1920.

NEW ZEALAND.

CLUTHA RIVER

(REPORT OF RIVERS COMMISSION ON).

Presented to both Houses of the General Assembly by Command of His Excellency.

REPORT.

To His Excellency the Right Honourable Arthur William de Brito Savile Earl of Liverpool, Member of His Majesty's Most Honourable Privy Council, Knight Grand Cross of the Most Distinguished Order of Saint Michael and Saint George, Knight Grand Cross of the Most Excellent Order of the British Empire, Member of the Royal Victorian Order, Knight of Grace of the Order of Saint John of Jerusalem, Governor-General and Commander-in-Chief in and over His Majesty's Dominion of New Zealand and its Dependencies.

MAY IT PLEASE YOUR EXCELLENCY,—

Your Excellency's Commission, dated the 8th April, 1919, directed us to inquire into certain matters in respect of the Clutha, Orari, Rangitata, Waimakariri, Ashley, and Maerewhenua Rivers. The time within which we were required to furnish our reports was extended by Your Excellency to the 7th June, 1920. The present report deals only with the Clutha River. The report upon the Maerewhenua River has already been presented to Your Excellency. The reports upon the remaining rivers will be submitted in due course, when the requisite data have been collected.

Your Excellency's Commission directed us, in respect of each river,—

"(1.) To inquire into the cause or causes of the silting-up of the channel, the flooding of the adjacent lands by the said river, the erosion of its banks, and the damage to the surrounding country;

"(2.) To ascertain the nature and extent of the damage done to the lands adjacent to the said river, and what area of land is affected by such floods or erosion, or both, and whether it is practicable at reasonable expense to prevent such flooding or erosion, or both, either wholly or partially;

"(3.) To ascertain the best method of providing for the control of the said river and its tributaries so as to safeguard the lands affected, and to provide for the effective control and improvement of the said river and its banks;

"(4.) To ascertain the nature and extent of any drainage-works that may be required, and the best method of carrying out such works;

"(5.) (*a.*) To furnish estimates of the cost of such remedial measures as you may recommend should be taken for the effective control and improvement of the said river and its banks;

"(*b.*) To report what area or areas of land should be constituted a district in respect of which a rate may be levied to secure and pay the interest on and provide a fund for the repayment of any loan that may be raised to carry out any river-improvement works which you may recommend should be undertaken;

"(*c.*) To report your opinion as to what matters, if any, shoul be adjusted by legislation; and

"(*d.*) Generally, to report your opinion on all matters arising out of or touching the premises, including the question as to whether or not one or more competent authorities shall be appointed to control the whole or any portion of the said river, and what statutory powers should be possessed by such authority."

Your Commission also required us to report separately in respect of each river.

Investigations made.

Sittings, Evidence, and Inspections.—Your Commissioners met in Dunedin on the 11th June, 1919, and proceeded to Balclutha on the 12th June. The following day they inspected the damage done by the floods of January, 1919, in the Otanomomo, Inch-Clutha, Kaitangata, and Barnego districts. Among other features particularly examined was the Waitepeka Creek. Flood-levels, &c., at South Molyneux were pointed out by Mr. Ramsay, County Engineer, Clutha County Council.

On the 16th June a duly advertised sitting of the Commission was held in the Courthouse, Balclutha, when eleven witnesses were examined. This did not complete the evidence available at Balclutha, but, a sitting having been advertised for the 17th at Kaitangata, the Commission adjourned the Balclutha sitting and proceeded to Kaitangata, sitting there at the Courthouse and receiving evidence from ten witnesses. On the 18th June the Balclutha sitting was resumed, and further twelve witnesses were examined.

Accompanied by local residents the Commissioners the same day made a tour of inspection of the Balclutha protective works, the salient points of which, and the flood-levels marked thereon, being pointed out.

The following day your Commissioners made an examination by launch of the river below Balclutha, proceeding by one branch and returning portion of the way by the other branch until darkness overtook them.

On the 20th June a sitting was held in Dunedin, when the District Engineer and District Traffic Manager of Railways were examined, and plans relative to the subject were inspected in the Public Works Office, Dunedin. On the 21st June evidence was received from Mr. A. Whitley, Inspector of Metalliferous Mines for the Otago District.

On the 23rd June the Commission proceeded to St. Bathan's, and after arrival inspected the mining operations until darkness supervened. On the following day the Commissioners made a further examination of the sluicing claims, with a view to noting the nature and extent of the debris flowing from the mining operations, and also to obtain an idea of the actual amount of material which had been shifted from the claims since the discovery of the goldfields.

At 10 a.m. a sitting of the Commission was held in the Courthouse, and evidence taken from eight representative residents of St. Bathan's and the surrounding goldfields.

Later the Commissioners proceeded to Clyde, and the same evening took evidence from Mr. J. E. Menzies, County Engineer, Vincent County Council, and Mr. J. R. Marks, Assistant Engineer, Public Works Department.

On the 25th June as much of the valley of the Clutha as could be covered before midday was examined, particularly the mines at Bannockburn and the Cromwell Gorge. Evidence was then taken from four other witnesses at Clyde, and the Commission proceeded to Alexandra, where the evidence of four more witnesses was secured. The Commissioners then proceeded to Roxburgh.

The following day the sluicing operations at Commissioners Flat and elsewhere in the vicinity of Roxburgh were examined, and later a sitting was held in the

Courthouse, where the evidence of six witnesses was taken. The Commission then proceeded to Tapanui, inspecting *en route* all the mining operations and erosions along the banks of the river to Island Block, and from there obtaining a first-hand impression of the character of the country drained by the Pomahaka River, one of the principal tributaries of the Clutha.

On the 27th June the diggings in the Tuapeka watershed, notably at Blue Spur and Weatherstones, were inspected, also the Waitahuna diggings. At Lawrence the evidence of three witnesses was secured, and the Commission returned to Dunedin.

On the 28th June the Commission sat in the Public Works Office, Dunedin, and had a consultation with Professor Park as to the geological characteristics and probable geological history of the lower Clutha; also evidence was given as regards flood-levels in the Clutha River by Mr. F. J. Williams, Engineer to the Cromwell Development Company.

On the 30th June evidence was secured from Mr. R. Milne, District Land-valuer, as to land-values in the Clutha district, and the probable effects of floods in depreciating land-values.

After considering the evidence and the impressions received in the course of their investigations your Commissioners came to the conclusion that it would be impossible to intelligently and thoroughly consider the problem until a very considerable further amount of definite data as to levels, falls, erosions, discharges, &c., had been obtained; and with this in view a list of surveys required was drawn up and submitted to the Public Works Department, who agreed to carry out the work desired as soon as possible.

It was intended that the Commission should reassemble at Wellington on the 11th October, but the Chairman was unfortunately taken ill, and after two or three days spent in calculations and consideration of the problems Messrs. Hay and Hunter proceeded to Dunedin, expecting the Chairman to follow almost at once. He, however, became worse, and as there appeared no prospect of his resuming duty at an early date Messrs. Hay and Hunter, on the 22nd October, adjourned the work they were doing in Dunedin and returned to their homes.

Although their order of reference confines your Commissioners to the river where it runs in the vicinity of the town of Balclutha, nevertheless their investigations had to be extended farther into the watershed of the Clutha to enable reliable evidence to be obtained as to the extent of the mining operations in the Clutha basin, which it was contended were the primary cause of the shoaling of that portion of the river referred to in the order of reference.

The plans, &c., prepared by the Public Works Department having been completed at the beginning of February, 1920, the Commissioners reassembled as soon as their respective duties permitted, and arrived in Dunedin on the 17th February, and from then on proceeded with the preparation of their report.

Over fifty samples of water from the river and several of its tributaries were collected, and the percentage of solid matter determined. Samples of present-day and ancient silt were analysed by the Dominion Analyst, the object of this investigation being to ascertain whether any alteration in the character of the silt carried by the river in recent years as the result of mining operations could be detected.

Considerable difficulty was experienced in arriving at what was the actual discharge of the river during the great flood of 1878, the largest experienced within historic times. However, as the result of gaugings and levels that were taken, a discharge which may fairly be assumed to be correct was determined.

Nomenclature.

The lower Clutha River divides at Balclutha into two branches, the left or northerly one being known as the Matau Branch, and the right or southerly one as the Koau Branch. Prior to the 1878 flood these channels united at the bottom of Inch-Clutha, where they were separated from the ocean by a large sandspit, and flowed into the sea at Port Molyneux. The 1878 flood breached the sandspit where the Matau Branch met it, and since that date this breach has remained open, and the river has two distinct mouths.

The narrow neck of land almost enclosed by the bends of the river, on which the town of Balclutha stands, will be referred to in this report as "the peninsula." The island enclosed between the Matau and Koau Branches and the sea is known as "Inch-Clutha." The large area of swampy ground, now more or less reclaimed, lying on the right bank of the Koau Branch is known as "Otanomomo." The flat country lying to the left of the Matau Branch, and surrounding the Tuakitoto and Kaitangata Lakes, will be called "the lakes district."

Physical Features.

The Clutha River, with its tributaries, drains country exhibiting most diverse characteristics. The waters from its 2,749 square miles of drainage area pass through Lakes Wakatipu, Wanaka, and Hawea, and consequently violent freshets are to a large extent steadied, or prevented from affecting the country below the lakes; but, on the other hand, when sustained and violent rain or melting snow has raised the lakes considerably above their normal level the river below continues to run high, frequently for many weeks, while this surplus water is draining away. The characteristics of the flow of the lower river are therefore different from those of the great majority of New Zealand rivers, in that as a rule floods rise slowly, giving ample warning, and, having risen, remain up frequently for days, and take a long time to subside. This is a characteristic which must be seriously considered in deciding the necessary cross-section for levees and other matters.

The country above the lakes is highly mountainous, and rain and snowfall there is extremely heavy. Below the lakes to Balclutha there are 5,072 square miles, over the greater part of which the rainfall is low, and in some places very low; in fact, the Clutha watershed contains the driest locality in New Zealand. Heavy floods resulting from widespread rain over this lower watershed are most unlikely, though at times any one of the tributaries is likely to be in a raging flood quite irrespective of the main river. The total stream cross-section in the lower reaches is, however, so great that tributary floods cause no trouble, except in the case of the Pomahaka, in the watershed of which the rainfall is higher than in the rest of the watershed below the lakes. The Pomahaka drains 800 square miles, and reaches the main river only ten miles above Balclutha.

The experience of May, 1917, shows that a flood sufficient to create widespread damage may come from a flood in this tributary, augmented only by the ordinary normal flow of the main stream.

The character of the rocks and soil above the lakes has no effect on silting, as the lakes form reservoirs so large that all matter in suspension entering them is precipitated, even in times of the fiercest floods.

Through a large portion of its course below the lakes the river—or, rather, the two main rivers, the Clutha and the Kawarau, which unite at Cromwell, and which are from that point known as the Clutha or Molyneux—runs through what is geologically a very youthful gorge, in which the forces of denudation have not yet brought the slopes to a stable angle. It is only the extremely low rainfall that saves the precipitation into the stream of vastly increased quantities of the extremely loose and friable schist rock which forms the greater part of the country.

Unfortunately, the mines operating in the watershed are almost entirely confined to beds of old and also fairly recent gravels, which have already been reduced to such shape and size as permits of their easy transportation by the stream. Nature takes long periods to reduce rock to gravels, and the pouring-in by the agency of man of immense quantities of gravels which have taken ages to produce naturally causes accelerated deposition lower down.

The Pomahaka watershed is entirely different from that of the balance of the Clutha watershed, being largely rolling country, almost entirely grass- and bush-covered, and the amount of detritus travelling in this stream is surprisingly small.

The fall in the river is moderate, as will be seen by plan No. 6. Where passing through narrow gorges the fall is steeper than average, and is succeeded usually by some miles of flatter stretches in which occur old gravel deposits. These steep and flatter alternations both become progressively flatter as the coast is approached, and when the vicinity of Balclutha is reached the fall had become very slight,

there being only 9 ft. of fall from low-river level at the Balclutha traffic-bridge to ordinary high-water mark.

The tidal influence is felt for nearly eleven miles up the Matau Branch and about seven miles up the Koau Branch. Evidence was given that deep-draught schooners had navigated the Koau Branch up almost to the top of the tidal influence. At the present day a flat-bottomed shallow-draught steamer has great difficulty in traversing the same reach. This will show to what extent the shoaling-up has occurred.

The following table gives approximately the area of the various subdivisions, and also the total watershed of the river :—

	Square Miles.		Square Miles.
Lake Wakatipu	1,179	Waitahuna River	147
Lake Hawea	560	Waiwera River	94
Lake Wanaka	1,010	Puerua River	77
Clutha River above Clyde	4,680	Tuakitoto Lake	80
Manuherikia River above Ophir ..	802	Clutha River to Balclutha	7,821
Manuherikia River above Alexandra ..	1,164	Clutha River to mouth (total watershed) ..	8,091
Lindis River	405	Lake Wanaka (area of lake)	70
Pomahaka River	800	Lake Wakatipu (area of lake)	93
Tuapeka River	84	Lake Hawea (area of lake)	41

The watershed of the Clutha River below the lakes, before settlement took place, was covered with natural vegetation, principally tussocks, with scrub in the gullies. Owing to a variety of causes, chief among which were burning-off by the settlers and eating-off by rabbits and other animals, large areas are now bare; the gullies have not the help of the roots of the scrub and vegetation to retain the loose material, and consequently whenever thunderstorms—which are somewhat prevalent in parts of the watershed—occur immense quantities of material are torn from the hillsides and carried towards or into the main stream.

Your Commissioners consider that the effect of interfering with the original physical character of the watershed by agricultural and pastoral operations, including burrowing by rabbits and burning-off, has decreased the stability of the surface soil, and thereby enabled the natural denuding agencies to carry increased quantities of detritus into the river and its tributaries. This increase over the natural denudation that occurred before any settlement took place, and which the river was able to transport safely to the sea, would, in their opinion, be as much as the increase due to mining operations; and therefore the settlers and the miners are equally responsible for the shoaling that has taken place in the vicinity of Balclutha, as far as that shoaling is due to the increase of detritus poured into the upper reaches of the river and its tributaries.

The burning of the tussocks was done to a much greater extent in the past than is now done by the runholders, with the idea of improving the grass. Limited burning under strict supervision, and at the proper time of the year, may not do much harm, and possibly does improve the grass; but your Commissioners are so strongly of opinion as to the immense amount of harm which can be done, and frequently is done, by the burning getting out of hand that they consider the stopping of the practice of burning the tussock should be under strict regulation, if not forbidden by law. That there is now not so much burning as heretofore is largely due to the fact that there is nothing left to burn, and consequently nothing left for the stock to eat; or, what is more important so far as river-control is concerned, there is nothing to protect the face of the country against the elements.

Although within the watershed below the lakes there was never very much large timber, what there was has been almost entirely cut out, especially for mining-timber.

Whatever the cause of the disappearance of the native vegetation, there is no gainsaying the fact that the denudation from natural causes henceforth will be very much worse than in the past, and will be a very serious factor for consideration in connection with the safeguarding of lands lower down. At St. Bathan's, where there is a large number of water-races, your Commissioners received the direct evidence of those engaged in their upkeep that very much more work was now involved than in the past.

The geological evidence shows plainly that a great deal of subsidence has taken place in the lower valley, and the presence of undecayed forest *in situ* below high-water mark shows that subsidence has occurred within comparatively recent geological times. Whether this downward movement is now going on cannot be determined with certainty, but in any case your Commissioners do not consider that a movement either upwards or downwards is likely to occur at a sufficiently rapid rate to justify them in making any modification of their suggested works to cope with this movement.

Floods and Flood-discharge.

Heavy floods have been recorded in 1851, 1866, 1878, 1912, 1913, 1917 (two), and 1919. The 1878 flood was the highest known since settlement occurred, but physical evidence of a still greater flood was observed by the early settlers, showing that the water stood something like 6 ft. above the highest level reached by the 1878 flood, near the top of Inch-Clutha. It is quite impossible to form any idea of how long ago this flood occurred, although there is a Maori tradition as to its occurrence.

The heights of successive floods, as recorded on the gauge on the Balclutha traffic-bridge, are as follows:

September, 1878 (flood occurred before gauge was erected, and height was obtained inferentially)	16 ft.
October, 1912	12 ft.
March, 1913	13 ft. 6 in.
May, 1917	15 ft. 6 in.
September, 1917	11 ft. 6 in.
January, 1919	17 ft.

The heights of the floods occurring prior to 1878 were not recorded at the same station, because it did not exist before then. The evidence of witnesses, however, shows that at Inch-Clutha the 1866 flood was approximately 2 ft. below the 1878 flood. It might be imagined from the fact that the 1919 flood stood at 17 ft., while that of 1878 only stood at 16 ft., that the former was the greater flood; such, however, is not the case, because at the time that the 1878 flood occurred the conditions existing at and below Balclutha were entirely different from those obtaining at the time of the more recent floods, inasmuch as in 1878 no levees had been constructed, and the flood-waters, not being confined, spread over a considerable area of country. As a consequence of this, very considerable difficulty has been experienced in arriving at a definite conclusion as to what is the maximum flood-discharge which is reasonably likely to occur, and which should be provided for in any projected remedial works. However, after very careful consideration of all the facts and data at their disposal, including levels, slopes, and cross-sections at Clydevale and Pukeawa, where little alteration in the stream has occurred, your Commissioners have arrived at the conclusion that the flood-discharge of the 1878 flood may be fairly stated as not exceeding 180,000 cubic feet per second, while that of 1919 was about 120,000 cubic feet per second.

An interesting feature in comparing the 1919 flood with that of 1878 is that at Alexandra the 1878 flood was higher by 12 ft. 6 in., at Beaumont by 7 ft., at Clydevale by 4 ft. 6 in., at Pukeawa by 4 ft., at Barnego by 4 in., and at Balclutha 1 ft. lower. At Mr. Smaill's house (Sections 7 and 8, Block VI, Inch-Clutha) it was 6 in. higher, and at Mr. Aitchison's (Section 2, Block IV, North Molyneux) it was 15 in. higher.

Mining.

Your Commissioners found that mining operations of enormous magnitude in the aggregate have been carried out within the watershed of the Clutha River, the total yardage moved being estimated by them as in the vicinity of 300,000,000 cubic yards. Since the first recorded gold-output from the district this works out approximately at over 5,000,000 cubic yards per annum, the greater part of which may be termed foreign matter swept into the tributaries acting as sludge-channels, and far exceeds what might reasonably be expected from natural denudation. When

mining was very active the quantity per year was several times this average. It is not claimed that all this material has actually caused silting at or in the vicinity of Balclutha. An immense amount of it has come down the river and been swept out to sea, being carried in suspension after reduction to appropriate size. Probably a still greater quantity is still lying in the gullies and sludge-channels, as well as in the bottom of the main river. The very noticeable rise in the low-water level of the river at all points where evidence as to this could be obtained shows that there is an immense amount of material lying in the bottom of the main river, more especially in the upper reaches.

Of this 300,000,000 cubic yards probably 200,000,000 cubic yards has not yet reached the main river. Of the balance of 100,000,000 cubic yards probably 60,000,000 cubic yards is lying in the bed of the river, in thickness varying from 10 ft. in the upper reaches to 3 ft. in the lower reaches, while the residue of 40,000,000 cubic yards has been swept out to sea at an average rate of 670,000 cubic yards per annum.

The whole of this material must eventually be brought down by successive floods—how soon cannot be even estimated; but what your Commissioners wish to stress is that this large amount of foreign matter cannot have been sluiced into the river without upsetting the balance of nature and causing silting where previously silting had not occurred.

By analogy with other rivers of similar magnitude, and from the silt-samples obtained by your Commissioners, they are of opinion that it is not likely that in a state of nature the river brought down more than 2,500,000 cubic yards of detritus per annum. The increasing of this amount by the mining-debris cannot do otherwise than result in the silting-up of the bed wherever the current is such as to favour deposit. It must also be recollected that the amount given as an average was not really distributed over the whole period since the outbreak of the goldfields, but that when mining was in its heyday a great deal more than this amount would be poured into the river, and its power to transport the material to the sea would be proportionately less. Although mining may be considered now to have been reduced to a fairly low ebb, the amount of mining-detritus disturbed by sluicing, &c., and now lying in gullies and on hillsides, where it can be easily swept into the streams, must continue for many years to act as a disturbing influence in the regimen of the stream. It is probable that this material distributed along the whole course of the river will have such an effect that the stopping or not of the mining now going on is scarcely worthy of consideration.

Cross-sections taken in the stream at certain points show definite decreases in the cross-sectional area, and consequent raising of the low-water level; but it would be impossible for your Commissioners without extensive detail surveys (which are not considered justifiable for the purposes of this report) to determine what is the average amount of silting-up, or even the aggregate amount of silting-up over any given length. Suffice it to say that silting-up has undoubtedly happened.

So far as a diligent search of the Treasury and mining records will give, it appears that over £19,500,000 worth of gold has been won from the mines in the valley of the Clutha River; and the revenue derived by the General Government, and paid to the various local authorities in whose districts the gold was won, since 1877, which is the earliest date covered by the Treasury records, was £158,653, as supplied by the Accountant to the Treasury. This cannot be considered as in any way representing the actual monetary benefit to the State derived from the mining industry, which has been one of the principal foundations of the prosperity of Otago.

Your Commissioners cannot help repeating the statement made in their report on the Maerewhenua River—that the amount of gold being won is not sufficient to justify their recommending any contribution towards the cost of remedial measures being demanded from this source, but the General Government, having been responsible for the Proclamations authorizing the deposit of mining-tailings into the various tributaries, cannot escape liability to contribute in a greater or less degree towards the cost of the works recommended herein.

Similarly, it is considered not justifiable to recommend that any direct contribution to the cost of remedial measures in the vicinity of Balclutha be derived from the land under settlement in the watershed of the Clutha above the portion referred to in the order of reference.

Town of Balclutha.

Both before the appointment of the Commission and during its investigations a widespread feeling has been given expression to that the town of Balclutha should never have been built where it now stands, and that therefore the people, having gone into such an unsuitable township-site of their own volition, are entitled to no sympathy for the troubles in which they now find themselves. While your Commissioners agree that it is regrettable that such a site should have been chosen and developed to its present stage, nevertheless they feel that as the General Government was to a certain extent to blame in the first place in cutting up a limited number of sections on the peninsula, and as the town has now an established prosperity and has become recognized as the trading and official centre of a large and valuable district, its present existence must be recognized, and its value is such that it must be protected.

Your Commissioners have considered the possibility of removing the whole of the improvements now on the peninsula to higher ground, but are of opinion that the expense which would be thereby incurred, both in the actual work and in the dislocation of business, is too great to be warranted.

While the flooding of agricultural land is detrimental and should be avoided, nevertheless if it should happen it can be borne, and merely represents the loss of so-much money; but in the case of a closely built town such as Balclutha an inundation such as would occur in the event of the protective works failing would undoubtedly result in loss of life in addition to a great loss of property, and for the former reason alone very considerable expenditure on protection would be justified. Had no protective works been erected at Balclutha the risks and the actual damage to Barnego would be considerably lessened. It is not likely that the area of land at Barnego is sufficient to justify protective works adequate to withstand the greatest flood to be anticipated, but protection against all floods is required at Balclutha, and consequently Barnego must be prejudicially affected, and should receive from the town of Balclutha some assistance towards an insurance fund of a character to be outlined later on. If the inhabitants of Balclutha are not prepared to pay annually towards such an insurance fund, then they must be charged with a very considerable portion of the cost of raising the Barnego levee as high as the Balclutha levees.

Changes in Regimen.

That the lower reaches of the river do not now possess their original characteristics was affirmed by practically every witness old enough to recollect early conditions. Before the mining became an important factor the river was a deep clear-running stream, with the water the deep blue characteristic of its upper reaches at present. It is now, especially in the Koau Branch, full of shingle-bars, always muddy, and generally very much shallower than it was, say, in 1860. At that time, also, the tidal influence was felt considerably farther up-stream, and drains which were then constructed to discharge into the river through automatic tide-gates at low water cannot now so discharge.

Existing Works.

A great deal of useful work has been carried out for flood protection in the past. A general description of these works is as follows: The Barnego Flat, on the left bank, is protected by a levee approximately paralleling the river and connected with a hill at each end, the height of the levee being generally up to within an inch or two of the height to which the 1919 flood rose. This levee is not continuous, as portion of the river-bank is sufficiently high to be above the grade of the flood referred to. On the right bank there is a very strong levee extending from the hills about a mile and a half above the Balclutha traffic-bridge down to some comparatively high ground in the vicinity of the Agricultural Show Grounds. The greater portion of this levee was erected shortly after the great flood of 1878, and its top was made up to the observed flood-marks of that flood. No allowance was made for the inevitable rising of the flood due to the cutting-off of the flood-overflow across the peninsula. In later years this danger was partly realized, and the levee was raised 3 ft. and otherwise strengthened. Had this not been done a catastrophe must have occurred in 1919.

In addition to overflowing the peninsula in and prior to 1878, an active erosion of the peninsula on the western side was in progress, and simultaneously with the construction of the levee in 1880 a great deal of riprap was placed in the concave bends, so as to clothe the bank from the top to the bottom of the river. This was so successful that erosion, which had amounted to 50 acres between 1847 and 1880, has been entirely arrested.

At various times levees have been constructed on Inch-Clutha wherever the experience with previous floods has shown the danger of overflow. There are on the island many miles of them, some being fairly high, but the majority of moderate dimensions.

A large levee known as the Hermitage Bank, and one or two smaller banks immediately in the vicinity of the town, protect Stirling from the overflowing of floods of such volume as that of 1919. In this connection it may be well to remark that these levees should protect the land, but in actual fact they were breached by both the 1917 and 1919 floods, due to their not having been properly maintained and rabbits having been allowed to burrow clean through them. The same remark applies to the levees on Inch-Clutha, which have been breached at different times.

The Waitepeka Stream, which previously had joined the Puerua Stream near its confluence with the old mouth of the Clutha River, has been diverted into the Clutha River direct by a canal passing under the Catlin's River Branch Railway into an old lagoon, and thence into the river at Section 14, Block XXII, Clutha Survey District. A tidal gate has been constructed at the mouth of the Puerua River to prevent the high tide backing up the stream, and thus to improve the drainage of the Otanomomo Swamp.

A levee of small dimensions has been constructed near the mouth of the Waitepeka Canal referred to above, down to a point within a mile of the Koau mouth.

The outlet to the Tuakitoto and Kaitangata Lakes has been improved by the construction of the canal connecting the Kaitangata Lake with the river, and also by an extension connecting the two lakes, the high water of the Clutha being prevented from flowing through this canal into the lakes by the erection of tidal gates at the lower end of the canal. This protected a large area of the lakes district from Clutha flood-waters, and greatly improved the drainage.

Inch-Clutha, a large portion of which has been originally swampy, was also improved by a comprehensive scheme of drainage.

From time to time efforts have been made to prevent erosion of other portions of the banks, with more or less success.

Local Bodies interested.

At the present time the control of the area coming within the scope of our investigations is in the hands of the following controlling authorities: Barnego is under the control of the Otago Land Board; Balclutha is controlled by the Balclutha Borough Council; the lakes district is controlled by the Bruce County Council, which also carries out the functions of the Matau Drainage Board; Inch-Clutha is under the control of the Inch-Clutha Road, River, and Drainage Board; Kaitangata is under the control of the Kaitangata Borough Council; Otanomomo is controlled by the Otanomomo Drainage and River Board.

Inch-Clutha is also included in the Bruce County, and Otanomomo and Barnego are included in the Clutha County. There is also the Clutha River Board, which has control of the river, but confines its work almost entirely to such matters as concern the navigation of the river.

Land Settlement and Tenure.

The approximate area of land subject to flooding is 17,000 acres. The area of this requiring drainage in addition to river protection is approximately 6,000 acres.

The Barnego Flat is the property of the Crown, and is leased under the provisions of the Land for Settlements Act. A considerable portion of the Otanomomo district is also Crown land, leased in the same way. The balance of the land may generally be considered as freehold.

The following table gives the approximate capital values of the lands and properties affected by floods :—

——	District.	Area.	Capital Value.	Totals.
		Acres.	£	£
Farm lands	Barnego	563	9,000	
	Otanomomo	6,700	84,000	
	Inch-Clutha	6,780	150,000	
	Lakes district	5,120	100,000	
		19,163		343,000
Boroughs and towns ..	Balclutha	440	209,000	
	Kaitangata	..	110,000	
	Stirling	..	5,000	
				324,000
Government property ..	Railway-line, Balclutha ..	..	25,000	
	Government Buildings, Balclutha	..	8,000	
				33,000
Freezing-works	Finegand works	..	100,000	
	Carcases in store	..	350,000	
				450,000
Private railways	Kaitangata	..	17,000	
	Taratu	..	25,000	
				42,000
				£1,192,000

Your Commissioners, having received the necessary plans, met again in Dunedin on the 17th February, 1920, and, after revisiting the salient points on the Clutha River, drew up their report, and now beg to submit their findings on the various heads in the order of reference, as follows :—

Reference No. 1.

To inquire into the cause or causes of the silting-up of the channel, the flooding of the adjacent lands by the said river, and erosion of its banks and the damage to the surrounding country.

This is largely due to the quantity of debris coming down from the mining operations in the many tributaries of the river draining the gold-bearing country, and acting as sludge-channels for the mining operations carried on therein ; also to the acceleration of natural denudation by removal—by burning, agricultural, and pastoral operations—of the protective covering of natural vegetation, thereby giving the river an overcharge of detritus in excess of its natural carrying-capacity.

The fact that the traffic-bridge at Balclutha has a throttling effect upon even small floods has assisted to aggravate the silting-up between the town and Barnego Flat.

A certain amount of silting in the Koau and Matau Branches has also been caused by the growth of willows, though in this river this frequent cause of trouble is not so pronounced.

Reference No. 2.

To ascertain the nature and extent of the damage done to the lands adjacent to the said river, and what area of land is affected by such floods or erosion, or both, and whether it is practicable at reasonable expense to prevent such flooding or erosion, or both, either wholly or partially.

The damage is of a manifold nature :—

(1.) Actual erosion of the banks.

(2.) Damage to the improvements on the land, and the crops being grown thereon, by overflowing. The flood-waters sometimes lie on portions of the ground sufficiently long to kill the vegetation, and in other places they carry such a quantity of silt as completely covers the vegetation, and kills both grass and crops.

The amount of damage done varies greatly with the season and consequent condition of agricultural operations, but history does not seem to show any definite

CLUTHA RIVER.

PLAN SHOWING PROPOSED RIVER DISTS. AND FLOODED AREA.

REFERENCE.

BOUNDARIES OF PROPOSED RIVER DISTRICTS.

BOUNDARY OF FLOODED AREA.

ROADS

PROPOSED NEW LEVEES

ALTERNATIVE LEVEE EXCLUDING RAILWAY FROM PROTECTION AT BALCLUTHA.

LAKES R.D.

INCH CLUTHA R.D.

OTAHAMOMO R.D.

KAITANGATA R.D.

PART OF LAKES R.D

SOUTH PACIFIC OCEAN

BALCLUTHA

Kaitangata Rly Stn

Stirling Rly Stn

Otanomomo Rly Stn

Kaitangata Rly Stn

Clutha River

Waitepeka River

Purakaunui River

Swamp Rd

Southwards Swamp Road Branch Railway

Waitepeka Creek

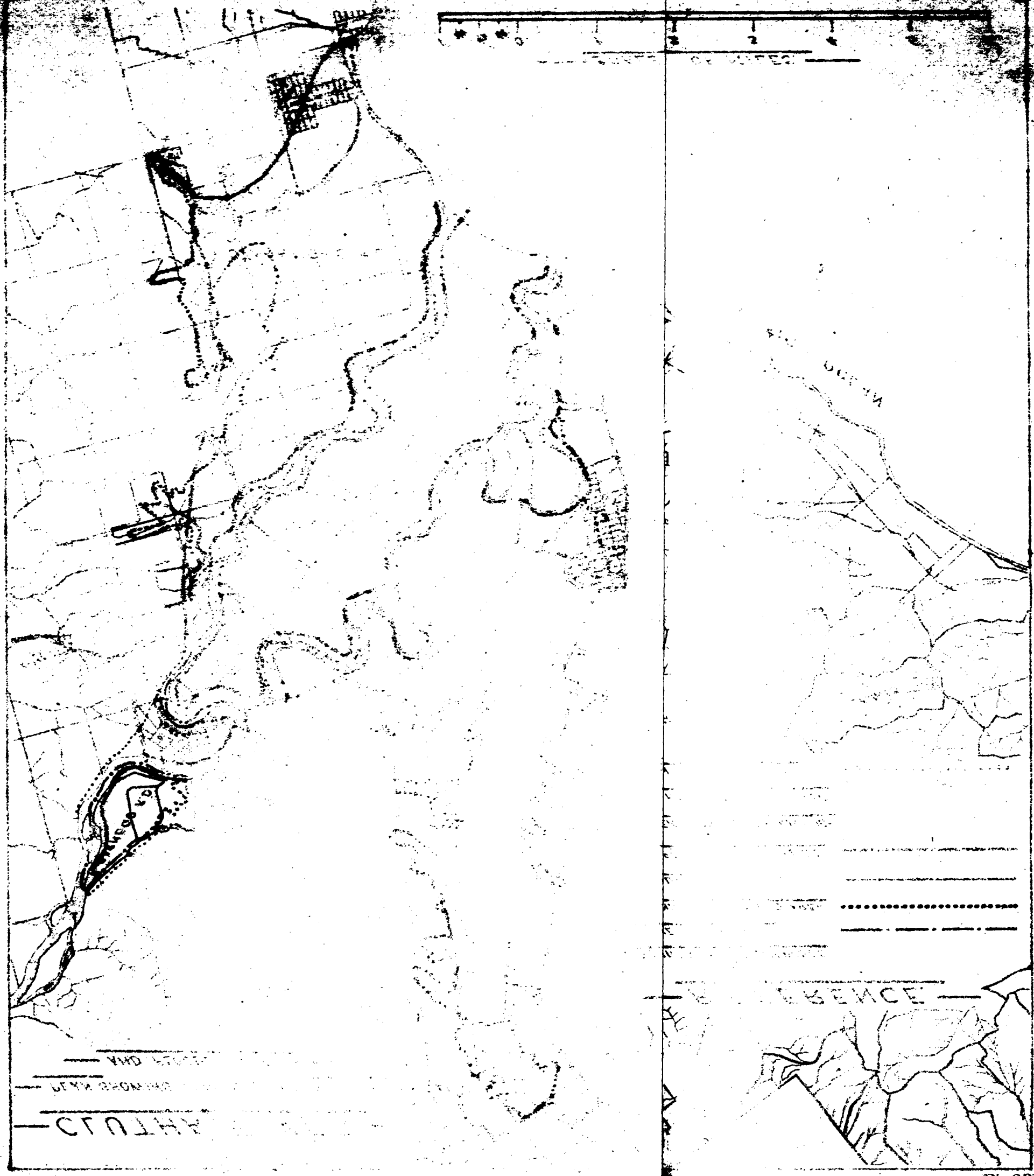
Come Creek

Waterfall Creek

Washpool Creek

SCALE OF MILES.

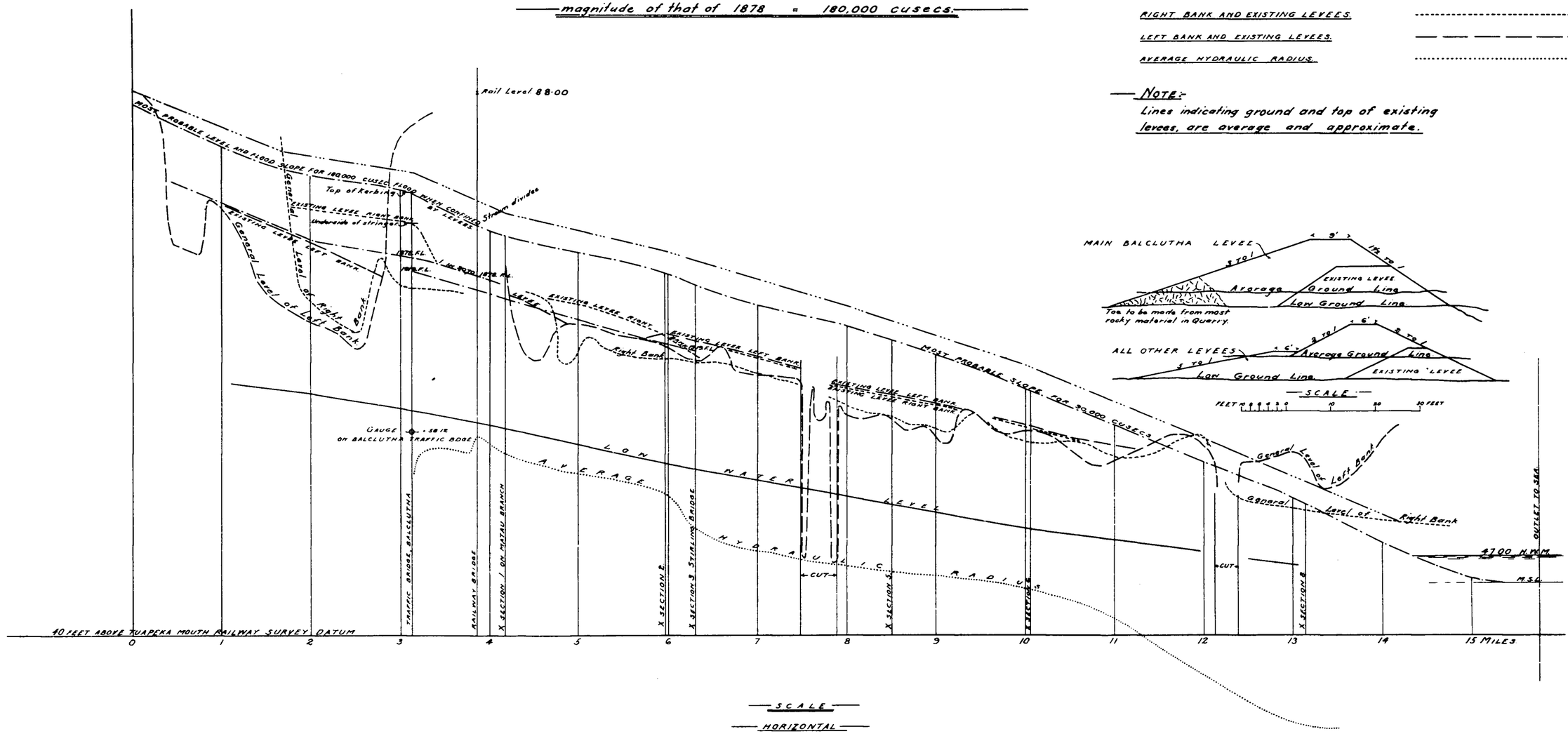
1 ¾ ½ ¼ 0 1 2 3 4 5 6



CLUTHA RIVER.

MATAU BRANCH WITH TWO CUTS.

Section showing present ground and water levels and proposed Grades of Levees to control floods of the magnitude of that of 1878 = 180,000 cusecs.



REFERENCE.

PROBABLE FLOOD SLOPE WITH 180000 CUSEC FLOOD

GRADE LINE OF PROPOSED NEW LEVEES

LOW WATER LEVEL.

RIGHT BANK AND EXISTING LEVEES.

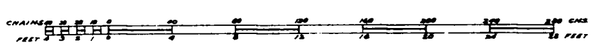
LEFT BANK AND EXISTING LEVEES.

AVERAGE HYDRAULIC RADIUS.

NOTE:-
Lines indicating ground and top of existing levees, are average and approximate.

SCALE

HORIZONTAL

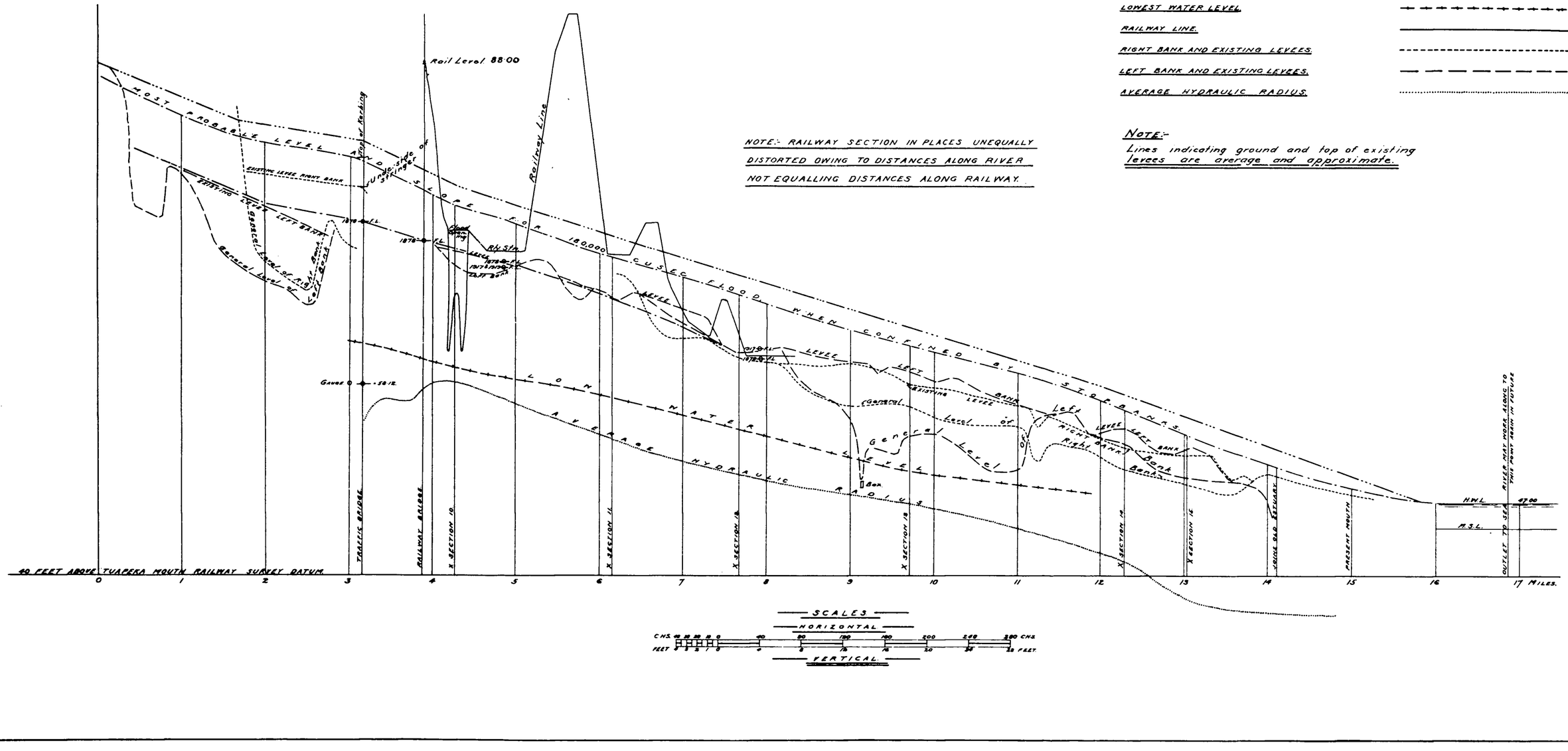


VERTICAL

CLUTHA RIVER

KOAU BRANCH

Section showing present ground & water Levels, and proposed grades of Levees to control Floods of the magnitude of that of 1878 = 180,000 cusecs.



NOTE:- RAILWAY SECTION IN PLACES UNEQUALLY DISTORTED OWING TO DISTANCES ALONG RIVER NOT EQUALLING DISTANCES ALONG RAILWAY.

REFERENCE

- PROBABLE FLOOD SLOPE WITH 180,000 CUSEC FLOOD.
- GRADE LINE OF PROPOSED NEW LEVEES.
- LOWEST WATER LEVEL.
- RAILWAY LINE.
- RIGHT BANK AND EXISTING LEVEES.
- LEFT BANK AND EXISTING LEVEES.
- AVERAGE HYDRAULIC RADIUS.

Note:- Lines indicating ground and top of existing levees are arerage and approximate.

SCALES

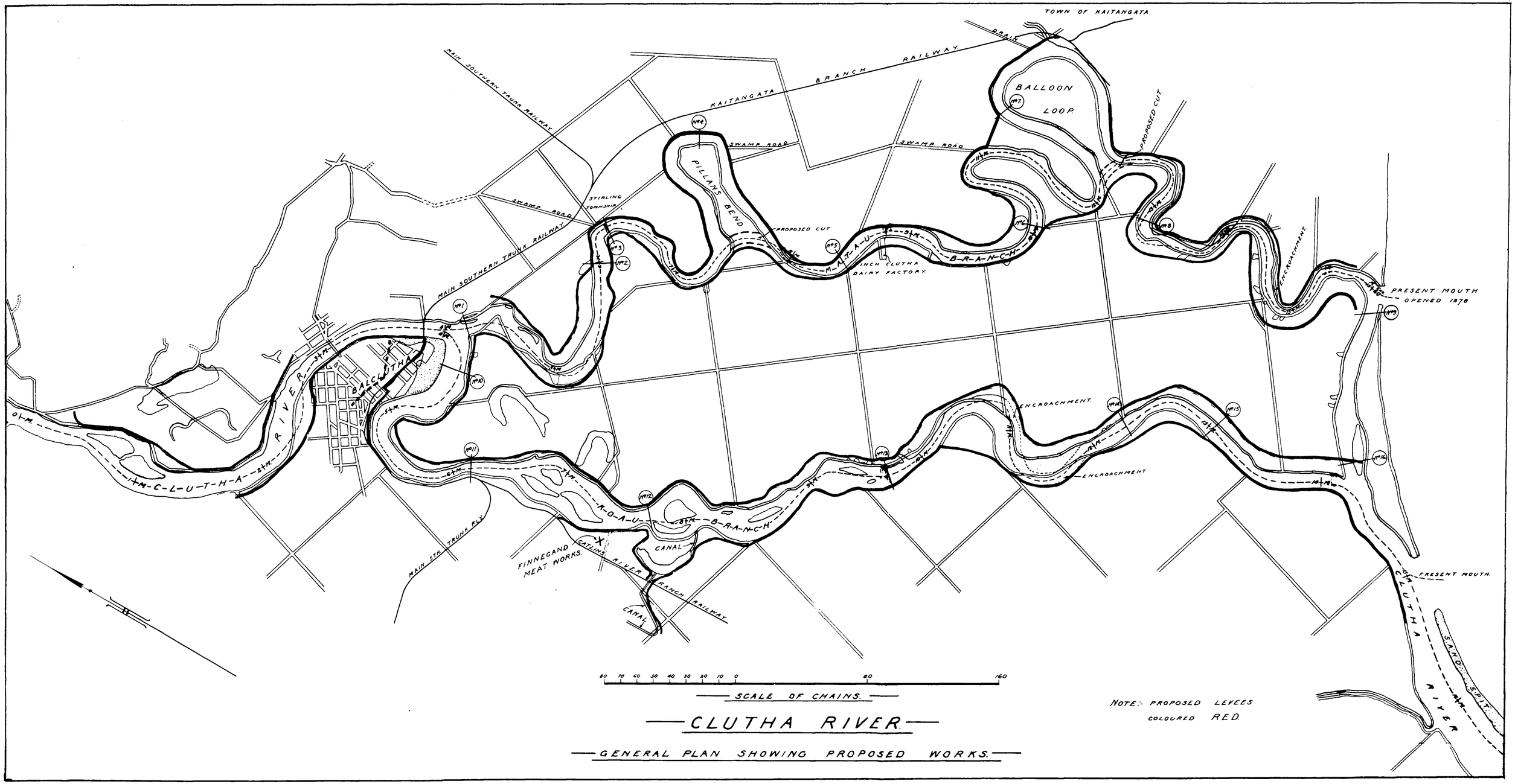
HORIZONTAL

VERTICAL.

REFERENCE

CLUTHA RIVER

MOAU BRANCH



NOTE:- PROPOSED LEVEES COLOURED RED.

CLUTHA RIVER.

GENERAL PLAN SHOWING PROPOSED WORKS.

flood season; of the heavy floods on record three occurred in the spring, one in the summer, one in the autumn, and one in the winter.

Damage is also done to house property and furniture, due to floods actually invading the houses; and the value of many portions of the district for building purposes and for agricultural pursuits is depreciating because the fear of floods prevents people living therein, or prevents them from carrying out agricultural operations which would be jeopardized by floods to a greater extent than would mere grazing. In 1878 the flood which swept over the town of Balclutha did an enormous amount of damage; it also did great damage to the farm lands in all parts of the flooded area. The flood of 1917 did considerable damage on the left bank of the Matau Branch and at Otanomomo. The flood of 1919 did immense damage to the same localities, and also on Inch-Clutha, and but a small amount of damage in the town of Balclutha. Enormous damage in Balclutha would have been sustained had it not been for the protection afforded to the town by the works erected by the General Government about 1880, and strengthened and raised partly at the expense of the Borough Council and partly at the expense of the General Government in 1913.

(3.) The roads in the flooded area were damaged by the metal being washed off them, and by the deposition of silt, sometimes to great depths, over the existing metal.

(4.) Railway traffic was interrupted on the Main South Railway in 1878 for a considerable period. The main line was also breached at Balclutha, and large and costly viaducts had to be erected in place of the banks which had been washed away. In 1919 railway traffic was interrupted for eight days. In both of these floods, and also in the flood of 1917, the private railway running from the main line at Stirling to Kaitangata was breached, and the traffic interrupted for considerable periods. Interruption of the private railway from Taratu to Lovell's Flat was also suffered. This resulted in the stoppage of the coal traffic, and represents a dead loss not only to the companies but to the local authorities and to the Government, which can never be made up.

The very valuable works of the South Otago Freezing Company, with all the valuable store of frozen meat, were seriously jeopardized by the comparatively moderate flood of 1919.

With regard to erosion, 50 acres of land was eroded from the peninsula between 1847 and 1880. The fear that the whole town would be swept away by this cause was what prompted the Government to carry out certain protective works, which they did. In addition to building a flood-protection levee on the upper side of the town, the whole slope of the river from the top of the levee to the bottom of the river was clothed with riprap, as before mentioned. This has been entirely successful, though it is probable that by now its toe is becoming eroded by the continual abrasion due to travelling shingle, and some work in this connection will be recommended under reference No. 3.

Erosions similar to those which took place near Balclutha have taken place in a great many of the concave bends between the town and the sea, but in almost all cases complementary accretion has occurred on the opposite bank of the river, so that the ultimate area of the river-bed or river-channel is not materially, if any, greater than it was when the land was first settled. Though certain hardship may have been caused to individual owners by the erosion, other owners have gained by the accretion. Nevertheless, the amount eroded at any one point other than at the town does not, in the opinion of your Commissioners, warrant the carrying-out of the extensive works which would be required to prevent further erosion. If the land between the stop-banks were the property of an organization controlling the river, then no hardship would be caused to any individual owner, and the central authority would gain in one place and lose in another, remaining substantially as it was. If erosion at any point proceeds to such a length that the levees are threatened with undermining, it would be better to purchase a strip of land and move them back than to attempt protection, unless there are some very special conditions which would warrant this latter course being adopted.

Your Commissioners consider it practicable to wholly prevent the flooding, at reasonable expense.

REFERENCE NO. 3.

To ascertain the best method of providing for the control of the said river and its tributaries so as to safeguard the lands affected, and to provide for the effective control and improvement of the said river and its banks.

The works recommended by your Commissioners are shown on plans marked 2, 3, and 4, hereto attached, and consist generally of—

(*a.*) The raising of the present traffic-bridge at Balclutha, the strengthening of its piers by the sinking of another cylinder up-stream, and by bracing all three together in a substantial manner.

Your Commissioners consider that the erosion of the terrace under the bridge on the left bank should be encouraged by ploughing the surface when a flood is likely to occur. The character of the river is such that ample warning can be obtained from stations higher up the river. Under the bridge, and along the banks in its vicinity on the right bank, the present inordinate growth of willows should be kept within bounds sufficient only to protect the works, so that silting-up in that locality during periods of low river and moderate freshets will not be encouraged.

(*b.*) The main levee protecting the town of Balclutha must be raised by an average height of 6 ft., at the grades shown on plans. It should be constructed of solid material, preferably a mixture of clay and rock from the hillsides from which the original material was obtained.

The suggestion has been made that the levee should be constructed with material pumped from the bed of the river, preferably on the Barnego side. While the material so obtained would not be so suitable for a levee, your Commissioners are satisfied that the cost would be no less, and probably would be greater, and the increase in the cross-sectional area of the stream obtained from the dredging-out of the material would be nullified by the first flood.

When the levee has been constructed to the raised height, and to the dimensions indicated (9 ft. on the top, with 3-to-1 batters at the back and 1½-to-1 at the front), it might with profit be dedicated as a public road after being sufficiently widened on the top, with natural batters. Its use as a public road would allow of subdivision for residential purposes of the land not now served by a public road, and would result in its being constantly patrolled and maintained, and therefore no longer serving as a harbour for rabbits, as it has done in the past, and does still to some extent, in spite of the alleged rabbit-proof fences.

In view of the fact that no maintenance to the riprap has been done for forty years, your Commissioners consider that the time has now arrived when a quantity of stone—say, 10,000 yards—should be distributed along the toe of the levee. This could best be done by tipping from barges moored at fixed distances from the water's edge, so that the stone is delivered exactly where required. It may be possible to place the stone by tipping it off the levee, but there is doubt as to whether it would roll into the desired position. Experiments should be made by this method before the barges are constructed.

(*c.*) From the end of the raised traffic-bridge a levee of similar dimensions to the levee just specified, and to the grades shown, should be carried down and connected with the present south abutment of the railway-bridge.

In 1919 the river-bed had been silted up to such an extent that the low-water level was considerably higher than the low-water level in 1878; and yet during the flood of 1919 the flood-level was lower than the flood of 1878 by 12 ft. 6 in. at Alexandra, 7 ft. at Beaumont, 4 ft. 6 in. at Clydevale, and 4 ft. at Pukeawa. At these places the conditions, other than that due to the silting-up of the river-bed, are very similar to what they were in 1878.

The effect of confining the flood-waters between levees must necessarily be to raise the flood-level; this point cannot be too strongly emphasized. In the case of the big flood of 1878 no levees worth mentioning existed at Balclutha, and the flood-waters had a clean sweep across the peninsula. This resulted in a much decreased flood-height compared with what would now be the case should a flood of similar dimensions occur, when the flood-waters would be confined by the levees to a definite channel.

Your Commissioners, after careful consideration of all the facts and data at their disposal, estimate that a similar flood to that of 1878 would, under existing

conditions, be between 5 ft. and 6 ft. higher now at the traffic-bridge than was the case in 1878. Therefore, although your Commissioners are recommending the construction of levees very much higher than the height to which the 1878 flood rose, they are nevertheless only providing for the same amount of water as came down in that flood.

On the Balclutha peninsula below the traffic-bridge there are three methods which may be adopted:—

(1.) If the Railway Department desire that their line should be above the new flood-level and are prepared to pay for raising the line, including the station-yard, then the railway should be raised, in which case the railway embankment would form the levee from the south end of the railway-bridge to the high country below the Balclutha Railway-station.

(2.) If, on the other hand, the Railway Department consider that it is preferable to take the risk and suffer damage when extreme floods occur, the balance of the town should be protected by raising the present levee which surrounds the show-grounds, continuing the same down Glasgow Street, then parallel to the railway-line into Baxter Street, and thence by Stewart Street beyond the junction of these two streets to connect with the high country at Rosebank. Where the levee-line is in a street the street should be raised and act as a levee.

(3.) The existing railway-bank might be used down to the vicinity of the present flood-opening viaduct, this viaduct to be removed and replaced by an embankment above flood-level down to Glasgow Street. The levee could then be taken round the outside of the station-yard to below the goods-shed. A gap could be left where it meets the two sidings serving the goods-shed; and protection could be afforded by raising the goods approach road to the necessary height, and from the present level-crossing to the hill by building a small bank as an adjunct to the present formation on the river side thereof above flood-level. This may necessitate some alterations of the sidings serving the stockyards, and possible alterations of the stockyards themselves, to give an equal area of stockyards with less width. The gap in the levee where the goods-shed sidings would pass could be closed in time of flood by means of stop-logs dropped into a groove prepared in concrete abutments.

Your Commissioners recommend the third method. Irrespective of which of these three schemes is adopted, it must be clearly understood that the levee must be carried down the river-bank below the traffic-bridge and connected with the railway-bridge abutment.

(*d.*) The bend of the river about two miles below Stirling, known as Pillan's Bend, should be cut off by a river-diversion, as shown on plan No. 2; and also the bend of the river known as the Balloon Loop, near Kaitangata, should be cut off by a diversion as shown.

In neither case is the diversion shown along the shortest route which could be found, but they are so located as to give easy curves, swinging off the existing alignment in such a way as to minimize the chance of future erosion. The result of these cuts will be that the average slope to the sea will be considerably increased, and they will thus minimize the tendency of the levees to raise the flood-level when they control the flood-waters within the actual boundaries of the river.

(*e.*) The present Hermitage Levee should be raised and continued down-stream as far as may be necessary, to the grade and levels shown. The alignment of the extension is shown approximately on plan, but its exact location is a matter for detail survey.

At the first diversion referred to above, the levee should continue round the existing channel; and at the Balloon Loop the levee should follow the Swamp Road to the Kaitangata traffic-bridge, and from thence run to the tidal gate recently constructed across the Tuakitoto Canal. From that point onwards it should run into the hillside at Kaitangata Township; from this point onwards, the areas of

land being small and the flood being never likely to rise far above the existing banks, a very small levee will be sufficient.

(*f.*) At all points on Inch-Clutha where the natural banks or the existing levees fall below the proposed new grade, levees should be raised to the levels shown, 6 ft. wide on top, and with side slopes of 2 to 1. These and all other levees should be constructed of the best material obtainable in their immediate vicinity, and should be constructed in such a way as to give the maximum of consolidation.

The levee following the right bank of the Matau Branch will, of course, follow the proposed new cuts, and in addition will run across the long bend which exists at Section 7, Block IV, Inch-Clutha. In this locality it may be desirable to raise the road to act as a levee. This is a matter which can be best decided by mutual arrangement with landowners when the work is put in hand.

On the left bank of the Koau Branch, where the existing levees are so close to the river as to be threatened by the erosion of the banks, they should be removed to a safe distance before being raised in a similar way, to the grades and levels shown.

(*g.*) The existing levee which now connects the high land in the vicinity of Mr. Telford's residence with the railway-bank at the Waitepeka Canal should be raised to the level shown, joining the railway on its new grade (see next paragraph). From this point onwards a levee must be carried down towards the sea under the same conditions as the others—that is, to the levels given, in the approximate location shown.

(*h.*) The Catlin's Branch Railway, where it passes over the Waitepeka Canal, must be raised so as to be safe from inundation by a flood at the probable new heights.

(*j.*) All drains now discharging into the river at such levels as would provide a channel for invasion of the adjacent lands by the floods must be provided with flood-gates.

(*k.*) The levees at present protecting Barnego should be raised and made continuous, to the grades and levels shown.

All the levels given are in terms of the Tuapeka Railway survey datum.

With the height of the levees given on the plans it will be seen that the road-bridge over the Matau Branch at Stirling is not sufficiently high. The Commission has not recommended raising it, in view of the fact that it is now a very old bridge, and because, in the opinion of your Commissioners, the community will be justified in accepting the risk of its destruction until such time as it requires rebuilding. When rebuilt it must be constructed at a high-enough level to allow reasonable clearance above the probable maximum flood-slope. If carried away before it is rebuilt it will not jeopardize the other bridge farther down, as owing to the cut at the Balloon Loop the main current of the river, if not the whole of it, will be diverted from that bridge.

Your Commissioners consider that all the land lying between parallel stop-banks, or between any stop-bank and the edge of the river, should be acquired by the controlling authority. This will obviate claims for compensation by the owners of farms in the bends which are to be cut off, while the controlling authority will be able to lease the lands when the works are constructed, probably at very little less than the interest on the cost of their acquisition.

Before any work is put in hand the controlling authority must make a complete survey to enable the levees to be constructed on the best lines, in such a way as to minimize the cost and reduce the flood-levels as much as possible. The flood-levels shown on the plans accompanying this report are based on a limited number of cross-sections; and on the detail survey being made it may appear that by increasing the distances between levees, or by removing some obstruction in the actual channel, a slight lowering of the flood-slope could be obtained. Alternatively, the surveys may result in it being found necessary to raise the levees higher than the grades indicated, but your Commissioners think that the latter is not at all likely.

Provision must be made to absolutely exclude rabbits from the levees around Balclutha, and eternal vigilance must be exercised throughout the district to prevent any of the levees becoming a harbour for rabbits. Otherwise a sense of false security will be engendered.

REFERENCE No. 4.

To ascertain the nature and extent of any drainage-works that may be required, and the best method of carrying out such works.

The river-protection works recommended in the foregoing paragraphs under reference No. 3 will not render the position as regards drainage any different from what it is at the present time. In other words, they will not render any more drainage-works necessary. Consequently, your Commissioners have not gone exhaustively into the question of drainage.

At least three of the subdivisions of the district—viz., Barnego, Otanomomo, and the lakes district—require improvement of drainage to a greater or less extent, and the same can apparently be provided without great difficulty.

At Barnego one main drain is required, approximately as indicated, running through the lowest ground, but the levels of the land are so even that this drain can be varied in position to suit the subdivisions or internal fences.

At Otanomomo the old channel of the Waitepeka should be opened up and a system of branch drains connected thereto. Here, again, the levels of the ground are such that the positions of the drains will be governed more by the farming operations and subdivisions than by any natural features.

The draining of the lakes district is a very complex problem. Possibly something on the lines of a contour channel on the seaward side of the lakes, picking up Lovell's Creek and carrying off the drainage from something over fifty square miles, would deal with the greater part of the water, while that on the other side of the contour channel, embracing most of what is lake now, could be dealt with by pumps of moderate dimensions. Owing to the position of the Taratu Coal Company's railway-line it would be advisable to place this line on top of the levee, which would constitute the lake side of the contour channel, or to divert the railway-line so as to connect with the New Zealand Coal and Oil Company's private line at or near Kaitangata.

The body carrying out the necessary drainage-works should be a Drainage Board elected from that portion of the river district affected, and these Drainage Board areas should coincide with the river ridings described later.

REFERENCE No. 5.

(*a.*) *To furnish estimates of the cost of such remedial measures as you may recommend should be taken for the effective control and improvement of the said rivers and their banks.*

Your Commissioners estimate the cost of the remedial measures recommended by them under reference No. 3 at £165,000. This estimate is based on earthwork at 1s. 6d. per cubic yard.

(*b.*) *To report, in the case of each river, what area or areas of land should be constituted a district in respect of which a rate may be levied to secure and pay the interest on and provide a fund for the repayment of any loan that may be raised to carry out any river-improvement works which you may recommend should be undertaken.*

The areas recommended to be constituted a district in respect of which a rate may be levied to secure and pay the interest on and provide a fund for the repayment of any loan that may be raised to carry out the river-improvement works recommended by your Commissioners are as follows: The portion of Barnego Settlement coloured yellow, the whole of Balclutha Borough, the whole of Inch-Clutha, the whole of the lakes district, the whole of Otanomomo district, and the whole of Kaitangata Borough, all as shown on plan No. 5.

Each of the above districts should contribute in the following proportion to the capital expenditure required to build the whole of the works:—

	Per Cent.
Barnego	3
Balclutha Borough	14
Inch-Clutha	20
Lakes district	10
Otanomomo district	9
Kaitangata Borough	4
	60

These proportions are based on the economic value of the protection to each district.

The cost of maintenance shall be borne by the following interests in the respective proportions set out hereunder, viz. :—

	Per Cent.
Barnego	4
Balclutha Borough	22
Inch-Clutha	31
Lakes district	16
Otanomomo district	15
Kaitangata Borough	6
Coal-mines	6

The General Government shall not contribute to the maintenance of the works.

Your Commissioners recommend that the rating should be on the capital value of all rateable property within the areas specified.

As in each of the areas specified some portions receive more benefit from flood-protection works than others, and other portions may receive no direct benefit at all, it is recommended that the rating be graduated, as defined in the River Boards Act, such areas as receive no benefit to pay no rates. The fixing of the rates in each area should be the duty of the controlling body hereafter described.

Your Commissioners recommend that the balance over and above the 60 per cent. as above be contributed as follows :—

	Per Cent.
Coal-mines	4
Railway Department	3
General Government	33
	40

(*c.*) *To report your opinion as to what matters, if any, should be adjusted by legislation.*

Your Commissioners consider that the whole of their findings, as set forth in this report, should be enacted in special legislation, to be called the Clutha River Improvement Act.

(*d.*) *Generally, to report your opinion on all matters arising out of or touching the premises, including the question as to whether or not one or more competent authorities shall be appointed to control the whole or any portion of the said river, and what statutory powers should be possessed by such authority.*

Your Commissioners consider that for the purpose of carrying out the works described generally in their recommendations under reference No. 3, and ensuring their proper maintenance in the future, also for the proper control of the river, and for the better protection of the interests of the whole community, one controlling authority should be appointed.

The district to be controlled, and over which rates shall be struck to raise portion of the moneys required for the protection-works, shall comprise the whole of the six areas referred to under reference No. 5 (*b*), and this district shall be termed " The Lower Clutha River Trust District."

Each of the areas comprising the district shall be termed a " river riding."

The Trust shall be composed of six local representatives, one member being elected from each riding, and also of two Government representatives, called " River Commissioners," appointed for three years by the Minister of Public Works, one of the Government representatives being preferably a Stipendiary Magistrate or some person fully qualified and experienced in local-body work, and the other an engineer with expert knowledge of river-control.

Your Commissioners further recommend that the duties of this controlling authority be clearly set out as follows :—

(1.) To have detail surveys, plans, estimates, and specifications made for carrying out the works recommended above. These plans shall be approved by the Government nominees on the Trust.

(2.) To assess the total sum to be derived from each riding in the proportion recommended, and to fix the rates on all properties in each river riding, in the ratios of the benefits to be derived, according to the principles laid down in the River Boards Act.

(3.) To submit the proposals to the ratepayers and obtain their authority by poll to raise the necessary loan.
(4.) To carry out the necessary work, either by contract or direct labour, in as expeditious a manner as possible.
(5.) To maintain the works efficiently, and to do whatever extra work may be necessary to improve the regimen of the river and secure the fullest protection for their district from floods.
(6.) To take all necessary observations and keep records that will assist in the study of the hydrology of the river, changes in its regimen, heights and duration of floods, &c.

The Trust should have all the powers of a local body, and, further, should have absolute jurisdiction over the channel and banks of the river, inasmuch as proposals for all drains emptying into the river, all locks, tide-gates, bridges, ferries, wharves, &c., shall be submitted to and approved by the Trust before being carried out. No planting or cutting of willows shall be done except by the Trust.

Drainage: Each of the ridings mentioned may be formed into a Drainage Board to do the drainage-work of its riding, and may obtain reports, plans, and estimates of drainage-works required, from the River Trust. The Drainage Board shall then proceed to raise the money from its area, and, having done so, shall carry out the work itself or request the River Trust to do so. The maintenance of the drainage-works shall be done by the Drainage Board.

Government nominees: The River Commissioners may be appointed as Government representatives on any River Trust similarly constituted, and they shall report progress to the Minister of Public Works after each meeting of the River Trust. It shall also be their duty to see that all valuable data are collected and forwarded to Wellington for embodying in the Government archives.

Insurance fund: Your Commissioners consider that the following sums should be paid by the various interests, in the proportions set out below, towards an insurance fund; the sums to be set aside annually and invested in a similar way to that in which sinking funds are controlled, as an insurance fund from which shall be met the cost of repairing or paying for any damage, not including damage to river-protection works, which may occur by reason of the possible failure of the works:—

	£
Barnego	20
Balclutha Borough	100
Inch-Clutha	160
Lakes district	80
Otanomomo district	70
Kaitangata Borough	30
Coal-mines	30
General Government	110
	£600

This suggestion is on similar lines to that made by your Commissioners in their report on the Maerewhenua River problem. It is recognized that any work of man, however well maintained, cannot be considered as absolutely infallible. While your Commissioners consider that their recommendations will enable any flood such as has been experienced hitherto to be safely passed, nevertheless failure might occur by reason of faulty maintenance, a flood of unprecedented magnitude, sudden erosion due to a change of direction of current during a flood, or other cause. Should such failure occur certain of those intended to be protected will suffer much greater damage than others, and it is to recompense them for this, and to make the sacrifice equitable, that the insurance fund is recommended. It has nothing to do with expenditure incurred for the restoration of river-protection works which may be damaged.

The moneys for this insurance fund shall be collected by the Lower Clutha River Trust, and shall be invested as before mentioned. On the receipt of claims for damages the Trust shall have an investigation made by a Stipendiary Magistrate assisted by two assessors to be selected by the Stipendiary Magistrate, preferably

one a civil engineer and the other a farmer. The Stipendiary Magistrate shall call such evidence and take such steps as he considers necessary, and advise the Trust as to the amount to be paid out in respect of each claim, and the Trust shall make the disbursements accordingly.

In the event of damage being done greater than the amount of money in the fund, then the claims shall be paid *pro rata* from the amount available in the fund, and such payments shall extinguish all liability then existing. In other words, no claims shall be carried forward as a charge against other moneys to be accumulated.

This our report, which has been unanimously adopted, we have the honour to respectfully submit for the consideration of Your Excellency, together with the transcript of the evidence taken by us in the course of our investigations, and the following plans illustrating our report:—

Plan No. 1: Plan showing position of cross-sections taken to compute flood-discharge. (Scale, 20 chains = 1 inch.)

Plan No. 2: Plan showing proposed levees and river-diversions. (Scale, 20 chains = 1 inch.)

Plan No. 3: Longitudinal section showing approximate ground-levels and proposed levee-grades, Matau Branch. (Scales — horizontal, 40 chains = 1 inch; vertical, 4 feet = 1 inch.) Also typical cross-sections of proposed levees. (Scale, 10 feet = 1 inch.)

Plan No. 4: Longitudinal section showing approximate ground-levels and proposed levee-grades, Koau Branch. (Scales — horizontal, 40 chains = 1 inch; vertical, 4 feet = 1 inch.)

Plan No. 5: Lithograph showing flooded area, rating-area, and proposed subdivisions. (Scale, 1 mile = 1 inch.)

Plan No. 6: Longitudinal section, Clutha River, from Hawea to the sea, showing flood-levels, &c. (Scales—horizontal, 10 miles = 1 inch; vertical, 100 feet = 1 inch.)

Plan No. 7: Graphs showing rise and fall of floods at various points. (Scales—vertical, 10 feet = 1 inch; horizontal, 1 day = 1 inch.)

Plans 1 to 7 are recorded in the office of the Hon. Minister of Public Works as P.W.D. 48357.

In addition to the plans which accompany the report a large number of plans have been prepared and are now lodged in the office of the Minister of Public Works, recorded as P.W.D. 48330. These consist of, *inter alia*, cross-sections of Clutha River (twenty sheets), including one at Clyde with details of flood-flow, and another with particulars of flood-heights as recorded on the railway and road bridges at Balclutha; diagrammatic section of the railways within the area subject to flood; section along both branches from Balclutha to the sea, showing bottom of river, low-water level, ground-level, flood-levels, and levees; plan and section in vicinity of Pomahaka Bridge which was carried away during the flood of 1917, prepared for the purpose of computing flood-discharge; plan showing the position of cross-sections taken at Begg's, Pukeawa; plan showing the position of cross-sections taken at Clydevale; cross-sections, Balclutha protective levee, showing flood-levels and leaks through bank; graph showing gauge-readings at Balclutha traffic-bridge during duration of survey; plan showing levels of Barnego Flat; plan of Tuakitoto and Kaitangata Lakes district, showing flooded areas, contours, &c.; plan of Waitepeka Canal diversion, showing levels of land damaged in floods of May and September, 1917; particulars of old bridge at Roxburgh, built in 1875 and carried away by the flood of 1878, showing rises in the low-water surface; graph showing rainfall at Clyde for the period 1906–19; plan of Balclutha to the sea, showing existing levees, erosions, ground-levels, and position of cross-sections, &c.

Given under our hands and seals, this 19th day of March, 1920.

F. W. FURKERT, Chairman.
ASHLEY J. HUNTER,
F. C. HAY, } Commissioners.

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