Lower Waitaki River Control Scheme Review

Options Report

Report No. R13/
ISBN 978-1- (print)
978-1- (web)

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March 2015

Environment Canterbury
Regional Council
Kaunihera Taiao ki Waitaha

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Report R13/
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Executive summary

Increasing costs and consequent rate increases, together with a high financial account deficit and significantly different local share contributions levied on Canterbury Regional Council and Otago Regional Council ratepayers, have resulted in requests for a strategy review of the Lower Waitaki River Scheme.

This report sets out the current objectives, problems, goals of the review, a description of the scheme, land use, catchment character and flood hydrology, river morphology, scheme administration, the current management approach, and concludes with a recommended option to provide a basis for community consultation.

Table of contents

List of Figures

List of Tables

1 Introduction

The Lower Waitaki River Scheme Liaison Committee requested that an updated strategy be developed for management of flood protection and erosion control expenditure on the Lower Waitaki River because of the costs and the accrued debt associated with the current approach.

In addition, the Otago Regional Council has expressed concerns regarding the current strategy and the financial implications for its ratepayers on the south side of the river east of Georgetown.

The last such strategy re-visit was the "River Control on the Lower Waitaki River - Sectional Plan", developed by the Waitaki Catchment Commission and Regional Water Board in 1989.

1.1 Current objectives

The Scheme management objectives are to:

- Maintain a cleared fairway below the Waitaki Dam 400 metres wide at Kurow and increasing to 700 metres at the coast.
- Maintain an active riverbed generally 1000 metres wide at Kurow and increasing to 1300 metres at the coast.
- Limit erosion of the active bed vegetated margins.

Scheme maintenance works aim to provide:

- The containment of flows up to 800 $m^3.s^{-1}$ within the cleared fairway and 1700 $m^3.s^{-1}$ within the river system (fairway plus vegetated berms).
- Minimisation, within financial constraints, of lateral erosion directly affecting developed farmland.

1.2 Current problems

The annual costs of the above approach and the high debt load that exists following a series of damaging flood events.

1.3 Goal of review

The goal of this investigation is to review the methods of river control and riparian management originally developed in the 1989 Sectional Plan (the last re-visit) using the principles of NZS 9401:2008 as a guide.

These methods are currently used in a modified form.

The principles include requirements to:

- Engage communities throughout the process.
- Understand the natural systems and processes.
- Appreciate catchment-wide interaction of natural and social systems.
- Undertake decision-making at the local level to balance private and public interests.
- Consider all forms and levels of management.
- Recognise residual risk (and monitor and report on it).

1.4 Scheme description

The Lower Waitaki River Scheme involves a 65 km length of river extending from downstream of the Waitaki Dam (near Kurow) to the Pacific Ocean at Glenavy.

Photo 1-1: The Waitaki Dam

Photo 1-2: The Waitaki mouth

The catchment area of the Waitaki River is 9,700 km^2 at the Waitaki Dam and 12,000 km^2 at the coast.

The total Scheme asset value is $11.6m (2011), made up of $9.7m of berm vegetation and $1.9m of groynes and ponding banks.

The capital value of the area benefitting from the Scheme is $351m (2012), $191m of which is in the Canterbury region and the remaining $160m in the Otago region.

The Regional boundary, by and large, follows the south bank of the river from the coast to Georgetown, some 25 km inland, before then heading south along Goulding Rd (see blue line on Fig 4-1). All the north bank land and the south bank upstream of Georgetown is within the Canterbury Region.

Land on the south bank downstream of Georgetown is generally within the Otago Region.

Separate Rating Districts are in place for each Region.

They use the same classification basis but have different Regional catchment works funding policies.

Within Canterbury the targeted rate is supported with a General Rate and Works & Services rating contribution, whereas in Otago the costs are fully funded by targeted rate.

Meridian Energy makes a significant Scheme funding contribution as discussed in the "Scheme Rating Classification and Funding" Section further on.

1.5 Land use

The river has an "active bed" made up of a cleared fairway (600-800 m wide) and a vegetation buffer zone (heavy willow growth typically 50 to 500 m wide on either side).

Extending beyond the active bed are berm lands and floodplain areas bounded by terraces or hill toes.

Farming activities have generally been confined to these floodplain areas, although in several locations these activities have extended into the landward margins of the active riverbed.

Development of this kind is usually preceded by the clearance of willow, gorse and broom, followed by cultivation to establish crops or grasses.

Increasingly, land development has included border dyke or centre-pivot spray irrigation.

Intensive farming within the active bed is undesirable, because the removal of vegetation buffers increases flood and erosion risk to the adjoining floodplain and increases Scheme maintenance costs.

Whilst the developer might increase their farm productivity in the short term, the effects of increased erosion and flooding can offset these gains and often extend beyond their boundary to affect adjacent and downstream properties and public infrastructure.

For higher flows, flooding onto berm lands beyond the active bed is likely. Overflows are likely to seek out and follow old river channels that weave their way down the berm areas (swales). The greatest risk is not the flooding in itself, but the possibility that the outflows will erode the land and occupy the swales to the extent that the old channel redevelops.

Photo 1-3: Farm encroachment onto berm lands

Photo 1-4: Farm development on berm lands

The redeveloped channel can isolate sections of berm land, eventually reclaiming them into the active bed through the combined processes of erosion and deposition.

On the opposite bank, (or, in the absence of fairway clearance, on islands), temporary abandonment of roughly equivalent areas of riverbed may occur, which in time vegetates to provide new berm land.

2 Catchment character and flood hydrology

2.1 Catchment geology

The Waitaki River drains around 12,000 km^2 of the eastern side of the Southern Alps.

Tributary rivers and glaciers drain into the large lakes of Tekapo, Pukaki and Ohau in the Mackenzie basin, which trap the sediment output from the Southern Alps and store flood waters.

Below these lakes, the river flows through the ranges of greywacke on the northern side and schist on the southern side, then through the hydro lakes of Benmore, Aviemore and Waitaki.

Between the Waitaki Dam and Kurow, the river forms a single channel within a gorge and then widens out into a braided channel and maintains this braided form all the way to its mouth.

There is base rock underlying the river channel at Duntroon and Black Rock.

Downstream of Black Rock, the river grade steepens as the river crosses a large fan extending to the coast.

The Waitaki Fan was formed by the deposition of material mainly carried down from the Mackenzie Basin during the late Quaternary (last 100,000 years or so). A massive supply of glacial outwash was followed by sea-level rise and a decrease in sediment delivery to the coast.

The fan has been shaped at the coast through erosion caused by a rising post-glacial sea-level and a wave environment dominated by large swells and storms generated in the Southern Ocean.

Erosion of the Waitaki coast over the last 7,000 years is attributed to natural processes resulting from coastal adjustments to the post-glacial sea level rise and the development of an equilibrium shore relative to sediment supply and the dominant wave action.

Tributary fans can locally influence channel position, flood levels and erosion processes until the main river reworks those deposits.

2.2 Upper catchment

The Waitaki Basin upstream of the Waitaki Dam has a catchment area of about 9,700 km^2.

The majority of the catchment rainfall occurs during North-Westerly events near the Southern Alps, with the upper tributaries flowing into Lakes Tekapo, Pukaki and Ohau, then via their respective connecting rivers into Lakes Benmore, Aviemore and Waitaki.

The Waitaki Dam mean flow is 358 $m^3.s^{-1}$.

Flood flows from the upper catchment are significantly dampened by natural lake storage as enhanced by the hydro dams.

These hydro dams are Tekapo (generation commenced 1951), Pukaki (1951 for Low Dam, 1979 for High Dam), Ohau (1979), Ruataniwha (1981), Benmore (1965), Aviemore (1968) and Waitaki (1935).

An example of lake storage dampening was the January 1994 flood, which had the largest inflows so far recorded at Lakes Pukaki and Ohau and the second largest inflow at Tekapo.

Inflows of 1,697 $m^3.s^{-1}$ at Tekapo, 3,096 $m^3.s^{-1}$ at Pukaki and 1,606 $m^3.s^{-1}$ at Ohau were absorbed into storage and required no spill flow. A peak flood flow of only 1,514 $m^3.s^{-1}$ was recorded at the Waitaki Dam.

2.3 Lower Waitaki tributaries

The catchment area of the lower Waitaki River tributaries is about 2,300 km^2. The main tributaries are the Hakataramea, Maraewhenua, Awamoko and Otekaieke Rivers. These rivers have a much lower average rainfall than the upper catchment; a combined mean flow of 10.3 $m^3.s^{-1}$ and mean annual flood flow of 240 $m^3.s^{-1}$.

South-westerly rainfall events are the most likely events to cause tributary flooding.

2.4 Lower Waitaki flood hydrology

The flood hydrology of the length of Waitaki River downstream of the Waitaki Dam is dominated by the upper catchment and lakes.

The maximum recorded flow was about 3,000 $m^3.s^{-1}$ during the December 1995 flood, which had an estimated return period approaching 200 years, Hicks (2002).

The largest tributary flood event was that of March 1986, which had a Waitaki Dam flow of 580 $m^3.s^{-1}$ (a normal flow) which when added to the sum of the tributary peak flows (assuming coincidence) gave a potential peak flow of 2,638 $m^3.s^{-1}$. This peak flow approached the record flow recorded at the Waitaki Dam (3,000 $m^3.s^{-1}$).

At least two 1990s reports state that the Waitaki Dam mean annual flood flow has reduced substantially as a result of hydro storage; from about 1,150 $m^3.s^{-1}$ to 900 $m^3.s^{-1}$ in one case and from 1,250 to 800 $m^3.s^{-1}$ in the other - Hicks (2002).

However, Waugh and Payne (2002) did not find any significant change between mean annual flood size in the 1927-2000 period (1,180 $m^3.s^{-1}$) compared to the 1980-2000 period (1,200 $m^3.s^{-1}$).

A brief analysis of the data at Kurow from 1979 to March 2013 (including years with incomplete data) undertaken for this report shows a mean annual flood of about 1,070 $m^3.s^{-1}$.

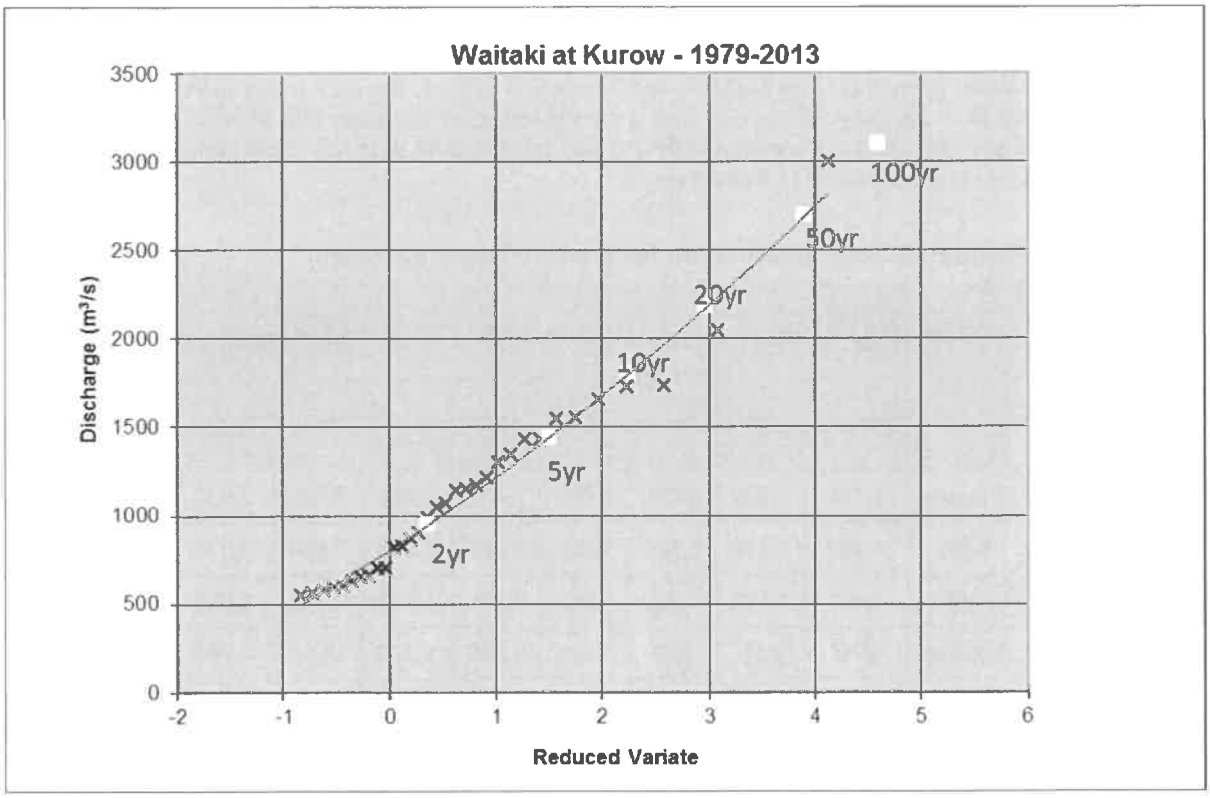


Figure 2-1: Flood Frequency Graph (with 'Return Periods')

The following peak flows over 1500 $m^3.s^{-1}$ have been recorded or estimated at the Kurow recording site over recent years. The return period estimates are based on the data in Figure 2-1.

Table 2-1: Flows over 1500 $m^3.s^{-1}$ at Kurow

Date	Flow ($m^3.s^{-1}$)	Approx. Return Period (years)
26 Nov 1957	1,740	10
17 Sep 1970	1,630	5-10
23 Dec 1984	2,050	20
12 Mar 1987	1,650	5-10
10 Jan 1994	1,550	5
15 Dec 1995	(2,669 – recorder failed 14th Dec) 3000 (Waitaki Dam)	~100
19 May 2009	1,540	5
1 Jan 2011	1,740	10
8 Feb 2011	1,550	5
(12 Jan 2013)	(1,210)	2-5

Note: 15 Dec 1995: 2956 cumecs recorded at Waitaki Dam, assessed as 200yr return period in reports of the time and regarded as the largest flood since 1868.
The flood flows listed in Table 2-1 above are instantaneous peaks.

Table 2-2 below, reproduced from Waugh and Payne (2002), gives flood frequency information for the Waitaki Dam site for the flow record from 1928 to 2000. Annual maximum flows have been fitted, using standard flood frequency distributions, for 3 hourly, 1 day, 7 day and 1 month intervals, with the intervals starting at 1 January 1928. As it is a combination of duration and size of flood peak that causes downstream flooding and erosion effects, this table provides more meaningful information on the flooding and erosion potential of flood events.

Table 2-2: Flood frequency information for Waitaki Dam (1928-2000)

Interval	Return Period							
	Annual	5yr	10yr	20yr	50yr	100yr	200yr	1000yr
3 hourly	1,180	1,520	1,800	2,060	2,410	2,660	2,920	3,510
1 day	1,100	1,430	1,700	1,960	2,290	2,540	2,800	3,370
7 day	900	1,150	1,350	1,550	1,800	1,990	2,180	2,620
1 month	670	840	970	1,090	1,260	1,380	1,500	1,780

The flood events of April and May 2009, January and February 2011 and January 2013 were particularly damaging within the Lower Waitaki River Scheme. The estimated maximum 7 day mean flows for these events are summarised in Table 2.3, along with the estimated return period as taken from Table 2-2.

Table 2-3: Estimated 7 day mean flows and return periods

7 Day Flood Interval	Average Flow (cumecs)	Return Period (years)
29 April to 6 May 2009	1,000	2-5
17 May to 24 May 2009	1,150	5
29 Dec to 5 Jan 2011	1,500	20
5 to 12 Jan 2011	1,140	5
8 to 15 Feb 2011	1,250	5-10
4 to 11 Jan 2013	950	2
11 to 18 Jan 2013	1,050	2-5

The scale of these events are not exceptional when looked at in isolation. They do, however, represent an unusual cluster of events when taken in their entirety. The probability of occurrence of one 20 year and four 5 year return period events in a four year period is low.

Also of significance is that the January 2011 and 2013 events had long duration and square shaped hydrograph peaks (as is common for controlled release flows), which exceeded the mean annual flood flow for a total of 24 days. These long duration steady flows tend to develop a channel form with the majority of the flow locked into a single thread meander pattern.

These flows cause substantial erosion where they impinge directly onto riverbanks.

In general, larger flood flows tend to spread over the whole river bed, with smaller flows tending to develop a braided channel form.

Table 2-4: Waitaki at Kurow – percentage of weeks with average flow over 700 cumecs, 1979-2013

Period	% of weeks with average weekly flow over 700 cumecs (where data is available)
1979-1983	2.3%
1984-1988	3.3%
1989-1993	0.8%
1994-1998	3.1%
1999-2003	0.0%
2004-2008	0.0%
2009-2013	4.1%
1979-2013	Average 1.8%

Table 2-4 illustrates that the 2009-2013 period (data to 31 Mar 2013) had the highest proportion of weekly average flows over 700 $m^3.s^{-1}$ of all the five year periods since Lake Pukaki was raised in 1979. Notably, the proportion was higher (6%) in the 1964-1970 period, which suggests that long duration flows did occur prior to the raising of Lake Pukaki.

In contrast, Table 2-4 also illustrates that 1999-2008 was a relatively quiescent period.

The mean annual flood in this period was 675 cumecs and there were no floods greater than 1,070 cumecs (the mean annual flood for the period 1979-2013).

These drier and wetter periods can also be discerned in Figure 2-2 below.

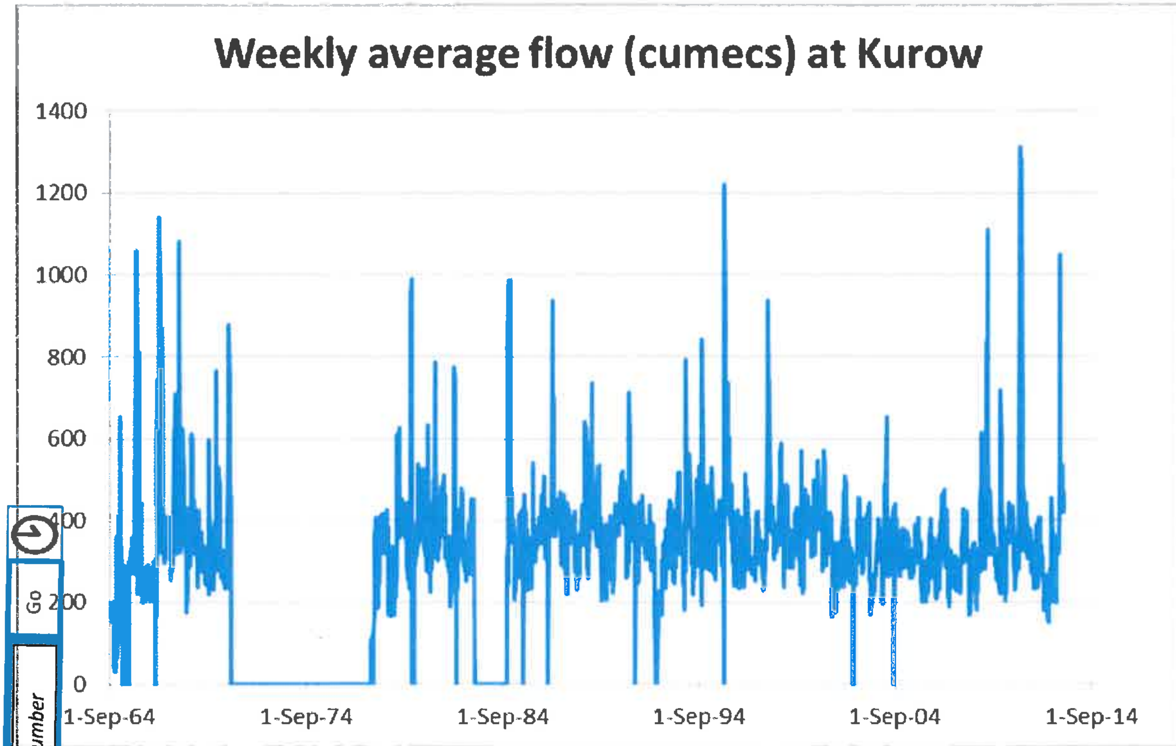


Figure 2-2: Weekly average flow rate at Kurow

Overall, it can be concluded that 2009-2013 has been a period with a relatively large number of sustained high flow events. On average one would expect fewer high flow periods, and consequently less damage and reduced repair costs. These factors need to be taken into consideration when deciding on any future strategy.

3 River morphology

Whilst the Lower Waitaki River is a wide, braided, gravel river similar to others of the large catchments draining the eastern side of the Southern Alps, it has particular characteristics inherited from its morphological past that influence its' behaviour. These behavioural trends have been further modified by the development of hydro storage within the middle and upper reaches of the river's catchment. The glacial and hydro lakes influence the supply of gravel and the flows.

The river passes through a short gorge at Kurow and has built a large alluvial fan up to 30 km wide near the coast.

Coastal retreat has led to a gradual steepening of the fan from Georgetown to the coast and the river has abandoned the higher fan terraces.

The river now occupies a width of up to about 2.2 km in larger floods. A base of rock at Georgetown/ Black Point limits degradation upstream of there.

Hicks (2006):

> *"..from the Kurow Gorge until just upstream of the confluence with the Otekaieke River, the Waitaki channel transitions through a semi-braided pattern into a multi-thread, braided pattern which then remains down to the coast…*
>
> *Overall along the fully braided reach, up to a flow of about 350 m^3/s, the number of channels increases with discharge. The braiding density appears to saturate at about 8-9 channels over the discharge range 350-500 m^3/s, then probably decreases at higher flows as channels merge. Locally, the braiding density fluctuates downriver, following a quasi-regular cycle averaging about 4 km in wavelength. The less densely braided reaches tend to have a few, deep, well armoured channels and display greater stability, while the more densely braided reaches tend to have finer, more mobile bed material and are more dynamic.*
>
> *In profile (Figure 3.3), the river channel slopes at about 1.2 m/km through the Kurow Gorge, then steepens to a uniform grade of 2.73 m/km as far as Georgetown. From Georgetown to the coast, the channels have a uniform grade of 3.23 m/km. The 'hinge point' at Georgetown coincides with outcroppings of Tertiary sedimentary rocks in the river bed... Locally, the water surface and bed slope fluctuate along the main channel at a typical spacing of 500-1000 m associated with the bar-pool morphology. The valley slopes are slightly steeper (e.g., 3.55 m/km downstream from Georgetown).*

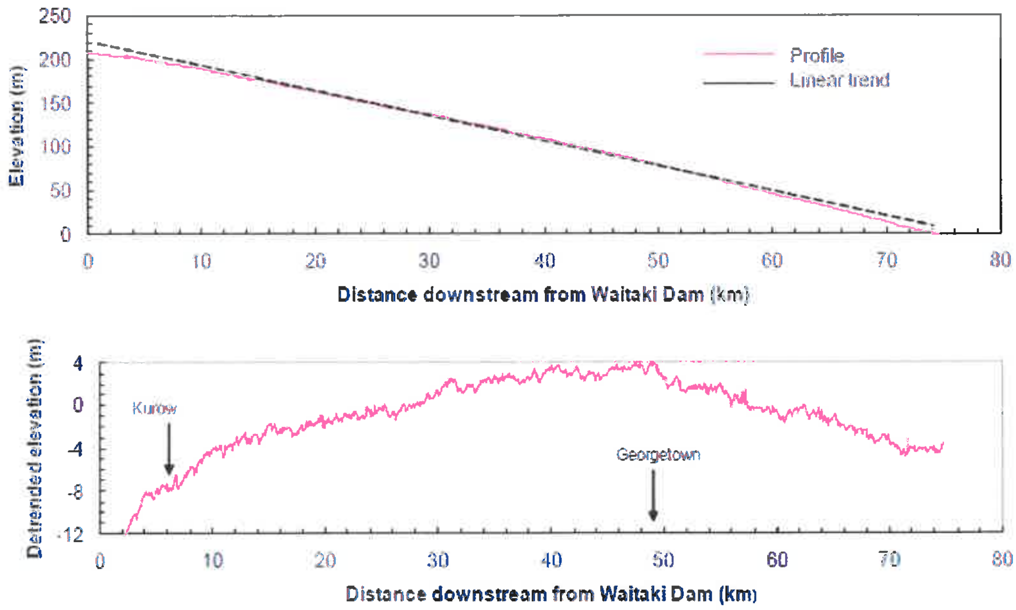


Figure 3.3: Longitudinal profile of water surface of Waitaki main channel between Waitaki Dam and coast, surveyed by LiDAR in 2001. Lower plot shows deviation form linear trend.

3.1 Effects of historical changes in riverbed vegetation and hydro development

Early European settlers first introduced crack willows to the Waitaki Valley as a source of shelter and fuel (Hall, 1984).

However, Thompson *et al.* (1997) described the riverbed in 1943 as:

> *"largely bare and windswept, up to 2km wide, with extensive areas of shifting channels; there were only scattered willow trees and numerous islands vegetated to varying degrees with grass or exotic shrubs".*

Vegetation in the active river bed has since increased substantially, particularly willow, gorse and broom. Since the start of fairway clearance programmes in 1959, willows have generally been encouraged on the berms outside the fairway but some have been cleared for farm development.

The most significant influences of hydro development on river bed management can be summarised as:

- *An interruption to the main sediment source following construction of the Waitaki Dam in 1934-37.*
- *Progressive changes to the flow regime, particularly since the construction of control gates at Lakes Pukaki (1947, dam raised in 1979) and Tekapo (1951), resulting in a generally steadier flow.*[1]
- *The sediment and flow regime changes have had significant influence on braid development and vegetation establishment and consolidation.*

[1] *Pickford and Rogers (1990) estimated the mean annual flood had reduced from 1250 m^3/s to 800 m^3/s. Thompson et al. (1997) estimated the reduction was from 1150 m^3/s to 900 m^3/s.*

3.2 Sediment transport effects

Hicks (2006):

> *"Since the Waitaki Dam was constructed, the bed-material supply from the upper catchment was all intercepted by the hydro-lakes. The river has recovered some of this deficit by scouring material from its own bed. There is certainly evidence from cross-section surveys and terraces that degradation (i.e., long-term lowering of bed levels) has occurred in the Kurow area and the river appears to have settled into a semi-braided meandering main channel for some 10 or so km downstream of the Hakataramea confluence... Further downstream, however, there is little evidence of degradation."*

Bed armouring appears to have limited degradation.

The sometimes disc shaped stones lock together and there is a lack of finer sand material (especially near Kurow) which normally makes the bed easier to mobilise.

3.3 Flow duration effects

Hicks (2006) again:

> *"The flow regime feature that most influences the bedload transport capacity of a river is the flow duration distribution. This determines how long the river can provide flows capable of entraining bed material. Figure 3.9 shows how this altered at Waitaki dam site after hydro control. The most frequent flows are now within the 240-480 m^3/s range compared to the natural case when the most frequent flows were in the 150-270 m^3/s range. Also, there are now fewer low flows and fewer days at high flow (e.g. under the natural regime flows exceeded 480 m^3/s 20% of the time but under the actual regime this figure reduced to 13%). Thus flow regulation means that the river's bedload-mobilising flows have occurred less often and its bedload transport capacity has been reduced."*

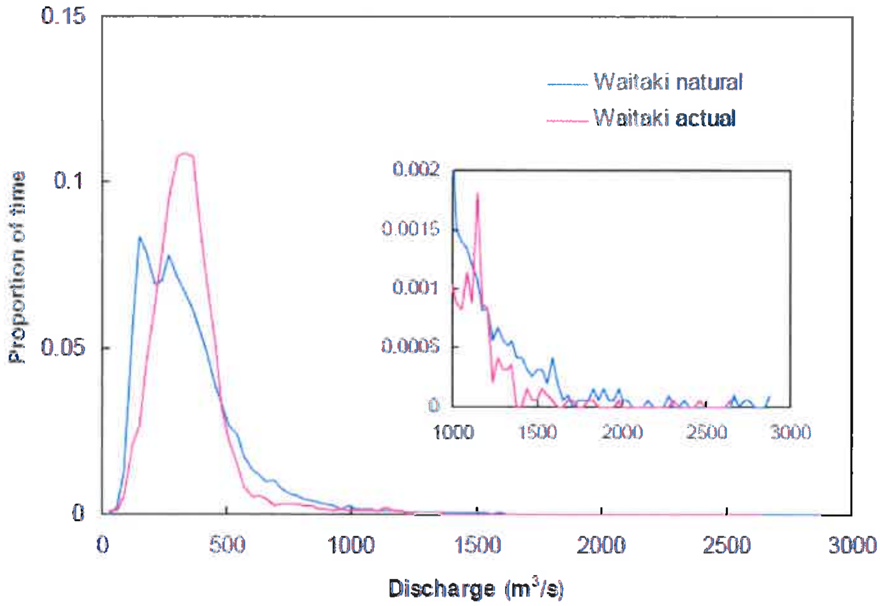


Figure 3.9: Waitaki River flow duration distribution recorded at Waitaki damsite, 1927-1949, and 1950- 2004 and for the simulated natural record 1950-2004 (daily mean flows).

3.4 Vegetation changes

Hicks (2002) reviewed the vegetation history for Project Aqua in 2002, using a comprehensive approach, including a series of aerial photographs dating back to 1932. The major trends are summarised below:

- *"A generally progressive reduction in fairway width.*
- *An increase in width (typically 300m) of developed (farmed) riverbed, particularly between 1965 and 1985.*
- *An overall trend for increasing tall and low vegetation cover.*
- *A reduction in braiding and flowing width, particularly between 1936 and 1964."*

The large 1995 flood temporarily reversed the trend of increasing vegetation; over 700 hectares of vegetation or 14% of the total vegetation cover was lost and this 3,000 m^3/s flood was 4-5 times more effective at removing vegetation than an earlier 1,500 m^3/s flood.

An analysis of vegetation cover in two reaches of river in 2001 put total vegetation cover at about 30% between flowing channels and at 50% of the total (active bed) river width.

The history of fairway vegetation management, aside from floods, is included later in this document in the summary of Lower Waitaki River management in Table 4-3 (under Scheme History).

Increasing vegetation, reduced sediment supply and the altered flow regime all reduce the propensity of the river to braid, which tends to lead to a deeper, larger, main channel.

Hicks (2002) examined the braiding threshold of the Waitaki and showed that braiding on the Waitaki is very sensitive to vegetation cover, more so since the development of the hydro dams.

> *"Morphological adjustments take time, but there is a weight of evidence, some of it yet fairly fuzzy, that collectively confirms that the river has indeed moved, and is probably still moving under its existing regime, to a less braided state. This includes a reduced number of channels, a more dominant main channel (or two) that tends to be more persistent with time, and a progressive narrowing of the bare-gravel or wetted areas of the riverbed"*

Several factors appear to be influencing a trend of stronger, more dominant braids.

Removal of vegetation from the fairway is the primary means of reducing this trend.

3.5 Importance of maintaining braiding patterns

Maintaining the propensity for the river to braid is important for a variety of reasons, including:

- The delivery of sediment to the coast influences the rate of coastal erosion. Less braiding in the river gradually leads to greater erosion along the coast.
- Open gravels provide nesting habitat for several endangered or threatened bird species. The Lower Waitaki is an important area for black-fronted terns (10% of national population) and black-billed gulls. The highly endangered black stilt (kaki) and threatened wrybill also use the river. Vegetation (of all types) provides cover for bird predators.
- Large, dominant channels have greater potential to erode adjacent land and require more costly erosion protection measures to limit their development into adjacent lands.
- Increased extent of wetlands, riparian shading and leaf litter drop improves aquatic habitat quality and quantity.
- Recreational opportunities are enhanced due to improved aquatic habitat and access.
- Preservation of the natural character of rivers is a matter of national importance recognised in the Resource Management Act.

The Canterbury Water Management Strategy has a number of targets around the natural character, processes and ecological health of braided rivers.

The Lower Waitaki and Coastal South Canterbury Zone Implementation Plan (under the CWMS) has recommended improvement of the braided river character and braided river bird habitat.

A more vegetated fairway would raise flood levels, increasing the frequency of flooding of adjacent land.

Removal of vegetation from the fairway is the single most important activity the scheme undertakes.

4 Scheme administration

The Waitaki Soil Conservation Committee administered the area since establishment in 1947 and was replaced by the Waitaki Catchment Commission in 1960.

The Commission became the Waitaki Catchment Board in 1988, which was disestablished with its' powers and functions transferred to the Canterbury Regional Council and Otago Regional Council in their respective areas in November 1989.

Canterbury Regional Council has continued to manage the river control scheme from day-to-day, including that part within the Otago Regional Council's area.

4.1 Scheme rating classification and funding

The area covered by the Lower Waitaki River Control Scheme Rating District Classification is shown on Figure 4-1.

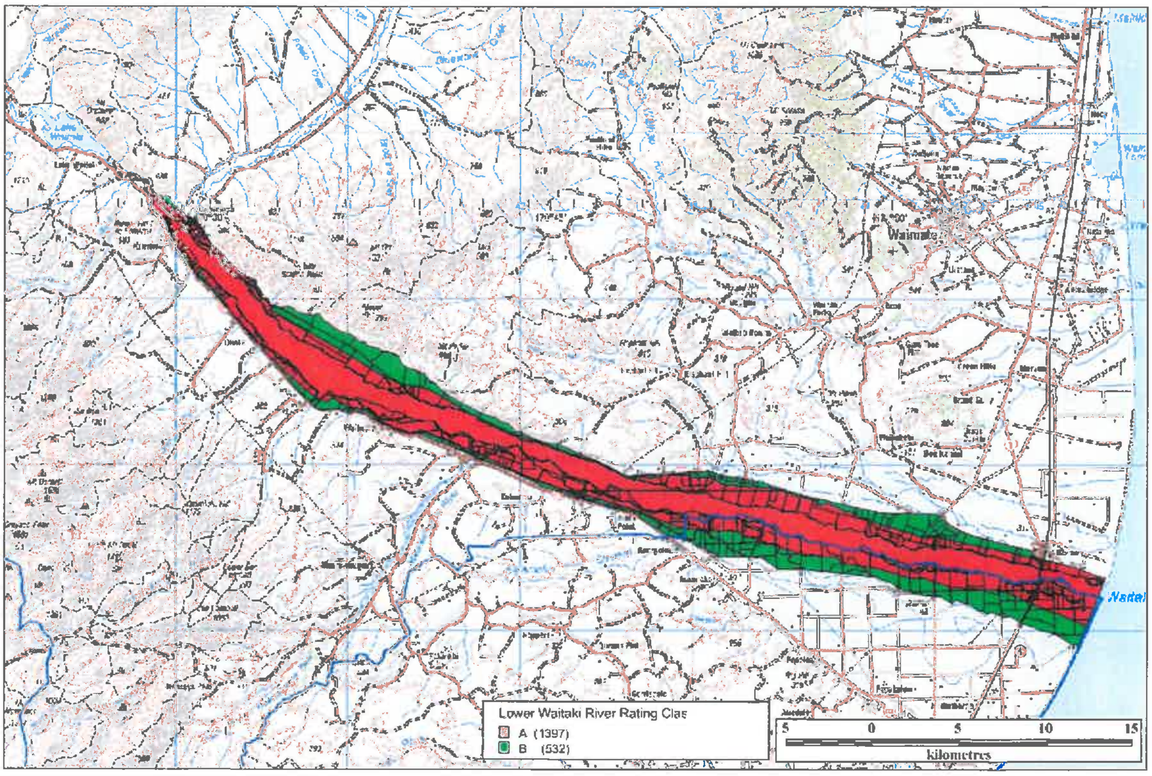


Figure 4-1: Rating District Classification

The targeted rating classification is based on three classes, each levied per $100,000 of property capital value within each class, with class weighting differentials as shown in Table 4-1. The targeted rate for an individual property is assessed on the weighted capital value for their classified area, as a proportion of the total weighted capital value for the Rating District as a whole multiplied by the total targeted rate requirement for the Rating District.

Class U1 is the rated part of urban Kurow.

Table 4-1: Rating classes and weighting differentials

Rating classes	Weighting differentials
Class A	60
Class B	30
Class U1	30

The classification was adopted in 1999.

In 1995, it was recognised that the Canterbury Regional Council did not have the authority to rate the properties within the Otago Region. This, and concerns over the equity and rationale behind the 1963 rating classification, led to a review of the classification and adoption of two differential rating districts covering land within the Canterbury and Otago Regions respectively.

The two Rating Districts have the same classification basis.

The total rate requirement from each of these regional areas is proportional to the relative weighted capital value within their classified areas.

The Catchment Works Funding Policies differ for each Regional Council.

Environment Canterbury provides Works and Services rate and General rate contributions equal to the targeted rate from their portion of the Rating District.

Otago Regional Council recovers costs by way of targeted rate, therefore, the rate requirement for an ORC property is in effect three fold that of an Environment Canterbury property with equivalent rating classes and capital value as set out in Table 4-2.

Meridian Energy has agreed to make an annual Scheme funding contribution equal to 40% of the combined total income from Meridian Energy, the Canterbury and Otago Regional Councils and their targeted ratepayers. This contribution was negotiated with ECNZ (Meridian Energy's predecessor) in recognition of the effect of power generation on Scheme flood control work costs.

Table 4-2: Funding policy ratios (%)

Funding source	ORC	ECan
Differential Targeted Rate	60	20
Works & Services Rate	-	20
General Rate	-	20
Meridian Energy contribution	40	40

4.2 Benefitting floodplain area, land use, public and private utilities

LiDAR, an aerial survey technique, has been used to develop maps at a scale of about 1:5000 scale with 1m and 10 m contours, and to define terraces of the order of 1 m high. The LiDAR was commissioned by Meridian Energy in 2001.

The maps have been overlain with the 1995 flood extent and groyne positions. From this combined information, the areas thought to be at greatest risk of flooding have been identified.

These areas are generally between the first main terrace and the river.

In addition to the erosion risk at sites immediately adjacent to active channels, these areas of potentially significant floodplain flow have a significant risk of erosion, which represents the greatest threat to productive farmland value.

The river could reoccupy these areas relatively easily, especially so without intervention.

These areas are the primary areas that benefit from current scheme maintenance works.

The landward extents of these areas are marked as yellow lines on the maps in Appendix 1.

Overlain on these maps are the areas currently classified as Class A (red) and Classes B and U1 (green). In general, the yellow line either follows the edge of, or lies within, the Class A area.

If there was not a scheme in place and there was no maintenance undertaken, the extent of areas at threat may very well be greater than the yellow lines show.

These primary areas include a variety of land uses and important infrastructure, including:

- Large areas of freehold farm land, the largest being:
  - Adjacent to a 9 km length of the river on the true left bank (looking downstream) from Station Peak to the Penticotico Stream (1,300 ha).
  - Adjacent to a 17.5 km length of the river on the true right bank from the Otekaieke River to Black Point (1,200 ha).
  - Adjacent to a 20 km length of the river on the true left bank from Stonewall to downstream of Ferry Rd (1,700 ha).
  - Adjacent to a 14 km length of the river on the true right bank from Papakaio Rd to the Coast (1,300 ha).
- Large areas of Department of Conservation land, some of which is leased for farming, but the majority of which is heavily vegetated and providing a valuable flood and erosion protection buffer. **Note: Any strategy adopted as a result of this review needs to include protocols in relation to DoC land.**
- Large areas of Crown river bed land administered by LINZ, the majority of which is in the active channel or heavily vegetated buffer. **As per the above note.**
- State Highway bridges at Kurow and Glenavy and a South Island Main Trunk rail bridge at Glenavy.
- Lengths of SH82 (5km of the Duntroon to Georgetown section) and SH83 (most of the 18km from Hakataramea to Penticotico Stream).
- A Transpower transmission line (18km Hakataramea to Penticotico Stream).
- Various irrigation intakes and races servicing around 68,000 ha, including:
  - Maraewhenua and North Otago Irrigation Companies (true right bank downstream of Duntroon).
  - Morven-Glenavy-Ikawai Irrigation Company (intakes on true left bank at Stonewall and Ross Rd).
  - Lower Waitaki Irrigation Company (true right bank at Black Point).

4.3 Scheme history

The major historical scheme management changes are summarised in Table 5.3 below, with discussion following.

Table 4-3: Lower Waitaki River management changes

Year	Significant management decisions	Major reasons
1963 Establishment.	Fairway (500 m) bulldozed.	Increasing congestion, erosion (perhaps exacerbated by a change in flow regime as a result of hydro development).
1977 Capital works.	Fairway (400 m) adopted and the construction of 31 groynes (some added later; several since washed away).	The intention was to increase land available for farming and reduce the impact of hydro schemes on adjacent land.
1981 Maintenance.	Cessation of control scheme; focus on maintenance.	Concerns at level of expenditure and lack of benefit.
1984 Retreat, consolidate.	Fairway (700 m) proposed; minimum maintenance; focus on establishing live planting buffer.	As above.
1989 Sectional Plan Establish guidelines, expectations.	Fairway (400-700 m) mapped; berm buffers mapped; focus on fairway clearance and berm strengthening. Erosion protection only with landowner contribution and within available funds.	Withdrawal of government subsidies resulting in expenditure being reduced.
2000 Modify guidelines.	Continue with 1989 guidelines; add maintenance of key groynes.	Increasing threat of erosion with lack of groyne maintenance & clearance of buffer.
2012/13.	Reintroduction of bylaws in both Canterbury and Otago to protect existing flood protection works.	Reduce clearance of buffer; protect existing works.
2013 Review.	Recommended future management approach. Reduced reliance on heavy bank protection, farming operations pulled back from river bank, develops vegetation buffer zone between active river channel & farmland.	Concern over increasing cost of recent flood damage and the extent of the Rating Account deficit. Clearance of buffer has led to increasing landowner erosion control work expectations.

In the 1950's, the central part of the active bed became increasingly congested with willow trees, resulting in a loss of flood capacity and increased erosion and flooding of the river margins.

A "Pilot Scheme", promoted by the Waitaki Catchment Commission and undertaken by the Ministry of Works, consisted of bulldozing a path down the central part of the active bed to remove willows and restore channel capacity.

This was followed in 1977 by the Lower Waitaki Catchment Control Scheme, designed to consolidate the benefits provided by the Pilot Scheme and fully develop and maintain a 400 m wide cleared fairway.

This was to be achieved by fairway willow removal and herbicide spraying, strategic placement of rock armoured groynes and buffer zone plantings.

The economic justification of this work was to increase the area of land available for farming from approximately 2800 ha to 5800 ha. Government subsidy was made available and a Rating Classification prepared to recover the local share of the annual capital and maintenance work costs.

Thirty-one groyne structures were initially built under the 1977 scheme, with a further five being built in the early 1980's. Twenty-six of these groynes were located on the south bank with the balance on the north side.

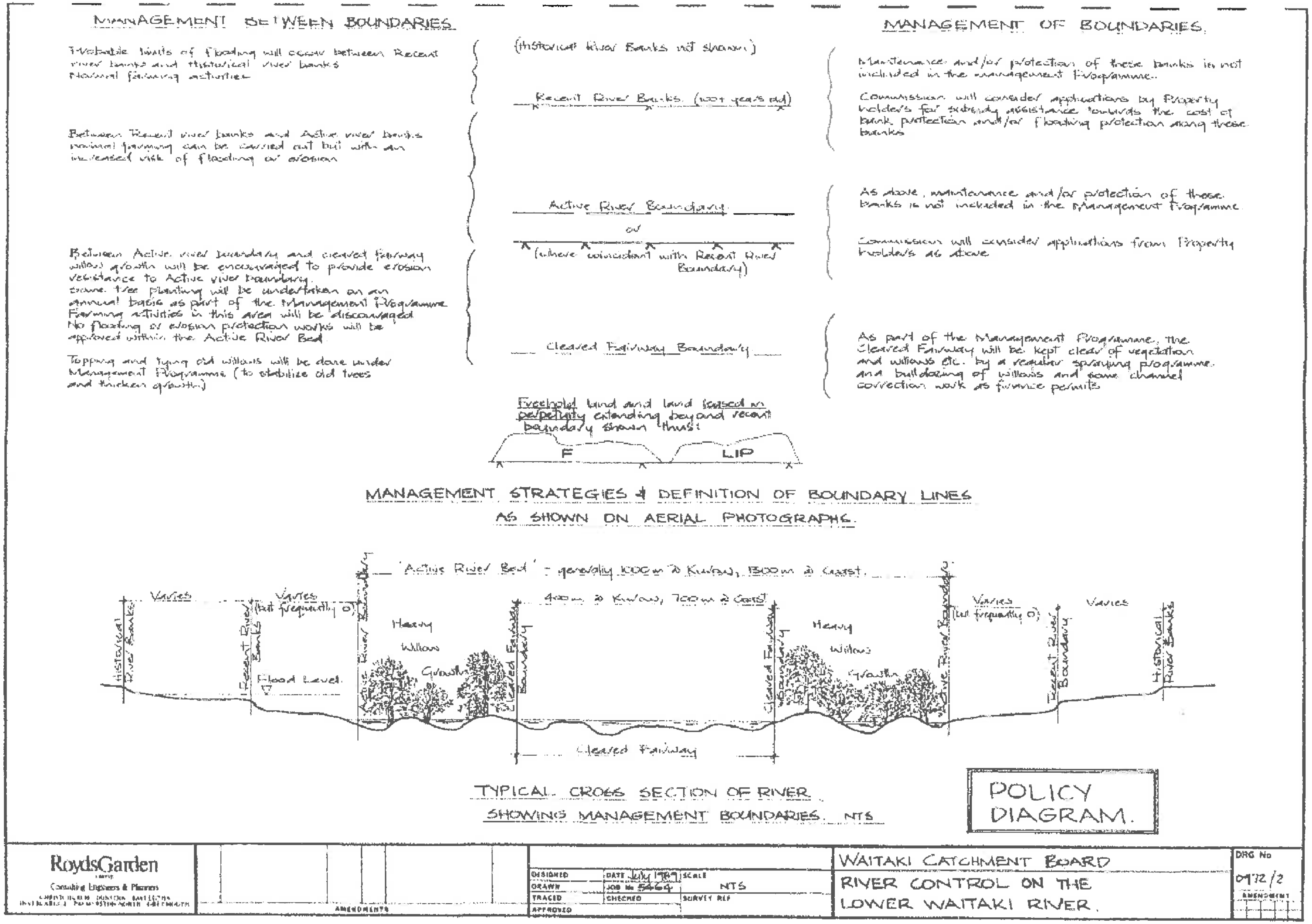
The 1984 scheme review determined that the cost of maintaining the 400 m fairway was prohibitively expensive and that an alternative strategy was needed. This was to focus on regular spraying of willow-infested islands within a re-defined central fairway, accompanied by judicious removal of willows where necessary.

The portion of the active bed flanking the central fairway was to be encouraged to develop as a vegetation buffer, assisted with new plantings and the layering and tying of willows to strengthen berm protection.

Although not encouraged, some channel diversion works would be permitted to relieve pressure on threatened berm areas.

In July 1989, the Waitaki Catchment Board adopted the "Sectional Plan" for ongoing management of the Lower Waitaki River. This plan allowed for further cleared fairway development (400m at Kurow and 700m at the coast) and the berm management philosophies promoted under the 1984 Scheme Review.

Extract from River Control on the Lower Waitaki River, Sectional Plan 1, Waitaki Catchment Commission and Regional Water Board, 14 July 1989.


MANAGEMENT BETWEEN BOUNDARIES.
Probable limits of flooding will occur between Recent river banks and historical river banks. Normal farming activities.
Between Recent river banks and Active river banks normal farming can be carried out but with an increased risk of flooding or erosion.
Between Active river boundary and cleared fairway willow growth will be encouraged to provide erosion resistance to Active river boundary. Some tree planting will be undertaken on an annual basis as part of the Management Programme. Farming activities in this area will be discouraged. No flooding or erosion protection works will be approved within the Active River Bed.
Topping and tying old willows will be done under Management Programme (to stabilize old trees and thicken growth.)
(Historical River Banks not shown)
Recent River Banks (100+ years old)
Active River Boundary
or
(where coincident with Recent River Boundary)
Cleared Fairway Boundary
Freehold land and land leased in perpetuity extending beyond recent boundary shown thus:
F
LIP
MANAGEMENT OF BOUNDARIES.
Maintenance and/or protection of these banks is not included in the management Programme.
Commission will consider applications by Property holders for subsidy assistance towards the cost of bank protection and/or flooding protection along these banks.
As above, maintenance and/or protection of these banks is not included in the Management Programme.
Commission will consider applications from Property holders as above.
As part of the Management Programme, the Cleared Fairway will be kept clear of vegetation and willows etc. by a regular spraying programme and bulldozing of willows and some channel correction work as finance permits.
MANAGEMENT STRATEGIES & DEFINITION OF BOUNDARY LINES
AS SHOWN ON AERIAL PHOTOGRAPHS.
'Active River Bed' = generally 1000m @ Kurow, 1500m @ Coast.
400m @ Kurow, 700m @ Coast
Varies
Varies (but frequently 0)
Historical River Banks
Recent River Banks
Flood Level
Active River Boundary
Heavy Willow Growth
Cleared Fairway Boundary
Cleared Fairway
Recent River Boundary
TYPICAL CROSS SECTION OF RIVER
SHOWING MANAGEMENT BOUNDARIES. NTS
POLICY DIAGRAM.
RoydsGarden
Consulting Engineers & Planners
AMENDMENTS
DESIGNED
DRAWN
TRACED
APPROVED
DATE July 1989
JOB No 5464
CHECKED
SCALE NTS
SURVEY REF
WAITAKI CATCHMENT BOARD
RIVER CONTROL ON THE
LOWER WAITAKI RIVER.
DRG No
0172/2
AMENDMENT

The current river management approach generally follows the "Sectional Plan" guidelines, with broadened scope as agreed with successive Liaison Committees and as described below.

5 Current management approach

The Lower Waitaki River Control Scheme Asset Management Plan of June 2012, sets out the current Scheme management approach.

The Scheme management objectives are set out in Section 2.1.

The focus of the current approach is to maintain a defined central cleared fairway through spraying and removal of critical obstructions within the braid network.

Fairway lines redefining a 600 m cleared fairway were drafted in 2009 (Williams). These lines define the limits the current fairway clearance programme, but have not as yet been formally adopted for river management purposes.

Maintenance works include aerial herbicide spraying of the cleared fairway on a three-year rolling programme to eliminate crack willow infestation. Follow-up ground herbicide application is carried out where necessary.

Where stranded willows create a flow diversion or bank erosion risk, the trees are removed from the clear fairway and disposed of, or incorporated into bank protection works.

Flow diversion channel work is undertaken sparingly where it is evident that such activity will provide immediate and necessary relief to active erosion sites and longer-term benefits are expected. Diversion works are also undertaken to dewater sites to enable bank protection works to be constructed and established.

Fairway edge protection works consist of layering mature willows on a 10-year rolling programme, anchoring willows as bank protection and the planting of willow poles.

The establishment of vegetation protection in the area between the cleared fairway edge and the boundary of the active riverbed is aimed at being achieved through the retention of existing vegetation (willow, gorse, broom, flax, toi toi, sedge) and strengthening through layering, tying of willows and planting of willow poles.

A total of 36 groynes were constructed under the Pilot and 1977 Schemes. 11 of these have been lost. The most important 18 of the remaining groynes are actively maintained. 7 groynes (generally those more remote from the fairway) are retained but not actively maintained.

Gravel extraction management is carried out to help meet Scheme objectives but demand for gravel in the area is relatively small in scale in relation to the size of the river.

The Asset Management Plan recognises that removal of buffer zone vegetation along the fairway margin for farm development is a major concern.

This development increases the flood and erosion risk to adjoining and downstream property, compromises Scheme objectives and increases maintenance costs.

Control methods are suggested such as acquisition of control over Crown riverbed and riparian land, introduction of Regional Plan rules and implementation of Flood Protection Bylaws.

Flood protection bylaws were recently introduced in both Otago (2012) and Canterbury (2013). It is too early to say how effective these are in reducing loss of flood and erosion protection vegetation.

5.1 Maintenance expenditure

Table 5-1: River management on the Lower Waitaki uses a hierarchy of building blocks:

Operation	Comments
1. Fairway clearance	Vegetation in the fairway (refer page 19 Sectional Plan & Appendix 2) is a primary factor in conveyance of water and sediment within the river system. A lack of channel capacity would quickly lead to increased flooding and/or erosion of developed land. Many of the other operations listed here rely on adequate fairway capacity for their effectiveness.
2. Land use controls	Bylaws have been established to protect existing community investment in flood protection and erosion control. Stock proof fences are essential to protect existing trees.
3. Planting and strengthening of berms including berm layering	Takes time for new plantings to become established. Layering on the berms is relatively cheap and results in dense berms.
4. Fairway channel realignment	Can be used to varying degrees to complement other works. Can be costly and may not be enduring. Of greatest benefit where directly related to establishment of other works.
5. Maintenance of existing groynes	Complements fairway clearance by helping to maintain channel position.
6. Fairway edge layering	Layering strengthens the edge of planted berms
7. Anchored tree edge protection	Anchoring strengthens the edge of berms but is more costly than layering
8. Rock-based edge protection	Rock can be more resistant to erosion than anchored trees but is expensive. Only used on the Waitaki to protect groynes, especially the heads of groynes.

An annual maintenance programme, budget and targeted rates requirement is prepared each year for consideration by the Scheme Liaison Committee.

The Liaison Committee is made up of representatives elected at three-yearly ratepayer meetings and appointed representatives from Canterbury Regional Council, Otago Regional Council, Meridian Energy and the Department of Conservation.

The Liaison Committee recommends the works programme and targeted rates requirement for inclusion in the Canterbury Regional Council and Otago Regional Council Long Term Plan. The programme includes core maintenance needs plus flexibility to prioritise for minor flood damage.

In the event of major flood damage and a requirement to exceed the annual budget by more than 10%, approval to proceed is sought from the Liaison Committee and Councils.

Table 6.1 shows the main expenditure items for the years for the Lower Waitaki Rating District from July 2006 to June 2012. The average expenditure in this period on maintenance (including flood damage repairs) has been $578,000. This period includes the floods of May 2009, Jan 2011 and Feb 2011. The last paragraphs of Section 3 should be noted here, namely:

Overall, we can conclude that 2009-2013 has been a period with a relatively large number of sustained high flow events. On average one would expect fewer high flow periods, and consequently less damage and reduced repair costs. These factors need to be taken into consideration when deciding on any future strategy.

Table 5-2: Lower Waitaki River Scheme costs by type of work (2006/07 to 2011/12)

Activity type	Cost
Fairway spraying	$723,500
Anchored bank protection	$617,500
Fairway channel realignment/improvement	$518,400
Berm planting	$494,100
Management	$354,300
Layering - fairway	$286,900
Groyne maintenance	$231,900
Other	$231,300
TOTAL	**$3,457,900**

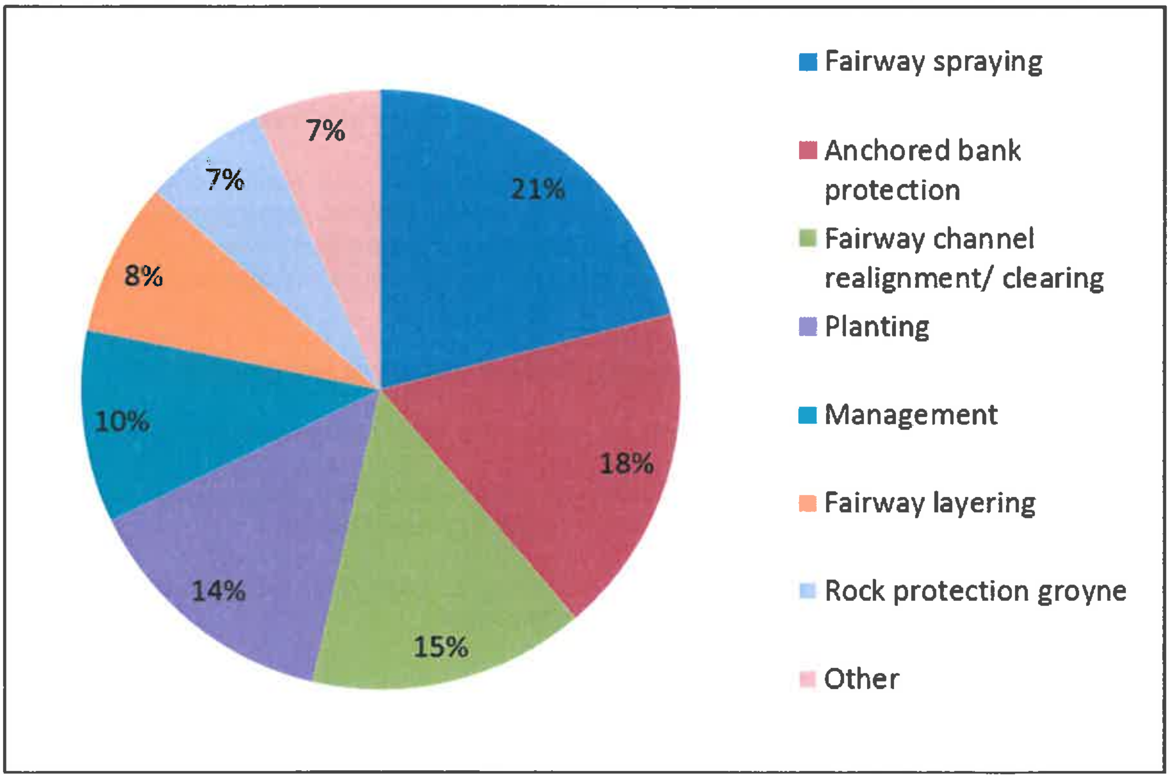


Figure 5-1: Lower Waitaki River Scheme Costs by type of work (2006/07 to 2011/12)

Table 5-3: Proportion of works expenditure by location across the river (2006/07 to 2011/12)

Fairway (spraying, clearance, realignment)	36%
Fairway edge (layering, groynes)	15%
Buffer zones (planting)	14%
Anchored bank protection	18%
Management & other	17%

6 Alternative management approaches

Three principles relevant to the Lower Waitaki, and based on the guidelines in NZS 9401:2008, have been used to assist with the development of a recommended future management approach (refer Lower Waitaki River Management Strategy - Progress Report, April 2013).

Principle 1: Residual risks will be recognised

- Flood and erosion risk can only be managed to limited effect.
- Damage to land is unavoidable.
- For technical, financial and environmental reasons, not all damage to land will be remedied.

Principle 2: River form will be managed to a clearly defined scope and levels of service

- The Scheme will deal only with high order preservation and control of flowpaths i.e. maintaining fairway capacity and condition and remedying outflows of major consequence.
- Activity and funding will be tightly linked with objectives and specified levels of service.
- Expectations regarding direct protection of private infrastructure will be clearly defined and understood.

Principle 3: Personal responsibility is a necessary part of managing residual risk

- Landholders have the responsibility to not exacerbate flood and erosion risk for themselves and others.
- Land shall be used in a way that does not compromise river management objectives, regardless of whether the land is privately (freehold) or publicly owned.

These principles have been used to develop the guidelines in Table 8-1 below, which also list the relevant equivalent 1989 Sectional Plan guidance for comparison.

7 Mapping

The Scheme area has been mapped from Kurow to the sea as part of this investigation.

Illustrated on the maps which are attached as Appendices 1 & 2 are the following:

- The Waitaki strategy area of interest.
- The existing rating classifications.
- The extent of flooding in the 1995 flood event.
- The Fairway.
- Primary (protecting largest areas with potential for overland flow and/or major course change, major infrastructure), Secondary (moderate areas protected or important for integrity of primary protection downstream) and Tertiary (generally only protects immediately adjacent farmland and /or adjacent downstream property) buffer zone extents.
- Currently maintained groynes.
- 2013 damage.
- Environment Canterbury bylaw boundaries.
- Lines in the Otago region drawn to the same criteria as the Environment Canterbury bylaw boundary lines.

Table 7-1: Areas protected by river frontage

	Canterbury Waimate District (North bank)	Canterbury Waitaki District (South bank)	Otago	Total
Length (km)				
Primary	8.0	2.3	6.0	16.3
Secondary	22.2	10.2	5.3	37.7
Tertiary	29.4	23.2	13.0	65.6
Total length (km)	59.6	35.7	24.3	119.6
Productive area protected (ha)				
Primary+Secondary*	3010	1230	1300	5540
Tertiary	240	280	120	640
*not including 300ha south of Waitaki Bridge to second yellow line				
Productive area protected (ha) per length of frontage (km)				
Primary+Secondary	144	123	251	163
Tertiary	8	12	9	10

There is some overlap between areas that benefit from primary, secondary and tertiary protection. Table 7-1 takes a broad-brush approach to assessing where the main benefits are found, and illustrates that the greatest benefit/cost ratios in terms of maintaining berm integrity are in the primary/secondary areas in Otago (i.e. the cost of protection, per unit area protected, is lower in Otago). This area includes the Waitaki Bridge settlement. On average, the primary and secondary areas protect about 16 times (per km of protection) the productive land area than tertiary areas.

Note that the mapping generally includes the most vulnerable major infrastructure (bridges, major irrigation intakes) within the "Primary" category, and some less vulnerable infrastructure (roads, pylons) within the Secondary and Tertiary categories.

8 Options

The Sectional Plan, Current (Modified Sectional Plan), and Recommended Future management approaches are compared in Table 8-1 below.

The Current approach, as described in detail in Section 5, consists of the original Sectional Plan approach, as modified by later asset management plan objectives to limit erosion of the active bed vegetated margins, and to minimise lateral erosion directly affecting developed farmland. Maintenance of key groynes has been ongoing.

The Recommended Future approach is put forward as a basis for community consultation and discussion. This approach includes clear fairway maintenance, occasional channel alignment, targeted bank protection, tying and lopping of willows, selective buffer zone planting, and maintenance of key groynes.

It is recognised that the active bed vegetated margins (buffer zones) have varying levels of importance depending on whether they offer protection to some or all of settlements, utilities, large areas of farmland, or individual properties. Desirable buffer zone extents have been identified and prioritised into Primary, Secondary, and Tertiary categories depending on relative community benefit (refer Appendix 2).

Grazing, vegetation clearance, and other farming practices would not be permitted within established buffer zones. Property holders would be required to fund buffer zone stock exclusion fencing and maintenance.

Where farming activities have already encroached into Primary and Secondary buffer zone areas, landowners would be expected to retire these areas and establish them in protective plantings.

It is recommended that the Primary Buffer Zones should be maintained and protected as they offer the highest level of community benefit. Erosion of the Primary buffer zones would typically increase the risk of flooding and/or course change for multiple landowners, settlements, and utilities. These works would be fully Scheme funded.

There is a lower level of community benefit for Secondary buffer zones. In this case a policy could be developed requiring the adjoining landowners to part-fund works costs.

Any Tertiary buffer zone protection work would need to be entirely funded by the adjoining landowner as the main beneficiary.

Utility owners would be expected to fund the whole cost of their protection works, regardless of location.

Any work undertaken within the river bed (including the clear fairway and buffer zones) would need to be undertaken under the control of, or with the approval of Environment Canterbury.

The ORC Flood Protection Bylaw 2012, and CRC Flood Protection and Drainage Bylaw 2013, would be used to protect existing rating district infrastructure such as protection plantings and groynes.

Table 8-1: Comparison of Management Options

1989 Sectional Plan	Current Approach - Modified Section Plan	Recommended Future Approach
Clear Fairway	**Clear Fairway**	**Clear Fairway**
Width of between 400 m at Kurow and 700 m at the coast.	Clear fairway width of 600 m from Kurow to the coast as defined in Williams report (with minor changes around intakes etc).	Clear fairway width of 600 m from Kurow to the coast as defined in Williams report (with minor changes around intakes etc).
Fairway boundaries are illustrated on the plans attached as Appendix 1 of the 1989 report.	Fairway boundary is defined on the plans attached as Appendix 2 of this report.	Fairway boundary is defined on the plans attached as Appendix 2 of this report.
The fairway is to be kept clear of willows and other vegetation by herbicide spraying, bulldozing of willows, and channel correction as finance permits. Clear fairway boundary maintenance and protection works are not included.	The fairway is to be kept clear of willows and other substantial vegetation by a programme of herbicide spraying and willow tree and debris removal.	The fairway is to be kept clear of willows and other substantial vegetation by a programme of herbicide spraying and willow tree and debris removal.
	Trees and flood debris removed from fairway are placed in adjoining buffer zones.	Trees and flood debris removed from fairway is placed in adjoining buffer zones.
		Occasional bulldozing or ripping may be carried out to reinstate a braided channel form, or encourage erosion of obstructive islands or beaches.
	Occasional channel realignment undertaken to prevent erosion of established primary buffer zone plantings.	Occasional channel realignment may be undertaken to prevent erosion of established primary buffer zone plantings.
	Bank protection works may be carried out along fairway boundary to limit erosion of buffer zones or developed farmland.	Bank protection works may be carried out along the fairway boundary to limit erosion of Primary category buffer zones as shown (green hatched) in Appendix 2 of this report.
		Subject to a funding contribution (as defined by policy) from the adjoining landowner(s), bank protection works may be carried out along the fairway boundary to limit erosion of Secondary category buffer zones as shown (blue hatched) in Appendix 1.

		Authorised bank protection works, if wholly funded by the affected landowner, may be carried out along the fairway boundary to limit erosion of Tertiary buffer zones or farmland.
Active river bed Consists of the cleared fairway plus left and right bank margins of heavy willow growth.	**Active river bed**	**Berm Buffer Zones** Consist of the left and right bank areas between the clear fairway and the active river boundaries.
The active bed boundaries are defined in the plans attached as Appendix 1 of the 1989 report. The width is generally 1,000 m at Kurow and 1,300 m at the coast. Willow growth is encouraged on the margins to provide erosion resistance. Some tree planting is undertaken annually. Lopping and tying of willows is carried out within margins. Farming activities are discouraged.	The active bed boundaries are defined in the plans attached as Appendix 1 of the 1989 report. The width is generally 1,000 m at Kurow and 1,300 m at the coast. Willow growth is encouraged on the margins to provide erosion resistance. Some tree planting is undertaken annually. Lopping and tying of willows is carried out within margins. Grazing, vegetation clearance and other farming practices are generally not permitted within established buffer zones.	The buffer zone boundaries are defined in the plans attached as Appendix 2 of this report. The active river bed width, inclusive of buffer zone, is generally 1,000 m at Kurow and 1,300 m at the coast. Willow growth is encouraged within the buffer zones to provide erosion resistance. Lopping and tying of willows is carried out within buffers. Grazing, vegetation clearance, and other farming practices are not permitted within established buffer zones. Some tree planting is undertaken annually within Primary & Secondary buffer zones. Property holders will fund stock exclusion fencing and maintenance. Where land development has encroached into buffer zone areas, landowners are expected to retire from farming and establish in protective plantings.
No flood or erosion protection works will be approved within the active bed. Active river boundary maintenance and protection works are not included.	Bank protection work is carried out on fairway boundary or within buffer zone to limit erosion of active bed vegetated margins, or where developed farmland is directly threatened.	Bank protection works may be carried out to limit erosion of Primary category buffer zones as shown (green hatched) in Appendix 1 of this report. Subject to a funding contribution (as defined by policy) from the adjoining landowner, bank protection

Applications from property holders for subsidy assistance towards the cost of bank and/or flood protection along active river boundaries will be considered.	Cost sharing undertaken with utility operators and landowners for bank protection works. The ORC Flood Protection Bylaw 2012 and the CRC Flood Protection and Drainage Bylaw 2013 will be used to protect existing rating district infrastructure. Key groynes are maintained.	works may be carried out to limit erosion of Secondary category buffer zones as shown (blue hatched) in Appendix 1. Authorised bank protection works, if wholly funded by the affected landowner or utility operator, may be carried out to limit erosion of Tertiary buffer zones, utilities, or farmland. The ORC Flood Protection Bylaw 2012 and the CRC Flood Protection and Drainage Bylaw 2013 will be used to protect existing rating district infrastructure such as protection plantings and groynes. Key groynes will be maintained.
Floodplain Area Beyond Active River Boundary	**Floodplain Areas Beyond Active River Boundary**	**Floodplain Areas Beyond Berm Buffer Zones**
Includes areas with recent and historical river banks. Between recent and active banks normal farming can be carried out with an attendant increased risk of flooding and erosion. Probable limits of flooding are between historical and recent banks within which normal farming activities are appropriate. Between historic river banks and the active river boundary maintenance and/or protection works are not included. Applications from property holders for subsidy assistance towards the cost of bank and/or flood protection will be considered.	Between recent and active banks normal farming can be carried out with an elevated risk of flooding, erosion and course change. Probable limits of flooding are between historical and recent banks within which normal farming activities can be carried out with moderate flood risk. Bank protection works is carried out to limit erosion of developed farmland. Cost sharing for bank protection works is undertaken with utility operators and landowners. Groynes outside the active river bed are not maintained, but are protected by Bylaw provisions.	Between recent and active banks normal farming can be carried out with an elevated risk of flooding, erosion and course change. Probable limits of flooding are between historical and recent banks within which normal farming activities can be carried out with moderate flood risk. Authorised bank protection works, if wholly funded by the affected landowner or utility operator, may be carried out to limit erosion of utilities or farmland. Groynes outside the active river bed are not maintained, but are protected by Bylaw provisions.

9 Peer review

The report has been peer reviewed by Tony Boyle of Environment Canterbury.

10 References

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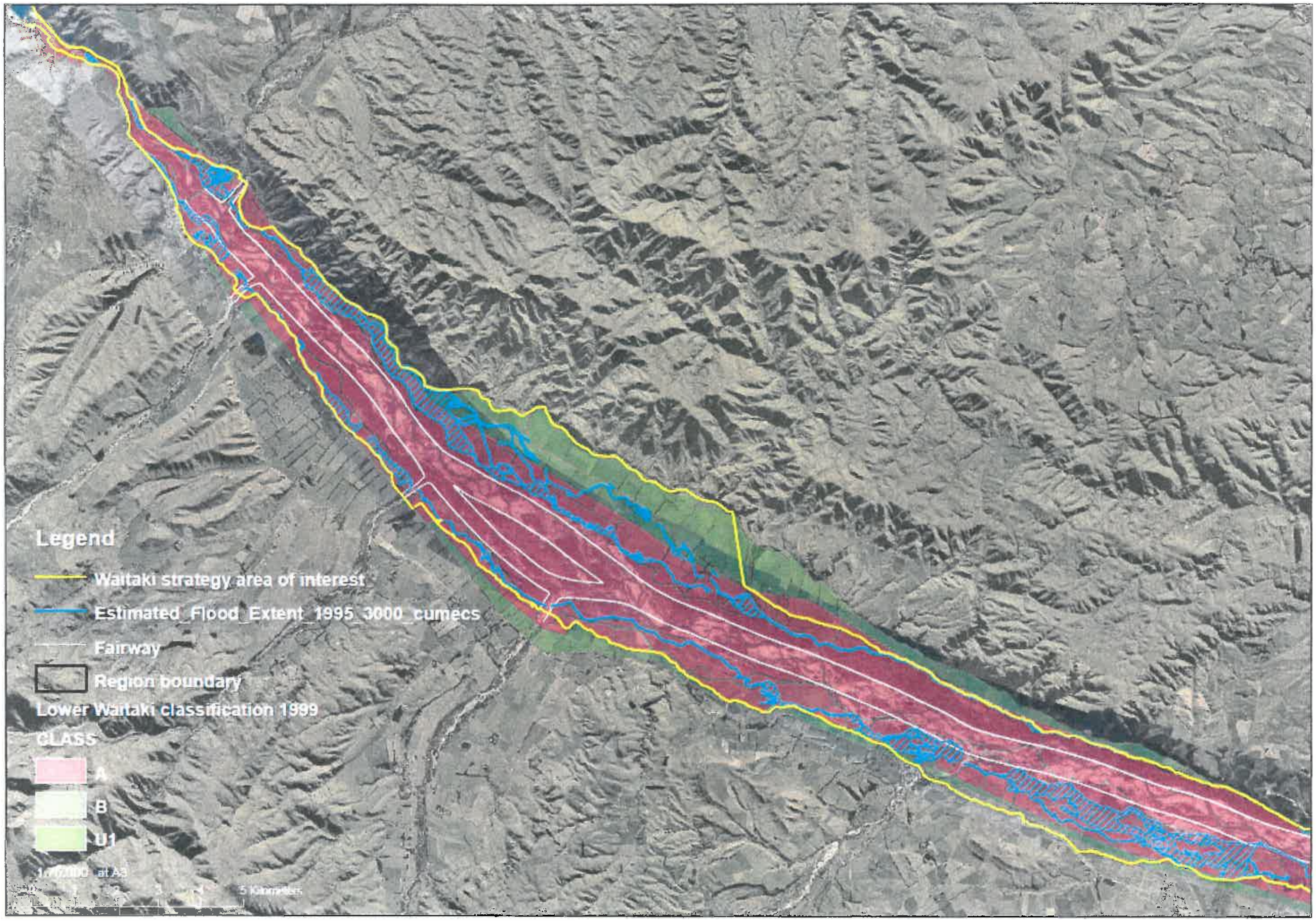
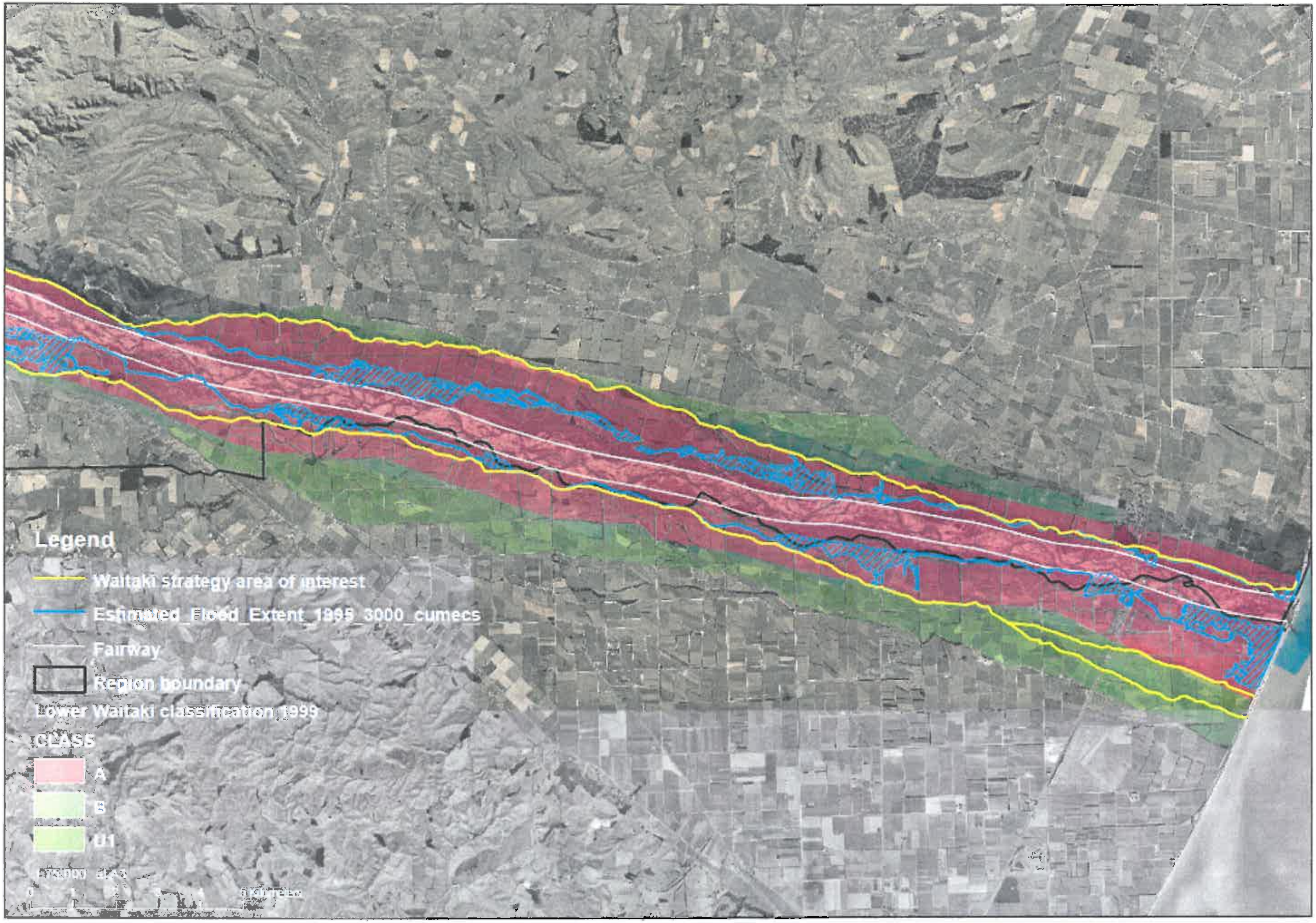
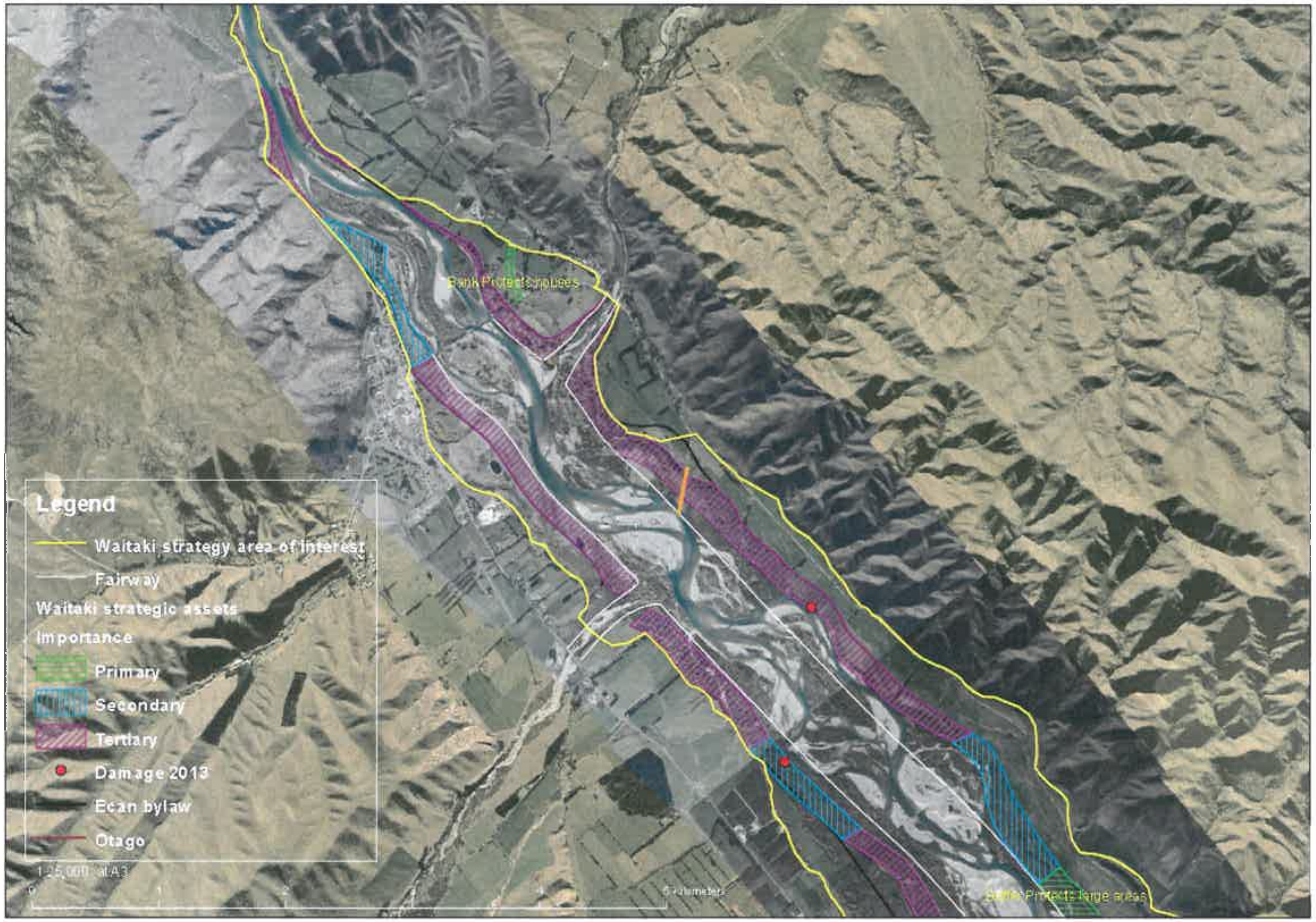
Appendix 1 – Rating Classification & Flood Extent Maps

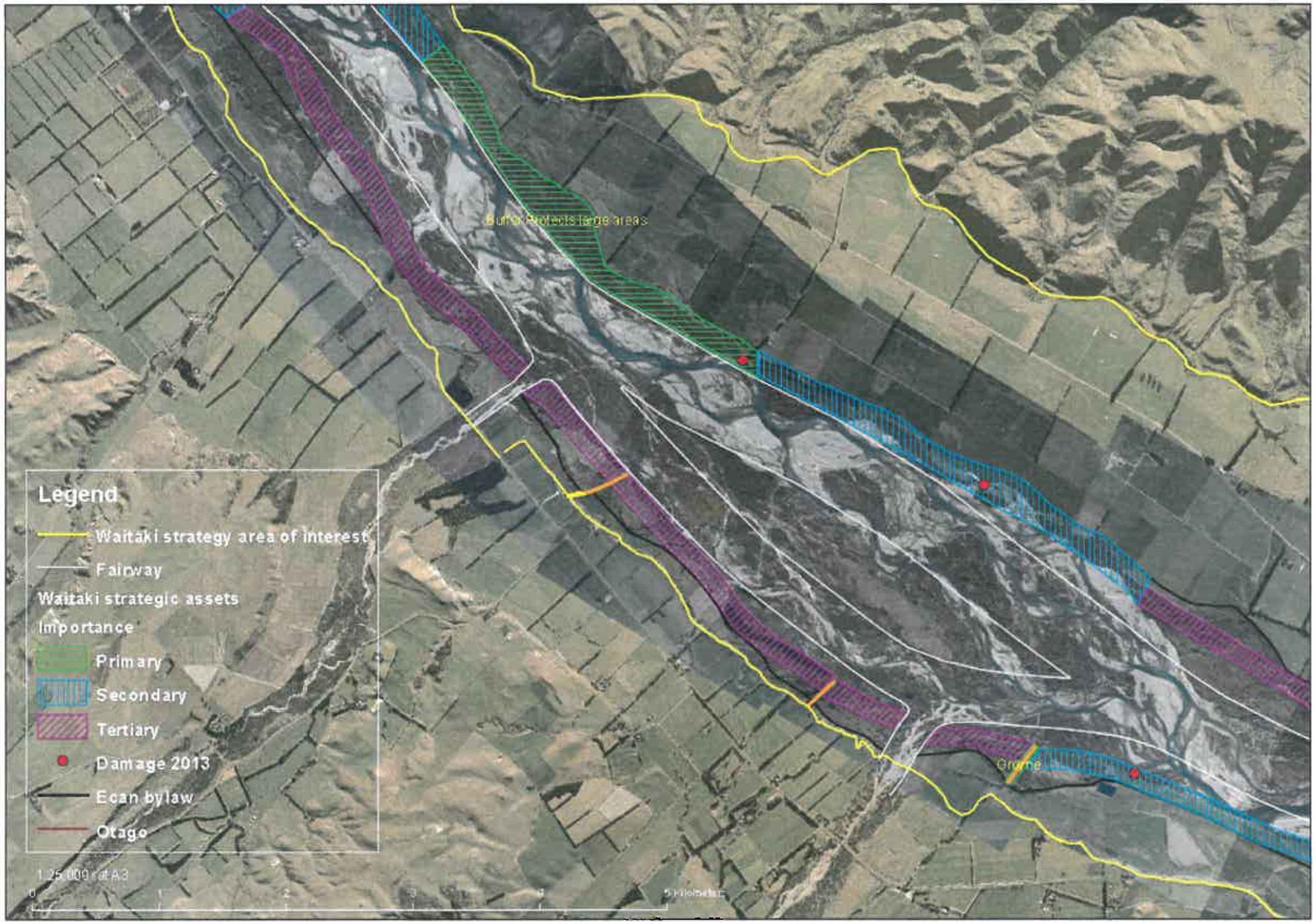

Legend
Waitaki strategy area of interest
Estimated_Flood_Extent_1995_3000_cumecs
Fairway
Region boundary
Lower Waitaki classification 1999
CLASS
A
B
U1
5 Kilometers


Legend
Waitaki strategy area of interest
Estimated_Flood_Extent_1995_3000_cumecs
Fairway
Region boundary
Lower Waitaki classification 1999
CLASS
A
B
U1

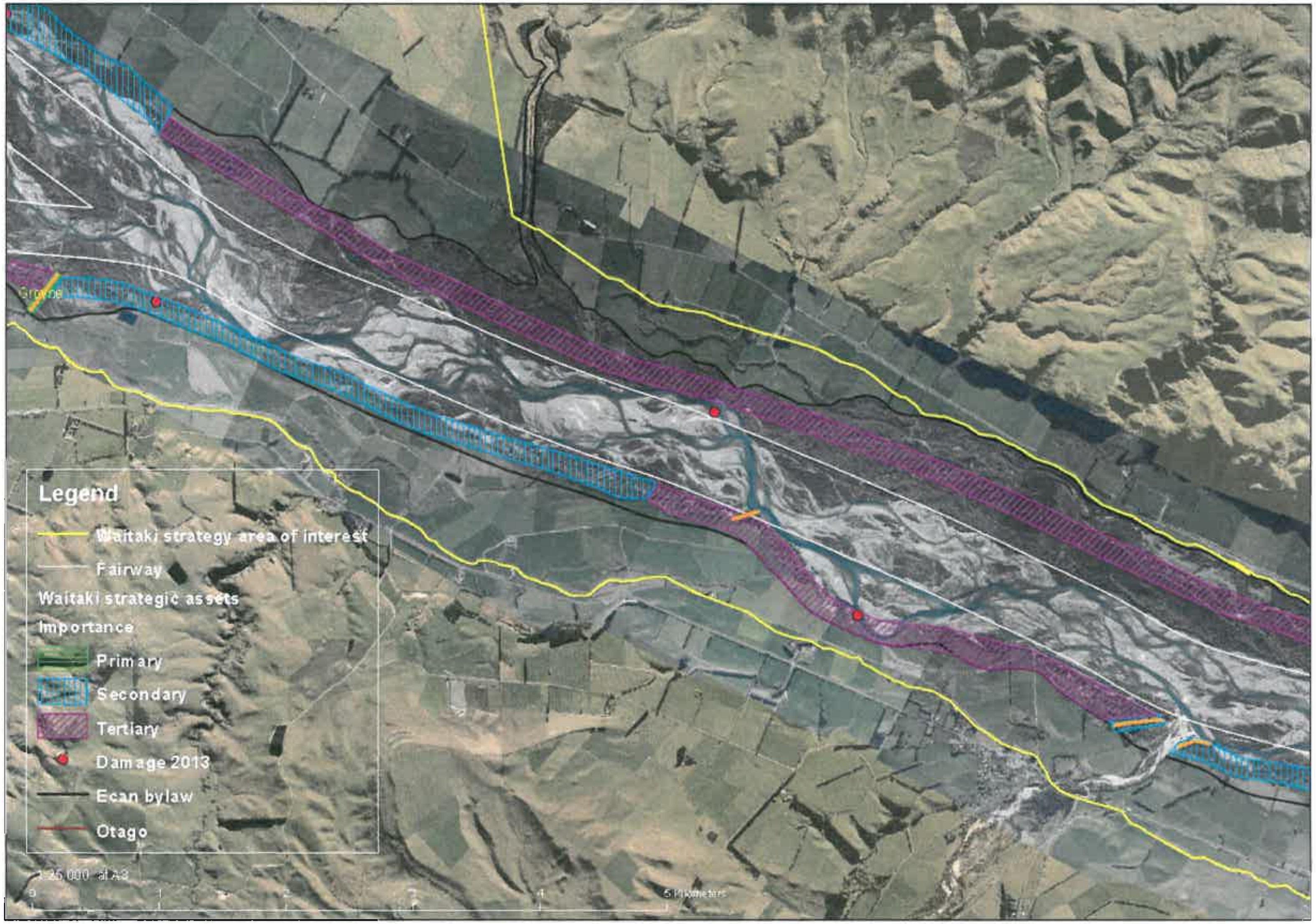
Appendix 2 – Fairway, Buffer Zone, Groynes, & Bylaw Boundary Maps



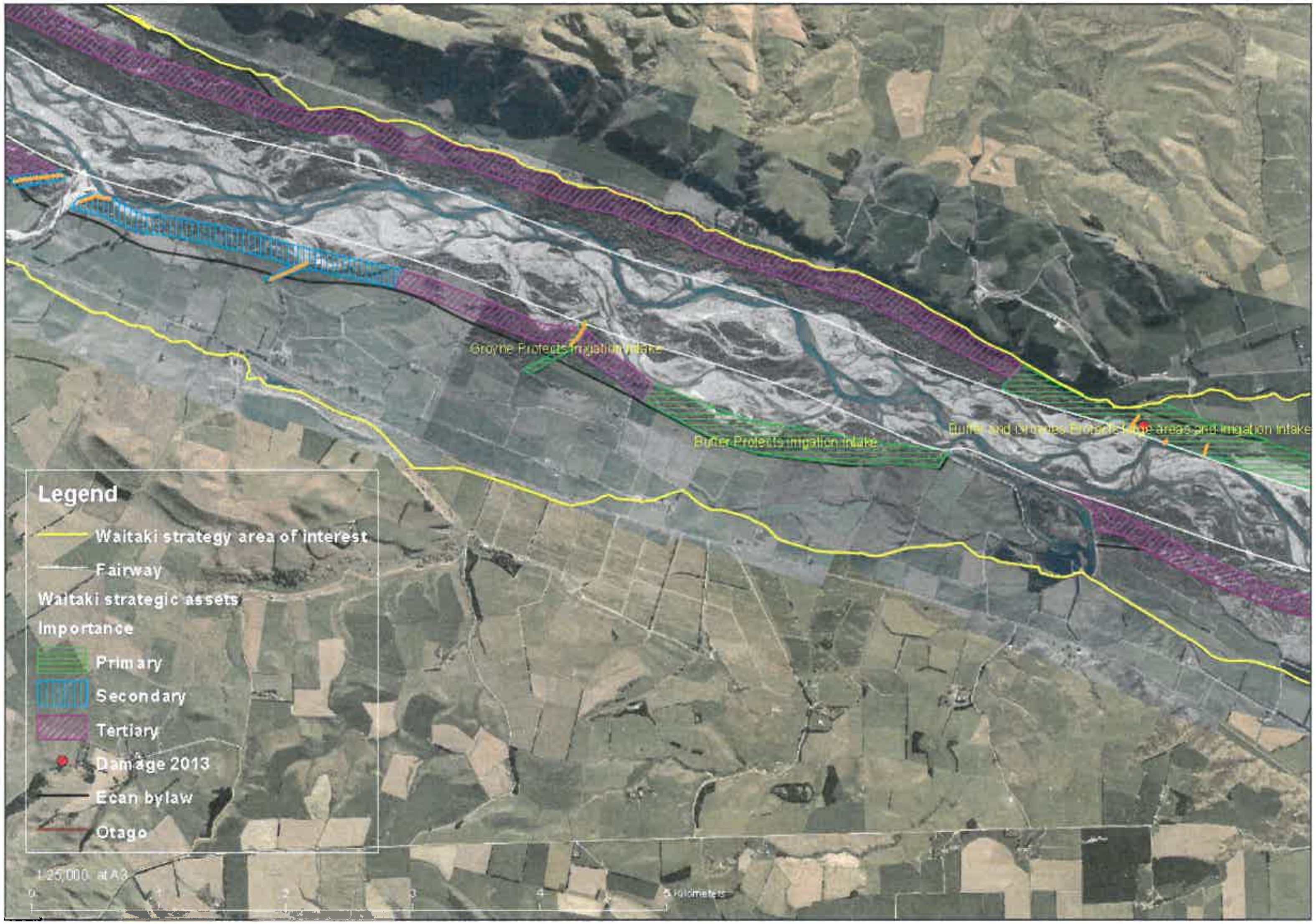
Map 1 Lower Waitaki Strategy (area of interest, fairway. primary, secondary and tertiary zones, 2013 damage, buffer zone groynes and bylaw boundaries)



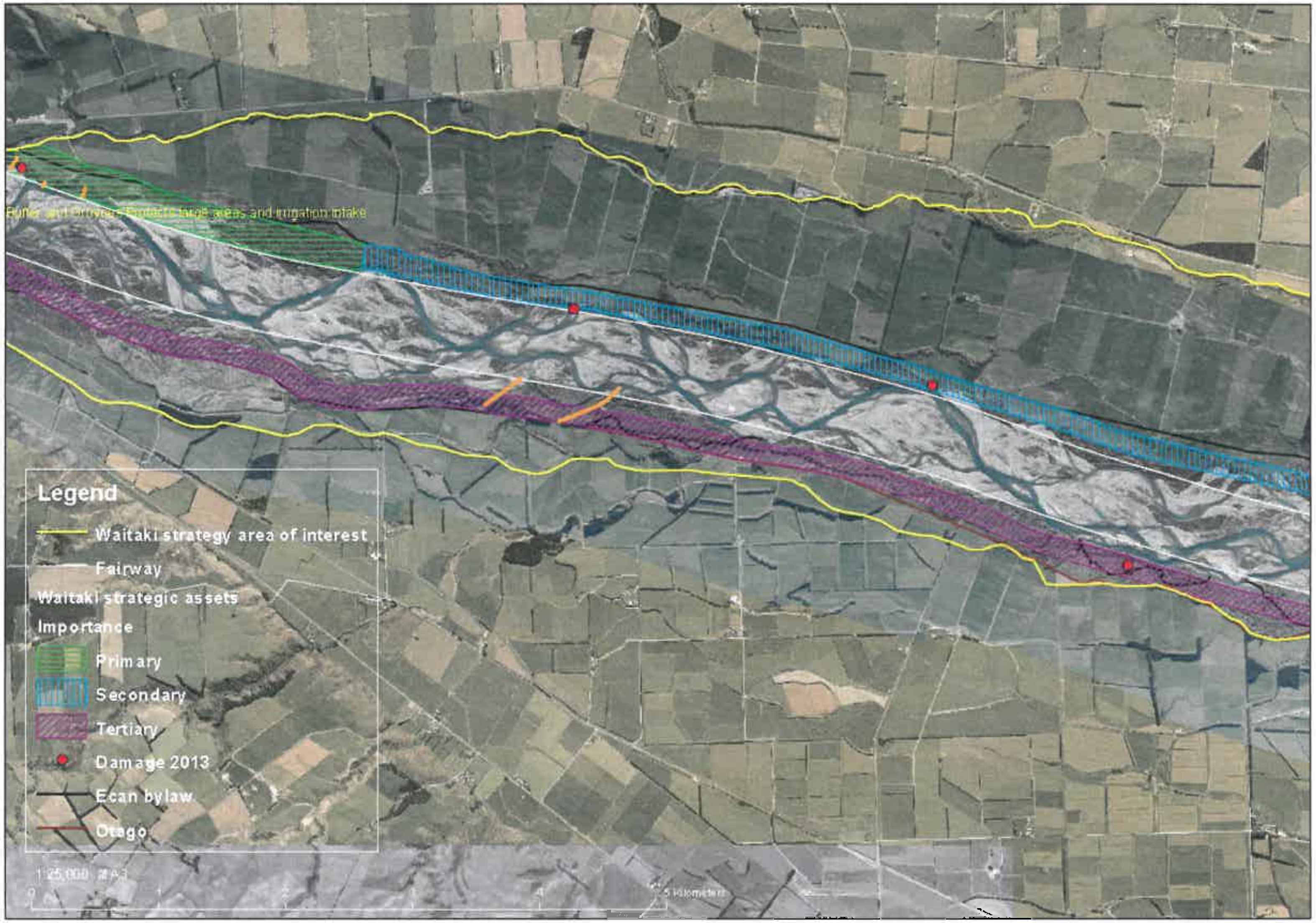
Map 2 Lower Waitaki Strategy (area of interest, fairway. primary, secondary and tertiary zones, 2013 damage, buffer zone groynes and bylaw boundaries)



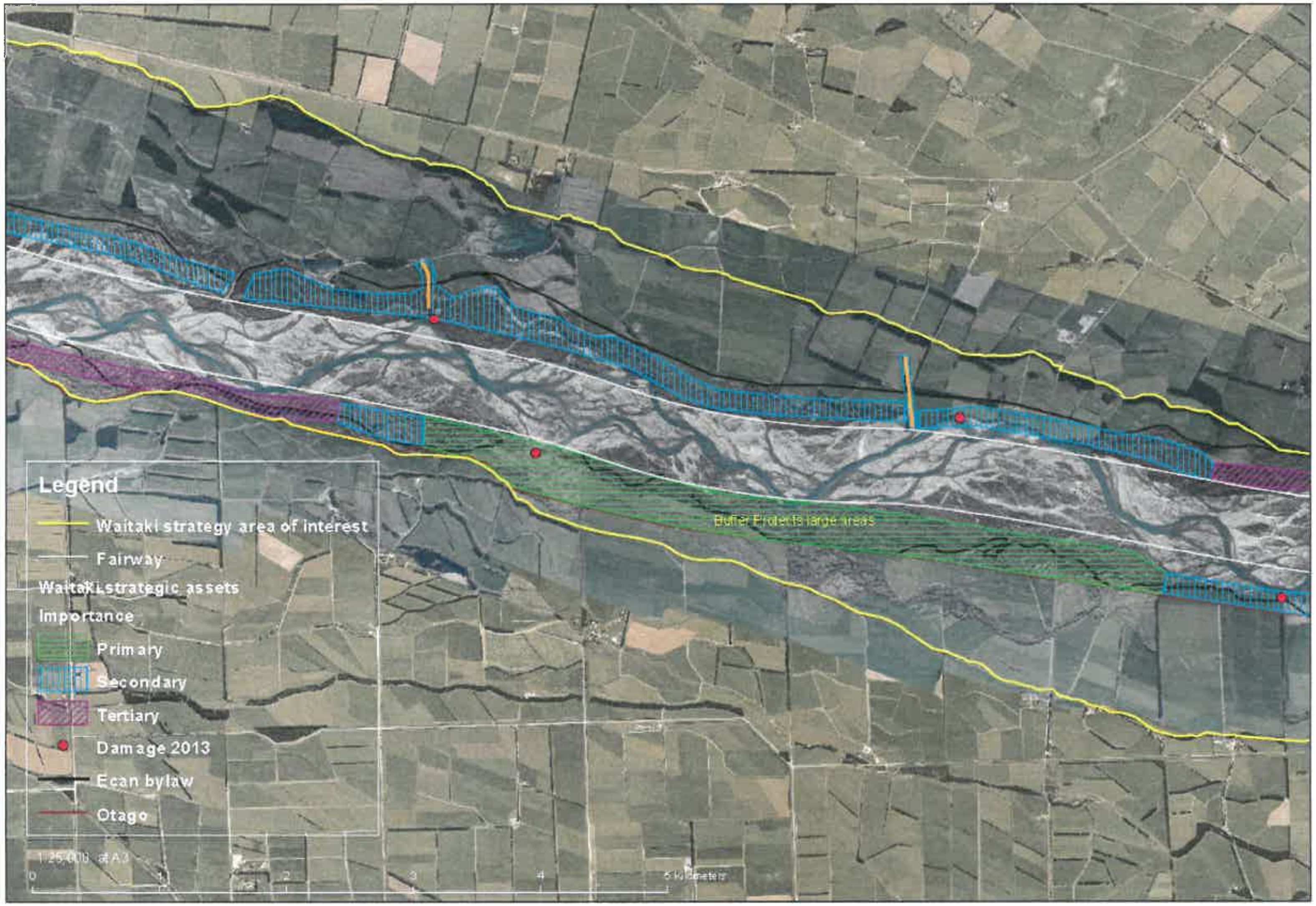
Map 3 Lower Waitaki Strategy (area of interest, fairway. primary, secondary and tertiary zones, 2013 damage, buffer zone groynes and bylaw boundaries)



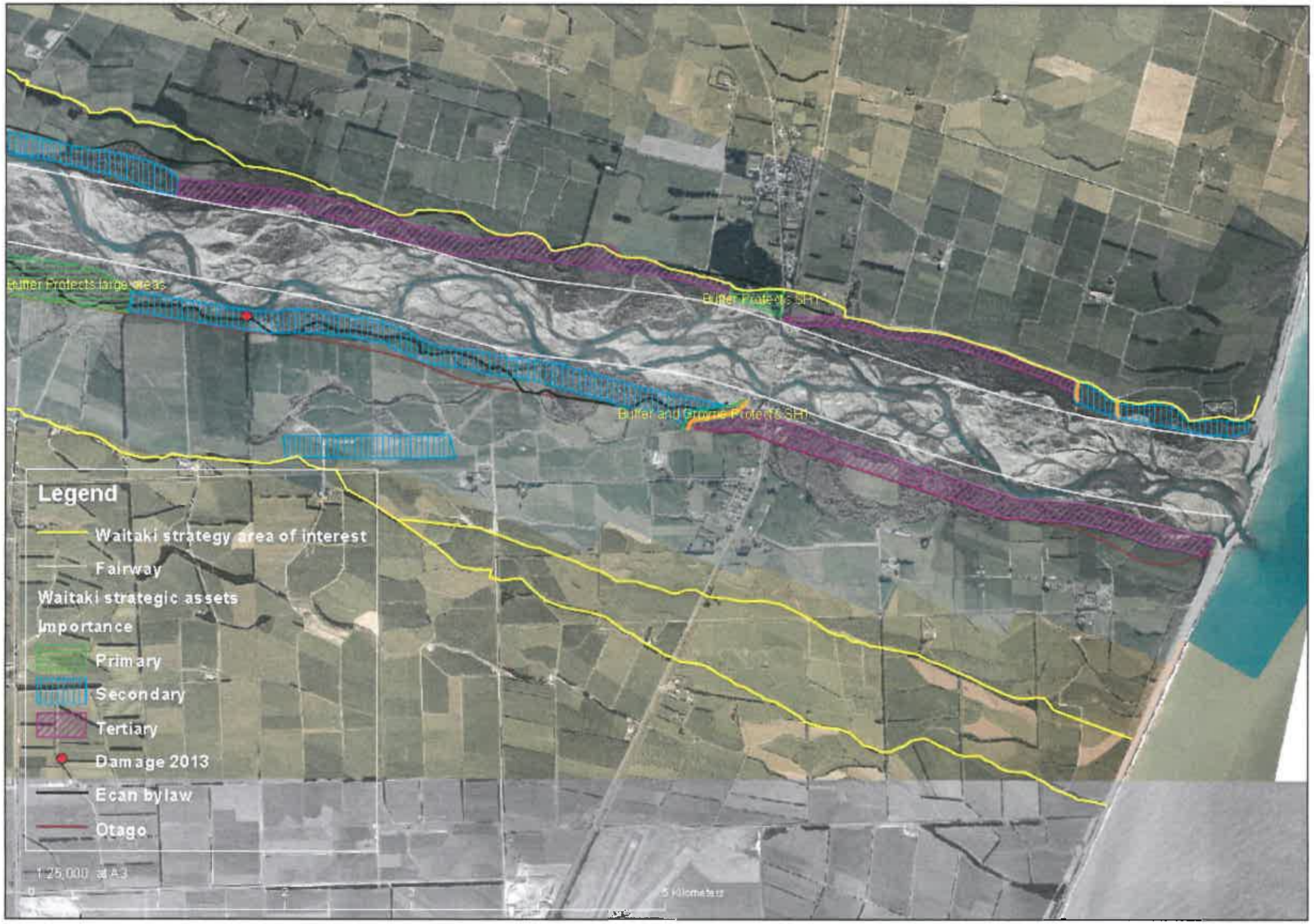
Map 4 Lower Waitaki Strategy (area of interest, fairway. primary, secondary and tertiary zones, 2013 damage, buffer zone groynes and bylaw boundaries)



Map 5 Lower Waitaki Strategy (area of interest, fairway. primary, secondary and tertiary zones, 2013 damage, buffer zone groynes and bylaw boundaries)



Map 6 Lower Waitaki Strategy (area of interest, fairway. primary, secondary and tertiary zones, 2013 damage, buffer zone groynes and bylaw boundaries)



Map 7 Lower Waitaki Strategy (area of interest, fairway. primary, secondary and tertiary zones, 2013 damage, buffer zone groynes and bylaw boundaries)