at my disposal, so that I have had considerable facilities for acquiring information. I have also examined the beach for some miles on each side of the town, and have gathered by personal inquiry of persons acquainted with the roadstead such information as could be procured. Above all, I have carefully observed the experimental breakwater constructed by Mr. Balfour.

It is agreed by every one acquainted with the subject, that the prevailing seas come from the South-east, and this is fully corroborated by the trend of the coast at points where the beach does not seem to travel.

The trend of the coast between the Waitaki and Timaru and for some miles to the North is somewhat East of North, so that the seas break on the beach, not at right angles, but obliquely, at an angle of about 50 degrees. It is to this obliquity that the motion of the shingle is due which makes Timaru so difficult a port to improve. When a wave coming from the South-east breaks on the beach, it carries the shingle forward with it in a North-west direction; the retreating wave does not, however, travel back on the same path, but runs down the slope of quickest descent, which is at right angles to the beach, or nearly East. Each piece of shingle, therefore, trails northwards in a series of zig-zags. It is evident, since the motion of the shingle is due entirely to the breaking of the waves on the shore, that any work, such as a breakwater, which would make still water on the beach, would deprive the shingle of all northward motion. It is not necessary that the breakwater should be attached to the shore: still water is as effectual a barrier as a masonry wall.

The shingle being thus stopped, it would collect on the south side of the breakwater, until in the course of time it had pushed out to the end of the latter, when the northerly motion would begin again. In the meantime the shingle to the north, beyond the protecting influence of the breakwater, would have been still moving northwards. As no new shingle could come to supply the place of that which had moved on, the coast would soon be bare, and the sea would begin to cut down the sub-beach.

These remarks apply as well to an imperfect as to a perfect breakwater. In the former the effects would be slower to show themselves, as, owing to the imperfect stoppage of the waves, a part of the shingle would continue to move along the beach, but the final effect would be the same.

The practical question to be solved is, at what rate does the shingle travel? Mr. Balfour found that some blocks of wood loaded with lead, which he threw into the beach, travelled as much as a mile in a day, even in fine weather.

This would indicate a very rapid rate of travel.

The experimental breakwater consisted of a concrete wall thirty yards long, placed on a reef below low water, and detached from the shore. It was hoped that the shingle would continue to travel along the beach, as the landward end of the breakwater was further to seaward than the line to which the shingle was drawn back by the undertow of the receding waves, and the breakwater was also so small that it was not expected to offer any perceptible protection from the beat of the waves on the shore during rough weather. It was found, however, that the protection given by this small work was sufficient to prevent the shingle from passing across the stiller water behind it. It was heaped up between the breakwater and the shore, and then behind the breakwater. To leeward the shingle was all carried on to the North, and the sub-beach cut away sufficiently to endanger the large store at the landing-place. This effect was perceptible at the foot of Caroline Bay, half a mile from the break-

water, and would have been much greater than it was if it had not been for the basaltic rock which forms the sub-beach over a part of the bay. This was all done in one storm, and no more convincing proof could be desired that the shingle travels with very great rapidity.

The breakwater was partially carried away, giving the shingle free vent, when the beach to leeward was at once restored nearly to its original shape.

There are open to the Board three methods of improving the harbour accommodation—

1. By erecting a breakwater on a large scale, completely stopping the shingle.
2. By endeavouring to give partial protection, and at the same time letting the shingle pass.
3. By improving the Boat Service.

Plan No. 1.—The first thing to be done on this plan would be to construct a breakwater straight into the sea. It would have to be nearly at right angles to the average direction of the waves; for if it were made very oblique to it, the shingle would pass along it and cross the mouth of the harbour, turning the latter into a lagoon with a detached shingle beach. It would have to be carried out to deep water which would require a length of about 1,000 feet, and would have to be constructed in the most substantial manner, as it would have to resist the direct force of the very heavy seas which occur at Timaru. This part of the work would somewhat improve the Boat Service. A comparison with the Port of Oamaru shows that it would not do much more. At that port Cape Wanbrow takes the place of this first breakwater. It projects in the best direction for a distance of about 2,500 feet from the shore, but gives very little protection in heavy weather to any point behind it, of which the destruction of the Oamaru Jetty is a proof. The Timaru Breakwater would give still less, as it would be much shorter, and would not be carried above high watermark; but as the holding-ground is better, small vessels might perhaps ride out a storm behind it; they would, however, probably prefer getting to sea.

A second breakwater would then have to be built generally parallel to the shore, which, if of a good length, say 300 yards, would give shelter in which vessels drawing 12 feet to 14 feet of water could lie. Landing and shipping of goods could be carried on here during somewhat rough weather, unless the sea was from the North-east, to which the harbour would be quite open. The first effect of the above works would be the degradation of the coast to the North. Caroline Bay would be deepened, unless the bottom is rock, and would extend somewhat further inland at Mr. Henry John LeCren's; but it is so well protected by the rocky capes on both sides, that no great change would take place there. The detached shingle beach across Washdyke Lagoon would next begin to disappear, and it would take very many years before this supply was exhausted, so that there could be no effect on the coast further northward.

In the meantime the shingle from the South would have been heaping up behind the breakwater. It is quite impossible to say how long it would be before it would reach the end; but eventually it would certainly do so. A new breakwater seawards would then be required. I consider it so probable that this would happen within a few years, that I strongly recommend the Board not to undertake the work, notwithstanding the great benefit which a harbour at Timaru would cause to the rich surrounding country.

The cost of such a work as I have above described would be about £100,000 if of concrete, or about £80,000 if timber were used for part of the work, and its value, when completed, would not be great, as but a small part of the roadstead would be sheltered, and that only indifferently.

Plan No. 2.—The chances of failure with this plan are very great. Mr. Balfour's experimental breakwater had this object in view, but completely failed, although it was very well selected for the purpose. It has been suggested that if a long jetty were constructed, with a short, solid breakwater at the end, the object would be gained; but a short breakwater detached from the shore would give no shelter, the waves would simply curl around it, and a long one would stop the shingle, with the further disadvantage that it would be difficult to predict exactly where the shingle would be deposited, and more harm than good would probably be done. I consider this plan even less advantageous than the first.

Plan No. 3.—It is to the improvement of the Boat Service that I think the Board should look.

An iron jetty would, by shortening the distance to be gone over by the boats, help considerably to make the landing and shipping of goods less tedious. It would be only on a very few days in the year that a ship could lie along it, so goods would have to be carried from the pier-head to the ship in boats, as at present; and as the jetty would be very high, there would be considerable inconvenience in raising and lowering; still, there would be a balance in favour of the jetty, especially if steam cranes were used. A jetty extending into 16 feet of water, supplied with two steam cranes, would cost about £10,000, and I think the expenditure of this sum would give a good return.

The use of a couple of small steam launches to tow the boats out and in would perhaps be nearly as good as a jetty. They would cost about £750 each.

I have, &c.,
JOHN CARRUTHERS.

To the Chairman of the Timaru and Gladstone Board of Works.

P.S.—A copy of this Report is forwarded to the Hon. the Minister of Public Works.

IV.—OAMARU HARBOUR WORKS.

MR. J. CARRUTHERS to the Hon. Mr. GISBORNE.

SIR,— Wellington, 30th October, 1871.

I have the honor, in accordance with your instructions, to submit the following Report on the Harbour Works at Oamaru:—

The works which it is proposed to carry out there are shown in the accompanying general plan, and consist of—1st, A south concrete pier; 2nd, A north concrete pier; 3rd, A dock.

It is proposed that the south pier only shall be constructed at present, the others being left for future consideration.

I made, accompanied by Mr. McGregor, the Engineer in charge of the Harbour Works, a careful examination of the coast from the mouth of the Kakanui River to the North Cape of Oamaru Bay, and again at the mouth of the Waitaki River, with the view of finding out where the shingle which forms the beach at Oamaru comes from, and whether it is stationary or not.

I feel pretty confident that the beach south of Cape Wanbrow is permanent, and that no shingle to speak of comes from the south into the harbour.

To the north the shore consists of shingle cliffs from twenty to fifty feet high, which are being rapidly cut down by the sea, and there is little doubt that this is the cause of the Oamaru beach. There is also, I think, no doubt that on the whole the beach is stationary; with northerly seas the shingle is heaped up opposite the town, and with southerly seas it is driven away again to the north. The heaviest seas are from the south-east, and the harbour is partially protected from them by Cape Wanbrow. It is found, however, that the waves curl round the end of the Cape into the harbour, and it is to prevent this that the south pier is to be constructed.

The pier is to consist of a concrete wall, 1,000 feet long, and raised to high water level, and is estimated to cost £35,000. I have no doubt but it will much improve the harbour, and it appears to me to be designed of sufficient strength to resist the heaviest seas.

It is not unlikely that the shingle will collect to a considerable extent inside the harbour when the pier is completed. At present the shingle brought in by the northerly winds is driven out again by the southerly; the pier will offer no hindrance to its coming in, but by breaking the force of the southerly waves will prevent its being driven out again. I do not think this will cause serious trouble for many years; and when it does, the erection of the proposed northern pier will stop it.

The northern pier is to be of concrete, about 2,000 feet long, and will cost about £70,000.

As it is not intended to go on with its construction at present, detailed plans have not been made; but there will be no difficulty in building it, and thus completing the protection of the harbour from all seas.

It is not proposed to build the dock until both piers shall have been completed, so neither plans nor estimates have been made.

I have, &c.,
JOHN CARRUTHERS,
Engineer-in-Chief.

The Hon. the Minister for Public Works, Wellington.

The plan is in the Exhibition Room, Public Works Office.