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ORARI AND WAIHI RIVERS IMPROVEMENT

(REPORT ON) BY INSPECTING ENGINEER, PUBLIC WORKS DEPARTMENT.

Laid on the Table of the House of Representatives by Leave.

Wellington, 1st May, 1915.

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ACTING under instructions from the Hon. F. H. D. Bell, Minister of Internal Affairs, I visited the country drained and flooded by the Orari and Waihi Rivers in Canterbury, and examined the beds of both streams from their mouths up to the mountains in which they rise.

The Orari River is much the larger, draining 220 square miles above the railway-bridge (over 200 of these are above Blair's Road). The Waihi drains approximately sixty-five square miles, about forty of which are above Geraldine. In addition to the difference in their drainage area the flow in the Orari is in the spring-time much augmented by melting snow, which, if synchronizing with heavy rain, causes severe floods. The Waihi is not much affected by melting snow, but, being a shorter stream with smaller watershed, is subject to rain-floods more intense in relation to its drainage area than the Orari.

Both rivers possess the peculiar characteristic that in normal times their flows get smaller as they leave the hills and approach their mouths for a certain distance, and then increase slightly again. This may be so marked that after leaving the hills a certain distance they may become quite dry for a number of miles, and then a small stream appears again, and various springs augment their flow, until at their mouths they always have a considerable flow. This peculiar behaviour is due to the materials of which the greater portion of the Canterbury Plains is composed, and which form the beds of the streams in question. A portion of the water sinks in the coarse shingle as the streams flow on, until at some point (depending on the initial quantity and the porousness of the shingle) it has all disappeared. Farther down the shingle becomes finer and impervious layers force the water, or a portion of it, again to the surface as springs, and thus partially restore the flow.

In times of high flood the volume of water discharged from the hills is very much larger: the shingle is probably already soaked by the local rains, and consequently the flood-waters cannot sink into it, and the stream is augmented by the rain actually falling on the lower plain. The result of these causes is that in flood-times the diminution referred to in the previous paragraph is replaced by an actual increase in the flow. Other smaller floods may show a slight diminution, or a steady flow or increase according to the relative intensity with which the above cause may be acting.

A further disturbing element in these streams is the shingle being brought down from the hills. Examination of these and other shingle rivers has shown that avalanches or other spasmodic causes sometimes deliver into the bed of the river vast masses of shingle beyond what is always being brought into them by the ordinary regular agencies of denudation. These spasmodic accumulations of debris are carried forward by the rivers more or less in the form of a wave, which gradually flattens out and is lost in the general travel of shingle, if we follow it far enough down the river. In exceptional cases it is possible that this wave may reach the mouth. What I have called a "wave" is often spoken of as a "bar" of shingle. The rate at which it moves down the river is slow, and may occupy years before it is disposed of: it all depends on the magnitude of the initial disturbance.

The immediate result of the progress of these waves of shingle is to cause variations of the flood-level, abnormally raising it at the point and above where the crest of the wave occurs. Thus banks, whether natural or artificial, which have always proved of ample height for safety may be overtopped by a flood carrying perhaps less water than those which have been safely passed in years gone by.

It has been suggested—and, I think, with reason—that the depredations of the rabbits and other stock, and more especially the practice of burning off the natural vegetable covering of the ground (tussock particularly), has caused much more detritus to be carried into the river-beds than was the case in years gone by. All the evidence of old settlers is to the effect that the rivers now carry more shingle than they did when the land was first settled.

The gradual filling-up of the river-beds results ultimately (in the absence of remedial measures, natural or artificial) in a change of course, the water flowing into a lower channel or one offering a less encumbered passage, and then proceeding to fill it up and shift again, and so on. This results in the formation of flood-plains, such as Canterbury, which is covered in all directions by either live, dead, or moribund river-channels.

Old maps show that when the Canterbury Development Company first explored the country the Orari River flowed through a depression which still to some extent exists near the Geraldine Racecourse, and did not have any defined flow along its present bed below this point.

Now that settlement has extended over all the available land it becomes a serious matter when a river threatens to change its course.

It appears that about 1871 the Orari River overflowed its banks and threatened all the land lying to the south of its present course between the railway and the sea as far from the river as the high ground along the Winchester Beach Road. The occupiers of this land had the district constituted as the South Orari River District in 1872, raised money and carried out remedial measures, which were so far successful that the river has ever since remained in its proper channel. Unfortunately, for some years past this Board has levied no rates, and entirely discontinued the work of maintenance.

In 1902 the river again overflowed its banks, this time just below the road-bridge, six miles above the railway, and flowed into the Waihi River and thence into the Hachaetemoana, severely flooding the Town of Temuka and the country between it and the point of overflow for a width of from two to three miles. This flooded and threatened district was promptly formed into the Upper Orari River District in 1903, and the Board erected defences, and since then has suffered no damage from the river.

More recently the river showed an inclination to break over about two miles above the railway, and protective works have just been erected there.

It is impossible now to say how much of the past immunity from damage has been due to the works erected, and how much to the absence of exceptional floods and the passing-away of the waves of shingle (previously referred to), which probably largely contributed to the overflow in the first instance.

Local government in the district is rather involved. The whole is included within the boundaries of the Geraldine County Council. The County Council, however, does practically nothing beyond maintaining the bridges which are over 30 ft. in length. The control of the county affairs is divided between three Road Boards, two River Boards, and the County Council. None of these local bodies employs an engineer, and there appears to have always been a diversity of opinion amongst the various authorities as to where the responsibilities of one began and another ended. In the absence of expert engineering advice the local authorities have failed to realize the importance of proper maintenance, and of making all work conform to a comprehensive scheme.

Probably over twenty years ago the value of willows for protective work began to be realized, and when local erosion threatened or had taken place willows were planted sometimes successfully, sometimes not. As they grew they were cut, and frequently (by the careless or ignorant) thrown into the river. These cuttings, and also whole trees which were torn out by the further erosion of the river-banks, were carried down by the floods and deposited wherever an obstruction occurred, and particularly where the current slackened in the lower reaches. They immediately took root and spread; shingle and silt deposited around them through which they continued to grow, thus constantly and in some instances rapidly raising the bed of the river beyond the other causes outlined above. The willows coming down from above have been attributed by the lower owners to different persons or local bodies, and owing to everybody disclaiming responsibility the willows were not removed. The proper channel being blocked or excessively raised, the river naturally flows to the side and erodes the same. This has repeatedly happened, and the individual settlers and sometimes the local authorities have attempted protective works, but without removing the cause, consequently these efforts have not always been successful.

Another fruitful cause of trouble has been the action of the Government in leasing the beds of the streams and thus practically permitting lessees to fence across the stream (otherwise their leases would be valueless). These fences were frequently constructed with willow posts and stakes, which grew, and have in places formed an almost impenetrable barrier across the river-bed, forcing the streams elsewhere. This latter applies more especially to the Waihi Stream. The Orari, being the fiercer river, has been generally beyond the resources of the individual owners, and consequently has been able to greatly widen its bed by erosion of the original banks. This has resulted in furnishing a wider field for the growth of willows, has caused the stream to be shallower, and consequently of lower velocity, and has permitted the deposit of still more shingle.

It will be seen from this that the trouble, unless soon coped with vigorously, tends to become aggravated in a constantly increasing ratio.

Some of the interested parties made a point of the fact that no shingle now reaches the lagoon at the mouth of the Orari. But I doubt if much, if any, ever did. By the time the detritus reaches the sea it is reduced by natural attrition to sand or very small shingle. The grade in the lower reaches is too flat to allow of any but fine material reaching the lagoon. If more shingle is being delivered from the hills than can be ground up by the river before it reaches the sea, then the inevitable result must be the raising of the bed until a uniform grade sufficiently steep to enable the water to carry shingle is formed from the hills to the sea. This need not be greatly feared for many years.

On the Waihi River, the actual fine-weather channel growing steadily smaller as it approached its mouth, the land when subdivided for settlement was pegged up to the edge of this constantly narrowing channel.

The settlers, in order to preserve their land from erosion, planted thick willow fences along their boundaries, and in places I believe even encroached on the already too narrow waterway. These fences, even had they been kept within control, from their too close proximity to one another must have resulted in the flooding of the land unless very high and secure banks had been constructed—which was not the case. Lately the position has become so acute that the Upper Orari River Board, acting under the authority of clause 7 of the Land Drainage Amendment Act, 1913, has served notices on a number of occupiers adjoining the Waihi River, calling upon them to clear out all obstructions, whether willows, gravel, or material of any kind, from the centre of the bed of the river to a line 10 ft. back from the banks. When only one occupier complied with the notice the Board instituted legal proceedings against those objecting, and when I visited the district the cases were still *sub judice*.

It seems to me that it will be very difficult to compel occupiers to carry out clearing-work at their individual expense which will be of benefit to the land below over a considerable area,

especially when it is borne in mind that some of the present occupiers have only been in possession a short time and are in no way morally responsible for the present condition of the river-bed. Quite probably there are some settlers who by their carelessness or wanton disregard of ordinary precautions are primarily responsible for the condition of things along their own sections, but this would be a difficult matter to prove in view especially of the fact that it is well known that local bodies have planted willows higher up and have allowed them to be washed out and carried down the river, and have also, according to common report, trimmed the overhanging willows and allowed the cut-off branches to float down and take root elsewhere. Also, matters having been allowed to reach the present desperate pass without the riverside occupiers being compelled to effect remedial measures, it is questionable whether it would be fair to now demand that they should carry out work which may be financially beyond their resources, and which, as mentioned above, is not solely for their own benefit. Should this view be upheld and future work done by the district as a whole, then any occupiers who complied with the notices and cleared the creek at their own expense should have the value of work refunded to them.

So far no riverside occupier on the Orari has been served with notices to clear, partly because the area within the jurisdiction of the South Orari River Board is bounded by the south bank of the Orari River as it existed in 1872, and there is doubt as to whether the sentence in clause 7 aforesaid, "or within one mile beyond the boundary of the district," can be interpreted to mean one mile in any direction outside the legal boundaries or "only one mile beyond" measured along a watercourse flowing into or out of the district and which requires clearing. In addition it is probably clear to the Board that it would be unwise to clear out all the willows from the bed and banks, thereby rendering the banks liable to attack and widening the river-bed, which is already too wide. And apparently the Act makes no provision for calling upon an occupier to remove a portion of the obstruction or certain specific trees, &c.

Before it will be possible to design proper remedial measures a complete survey will be required showing the present beds of the streams, indicating where erosion has already taken place, also accretion, if any, and also the position and character of the obstructions. Cross-sections of the beds and the adjacent banks for some distance back, particularly when same are below flood-level, will be required, also longitudinal sections of the streams properly connected to the cross-sections and plans. Further, a small scale plan will be required with isolated levels freely scattered over it, showing all the areas which have been and which might be flooded in the event of either of the major streams overflowing or changing their courses. Flood-levels wherever obtainable either from direct observation or from local evidence must be collected, the two kinds being distinguished from one another. Any other obtainable data *re* floods, such as velocity, duration, relation to rainfall, &c., should be collected, and rainfall and snowfall data within or adjacent to the watersheds compared therewith. Particulars of all the types of protective work employed and their locations should be collected, with information as to which have proved most successful, and the probable reasons for the failure of those unsuccessful.

While this survey is being made steps should be taken to abolish the Road and River Boards and to place all the questions of river-conservation and roading under the County Council, which should engage the service of a properly qualified civil engineer.

When the survey is complete a minimum width consistent with safety and economy should be decided on for each stream, and an alignment as straight as possible consistent with making good use of the existing clear channels should be fixed and pegged out, all future work being carried out in conformity with this scheme.

In connection with the Waihi Stream, it will be necessary in parts to construct banks at a little distance back from the existing channel-banks, and to entirely clear out all fences, willows, and other obstructing vegetation within the constructed banks. No doubt there will be opposition from the adjoining occupiers, but if the banks are constructed with flat slopes and sown with grass they can be used for grazing as well as or better than the present damp flats; and while the land within the banks will be subject to no more flooding than before, and for a shorter time, the land outside the bank will be entirely flood-free and can be used for cropping, and will be enhanced in value by reason of its immunity from floods by £10 per acre, or perhaps more.

In the lower reaches it will probably be necessary to return the protective banks some distance along the sides of some tributary streams, and also the Haehaetemoana, in order to prevent flood-waters getting behind the banks. The extent to which this would be necessary can only be settled by accurate surveys.

Although the Haehaetemoana did not come within my order of reference, it will be necessary to deal with it for some distance above and below the junction with the Waihi in much the same manner.

In connection with the Orari quite an opposite course will be necessary: that is, the river-bed will require narrowing. In some places flood-banks will probably be required, and as the present river-bed is lower than the natural banks, and too porous to serve as a satisfactory base for a bank at moderate cost, it may be necessary to build banks temporarily at least on the land adjoining the river until such time as the banks are permanently fixed at the locations decided upon. All the river-bed within the future permanent bed should be cleared of willows, &c. All those which can be at reasonable cost pulled up should be planted along the new bank-lines, and made the nucleus of the continuous protective work which will be finally necessary. Those which, by reason of their being deeply buried or their enormous size, cannot be profitably removed should be killed *in situ* by the same process as was used on the Waihou and Ohinemuri Rivers improvement-work, and later on impregnated with paraffin or other inflammable liquid and burnt. To burn off the tops only would not be sufficient.

The central channel having been cleared more or less completely, systematic planting of dense willow fences should be carried out as probably the cheapest form of permanent protection. It is quite likely that portions of this will be washed out in the early stages, but when once established it should prove sufficient to keep the river within the cleared channel. It therefore would hardly be economical to build strong and therefore expensive works which would be capable of withstanding all onslaughts of the river from the commencement. As the work proceeds it will be found advisable no doubt to specially strengthen spots where the current is making a

determined onslaught. These should be backed by willow work also. The slackening of the current due to the willows will induce the deposit of silt and debris, and thus gradually the banks will be built up by natural processes, while the bed being narrowed may be expected to sink somewhat, so that in time all the land between the new-formed stream-boundaries and the present banks will become flood-free and fit for use. To guard against such damage as would occur if the river got behind the new banks through a local breach it will be necessary to erect protection at intervals transversely to the general course of the river between the new banks and the old. At present it is valued just for such rough grazing as it contains at £2 per acre, and when properly protected and planted for a few years with some such growth as lupins should become considerably more valuable. Even if only used for the growth of willows or other timber for firewood it would serve a very useful purpose. From information supplied to me by one settler it appears that there is a good market for willow firewood at remunerative rates.

When the new banks have been decided on, the area of this land up to present banks, if beyond the lines of the original freehold, should be vested in the adjoining owners at a price to be fixed if necessary by arbitration, while any land which it may be necessary, by reason of straightening, to include in permanent river-bed should be paid for at prices to be similarly fixed, using the moneys obtained from the surplus land mentioned immediately before this.

On this river very successful work has been carried out by Mr. McDonald, of Orari, and he has expressed himself as prepared to construct further protective works out to the lines which may be fixed by the Government as the final permanent bank, always provided that he is not expected to proceed immediately to a completion, but is allowed a reasonable time to work progressively, and has the reclaimed land vested in him as suggested above. This seems a good offer, and should any of the other settlers be prepared to do similarly they might with advantage be allowed to do so, taking care, however, that there is some guarantee that the work will be done within a reasonable time and in accordance with a system which has the approval of the Department.

The case of Mr. McDonald possesses peculiar features in that the erosion of his land would have only a small effect on other settlers (through unduly widening the river-bed); also if the river overflows its banks along his land, which it can only do to a limited extent, the water only damages his land and returns to the river within a short distance, owing to the configuration of the ground; and also he has already carried out such effective work that during the past twelve years no erosion has taken place along his river-bank.

One of the chief questions in connection with this protective work will be the financial one—who is to pay, and how much? I think that when the surveys above referred to are completed it will be possible to lay down what lands are vitally affected, which affected to a minor degree, and which are only consequentially affected. These lands should be then rated in accordance with the degree of their interests to provide security for a loan to carry out the work. As the county as a whole must indirectly benefit by any extensive improvement in the rivers and consequent improved productivity of the lands, it should out of its general funds provide a portion of the necessary money. Also, as the Dominion as a whole will benefit in a still more indirect manner, the General Government might with propriety assist, especially as the Crown owns certain lands within the threatened or damaged areas which would not contribute through the general rates. Before rates were actually struck prospective ratepayers would, of course, have an opportunity of being heard. The fact that the Upper Orari River Board's area is already classified as first, second, and third class for purposes of rating should make matters easier. The value of the land within the present river districts is roughly £1,000,000.

Should there be any hitch in the County Council immediately proceeding with the necessary surveys, the Government might undertake the same on the understanding that the cost was recovered later from the moneys raised for purposes of executing the work or from the Government's subsidy thereon.

When the survey and collection of information is completed the Public Works Department should draw up a general plan of works which will be necessary, with sufficient detail plans to enable an estimate of the cost to be arrived at.

The necessary money having been raised, the work could be carried out either by the Department or by the county (provided they employed a qualified engineer) under the general supervision of the Department. It may prove necessary as works proceed to somewhat modify details of the work, but this should be done only after the circumstances and fresh designs have been approved by the Department.

In conclusion, my opinion is that even if it cannot be actually shown by figures that the immediate enhancement of the properties will equal the capital cost necessary for the works of preservation and restoration, nevertheless the duty devolves on the local authorities, and more so on the General Government, to see that the lands of the Dominion are not allowed to be destroyed while there is still a chance to save them at reasonable cost. Further, it must be recollected that if delayed the necessity for remedial measures will become more acute and finally imperative, while the cost of same will constantly increase. This is very good exemplification of the old adage, "A stitch in time saves nine."

I have to thank the gentlemen who met me at Orari, and also at various points along the lines of my investigations, and assisted me with local information and otherwise, and those particularly who at considerable inconvenience to themselves met me at an informal conference at Temuka and thoroughly discussed the matter.

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