Kakanui River

morphology and riparian management strategy

Version 1.0 – October 2015

Otago Regional Council

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Cover image: Kakanui River looking south east towards Gemmells Crossing (30 October, 2014).

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Overview

The Kakanui River morphology and riparian management strategy has been prepared by Otago Regional Council (ORC), with input from the local community, to help protect the recreational, cultural and ecological values of the Kakanui and Kauru riverbeds, and to enable long-term, sustainable use of the land which borders the river.[1] The strategy, as summarised in the two diagrams below, is intended to help achieve this by guiding work programs, decision-making and activities, for the community, stakeholders, and ORC. It is therefore recommended that people who live, work or play within the Kakanui catchment consider, and give effect to the principles, objectives, and actions listed in this strategy.

The strategy is not a statutory document; rather it is intended to present the aspirations of the community and the various stakeholder agencies. However, the statutory processes which do influence river management activities[2] are more likely to be used effectively and efficiently if there is a general consensus on what is valued about the river, and commonly understood objectives.

The strategy is intended to be a living document, which will evolve in response to new information, changes in the environment, the needs of the community and the work of ORC and other stakeholders. The strategy will be reviewed regularly, and this process will involve landowners with property alongside the river, other stakeholders and ORC,[3] and will help to set priorities and work programs for all of these groups. The strategy document will also record progress made towards achieving the stated objectives. It is intended that version 2 of the strategy will include further guidance and plans for undertaking planting on riparian margins, for river management purposes and for habitat enhancement.

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1 Note that both the English and Maori spelling of Kakanui/Kākaunui are used in this strategy

2 Including the Local Government Act (in regards to funding considerations), and the Resource Management Act (in regards to managing environmental effects)

3 In particular, staff with responsibilities for rivers and waterway management and natural hazards

Kakanui River morphology and riparian management strategy - overview

Purpose

→ To provide guidance to landowners, stakeholders, and the community for good decision-making and appropriate activities within the riverbed and riparian margins of the Kākaunui and Kauru rivers.

Vision

→ The long-term sustainable use and enjoyment of the Kākaunui and Kauru rivers and their riparian margins.

Functions

Appropriate guidance and active engagement to empower good decision-making and to ensure that activities are undertaken in a sustainable and appropriate manner

Understand natural river processes and morphological characteristics, and the potential effects of those on the river and its margins.

The wise use of resources to:

- → manage the risk to property and assets
- → enable sustainable gravel extraction
- → protect and enhance community values
- → improve community resilience.

A shared vision of the rivers values and features to be utilised, preserved and enhanced.

Objectives & associated actions
(these are further refined in Section 7 - implementation)

1
Recognise and characterise natural river processes

- Collect information about flood and erosion processes.
- Report on changes in channel morphology.
- Provide information to the community.
- Identify the location of river corridors, within which the river will naturally meander.

2
Equip the community to live with the effects of changes in river morphology

- Promote land-use practices and the placement of assets which reduce the risk associated with changes in riverbed morphology
- Consider all available options to manage the effects of bank erosion, including structural and non-structural options.
- Enable works that will, where necessary, improve the conveyance of floodwater and ‘train’ the river within its natural corridor, without compromising the features which are of high value to the community.

3
Enable sustainable gravel extraction

- Identify areas where gravel accumulation can naturally occur.
- Identify areas where permanent removal of gravel may have a detrimental effect on assets, riverbed morphology or community values.
- Identify minimum bed levels/profiles, below which extraction will not occur.

4
Promote activities that enhance the natural character and enjoyment of the river

- Provide maps showing the location and characteristics of features which are of high value to the community.
- Encourage the establishment of riparian plantings that are practical and appealing.
- Provide access and habitat for fishing and whitebaiting activities.
- Support pest and weed control activities.
- Discourage dumping, and arrange the regular collection of rubbish.

Contents

1. Introduction

Changes in the morphology (physical form) of unconfined and braided riverbeds occur as a result of natural processes that are often uncontrollable, and also from human intervention. The Kākaunui and Kauru riverbeds are an integral part of the wider Kākaunui catchment (Figure 1). The riverbeds are part of a dynamic river system, and have experienced changes in morphology in recent decades. These changes will have occurred in response to naturally occurring flood events, as well as gravel extraction activities and historic river management decisions. Changes to riverbed morphology have included degradation[4] and sedimentation within the main channel, and significant bank erosion in places (Figure 2). In some cases, these changes have negatively affected the values placed upon the river by the community and stakeholders (landowners, iwi, Fish & Game NZ, Department of Conservation (DoC), Waitaki District Council (WDC) and residents).

Land alongside the river channel is often referred to as the 'riparian margin'. More intensive use of the land that borders the river has occurred in recent decades, with valuable farmland replacing what was previously rough vegetation (Figure 2, Figure 3 and Figure 4). As a result, changes in the position and form of the riverbed can cause issues for landowners and other river users.

The Otago Regional Council (ORC) has proposed the Kākaunui River morphology and riparian management strategy ('the strategy') to help provide guidance (for all users of the rivers) for good decision-making and appropriate activities on the riverbed and riparian margins of the Kākaunui and Kauru rivers. The strategy has a vision of long-term sustainable use and enjoyment of the Kākaunui and Kauru riverbeds and their riparian margins. It is also important when undertaking activities within the riverbed and on the riparian margins of the Kākaunui and Kauru rivers that people recognise, and allow for, the traditional, spiritual and cultural values of the local iwi.

The strategy's key objectives are to:

- recognise and characterise the natural river and catchment processes that occur in the Kākaunui and Kauru rivers
- equip the community to understand, and live with, the effects of changes in river morphology
- enable sustainable gravel extraction
- promote activities that enhance the natural character and enjoyment of the river.

The strategy is also intended to guide the nature and extent of land use, so that the negative effects of morphological change in the riverbed do not increase, and, where possible, are progressively reduced. It provides a framework for decision-making, so that activities undertaken by people occur in such a way that results in:

- a visually appealing river system
- a habitat that supports existing wildlife, fish and preferred plant species

[4] The term 'degradation' in this case refers to the wearing down of the channel by the erosive action of water

- limited effects on assets as a result of flood events
- resilient infrastructure (roads, bridges, water supply).

Many of the actions listed in this strategy are voluntary, and will rely on interactions between the key stakeholders and the community to be successful. It is therefore recommended that people who live, work or play within the Kākaunui catchment consider, and give effect to, the principles, objectives and actions listed in the strategy.

1.1 Report outline

Section 2 describes the scope of the strategy; while Section 3 summarises the natural environment within which it sits, and the community values associated with the river[5]. Section 4 describes the legislative context within which the strategy has been defined and will operate. Section 5 outlines the strategy's guiding principles and core components. Section 6 outlines the work that ORC has undertaken to help define an appropriate and sustainable river form for the riverbed and riparian margins. Section 7 summarises the methods that the various parties (ORC, stakeholders and the community) have designed to meet the strategy's key objectives.

A series of appendices are included at the end of this document:

- Appendix 1 describes the physical river management work to be undertaken by ORC in the next three years, which will also assist in achieving the strategy's objectives.
- Appendix 2 describes the areas where gravel has been identified as naturally accumulating and the river management profiles which have been calculated for those areas.
- Appendix 3 contains the mapped river corridors (the active fairway, and buffer zones).
- Appendix 4 provides location maps of particular values identified by the community and other stakeholders.
- Appendix 5 provides a summary of the public feedback received in mid-2015 regarding the initial proposal of the strategy.
- Appendix 6 contains information from the initial consultation with landowners and stakeholder groups in 2014 - early 2015.
- Appendix 7 shows the longitudinal profile of the river.
- Appendix 8 contains a guide on planting on river banks.
- Appendix 9 contains information on the threat status of native fish and birds.

[5] as determined by landowners, stakeholders and members of the public during community consultation in July 2014, and May 2015.

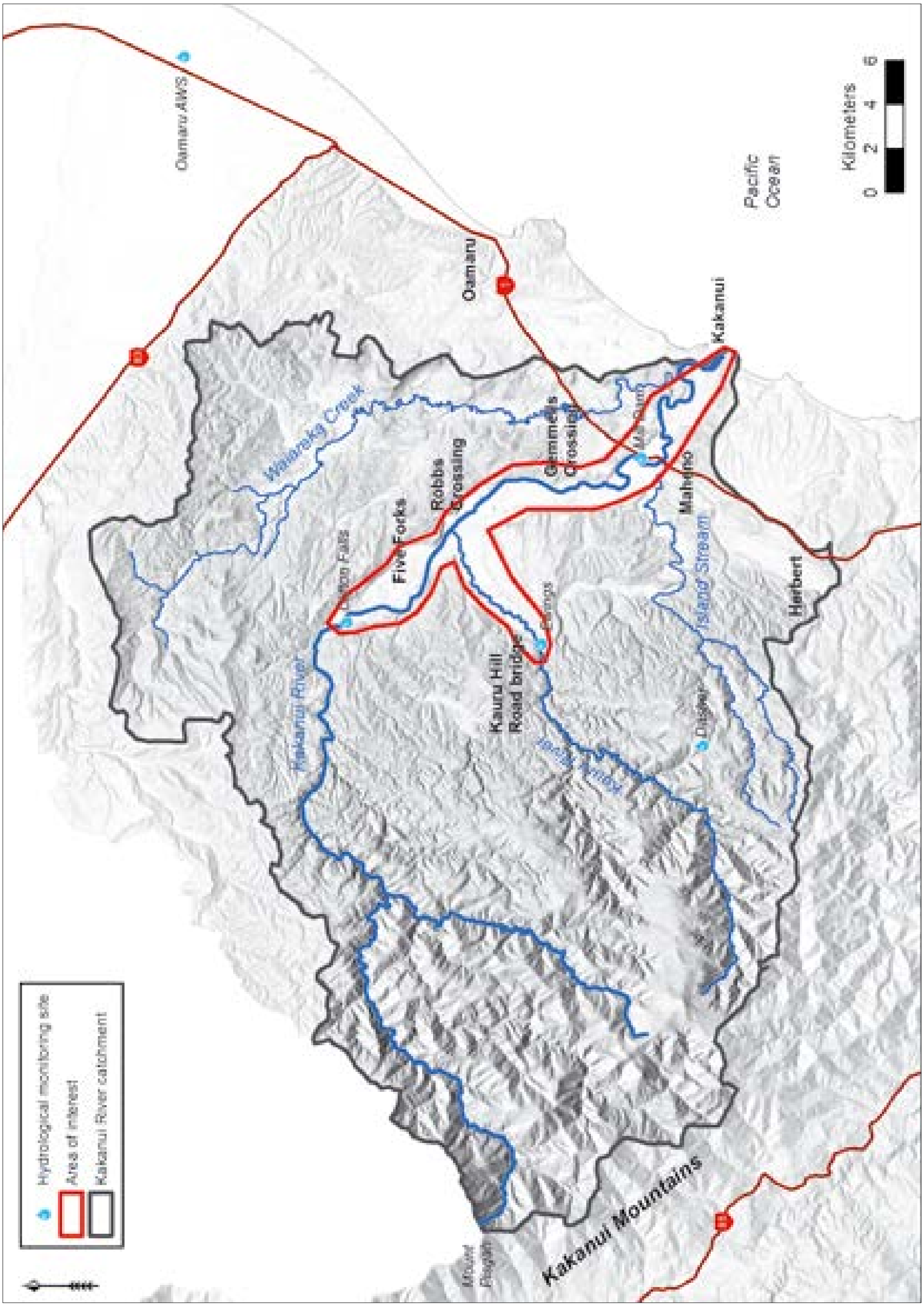


Figure 1. Kākaunui catchment boundary, showing main tributaries and the area of interest

Figure 2. Examples of recent changes in channel morphology. Top: Bank erosion on the true-right bank of the Kauru River (June 2013). Bottom: Bank erosion and sediment deposition in the Kākaunui River downstream of Gemmells Crossing (May 2014).

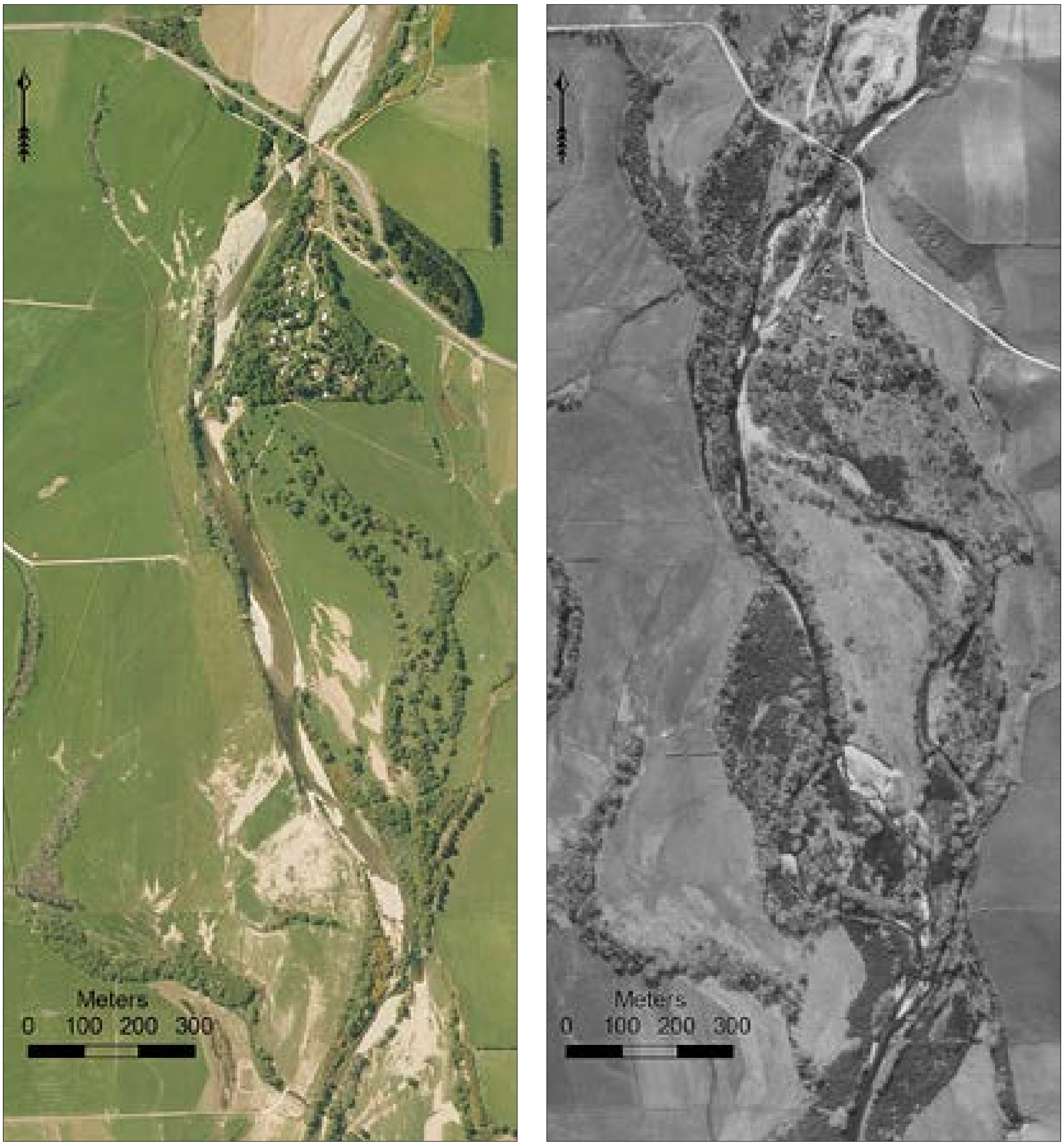


Figure 3. Comparison of aerial photography illustrating changes in vegetation, aerial photography collected in summer 2013/2014 (left) and 1957 (right)

Figure 4. Kākaunui River at the confluence with the Kauru River, looking upstream, highlighting changes in vegetation and river morphology (September 1969 (top), April 2015 (bottom))

2. Scope

2.1 Geographical

The strategy's geographical scope is the lower reaches of the Kākaunui and Kauru rivers (Figure 5), respectively:

- from Clifton Falls to the township of Kākaunui, and
- between Kauru Hill Road bridge and the confluence with the Kākaunui River.

Activities that occur in the upper catchments of both rivers and in other tributaries, such as Waiareka Creek and Island Stream, may have an effect on the lower reaches of both rivers. The upper reaches of the Kākaunui and Kauru rivers, as well as tributary waterways, were not investigated, because most concerns raised by the community concerned the lower reaches. The focus, therefore, was on these locations.

2.2 Risk

This strategy has a focus on the risks and effects associated with changes in riverbed morphology (including channel degradation and bank erosion, sedimentation and flooding) in the lower reaches of the Kākaunui and Kauru rivers. However, it is acknowledged that heavy rainfall events may lead to a range of other risks, including widespread river flooding and surface runoff.

There are several other environmental issues and hazards in the Kākaunui catchment. These include natural hazards such as seismic activity and extreme sea levels, and water quality and quantity issues. While numerous other issues do exist, this strategy is primarily concerned with the negative effects of changes in river form on the values associated with the Kākaunui River. Guidance and regulations relating to other issues can be obtained from the ORC. [6]

[6] For example, the Otago Natural Hazards Database, the Water Info website and the Regional Plan: Water, all available from www.orc.govt.nz

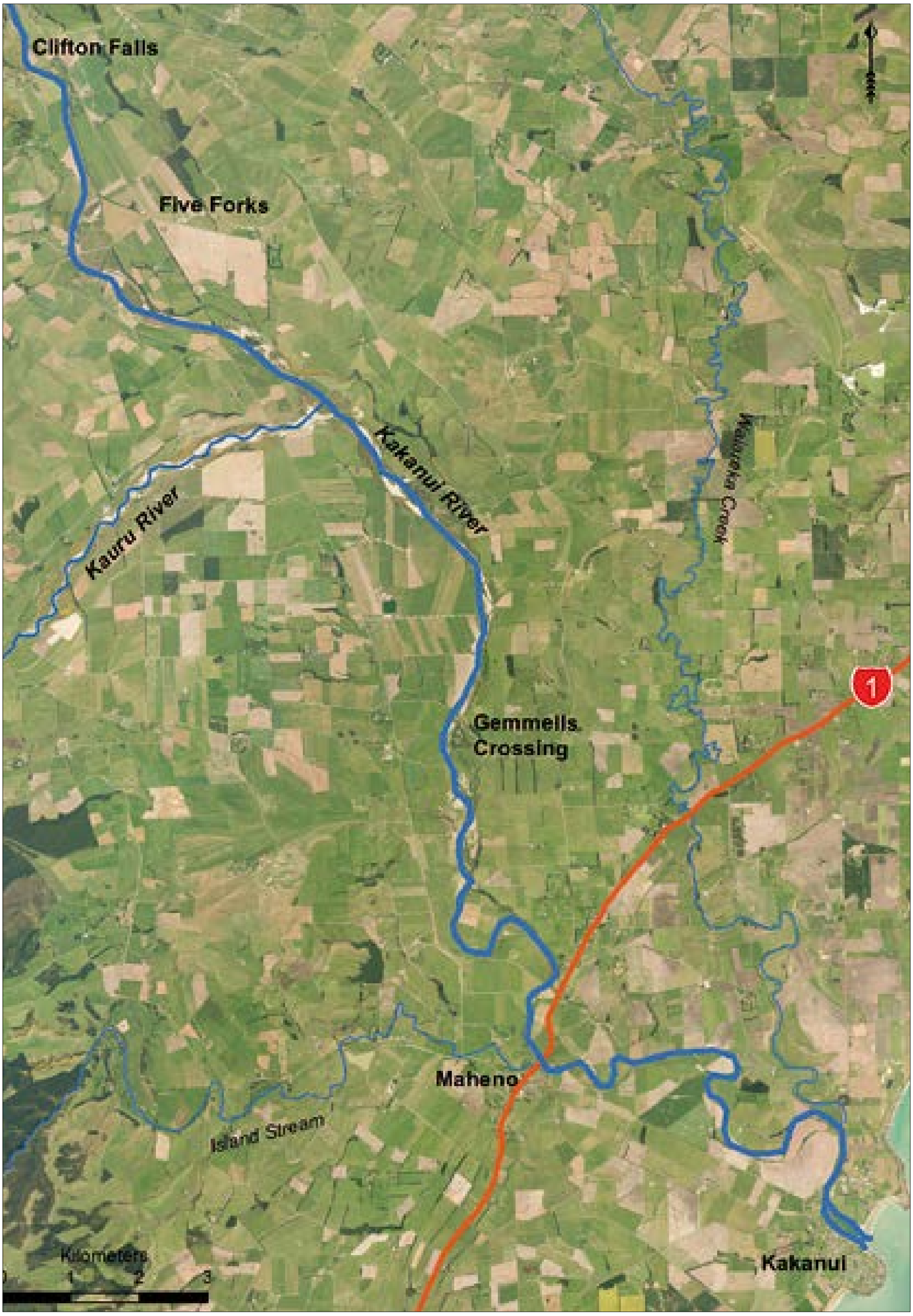


Figure 5. Map showing the reaches of the Kākaunui and Kauru rivers to which this strategy applies, and other tributaries of the Kākaunui River

2.3 Strategy development

The strategy is intended to be a living document, which will evolve in response to new information and changes in river morphology,[7] the needs of the community and the work of the ORC and other stakeholders. It will be reviewed regularly as part of council's annual and long-term planning process, or in response to large flood events. The review process will involve landowners with property alongside the river, other stakeholders, and ORC staff with responsibilities for rivers and waterway management and natural hazards. The review is proposed to monitor the effectiveness of the strategy, the workability of its stated objectives and to note progress towards achieving those objectives. It will also help ORC to set priorities when considering funding and undertaking river-maintenance work in the rivers concerned.

Before the review process, ORC will arrange and facilitate a workshop with the local community and invited stakeholder groups. This will consist of two parts:

1. an opportunity for participants to present to the group any issues they face as to changes in channel morphology or riparian management; work they have undertaken or would like to see undertaken; or to discuss, question or suggest changes to the strategy itself
2. a facilitated process to coordinate activity and work towards achieving the principles and objectives outlined in the strategy.

3. Environment setting

The natural and social settings of the Kākaunui catchment are described in this section, with particular focus on the special characteristics that give rise to the risks associated with changes in riverbed morphology.

3.1 Geological setting

The stretch of river to which this strategy applies is located within the broad floodplain areas in the mid- to lower reaches of the Kākaunui catchment, to the west and south of Oamaru (Figure 1 and Figure 5). Sediment has been eroded from the surrounding hill country, and subsequently deposited by fluvial processes to create the wide floodplain within which the river sits. This process is thought to be still occurring on a limited scale, in areas actively affected by floodwater at the base of the surrounding hill country, such as upstream of the Kauru Hill Road bridge (Figure 6) (Opus, 2009). The geology of the floodplain is described as gravel, sand, silt and mud, consisting of postglacial floodplains and low-river terraces (Forsyth, 2001). In several locations, the floodplain (and the Kākaunui River itself) lies alongside areas consisting of much older 'tuff' rocks of volcanic origin (Figure 7).

[7] Including additional understanding gathered during future flood events

Figure 6. View upstream of Kauru Hill Road bridge (July 2013)

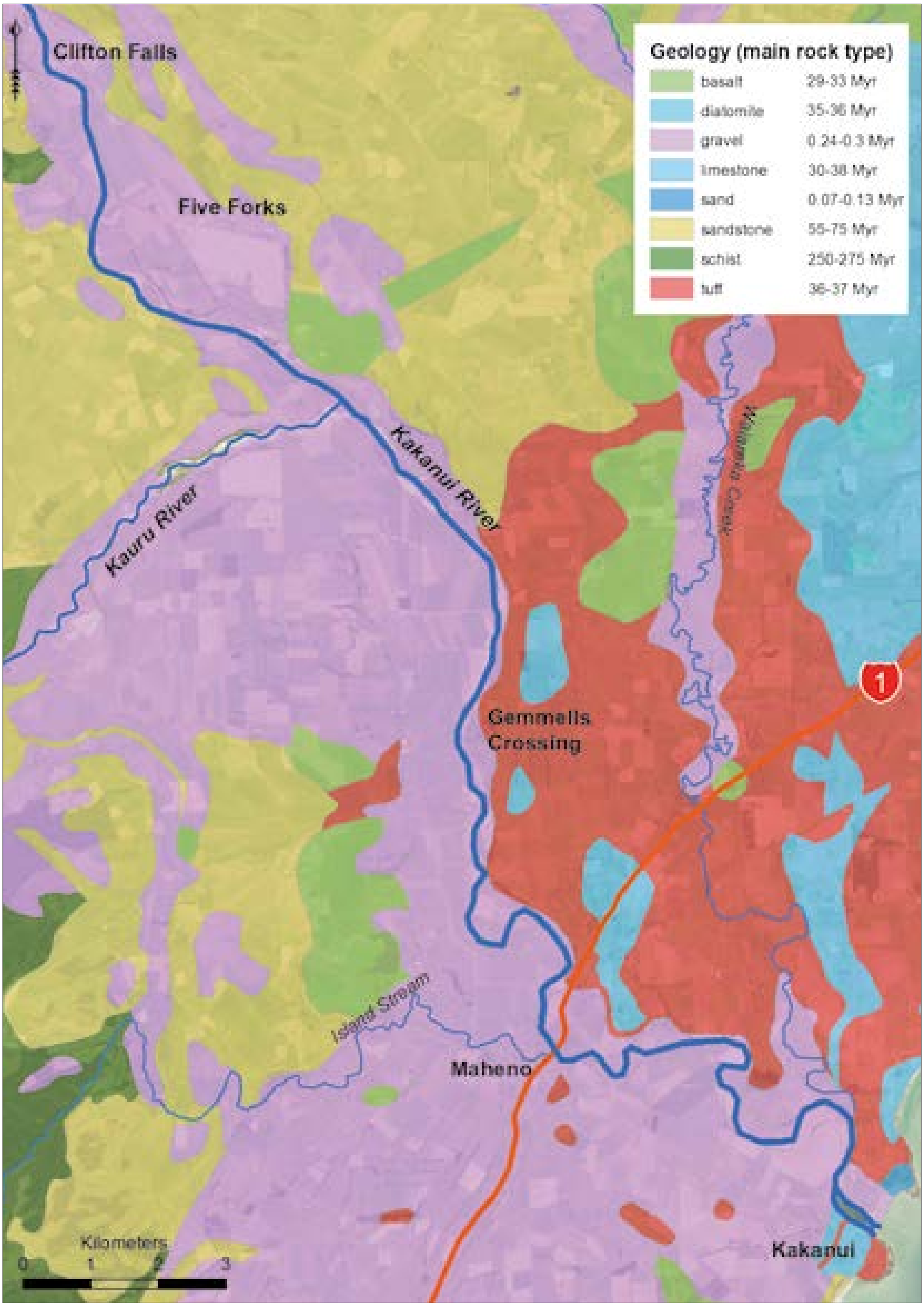


Figure 7. Geological map showing the reaches of the Kākaunui and Kauru rivers to which this strategy applies. The approximate ages of the main rock types are shown (in millions of years).

3.2 Geographical setting

The upper catchment (upstream of Clifton Falls) consists of rolling hills and steeper mountainous country, with the river having a single thread meandering planform that passes through tussock land, native and indigenous forest. The lower part of the catchment consists of rolling hill country and floodplains, with farmland extending to the river margins.

The Kauru River has a catchment area of 143 km^2, which is 16% of the total Kākaunui catchment. It rises to an elevation of 1,285 m above mean sea level (amsl) at Siberia Hill. The upper reaches of the Kauru River consists of gorges and steep valley slopes, with the river constrained to a single-thread, wandering channel planform (Figure 8). The lower catchment consists of a terraced alluvial fan, which starts at the gorge (1.5 km upstream of Kauru Hill Road bridge), and then slopes downwards towards the confluence of the Kākaunui and Kauru rivers.

Figure 8. Upper Kauru River catchment (photograph taken October 2014)

The entire Kākaunui catchment is 894 km^2, and is bounded by the Kākaunui Mountains and Pisgah Spur to the south and west (Figure 1). Mount Pisgah is the highest point in the catchment, at an elevation of 1,630 m amsl. The main tributaries of the Kākaunui River include the Kauru River, Island Stream and Waiareka Creek.

3.3 Meteorological setting

The Kākaunui catchment is located on the east coast of the lower South Island, within the Waitaki District. Flood events in coastal catchments such as the Kākaunui are generally caused by persistent rain-bearing easterlies, with continual rainfall over several days saturating the soil, leading to rapid runoff. Generally, these types of events occur in late summer to late autumn, although they can occur at any time of the year.

The nearest long-term automatic gauges are at Clifton Falls, The Dasher and Oamaru (Figure 1). Annual average and peak daily-rainfall intensities for these sites are listed in Table 1.

Table 1. Annual average and maximum observed 24-hour rainfall intensities for rain gauges in North Otago

Site (date records commence)	Annual average rainfall (mm)	Peak 24-hour rainfall (mm)	Date of peak 24-hour rainfall (mm)
Kauru at The Dasher (1953-2014) (missing data 1995)	809	187.9	5 June 1980
Kākaunui at Clifton Falls (1988-2014)	465	108	19 March 1994
Oamaru AWS (1982-2013)	504	69.9	26 April 2006

Although weather conditions tend to clear quite quickly after heavy rainfall events, enabling river levels to drop away, a sequence of fronts will occasionally move across the east coast, bringing further rain to already saturated catchments. The effect of these frontal bands can sometimes be compounded by the added runoff from snowmelt in the upper catchment.

3.4 Hydrological setting

Information on river flow is available from a number of long-term monitoring sites (Figure 1 and Table 2). The Mill Dam, Clifton Falls and Ewings sites have been operating since 1989, 1981 and 1991, respectively, and the ten largest flows on record for these sites are shown in Figure 9 Figure 10 and Figure 11. The largest flood event on record at all three sites was in April 2014, although historical records of larger flows do exist (OCB, 1988). There have been a relatively high number of large flood events in the last decade (2006-2015) at all three sites. The river can rise very quickly during flood events, with a rate of rise of greater than 100 cumecs[8] per hour observed at the Clifton Falls site, and an increase in flow of almost 50 cumecs in just 15 minutes observed at Mill Dam in April 2006. Peak velocities observed at these sites range from 3 m/sec. to 5 m/sec., with velocities likely to be higher in the steeper more confined sections of the Kākaunui River.

[8] 1 cumec equals 1 m^3 of water per second

Additional evidence (photos, council reports) of flood events in the Kākaunui catchment during the 1960s and 70s also exists, and this can be accessed through the Otago Natural Hazards Database.

Table 2. Summary of hydrological information for sites within the Kākaunui catchment

Site	Maximum observed flood (date)	Annual flood (2.3 yr return period) (cumecs)	Median flow (cumecs)
Kākaunui at Clifton Falls	565.8 (18 April 2014)	170	1.5
Kākaunui at Mill Dam	688.7 (17 June 2013)	298	2
Kauru at Ewings	159 (18 April 2014)	70	0.5

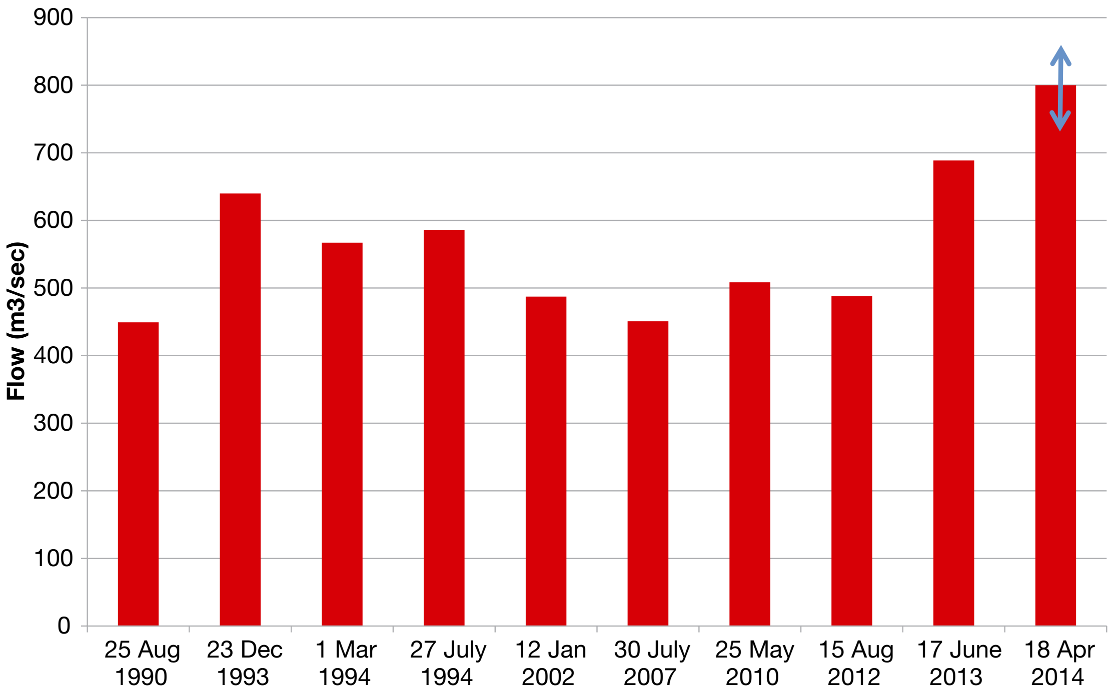


Figure 9. Ten highest flows in the Kākaunui River at Mill Dam since records began in December 1989. The accuracy of the April 2014 event is less than smaller events, due to some floodwater flowing out of its channel and bypassing the flow recorder.

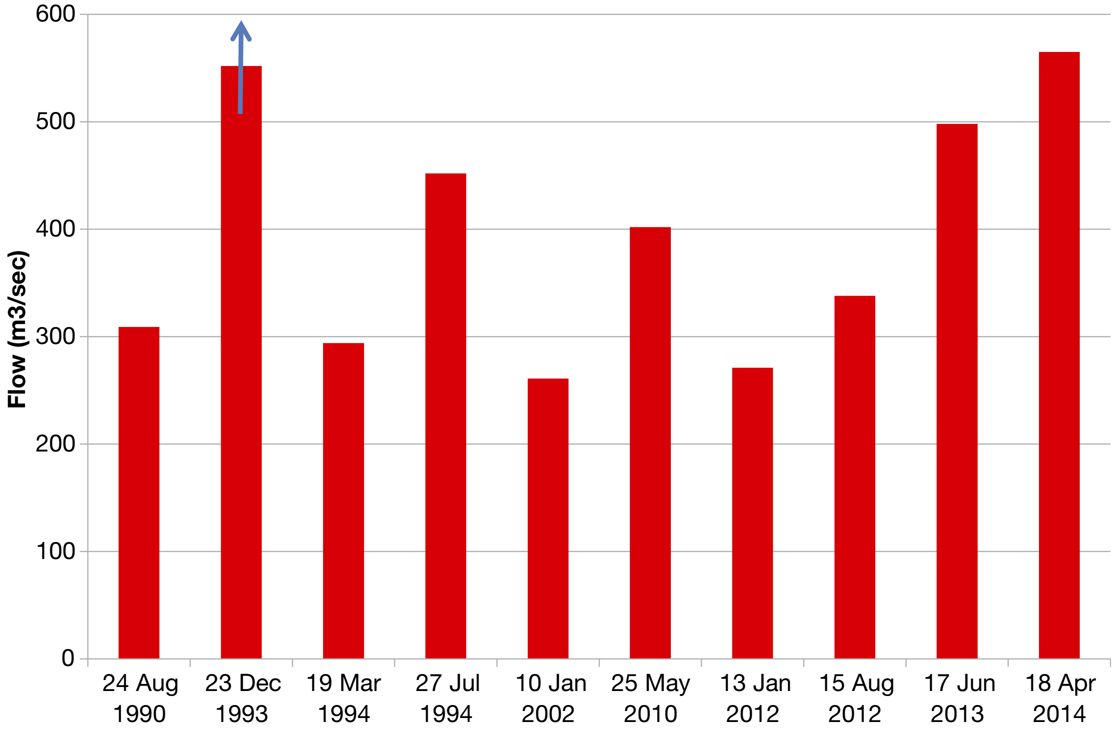


Figure 10. Ten highest flows in the Kākaunui River at Clifton Falls since records began in April 1981. The flow site failed prior to the peak of the December 1993 flood - the maximim flow is therefore not known, but was larger than shown in this figure.

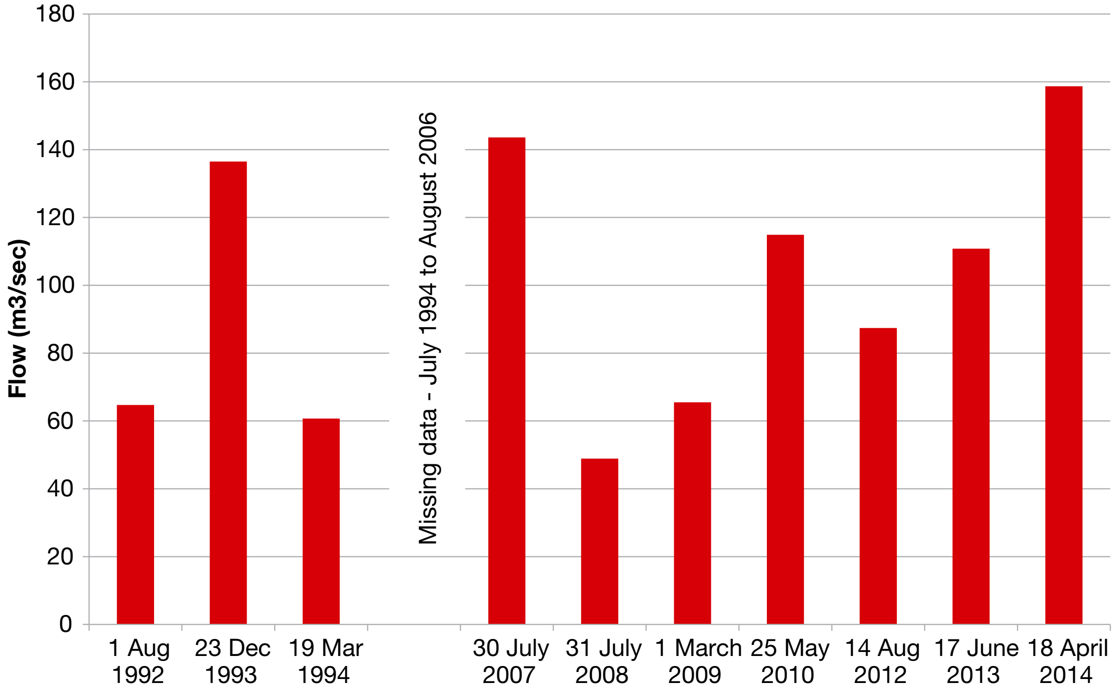


Figure 11. Ten highest flows in the Kauru River at Ewings since records began in November 1991

3.5 Riverbed morphology

The active channels of the Kauru and Kākaunui rivers are dynamic systems where flood events and sediment transport movement regularly cause changes in riverbed morphology (ORC, 2013). Changes in the longitudinal profile of the riverbed occur due to aggradation and degradation along the channel, and as a result of lateral bank erosion. Significant changes often occur as a result of extreme flood events, but small-scale, incremental changes can also occur over longer time-frames. Human activities, such as gravel extraction and physical works, can also result in significant morphological change, particularly near these works, but they also occur across the wider river system.

ORC undertakes work to describe these changes in morphology, using visual inspections, aerial and ground photography, and cross-section data. Reports summarising these investigations were published in February 2015, September 2013 and October 2010 (ORC, 2015, 2013, 2010).

3.5.1 Kākaunui River

A walkover of the Kākaunui River from the Kauru confluence to approximately 4km downstream of the Gemmells Crossing Road Bridge was completed by ORC staff in March 2015. Observations from this trip reinforced the findings of previous investigations, in particular that:

- the riverbed alternates between stable reaches with riparian plantings and limited bank erosion, and areas where there is limited bank vegetation and ongoing bank erosion
- some parts of the riverbed have experienced an increase in mean bed level (MBL), while other parts have experienced a decrease
- where decreases in MBL occur, these are generally larger than the increases
- there are numerous locations where bank erosion is occurring, and many of these are not captured by ORC's cross-section network
- at one cross-section (KA26), downstream of Gemmells Crossing, bank erosion of about 20m occurred over a 12-month period (October 2012 – October 2013).

A comparison between aerial photographs collected in 1957 and 2013 further highlights the dynamic nature of the Kākaunui River. In places, the fairway (the most active part of the riverbed) moved up to 200 m between 1957 and 2013 (Figure 14), while in the more stable reaches the fairway has remained in a similar position. This analysis also revealed that, between the Kauru River confluence and Gemmells Crossing, the river became less sinuous between 1957 and 2013 (i.e. it became straighter). In 1957, there were more backwaters in the Kākaunui River than in 2013, and, during this period, areas where gravel tends to accumulate (often referred to as beaches) reduced in size and/or changed positions (Figure 12, Figure 13).

A comparison of cross-sections, some dating back to 1985, also highlights the dynamic nature of the riverbed, and shows how the channel moved laterally in some locations, as well as becoming deeper (Figure 15).

Figure 12. Comparison of aerial photography illustrating changes in gravel beaches, aerial photography collected in summer 2013/2014 (left) and 1957 (right)

Figure 13. Kākaunui River looking downstream to Gemmells Crossing Road bridge (photograph taken 10 July 1978) a similar view taken in 2014 can be seen on the front cover

Figure 14. Comparison of the Kākaunui River fairway between 1957 and 2013 in the vicinity of the Fuchsia Creek Road bridge (aerial photograph collected in summer 2013/2014)

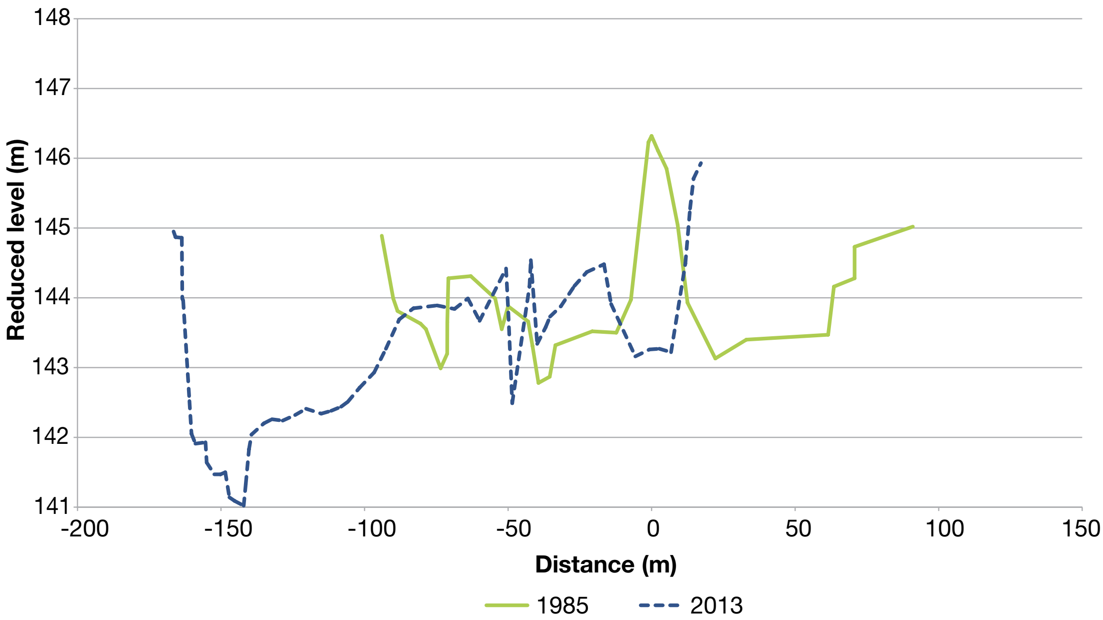


Figure 15. Kākaunui River cross-section KA8 (downstream of the Kauru River confluence), looking downstream. Between 1985 and 2013 the main channel moved about 100 m towards the true-left bank, and the deepest part of the channel lowered by 2 m.

Flood damage can be severe, given the rivers tendency to break out of the main channel and cross farmland, and the land immediately alongside the river is more likely to be affected by floodwater, sedimentation and erosion. Flooding can also cause disruption to the transportation network and damage to both private and public assets. A significant flood occurred in June 2013, which peaked at 689 cumecs at Mill Dam (Figure 9). This flood caused the Kākaunui River to overtop its banks onto the floodplain, and deposit gravel and silt well beyond the main channel (Figure 16). Bank erosion occurred at a number of locations between the Fuchsia Creek Road bridge and the mouth of the river. Another, larger flood occurred in April 2014, which peaked at about 800 cumecs at the hydrological site Kākaunui at Mill Dam (Figure 9). Although this is the largest flow that has occurred at this location since continuous records began in 1989, historical records of similar large flows do exist (OCB, 1988). As well as having an effect on the morphology of the Kākaunui riverbed, the April 2014 flood caused breaches of flood banks and again deposited gravel outside the main channel.

Figure 16. Kākaunui River overtopping its banks, (downstream of Gemmells Crossing) June 2013 event.

3.5.2 Kauru River

A walkover of the Kauru River from the Kauru Hill Road Bridge to the Kākaunui confluence was completed by ORC staff in March 2015. Observations from this trip reinforced the findings of previous investigations, in particular that:

- the riverbed is generally experiencing minimal change or a decrease in mean bed level.
- there are numerous locations where bank erosion is occurring, and many of these are not captured by ORC's cross-section network. Between September 2012 and October 2013, there were noticeable amounts (>1 horizontal metre) of bank erosion experienced at 11 of the 17 surveyed cross-sections (ORC, 2015). The largest amount of bank erosion observed at an ORC cross-section since records began in 1978 was about 110 m, about 700 m upstream of the Kākaunui Valley Road Bridge.
- sediment size decreases in a downstream direction, with larger boulders being present in the upper sections of the Kauru River.

A comparison of aerial photographs from 1957 and 2013 shows that the Kauru River is a dynamic system, and that the riverbed has changed its position within the floodplain at several locations. In some cases, the active fairway moved about 150 m between 1957 and 2013 (Figure 17). Between the Kauru Hill Road Bridge and Kininmont Ford, the channel increased in sinuosity between 1957 and 2013. Localised morphology of the Kauru River has changed over time and can be seen in cross-section changes that have been surveyed since 1978 (Figure 18).

These observations help to endorse the findings of ORC (2013) that sediment replenishment rates from the upper Kauru catchment are insufficient to maintain the profile of the surveyed reach, and that material is being eroded from the channel (in the upper section) and from the banks (lower section) during flood events, with this sediment then being re-worked downstream.

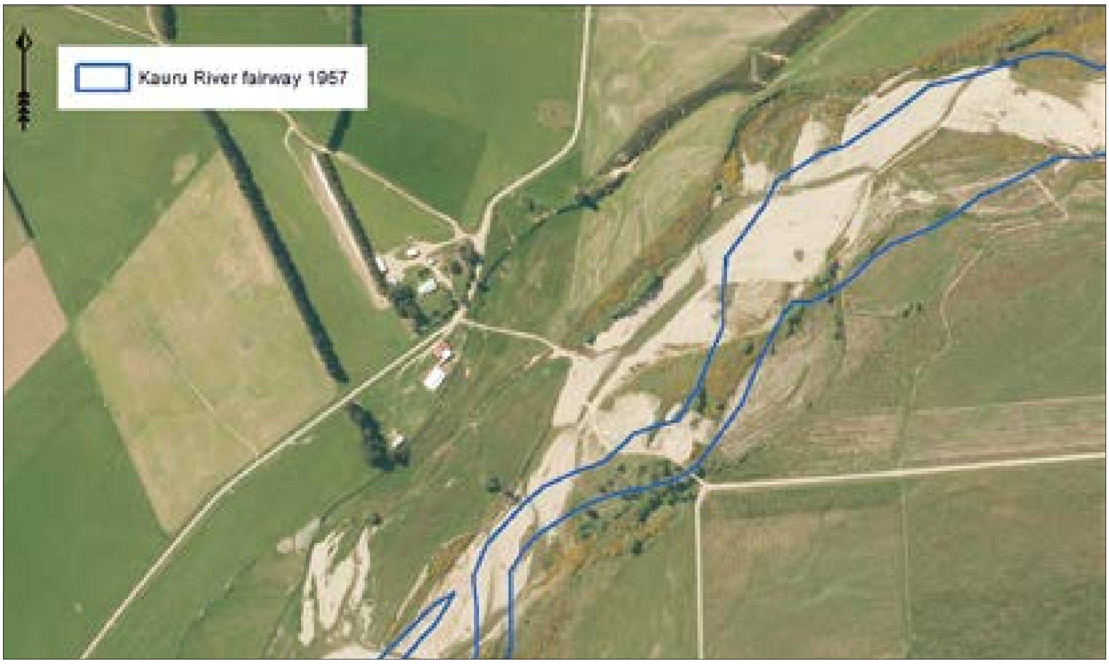


Figure 17. Comparison of the Kauru River fairway between 1957 and 2013 in the vicinity of Kininmont Ford (aerial photograph collected in summer of 2013/2014).

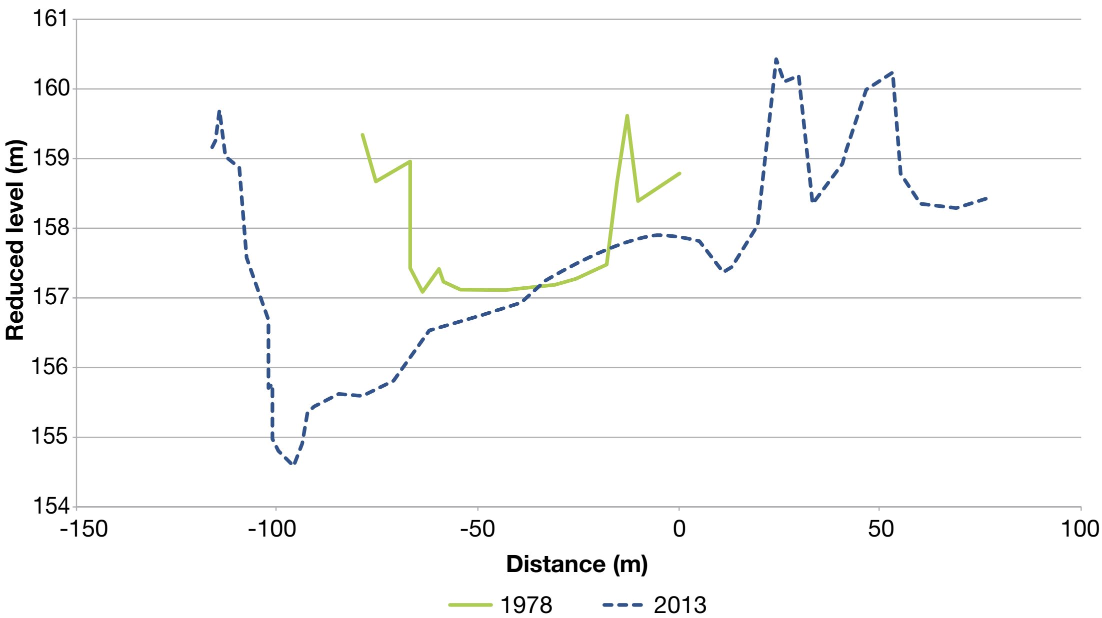


Figure 18. Kauru River cross-section K1 (upstream of the Kākaunui Valley Road Bridge, looking downstream). Between 1978 and 2013 the channel degraded by about 2.5 m and moved to the true-left bank by about 50 m.

The June 2013 flood peaked at 111 m^3/sec at the Ewings monitoring site. A flow of this magnitude can occur reasonably frequently. Figure 11 shows that this was the fifth largest flow observed in the Kauru River at the Ewings hydrological site since continuous records began in 1991. This flood caused a number of changes to the morphology of the Kauru riverbed, such as the main channel migrating from the true-right bank to the true-left bank upstream of the Kākaunui Valley Road Bridge and causing further damage to the bridge approach, as well as above Kininmont ford where the river bifurcated (split) and developed a second channel.

Another, larger flood occurred in April 2014, peaking at 159 m^3/sec (Figure 11). This is the largest flow that has occurred at this location since records began. The April 2014 flood event also had a noticeable effect on the morphology of the Kauru River at several locations: Gravel was deposited out of the main Kauru River channel near Kininmont ford, where bifurcation in the Kauru River had previously occurred; erosion of the true-left bank upstream of the Kākaunui Valley Road Bridge also occurred. Additional bank erosion was observed to occur at a number of locations between Kauru Hill Road and the confluence with the Kākaunui River. Although the April 2014 flood event was the largest since records began, the effects were mostly contained within the active channel and wider river fairway. There were limited effects across the wider floodplain. There are historical records of flood events in the Kauru River overtopping the river banks, resulting in sedimentation on adjacent farmland and bank erosion. Flooding can also cause disruption to the transportation network and damage to both private and public assets.

3.6 Riparian margins

The riparian margin is the area beside waterways that forms the interface between water and land. As noted in the introduction, more intensive use of the land that borders the Kākaunui and Kauru rivers has occurred in recent decades. In some parts of the catchment, farmland has encroached onto what was previously a more natural area of rough vegetation (Figure 3). This has resulted in a narrowing (or in some cases, complete removal) of the riparian margin which separates the active river fairway from land which is used for farming or which accommodates community infrastructure.

Previous ORC reports have identified that channel widening by bank collapse and erosion is now a common occurrence along much of the Kākaunui and Kauru rivers. The loss of primary agricultural land and physical property adjacent to eroding stream banks is very costly and the need for their protection against erosion has long been recognised.

Historically, the permanent removal of gravel from the river system has been used as a tool in an attempt to address bank erosion issues. The strategy identifies that gravel extraction, and other river management tools (such as the movement of gravel within the channel and spraying), should still be considered for river management purposes, where that is appropriate. However, a number of authors have identified that the most effective means of controlling river bank erosion is to establish a vegetative cover of strongly rooting plants (Slui 1991, Marden et al. 2005, ORC 2005, Phillips & Daly 2008). In general terms, vegetation roots increase bank stability by protecting soils against entrainment from flood flows, and root mass and density provide soil shear strength and thereby protect against gravity collapse of undercut banks.

Other indirect benefits of riparian plantings include a reduction in nutrient and fine sediment enrichment; shade, shelter and filtering qualities for the aquatic eco-system; and aesthetic and recreational value. If well managed, riparian margins can help to improve water quality, provide food and habitat for freshwater life, and improve diversity (ORC, 2005). A strong desire to see the form of the river include riparian plantings, particularly native species, was also identified by many individuals and groups during the development of the strategy.

3.7 Community setting

The Kākaunui and Kauru rivers fulfil a number of important roles within the community, at a local, district and regional scale. These roles include (but are not limited to) being:

- a source of water for irrigation, stock and people
- a source of gravel for roading and construction purposes
- for recreational purposes, including swimming and walking, fishing and hunting, boating, camping
- a habitat for native and introduced species
- for customary uses by local iwi, ranging from the use of water for ceremonial purposes, to maintaining the quality and quantity of water to sustain mahika kai populations and habitat.

3.7.1 Ecological values

Fish

The Kākaunui and Kauru rivers provide important habitat for a range of native (Appendix 9) and exotic freshwater species. The lower Kākaunui and Kauru rivers support the only known population of Lowland longjaw galaxias (Galaxias cobitinis), which is listed as 'nationally critical' (Goodman et al., 2014), the highest threat classification under the New Zealand threat classification system (Townsend et al., 2008).[9] They prefer a habitat of cool springs and streams made up of cobbles and gravels in braided-river environments such as those found in the lower Kauru River. The lowland longjaw galaxias require porous substrates so that they can burrow into the gravel during periods of low flow. Mechanical movement of sediment in the rivers can negatively affect the ability of the lowland longjaw galaxias to burrow into the substrate through compaction of the substrate by heavy machinery and reduced substrate size due to the extraction of larger particles (Dunn & O'Brien, 2006).

Brown trout (Salmo trutta) is an introduced species and is the most common fish in the area. Both the Kākaunui and Kauru rivers support a locally important brown trout fishery. The national angler survey suggests that angler effort in the Kākaunui catchment in recent surveys (2001/2002 and 2007-2008) has been much lower than in the

[9] equivalent to that assigned to the Kakapo

1994/1995 survey (Table 3). The lower angler days may be due to factors such as high allocation (of flows), low flows, riparian management and declining water quality.

Table 3. Angler effort in the Kākaunui catchment (angler day's ± standard error) based on the national angler survey (Unwin, 2009)

River	Angler usage (angler days ± SE)		
	1994/1995	2001/2002	2007/2008
Kākaunui River	2040 ± 650	220 ± 110	890 ± 380
Kauru River			180 ± 180

The Regional Plan: Water for Otago[10] also lists many natural values for the Kākaunui River, including significant fish and macroinvertebrate diversity, trout spawning and rearing habitat and a significant presence of eels.

Birds

The wider river environment provides habitat for a range of exotic and native bird species (Appendix 9) that nest or feed in the river bed and its margins. Banded dotterel, black stilts, kingfisher, shining cuckoo and grey warblers use the Kākaunui and Kauru rivers permanently, while other species such as the white fronted tern and South Island oyster catchers use the river intermittently for foraging. As the river bed and margins become modified, the habitat for some birds becomes threatened. Human activities in and around the river bed may also disturb nesting birds.

3.7.2 Community values and feedback

To help to identify aspects of the river environment that are important to the local community, ORC consulted with a wide range of stakeholders in 2014 - early 2015 and in again in May/June 2015. These included landowners, Te Runanga o Moeraki, Kākaunui Ratepayers Association, Fish and Game, WDC and the Department of Conservation.

The values that the community and other stakeholder groups said they identified with the river environment and its form and function are summarised in the box below.

[10] Schedule 1A of the Regional Plan for Otago (2004), p. 267

Community river form and function 'values'

- That the ***function*** of the river continues to support social, cultural, spiritual, recreational, and farming activities – as well as continuing to provide for the taking of gravel as a resource
- That the ***form*** of the river includes riparian plantings (including both native vegetation and willows), weed control and fencing
- That the river channel is able to shift laterally within an identified riparian margin, but:
  - farmland beyond that margin is not eroded, and
  - main flood flows are kept in the channel.
- A range of views on the amount of human modification within the riverbed were expressed, ranging from:
  - no/limited engineering work or gravel extraction
  - some engineering work or gravel extraction
  - considerable engineering work or gravel extraction.

The full list of 'future form and function values' identified through the consultation process is included in Appendix 6.

3.7.3 Maori cultural values

The Kākaunui and Kauru rivers are significant to local iwi for mahika kai and other cultural values. The Kākaunui River was used by Kai Tahu in the past as a stopover location as they travelled north and south along the coast.

Water has an important place in ceremonial occasions and is particularly recognised where the cultural components of tapu and noa are at work. Water symbolises the spiritual link between the present and the past, as the never-ending source of life for generations that have gone before and those to follow.

Kai Tahu's priority is to maintain the properties of water that are necessary to ensure the sustainability of customary uses. Customary uses range from the use of water for ceremonial purposes to the maintenance of the quality and quantity of water to sustain mahika kai populations and habitats.

3.7.4 Gravel extraction

The removal of gravel from the riverbed of the Kākaunui and Kauru rivers has occurred for many decades (Figure 19), with extracted material generally used for roading and construction purposes. Gravel extraction typically occurs from locations where sediment naturally accumulates (for example, where there is a decrease in the gradient of the river, leading to a reduction in the velocity of flood flows), or in an attempt to mitigate issues such as bank erosion. In either case, extraction from the bed of the river will tend to increase the conveyance of water during flood events, by widening the channel and reducing the MBL at that location. It can also lead to a decrease in the sinuosity of the river channel, as bends are straightened in an attempt to reduce the effects of bank erosion.

Records provided by extractors to ORC show that approximately 46,000 m^3 of gravel was extracted from the Kākaunui and Kauru rivers between March 2006 and October 2013, equating to an average rate of about 6,150 m^3 per year. By comparison, ORC (2005) estimated that the total gravel-extraction volume from 1969-2005 in the lower part of the Kauru River alone was about 560,000 m^3, equating to an average rate of about 15,500 m^3 per year, with additional extraction occurring from the Kākaunui River. Consented gravel extraction volumes were increasing up until the early 2000s, peaking at over 100,000 m^3 in 2001.

Figure 19. Gravel extraction in the Kauru River below the Kākaunui Valley Road Bridge (November 2014)

Ongoing channel degradation can allow increased water velocities (particularly during flood events) to scour the river bed, deepening the channel, which can result in continued bed degradation. As the channel deepens, flood flows become confined within the channel and continue to scour the bed. This ongoing degradation decouples the channel from the floodplain and alters the floodplain catchment interactions (Fuller et al., 2014), examples of which are shown in Figure 15 and Figure 18. Deeper channels contain larger floods and concentrate flows, leading to more incised channels, potentially generating higher sediment transport rates (due to bank erosion and further removal of material from the riverbed). This process gives the appearance of more prominent gravel bars within the active channel due to the deeper channel. As the channel deepens and gravel bars become more prominent, pressure is often exerted by adjacent landowners to remove the obvious (but in fact non-existent) excess gravel accumulation, which in turn exacerbates the degradation trend (Fuller et al., 2014).

The sediment replenishment rates from the upper catchment of the Kākaunui and Kauru rivers are insufficient to maintain the profile of the surveyed reaches of both rivers. Both the Kākaunui and Kauru rivers are currently experiencing an overall trend of bed degradation and bank erosion, although there are localised areas where eroded material tends to accumulate. The perception that bed levels are increasing in the Kākaunui and Kauru rivers and that more gravel needs to be removed to manage this is incorrect. The reality is that there is localised build-up of gravel that makes the gravel resource appear larger than it actually is.

The permanent removal of gravel can also result in the undermining of river protection works and other assets (e.g. water intakes, bridges and roads), as well as degrading ecological values. Gravel extraction can have a negative effect on the local ecology, with the severity of effects dependent on the extraction methods used and the environment from which the gravel is being extracted. Gravel extraction activities can lead to a reduction in habitat heterogeneity/diversity, an increase in fine sediment, as well as bed compaction that can have a negative impact on the native and exotic animals residing in and on the banks of the Kākaunui and Kauru rivers (Dunn & O'Brien, 2006). The potential beneficial and adverse effects of significant gravel extraction are summarised in Table 4.

Table 4. Potential beneficial and adverse effects of gravel extraction (Canterbury Regional Council, 2015)

Potential beneficial effects	Potential adverse effects
Channel capacity increased, flood levels lowered	Disturbance of fish and bird habitat
Concentration of flow against riverbanks, resultant lateral erosion, and localised bed scour is minimised	Accidental discharge of fuels and lubricants from machinery
Stable channel alignment and optimum bed level is maintained	Disturbance of the natural meander patter and channel stability
Open gravel beaches can provide a good habitat for indigenous birds	Overall degradation of the riverbed
A renewable gravel resource for local construction may be utilised	Increased bank erosion
	Sediment is discharged, increasing turbidity and smothering habitat
	Temporary reduction in recreational access
	Mauri (life force) of the riverbed affected
	Disturbance of fish spawning sites
	Dust generation
	Reduced river bed heterogeneity

As part of the work undertaken for this strategy, natural gravel accumulation areas were identified and mapped, along with other areas where localised, small-scale gravel accumulation occurs. Areas with high community values, or where negative changes in river morphology (such as bed degradation and bank erosion) are occurring were also mapped. These areas are shown in Appendix 2. Commercial gravel extraction may be possible in the natural gravel accumulation areas, provided it can be shown to be sustainable and can be managed in such a way as to not have any negative effects on the river system.

River management profiles were created for the areas that have been identified as currently accumulating gravel (Appendix 2). A river management profile is a level that is set at a site which allows gravel to be removed when the gravel beach surface is above the profile and limits gravel extraction when levels drop below the profile. The river management profiles are to be used in conjunction with a series of conditions which are discussed in Appendix 2.

4. Legislative context

The manner and degree to which the issues in the Kākaunui and Kauru rivers can be managed by the community, stakeholders and local councils is influenced by the obligation, powers and restrictions set out in various statues. No legislation confers the exclusive power or the right to manage the Kākaunui and Kauru rivers to ORC or WDC. Whether through works or services, individuals are empowered to initiate their own measures provided they operate within the law. They are also allowed to develop and promote proposals for bank protection works, to apply for and hold the necessary resource consents and to privately fund works and services should they wish to.

The law provides for a range of methods that both councils and the community can use to manage the Kākaunui and Kauru rivers. These methods do not only relate to physical works, but also to planning, information, emergency preparedness and response. They can only be implemented after taking environmental effects into account (under the Resource Management Act (RMA)) and funding consideration (under the Local Government Act (LGA)). The latter includes consideration of the distribution of benefits between the community as a whole, any identifiable part of the community and individuals.

The Otago Regional Policy Statement (RPS) provides a high-level policy framework for the sustainable integrated management of Otago's resources, as well as giving effect to the requirements of the RMA (ORC, 2015). This includes the management of the values of water bodies, natural resource systems and the form and function of Otago's rivers, whilst still enabling communities to provide for their needs.

This strategy is concerned with the form and function of the Kākaunui and Kauru rivers. Any activities in or on the bed and banks of the two rivers need to be focused on maintaining or enhancing that form and function. The strategy is not a statutory document; rather it is intended to present the aspirations of the community and the various stakeholder agencies. However, the statutory processes which do influence river management activities[11] are more likely to be used effectively and efficiently if there is a general consensus on what is valued about the river, and commonly understood objectives. The strategy sets out the values identified by the community, and the outcomes they seek from managing river form and function, and will be used to inform resource consent decision-making.

[11] Including the LGA and the RMA

5. Principles

The strategy provides a framework to guide activities and decision-making, based on an agreed set of principles. It is intended to help protect the recreational, cultural and ecological values of the Kākaunui and Kauru rivers, and to enable long-term sustainable use of the riverbed and its riparian margins.

ORC has developed the framework, in consultation with the local community and other stakeholders. The principles and associated strategic elements are outlined below, and these are intended to protect or enhance the important values and features of the river identified by the community and other stakeholders.

Principle 1: Ensure sustainable river management

Ensure that:

- there is recognition that certain river and catchment processes, such as flooding, bank and channel erosion and sedimentation, will occur naturally, and an understanding of the potential effects of those processes
- any practices undertaken limit exposure to negative natural-river and catchment processes
- there is an awareness and acknowledgement of the benefits and the risks (including the risk associated with 'super-design' events) that exist for activities such as farming that occur in areas prone to natural-river and catchment processes
- any negative effects of natural-river processes do not increase beyond their current levels, and are actively reduced where there is opportunity to do so
- activities are managed in a way that result in:
  - limited effects on assets during flood events
  - essential community infrastructure that is resilient (roads, bridges, water supply)
  - acceptable level of effects to farming caused by river processes
  - sustainable use of river resources.
- there is a recognition of the kaitiaki responsibilities of the Te Runanga o Moeraki.

Principle 2: Plan ahead

Ensure that:

- there is an adaptive approach to river management that will allow for the dynamic nature of the Kākaunui and Kauru rivers
- resources are used wisely to ensure that the location and form of community assets and essential infrastructure will result in a more resilient community
- the impacts of climate change and natural climate variability are considered so that future generations do not have to cope with the results of poor decisions made today
- the risk associated with natural-river processes are reduced over time by taking a broad-scale, adaptive approach over the longer term.

Principle 3: Maintain and enhance the natural environment

Ensure that:

- activities are managed in a way that results in:
  - a habitat that supports existing wildlife, fish, and suitable plant species[12]
  - a more visually appealing river system
  - the ability of the local community and visitors to access and enjoy the river is maintained and or enhanced
  - traditional and cultural use is enabled, maintained and enhanced.

6. River form and habitat enhancement

6.1 River corridor design and management

ORC has undertaken work to identify the location and width of the active fairway (or riverbed), as well as appropriate buffer zones, which together form a corridor within which the river would naturally lie. The widths of fairway and buffer zones were completed by assessing the appropriate meander form in relation to the nature and width of the river channel. The design channel has been drawn up using a consistent meander length or wavelength oscillation, while taking into account the existing channel location, channel areas and natural controls and restraints. This work has been undertaken in the Kākaunui River between Clifton Falls and the Kākaunui Estuary, and for the Kauru River between Kauru Hill Road Bridge and the confluence with the Kākaunui River (Williams, 2014). An example is shown in Figure 20, and a full set of river corridor maps is provided in Appendix 3.

The river fairway and corridor mapping provides guidance for multi-purpose river management, and for the design and implementation of management measures, protection works and in-channel design. When physical works or activities are being considered within the fairway or on the riparian margin, these should be undertaken with reference to the mapped fairway and buffer zones. Guidance for managing the river within this corridor, and across the wider floodplain is summarised in Figure 21.

[12] Many submitters, including representatives of Te Runanga o Moeraki, indicated a preference for native species, wherever possible. In some cases, a mix of native and exotics may be required to balance river management and biodiversity objectives. See also Appendix 8.

Figure 20. Kākaunui River mapped fairway deviating from the current channel alignment (aerial photography collected in the summer of 2013/2014).

ORC will work towards maintaining the Kākaunui and Kauru rivers to the mapped corridor lines in the lower reaches of both rivers where reasonable and practicable. The fairway management will be achieved through river-management processes such as sediment movement (i.e. cross-blading, bank reinstatement, targeted vegetation spraying, and in extreme cases, channel realignment). Keeping the fairways to the mapped lines will be undertaken as a pre-emptive process with the aim of limiting the degree of movement/deviation from these areas in flood events. This work will take into account the community values (as mapped in Appendix 4). Maintenance work undertaken in the Kākaunui and Kauru rivers (as discussed above) will be provided for through the budget set in the ORC Annual Plan.

In some locations, the mapped corridor crosses land that does not currently form part of the active channel of the Kākaunui and Kauru rivers (e.g. Figure 20). This is due to the fact that the mapped corridors show an ‘envelope’ within which the river would migrate under natural conditions. In many instances, they do not reflect the current position of the Kākaunui and Kauru rivers. In these situations, ORC will not actively move the fairway into these mapped areas; however, if the channel switches its location into these areas (e.g. in response to a large flood event), ORC may decide not to undertake work to reverse the new alignment if the channel still lies within the mapped corridor.

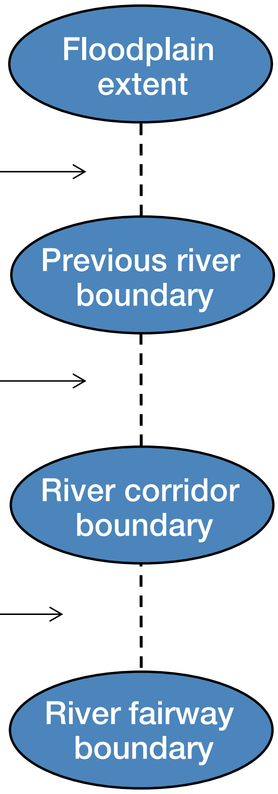
Management between boundaries

Probable limits of flooding will occur between floodplain extent and previous river banks (the floodplain). Normal farming activities.

Between previous river boundary and the river corridor boundary normal farming can be carried out but with an increased risk of flooding or erosion.

Between the river corridor boundary and fairway boundary, vegetation growth will be encouraged to provide erosion resistance to the active river boundary and improve habitat and community values. Tree planting will be encouraged as part of the strategy. Farming activities in this area is at the landowner risk.

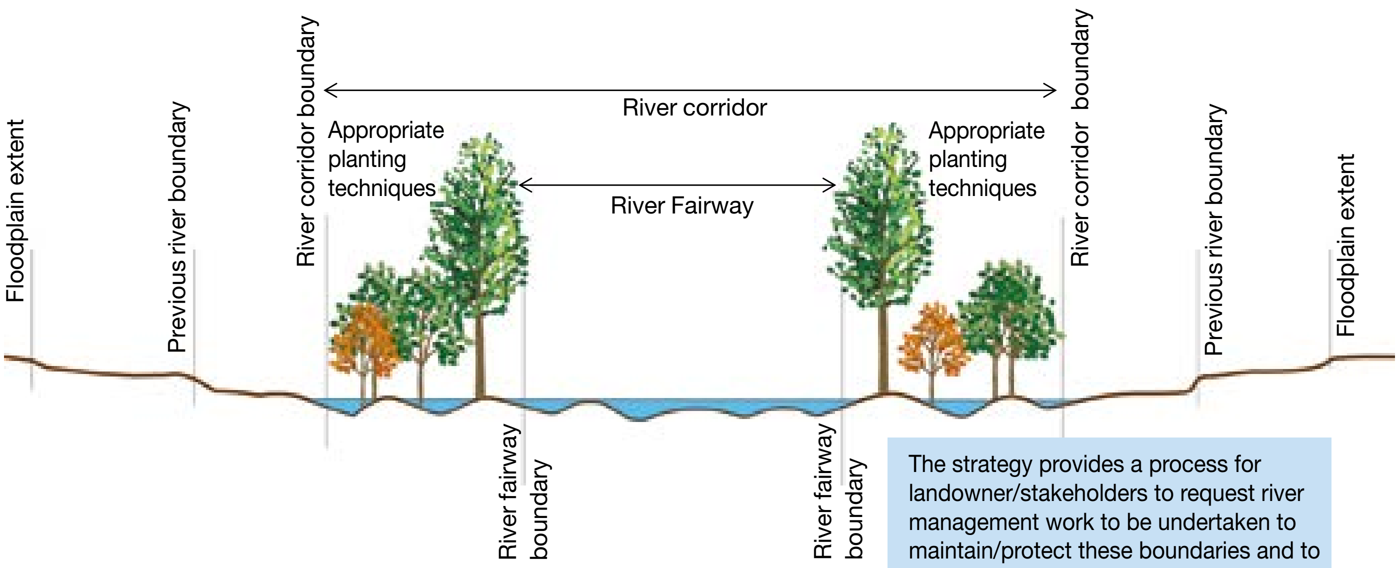
As part of the strategy, the fairway will be maintained through a regular maintenance programme, although the river may extend into the wider river corridor in some instances.



Management of boundaries

Maintenance and/or protection of these banks is not included in the strategy.

As above, maintenance and/or protection of these banks is not included in the strategy.



The strategy provides a process for landowner/stakeholders to request river management work to be undertaken to maintain/protect these boundaries and to coordinate the activity of different agencies to enhance the river corridor.

Figure 21. Policy diagram for management of river boundaries and appropriate land-use on floodplain areas of the Kākaunui and Kauru rivers

6.2 Riparian plantings

As identified in Section 3.6, careful management of riparian margins is key to achieving positive river management outcomes. In addition, one of the key values identified by the community was that they would like to see riparian plantings (including both native vegetation and willows) and associated weed control and fencing included in the strategy as a means of improving the amenity value, and to help to reduce the effects of erosion (Section 3.7.2). The principles identified in Section 5 reflect the importance of sustainable river management and enhancing the natural environment.[13]

Research (Slui, 1991; Phillips & Daly, 2008) shows that to achieve bank protection, the rivers riparian margins[14] should be planted in vegetation that assists with bank stabilisation. Planting these buffer areas would provide the banks of the rivers with greater stability and assist with limiting bank erosion, as well as providing vegetative cover to slow flood flows and limit the amount of sediment deposited out of the main channel, as well as providing habitat for aquatic life. The wider the area of buffer zone planting, the more effective this will be.

Willow species (particularly moutere and kemuti willow) are more suitable for planting close to the river margin, due to their rapid growth, ease of propagation and usefulness for vegetative groynes or bank-lining layering. Other vegetation can also be used, including poplars and alders on the relatively higher/drier land. Native vegetation can be used further back from the active river margin and can be useful, especially when part of other/wider riparian planting.

Development of the buffer areas can be undertaken as a staged approach, with planting of the active river margin occurring in areas where there is bank exposure as well as at possible river breakout locations. Planting of the back area can be undertaken where direct river attack (i.e. bank erosion) is less likely to occur and the native species will have time to become established. Buffer development is about establishing a wide and dense vegetated margin that can absorb river attack and provide habitat for aquatic life.

Planting of the banks of the Kākaunui and Kauru rivers is generally seen as a beneficial process in most locations. There are several methods to plant the banks of the two rivers with the best method being dependent on the environment where the planting is to take place (Appendix 8).

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[13] in particular, Principle 1.1, 2.2, 2.4 and Principle 3

[14] i.e. the area that acts as a buffer between the active fairway and land used intensively for farming or other activities

7. Implementation

The objectives of the strategy are listed at the start of this document (in the overview section). The mechanisms that can be used to achieve, or implement, these objectives are shown in the following tables. These have been derived using the principles outlined in Section 5. The tables below highlight the actions that should be undertaken to maintain and enhance the values associated with the Kākaunui and Kauru rivers, as well as the key parties responsible for undertaking the listed actions.

In some cases, ORC has already undertaken work to help achieve objectives, and this work is described within this document (for example, mapping of natural-river corridors and identifying target profiles). It is noted that many of the actions listed below are voluntary, and will rely on interactions between the key stakeholders and the community to be successful. It is also noted that many of the activities will be ongoing, and progress will depend on funding, not only through the ORC Annual Plan process, but also from other agencies and the wider community.

ORC has prepared the strategy, with input from the local community, to help protect the recreational, cultural and ecological values of the Kākaunui and Kauru riverbeds, and to enable long-term, sustainable use of the land that borders the river. The objectives and actions listed below are intended to help achieve this, by guiding work programmes, decision-making and activities for the community, stakeholders and ORC. It is therefore recommended that people who live, work or play within the Kākaunui catchment consider, and give effect to the principles, objectives and actions listed in this strategy.

Due to the dynamic nature of the Kākaunui and Kauru rivers, parts of this strategy are likely to change as the rivers themselves change; this strategy must therefore be treated as a 'live' document (Section 2.3). This means that some sections and maps in the strategy may change in response to changes in the Kākaunui and Kauru rivers (e.g. areas of gravel accumulation may shift).

Objective 1 Recognise and characterise natural-river processes

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
1.1. Collect information about flood and erosion processes					
	Map, describe and report on changes in channel morphology	Improved understanding of natural river processes	ORC	Ongoing	Previous reports describing changes in channel morphology are available
	Identify locations where erosion is occurring	Avoid high-value assets in erosion-prone areas	ORC	Ongoing	Previous reports identifying areas of bank erosion are available
	Make information publicly available, including through the Natural Hazards Database	Improved decision-making around placement of assets and land-use activities	ORC	Ongoing	Information is currently available through the Natural Hazards Database
1.2. Identify the location of river corridors, within which the river will naturally meander					
	Determine the natural meander form of the river, considering the existing channel location, and natural controls and restraints	Improved decision-making around placement of assets and land-use activities	ORC	Complete	Maps included in Appendix 3

Objective 2 Equip the community to live with the effects of changes in river morphology

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
2.1. Asset management and land-use practices (e.g. fences, vegetation clearance, and irrigation structure placement) are undertaken in such a way that reduces the risk associated with natural river processes					
	Land-use practices and other activities have greater regard to natural river processes	A reduction in risk over time	Landowners	Ongoing	ORC to provide guidance and information through field-days and other community programmes
	Consider implementation of land-use controls through the District Plan in areas with greater erosion risk	No net increase in risk over time	WDC	Long-term (5-10 years)	Incorporate into future revisions of WDC District Plan
	Identify mechanisms to modify / protect roading assets that consider natural river processes	Roading infrastructure is resilient	WDC	Ongoing	ORC to provide information as necessary
2.2. Consider all available options to manage the effects of bank erosion, including structural and non-structural options					
	Less intensive use of riparian margins	A reduction in risk over time	Landowners	Ongoing	
	Planting of native and exotic species on riparian margins	Increased stability of riparian margins and riverbanks, improve habitat and community values	Landowners	Ongoing	ORC to provide support, as determined through the ORC Annual Plan process
	Produce guidelines for undertaking planting appropriate for river control and provision of habitat	Increased stability of riparian margins and riverbanks	ORC	Complete	Guidance included as Appendix 8
	Produce maps showing priority planting locations	Community requirements and natural river processes are considered before planting is undertaken	ORC	Ongoing	
	Proactive river management programme	Bank erosion and other river management issues addressed early	ORC	Ongoing	Maintenance work undertaken as provided for through the budget set in the ORC Annual Plan

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
2.3. Enable works that improve the conveyance of floodwater and 'train' the river within its natural corridor, without compromising features that are of high value to the community					
	Physical works by ORC to address existing river management issues	The Kākaunui and Kauru rivers are contained, as far as possible, within the natural river fairway/ corridor, and convey small to medium floods without overtopping	ORC	Ongoing	Locations and detail of work to be undertaken between October 2015 and 2018 included in Appendix 1
	Physical works by landowners and other agencies to address river management issues	The Kākaunui and Kauru rivers are contained, as far as possible, within the natural river fairway/ corridor, and convey small to medium floods without overtopping	Landowners	Ongoing	ORC to provide guidance on suitable river-management methods (including resource consent requirements) through field days and other community programmes
	Provide maps showing the location and importance of community/ stakeholder values	Works are undertaken in a manner that does not compromise features that are of high value to the community	ORC and the community	Complete	(Attached as Appendix 4.) These may be modified or adjusted as part of future reviews of this strategy

Objective 3 Enable sustainable gravel extraction

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
3.1. Identify areas where gravel accumulation can naturally occur.					
	Assess the natural characteristics of the river (including longitudinal profile, meander shape and effect of tributary inflows), and historical extraction activity to determine areas where gravel naturally accumulates	Consent applications to extract gravel are targeted to appropriate areas	ORC	Completed	Maps of natural gravel accumulation areas included in Appendix 2
	Provide maps showing the location and importance of community/stakeholder values	Extraction is undertaken in locations, and in a manner that does not compromise features which are of high value to the community	ORC and the community	Completed	(Attached as Appendix 4.) These may be modified or adjusted as part of future reviews of this strategy
3.2. Identify areas where permanent removal of gravel may have a detrimental effect on assets, riverbed morphology or community values					
	Assess the natural characteristics of the river to determine areas where sediment does not naturally accumulate, but is conveyed through a particular reach	Extraction does not occur in locations, or in a manner that would compromise features that are of high value to the community	ORC	Completed	Maps included in Appendix 2, and Appendix 4
3.3. Identify minimum bed levels / profiles, below which extraction will not occur.					
	Identify a 'target' river shape, that will allow for sustainable extraction rates, and also help to achieve identified community values	The volume of gravel extracted is sustainable	ORC	Completed for areas identified under 3.1. above	Maps and profiles included in Appendix 2

Objective 4 Promote activities that enhance the natural character and enjoyment of the river

Activity	How this can be done	Intended outcome	Who will lead it	Timing	Comment
4.1. Identify the location and characteristics of features that are of high value to the community					
	Community values obtained through consultation and clearly identified within the strategy	Consideration of community values when making decisions	ORC	Completed	Maps included in Appendix 4
4.2. Establish riparian plantings that serve a purpose, and are appealing					
	Produce guidelines for undertaking planting appropriate for river control and provision of habitat	Increased stability of riparian margins and riverbanks. Improved aquatic and terrestrial habitat.	ORC	Completed. See also 2.2 above.	Guidance included as Appendix 8
4.3. Provide access and habitat for fishing and white-baiting activities					
	Planting work that enhances fishing and white-baiting activities	The Kākaunui and Kauru rivers support game fish, native fish and whitebait species	Fish & Game, DoC	Ongoing	
	Consent conditions ensure that gravel extraction and physical works are undertaken in a way that does not damage habitat	The Kākaunui and Kauru rivers support game fish and whitebait species	ORC, WDC, extractors and landholders	Ongoing	See Objective 3 also
	Encourage the creation of additional public access points	River-access opportunities are increased	ORC, WDC, landowners	Ongoing	
4.4. Adequate pest and weed control activities					
	Landowners (including LINZ) and other stakeholders work collaboratively to manage pest species	The Kākaunui and Kauru river fairways and riparian margins are relatively free of pest species	Landowners, stakeholders, ORC	Ongoing	
4.5. Discourage dumping, and arrange the regular collection of rubbish					
	Collection of rubbish by contractors, signs warning of penalties for rubbish dumping	Improved visual amenity and enjoyment of recreational areas	WDC	Ongoing	
4.6. Protect and enhance the natural character of the Kākaunui and Kauru rivers					
	Promote and encourage local restoration initiatives such as bank planting, and wetland restoration	Riparian margins are planted / restored, look visually appealing, and provide aquatic and terrestrial habitat	Community, with support from other agencies	Ongoing	

Appendix 1. ORC river-maintenance work within the Waitaki Special Rating District

Seven locations within the river corridor have been identified as requiring work to maintain the fairway within its natural position (as mapped in Appendix 3) and/or to ensure the adequate conveyance of floodwater.[15] These locations are shown on Figure 22 and Figure 23. These priority locations have been determined using the latest available information (September 2015) about specific locations that are experiencing river management issues. ORC intends commencing work at these locations during the 2015/16 financial year, and funding has been provided through the long term plan process to complete work at these locations within the next three years (i.e. by 2017/18). Ongoing maintenance may also be required at some of these locations into the future.

Priority will be given to work at locations B, D, and E (respectively, downstream of Gemmells Crossing, at the Kākaunui/Kauru confluence, and upstream of the confluence, as shown on Figure 23). Subsequent work is scheduled to take place at locations A, D and F.[16] ORC will work with other agencies, including gravel extractors, landowners and WDC where possible to reduce cost and maximise gain. This list and the need to undertake work at particular locations may change into the future, in response to flood events and to other river management issues that the community may identify through the process outlined in Section 2.3.

The river management work (outlined below) that is scheduled to take place in the Kākaunui and Kauru rivers will need to consider the following:

- The principles outlined in Section 5.
- The location and width of the natural river corridor and active fairway, as described in Section 6, and other natural river processes as described in the strategy.
- The objectives and associated activities listed in Section 7. In particular objective 2 (equip the community to live with the effects of changes in river morphology) and activity 2.3 (enable works that improve the conveyance of floodwater and 'train' the river within its natural corridor, without compromising features which are of high value to the community).
- The ecological, community and Maori values discussed in Section 3.6.

The increased program of work in the Kākaunui River by ORC will result in increased costs for the Waitaki Special Rating District (SRD). It is noted that river morphology and riparian management strategies are also to be developed for the Shag and Waianakarua rivers in the 2016/17 year. Revenue from rates within the SRD is projected to increase from $260,000 in 2015/16 to $420,000 in 2018/19, in order to fund additional in-stream work required to meet community river management expectations.

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[15] Note that riparian management/planting work is not described here. As outlined in the overview section, it is intended that subsequent versions of the strategy will include further guidance and plans for undertaking planting on riparian margins, for river management purposes and for habitat enhancement.

[16] Direct intervention by ORC is less likely at the 7th site (C), as described below

The dynamic nature of these three rivers and the inability to predict the timing or consequences of future flood events in the Waitaki District means there is a risk that this additional funding for river management work may still be insufficient. It is noted that all ratepayers within the Waitaki District contribute funding towards the Waitaki SRD.[17]

The anticipated budget for river management operations (physical works) in the Waitaki SRD until 2018/19 is shown in Table 5 below. This shows that $244,000 is budgeted for this work during the 2015/16 year, up from $104,000 the previous year. As noted above, this budget is not solely for the Kākaunui and Kauru rivers and includes other rivers in the Waitaki District, including the Shag and Waianakarua rivers.

Table 5. ORC river management budget for the Waitaki District

Year	ORC river management (operations) budget
2014/2015	$104,000
2015/2016	$244,000
2016/2017	$308,000
2017/2018	$316,000
2018/2019	$324,000

Planned river maintenance work - Kākaunui River

A. Kākaunui/Waiareka

Work will be completed at this location to limit the amount of bank erosion occurring on the true left bank. A secondary channel will be created across the gravel beach which will allow floodwater to flow downstream without cutting into the true left bank as much as previously. Gravel will also be redistributed across the beach and contoured to a suitable channel shape. It is noted that there are a number of important community values at this location, which will need to be considered and protected as part of any works undertaken.

B. Downstream of Gemmells Crossing

Work was undertaken at this location previously in February 2015. Additional work to be undertaken at this location will involve maintenance of existing bank protection as well as moving gravel to form bunds to protect the banks from further erosion.

C. Robbs Crossing

There is minimal work to be undertaken at Robbs Crossing, however gravel extraction will be utilised to manage the channel where applicable.

[17] The river management rate is currently collected from 12,500 rating units across that part of the Waitaki District which lies within the Otago Region, at a rate of 0.0000577cents per $1 of capital value

D. Kākaunui/Kauru confluence

In the lower reaches of the Kauru River (below the Kākaunui Valley Road bridge) work will be undertaken to pull the steep gravel edge back towards the true left bank as well as moving gravel to create a graded channel which will remove the existing deep cut channel.

E. Upstream of the Kākaunui/Kauru confluence

Work to be undertaken at this location will involve moving gravel across the beaches to create a wider channel to better convey flood flows as well as planting of the river banks to limit bank erosion on the true right bank. Spraying of vegetation present in the river fairway will assist in keeping the channel to the mapped fairway and will reduce the pressure of flood flows against the river banks.

Planned river maintenance work - Kauru River

F. Upstream and downstream of Kininmont Ford

There is minimal work to be undertaken currently at Kininmont Ford, however gravel extraction or movement will be utilised to manage the channel where applicable.

Figure 22. Priority locations for operations work – lower catchment

Figure 23. Priority locations for operations work – upper catchment

Appendix 2. Gravel accumulation areas and river management profiles

There are a number of areas within the Kākaunui and Kauru riverbeds where gravel tends to accumulate. These areas can change position in response to flood events, land use, and sediment inputs. Currently there is a reasonably extensive area of natural gravel accumulation near the confluence of the Kākaunui and Kauru rivers, and another at Robbs Crossing, as mapped in Figure 24. Commercial gravel extraction may be possible in these areas, provided it can be shown to be sustainable, will meet the values and principals outlined in this strategy, and can be managed in such a way as to not have negative effects on the river system.

Areas identified as having community values of high significance which may be negatively affected by gravel extraction, or where extraction will likely have negative effects on riverbed morphology have also been identified (shaded yellow in Figure 25).[18] In these areas, large-scale gravel extraction is generally not appropriate, unless there are exceptional circumstances. These reaches include the Kauru River upstream of the Kākaunui River Bridge, and the Kākaunui River upstream of the Kauru confluence, and downstream to below Gemmells Crossing Bridge.

Sections of river where small-scale gravel accumulation may occur in localised areas have also been mapped (shaded green in Figure 25). Gravel may accumulate on smaller pocket beaches (often found on the inside of meander bends) but is generally not available in significant quantities.

When gravel extraction or other river management work is being considered within the river corridor, it should be undertaken with reference to the information provided in this strategy. This includes the mapped fairway and corridor lines (Appendix 3), the areas mapped in Figure 24 and Figure 25, and the river management profiles created for particular areas (Figure 26 to Figure 41).

[18] It is noted that other sections of the river (outside those shaded yellow) also have a wide range of important community values which should be considered when assessing proposed gravel extraction activities.

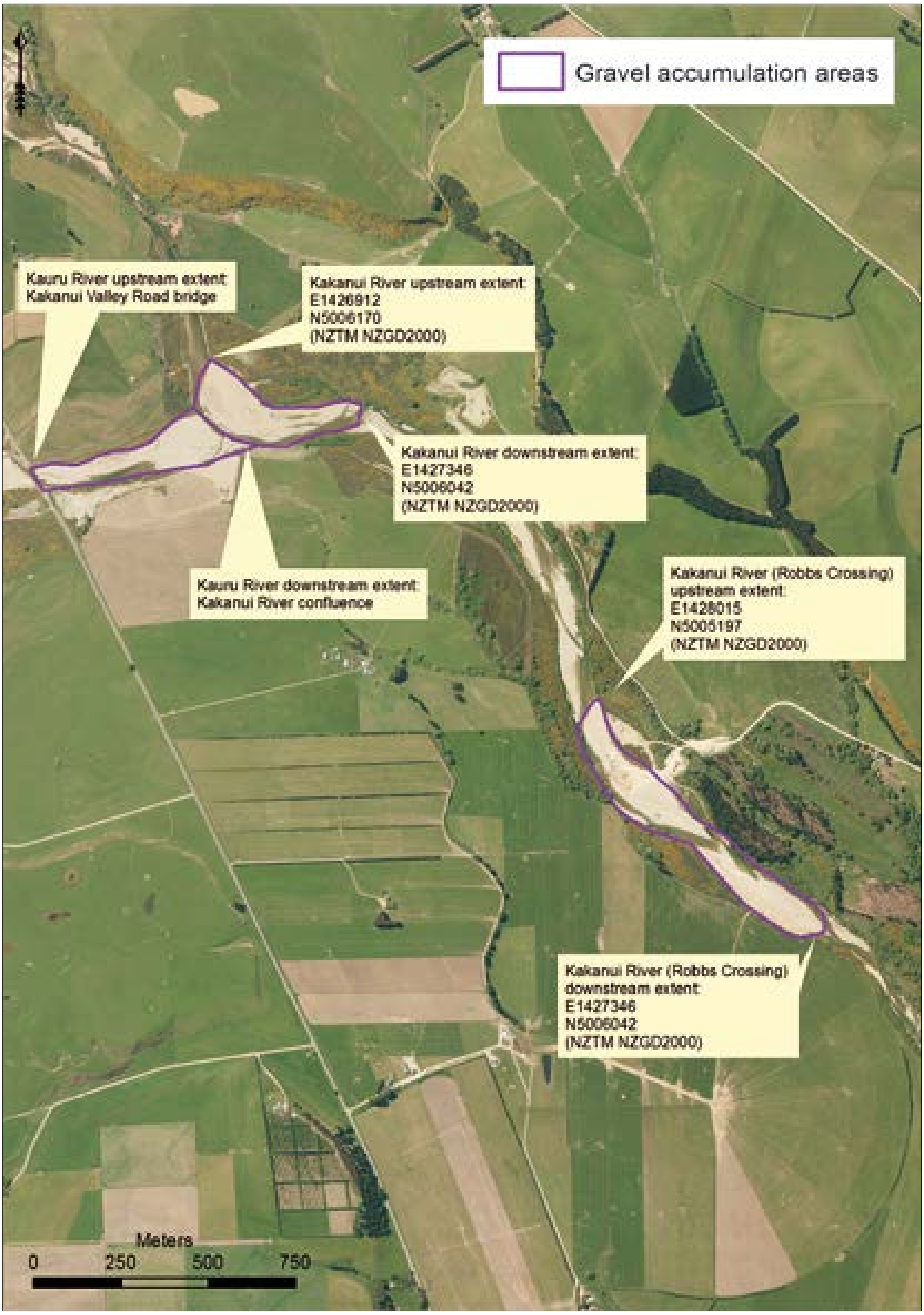

Figure 24. Areas where gravel tends to naturally accumulate in the Kākaunui and Kauru rivers; near the Kākaunui / Kauru confluence, and at Robbs Crossing (outlined in pink). The upstream and downstream extents are also identified.

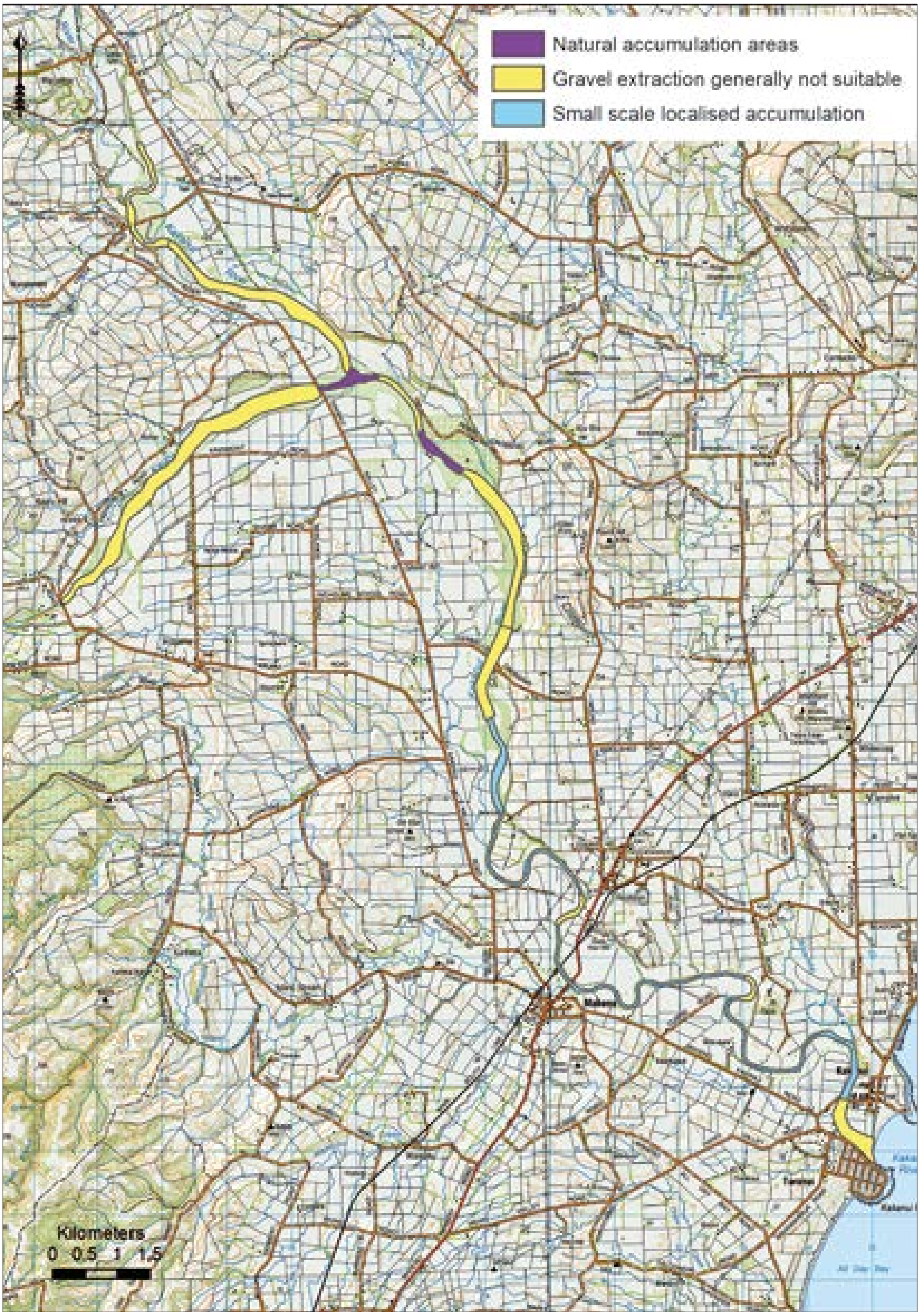

Figure 25. Areas of natural gravel accumulation (pink); areas where community values could be significantly affected by gravel extraction or where changes in river morphology such as bed degradation and bank erosion are occurring (yellow); and areas where small-scale, localised gravel accumulation may occur (green).

River-management profiles have been created for parts of the river identified as natural gravel accumulation areas, as shown in Figure 24. These profiles help to define the preferred form of the riverbed at particular cross-section locations, as shown on Figure 42. They are intended to guide gravel extraction and other river management work (eg, cross-blading, spraying) in these areas. The profiles have been set at a level that allows gravel to be removed when the beach surface is above the profile and limits gravel extraction when levels drop below the profile.

The river-management profile levels were set by assessing historic river changes upstream, at and downstream of, the three areas using the maximum and minimum MBL (collected over the whole cross-section record), longitudinal profiles, the location of the mapped river fairways/buffer zones and the local river morphology.

In order to guide the riverbed shape towards these river-management profiles, a series of conditions would apply to gravel extraction consents in these areas.[19] These are as follows:

3. Extraction of material can only occur across the whole beach (extraction area) where the MBL of the latest survey for that location is above the long-term average.
4. Extraction can only occur between the mapped fairway lines where gravel has accumulated above the management profile.
5. Extraction cannot occur below the long-term average MBL in areas outside of the mapped fairway lines
6. Any extraction activities must take into account the local river morphology, community values, and enhance the natural character/amenity of the area.

Currently, the river-management profiles are only set in areas where gravel is accumulating. These areas may move into the future and therefore river-management profiles will need to be calculated for areas outside of the current mapping. This approach will provide certainty to anyone wanting to extract gravel from the Kākaunui and Kauru rivers and prevent the excessive removal of gravel from the river system.

[19] along with the current suite of conditions used to manage gravel extraction consents

Kākaunui River management profiles

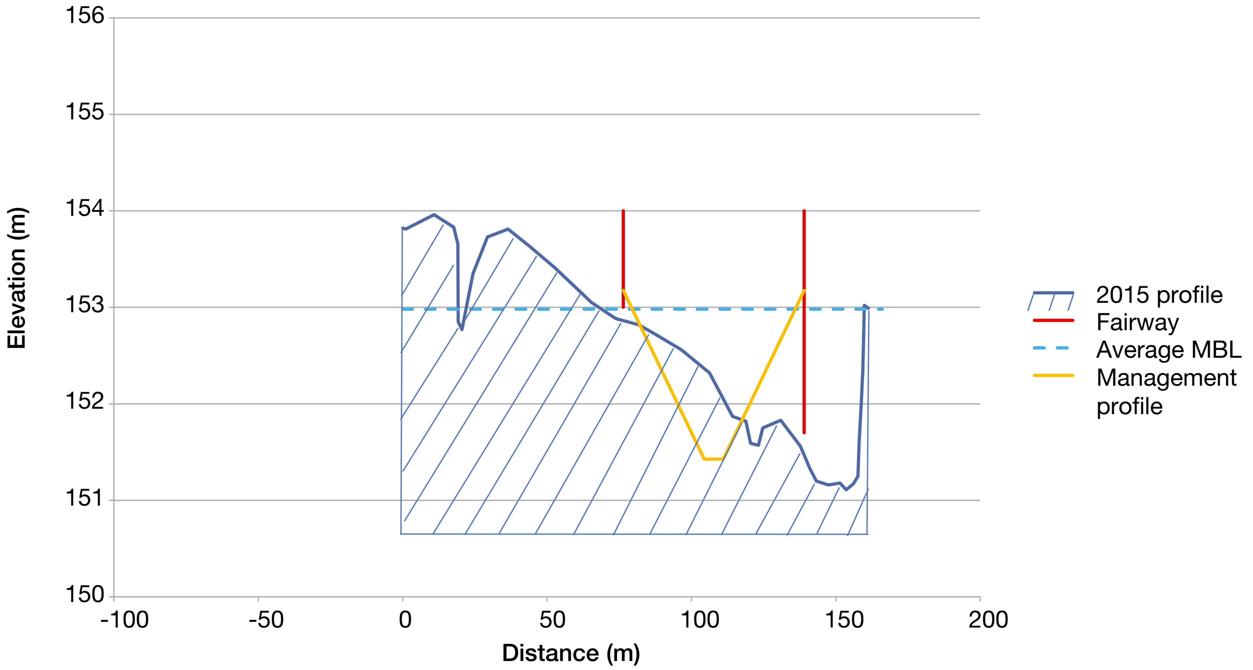

Figure 26. River management profile Kākaunui 1, looking downstream

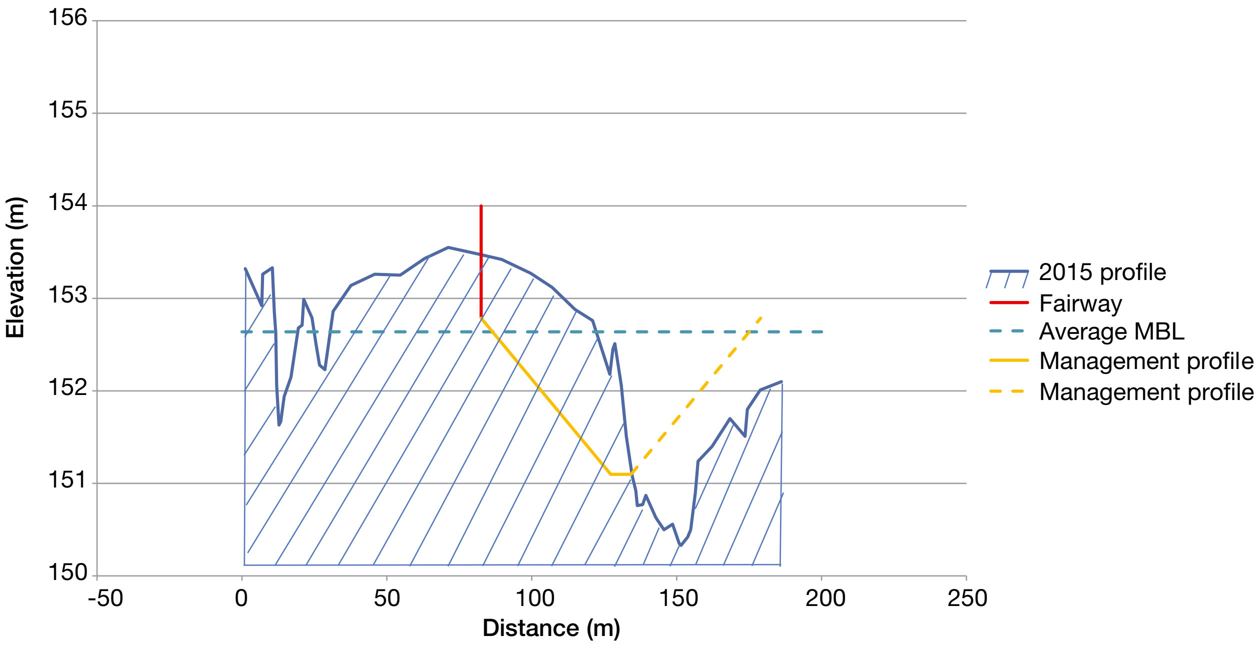

Figure 27. River management profile Kākaunui 2, looking downstream

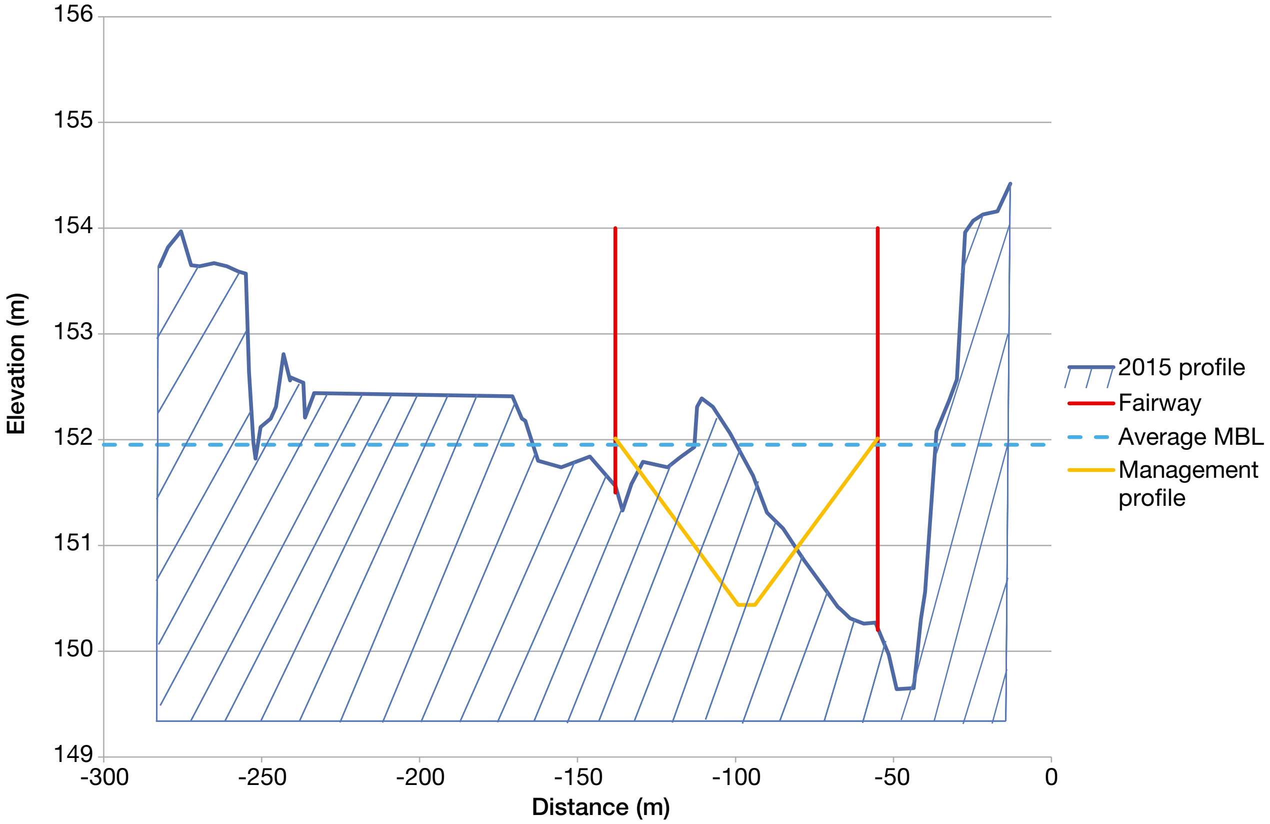

Figure 28. River management profile KA 11, looking downstream

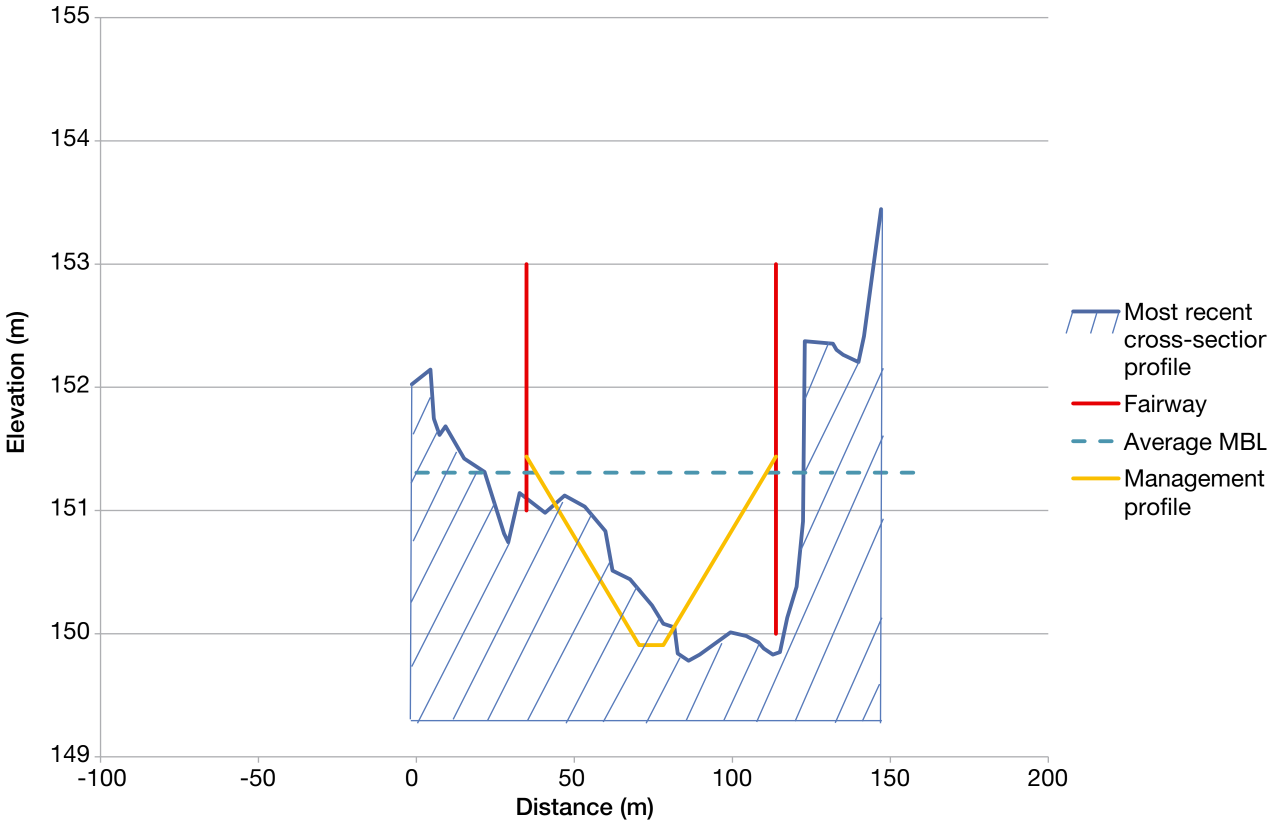

Figure 29. River management profile Kākaunui 3, looking downstream

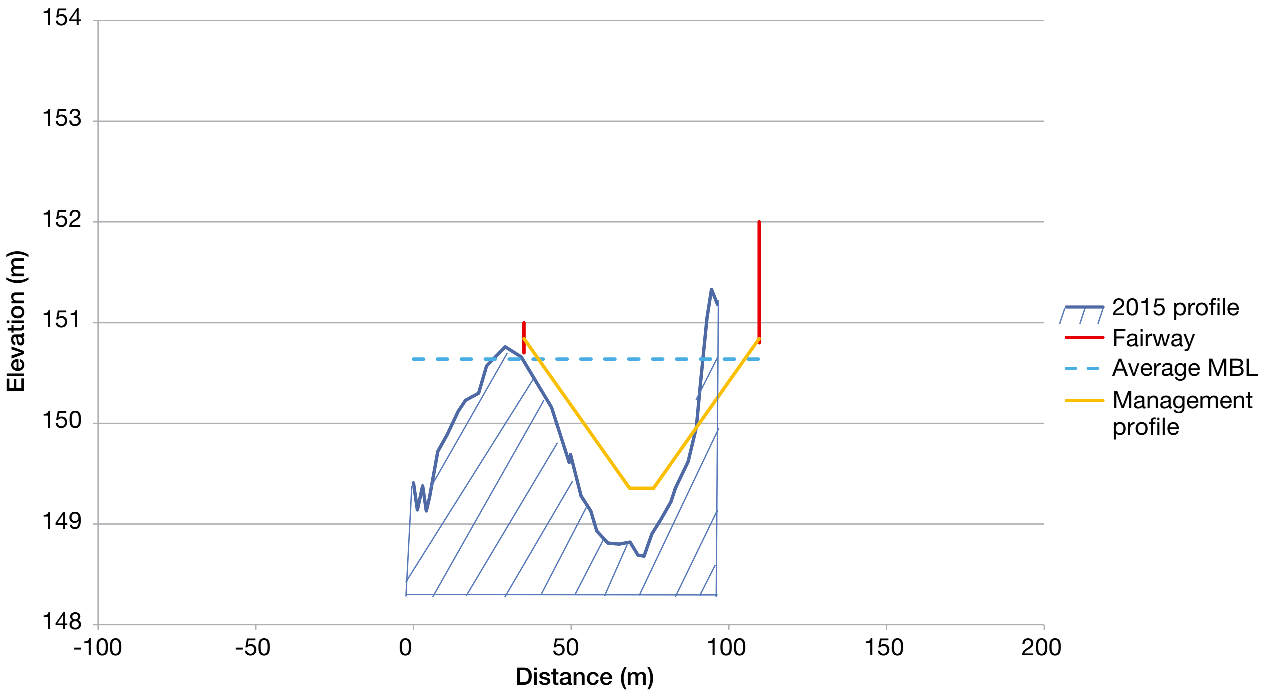

Figure 30. River management profile Kākaunui 4, looking downstream

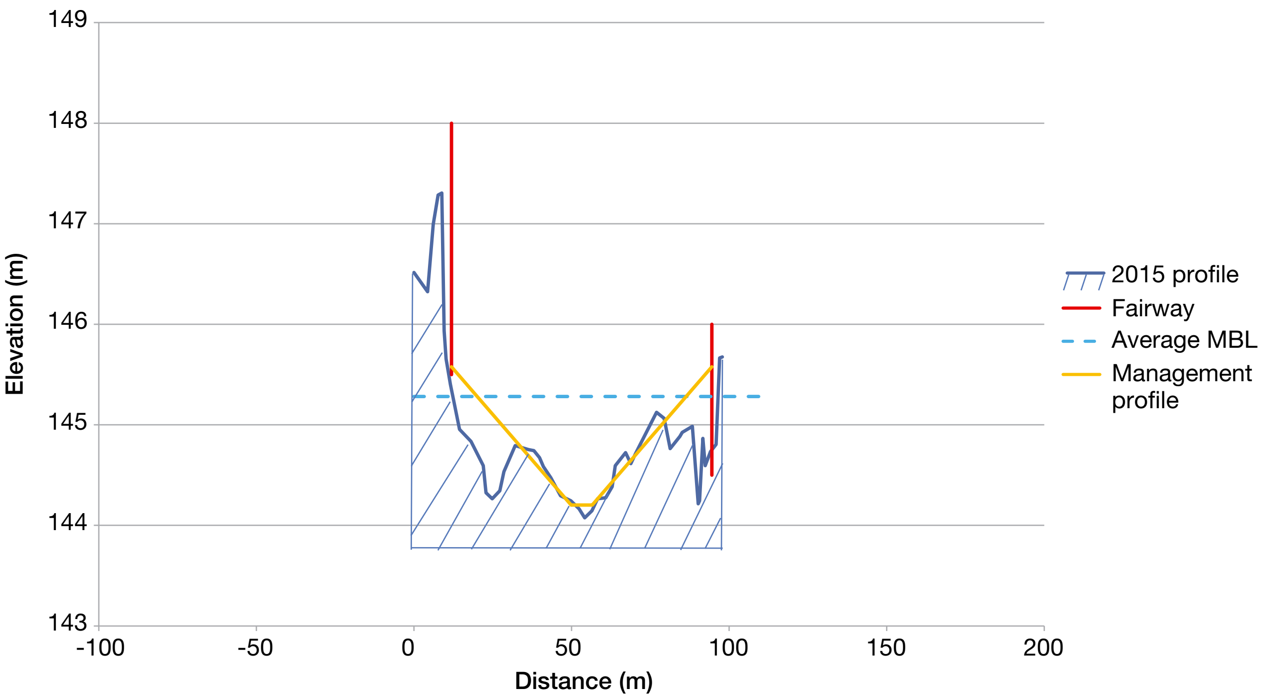

Figure 31 River management profile Kākaunui 5, looking downstream

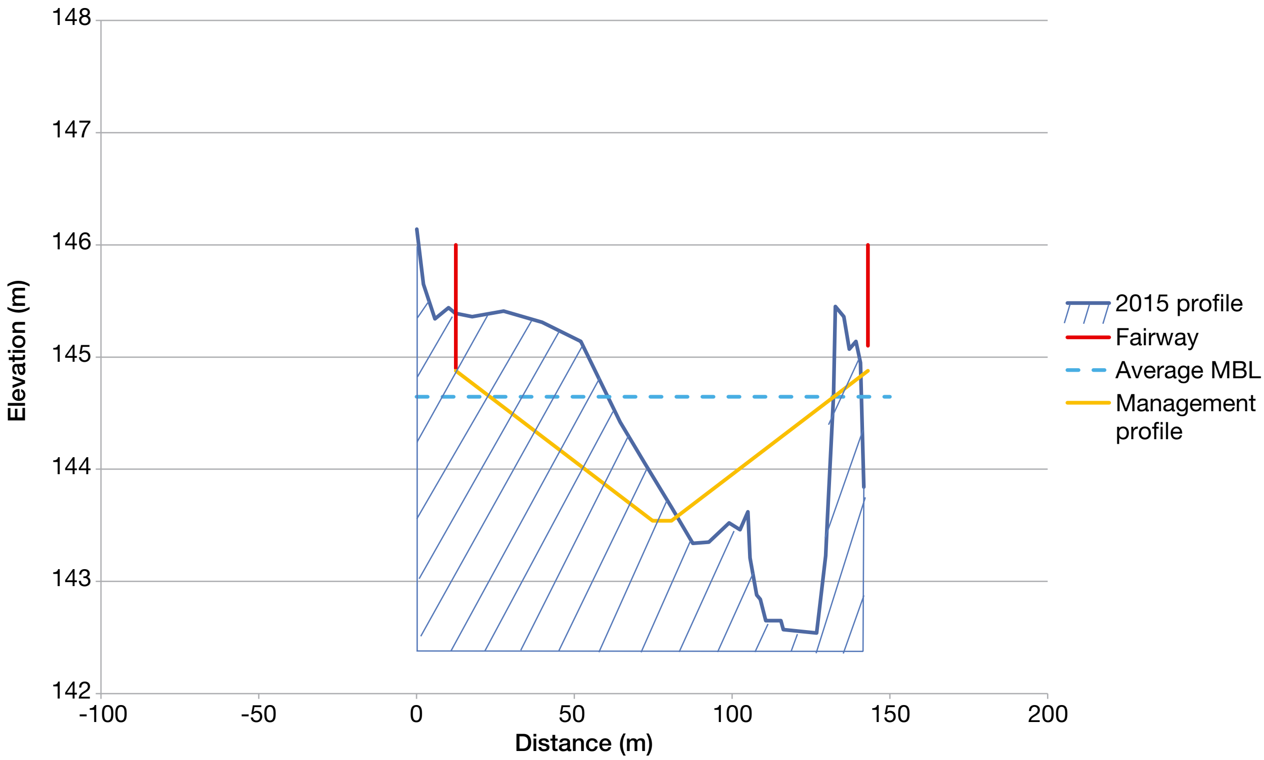

Figure 32. River management profile Kākaunui 6, looking downstream

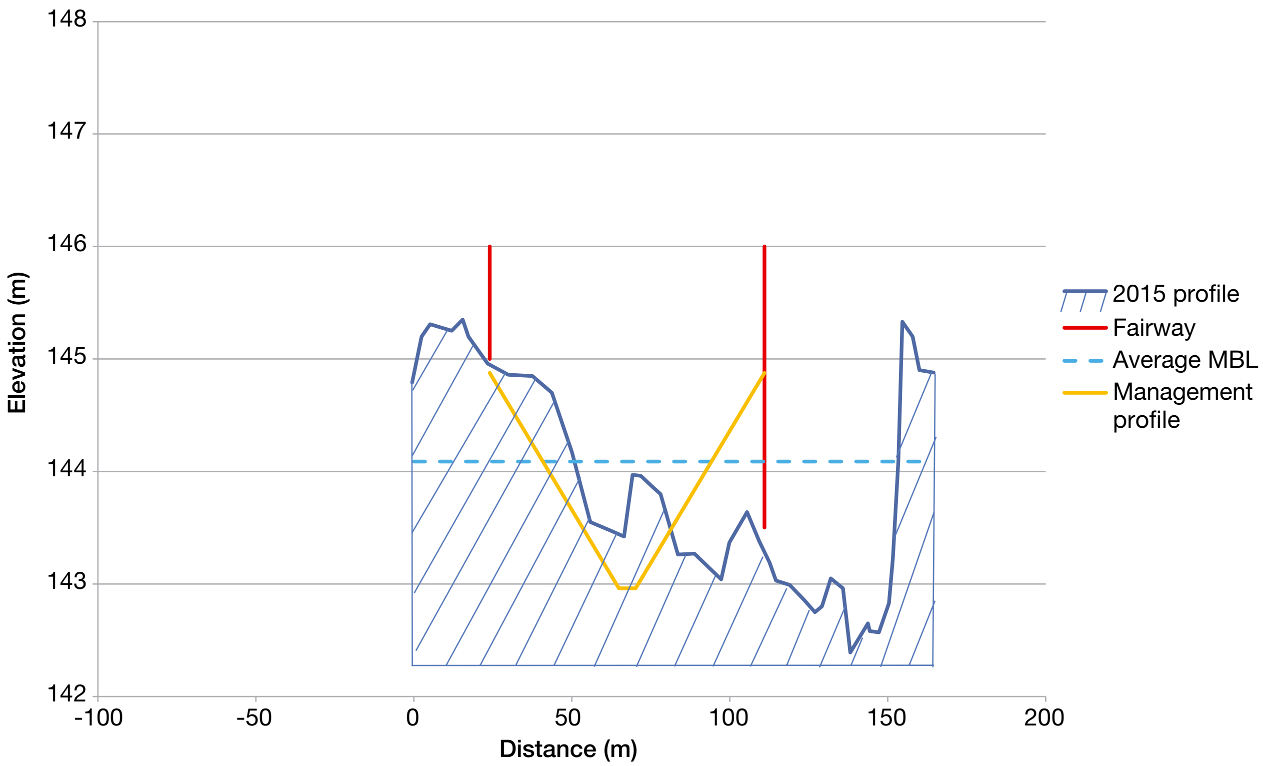

Figure 33. River management profile Kākaunui 7, looking downstream

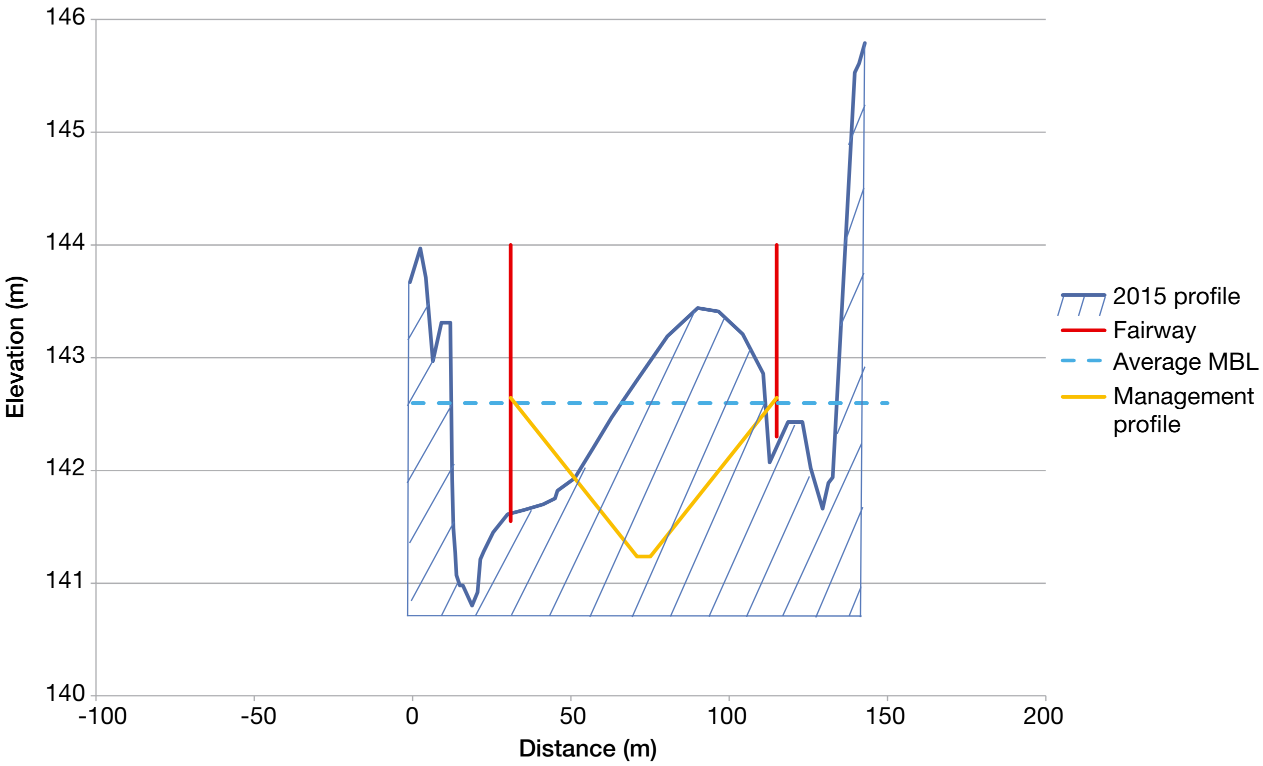

Figure 34. River management profile Kākaunui 8, looking downstream

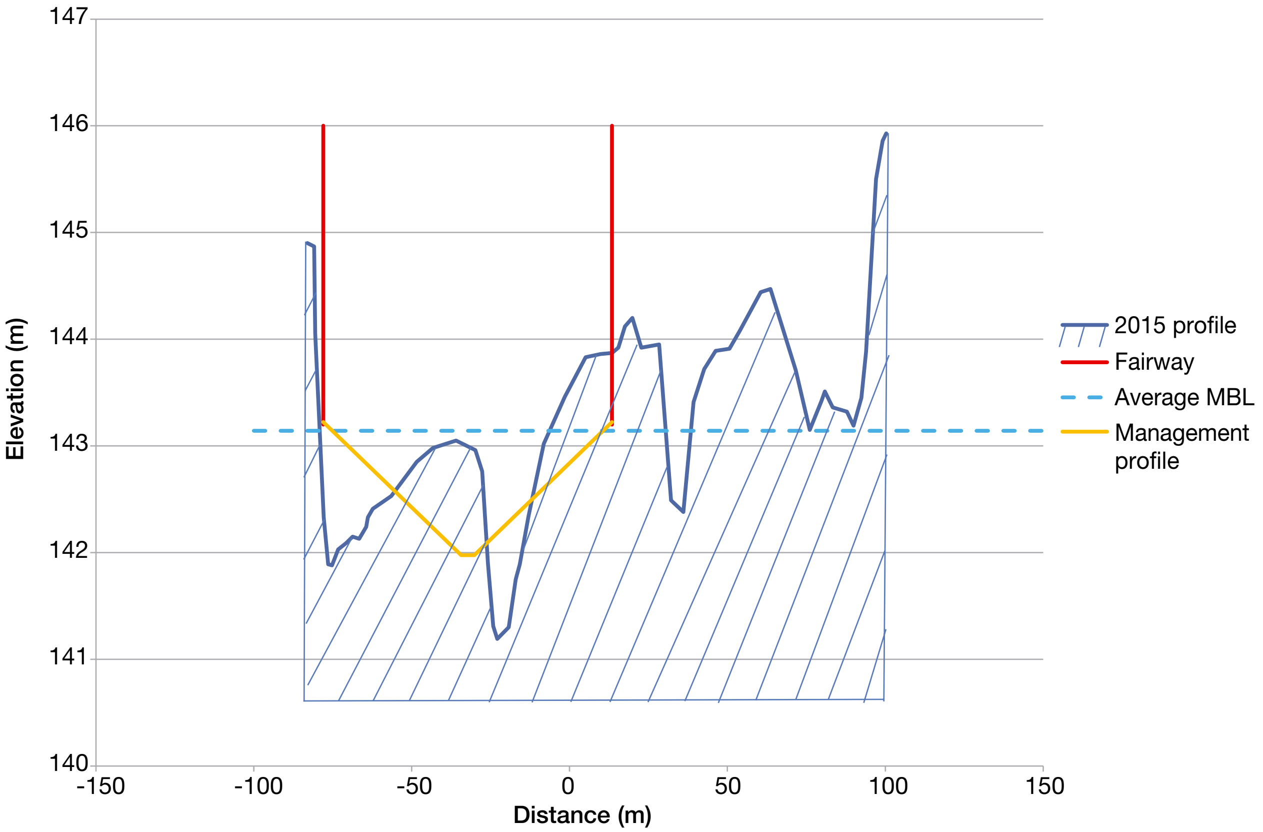

Figure 35. River management profile KA 8, looking downstream

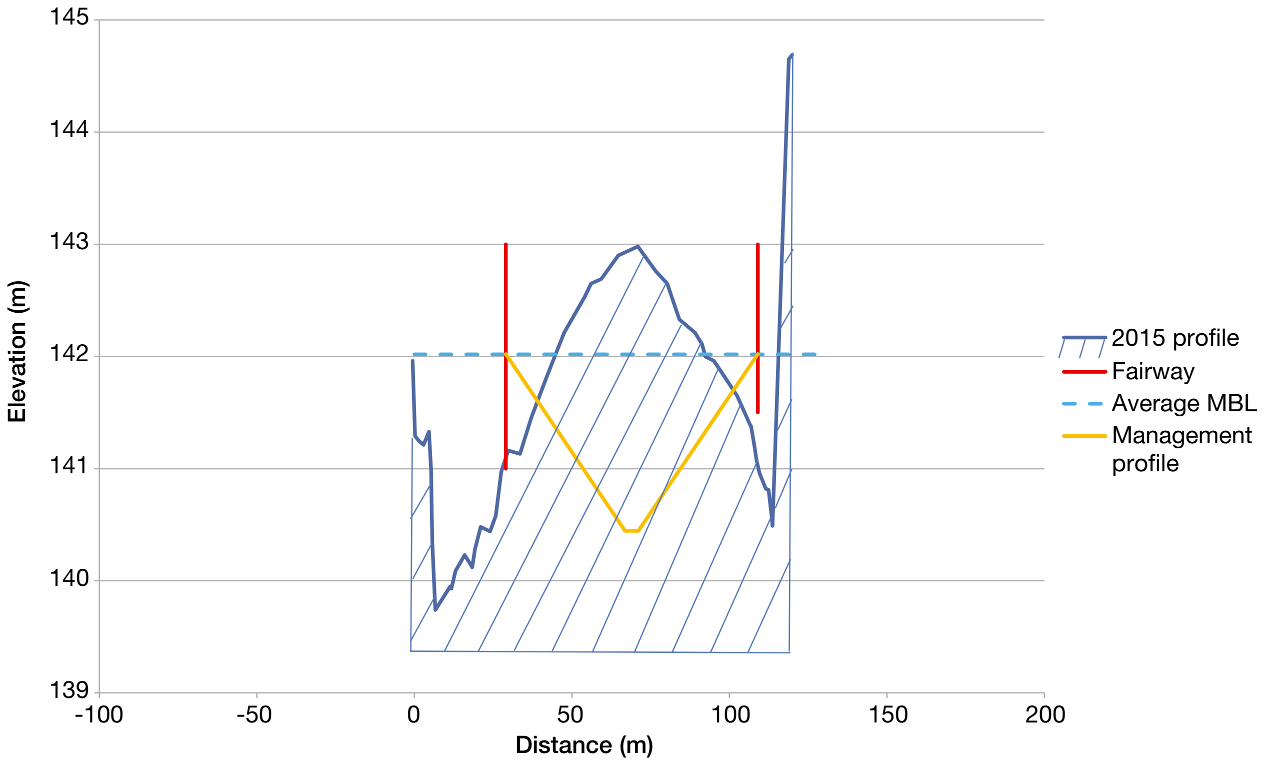

Figure 36. River management profile (Kākaunui 9) looking downstream

Kauru River management profiles

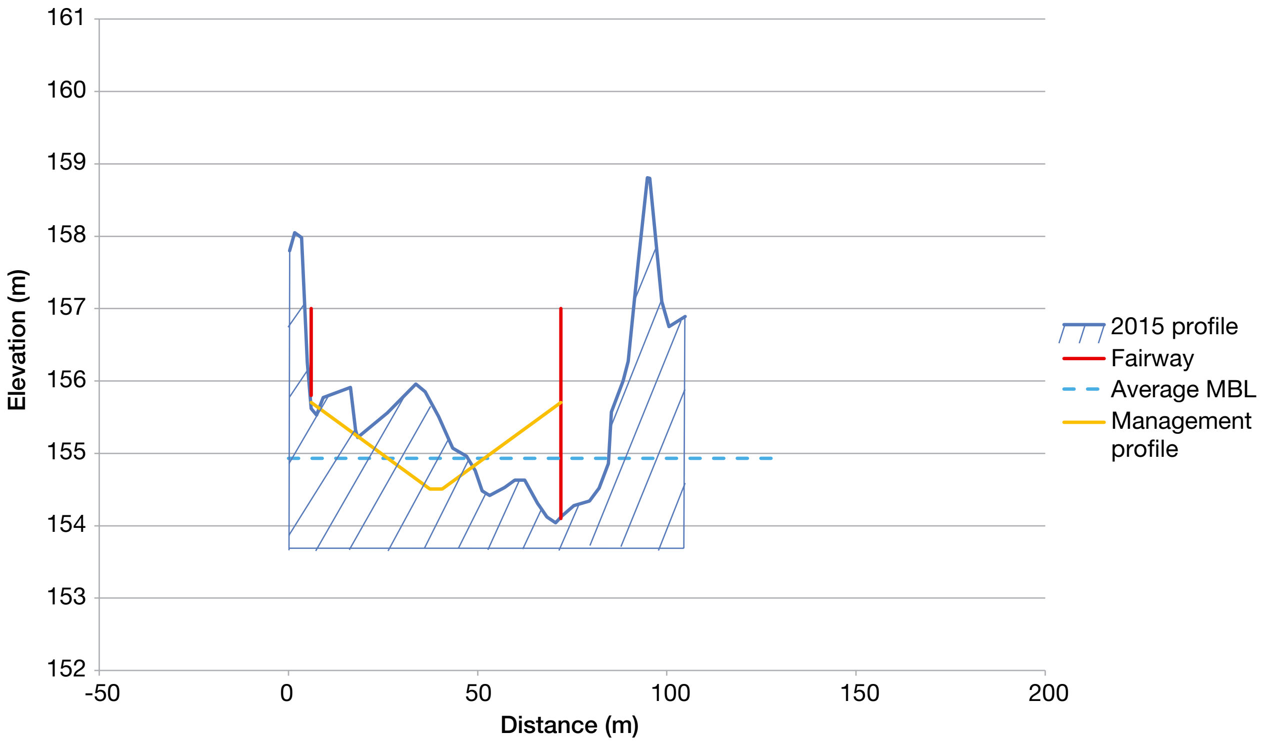

Figure 37. River management profile Kauru 1, looking downstream

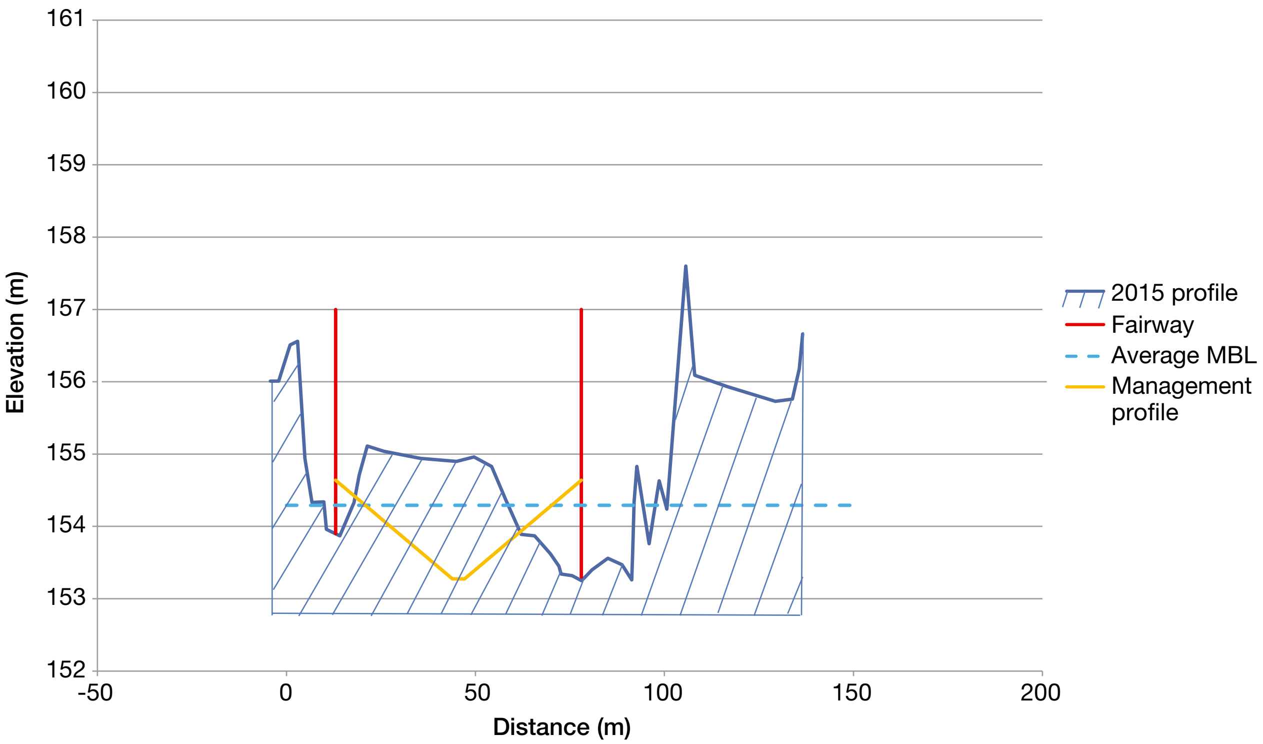

Figure 38. River management profile K1 B, looking downstream

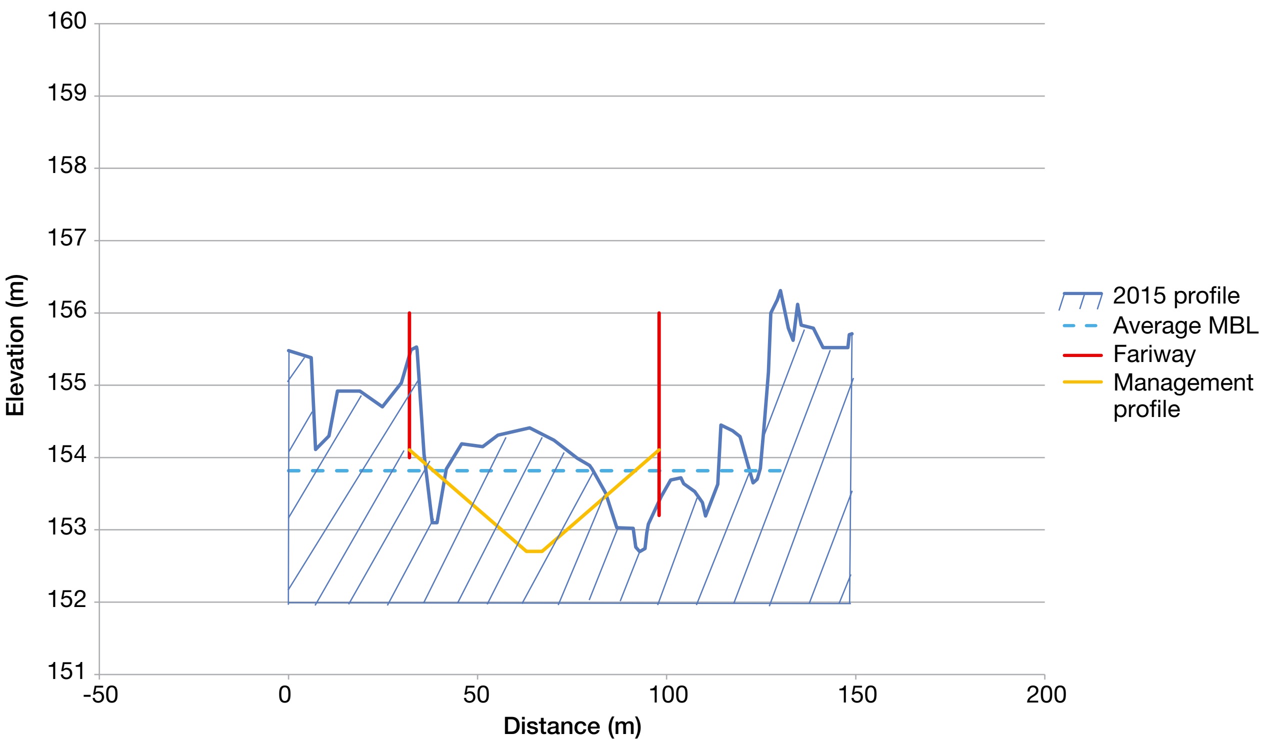

Figure 39. River management profile (Kauru 2) looking downstream

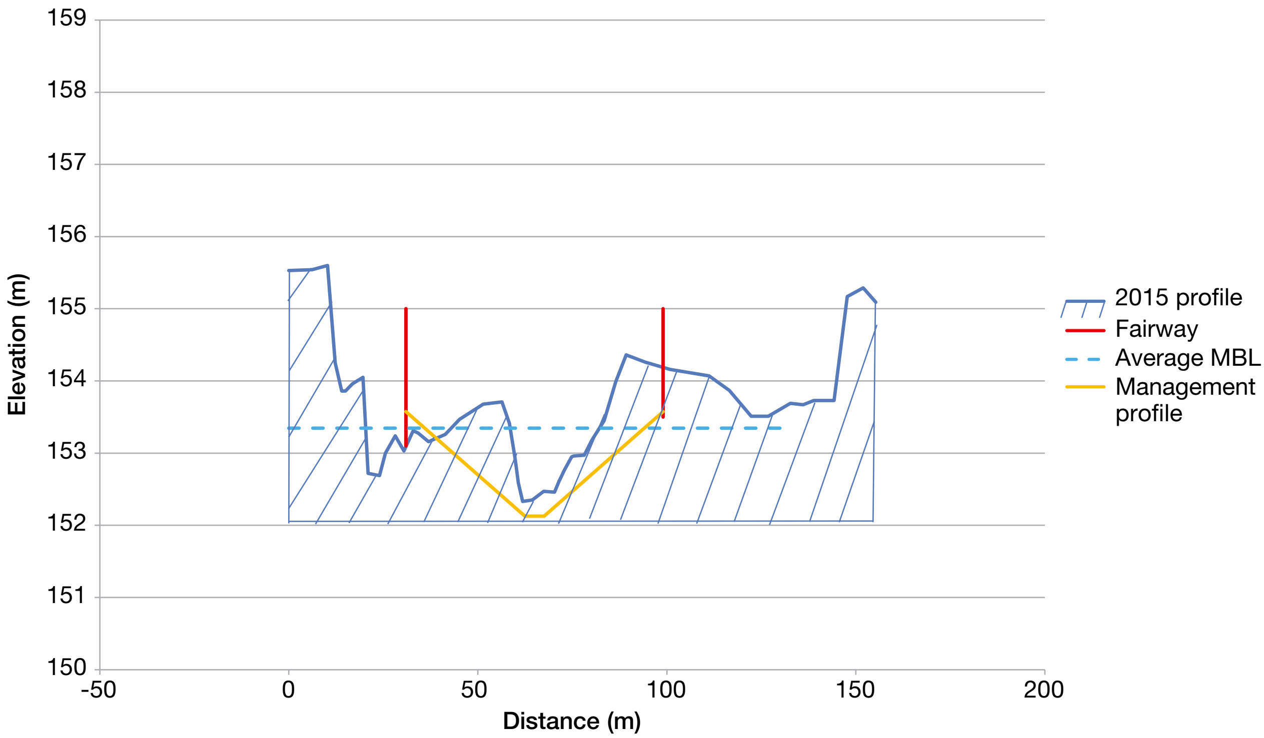

Figure 40. River management profile (Kauru 3) looking downstream

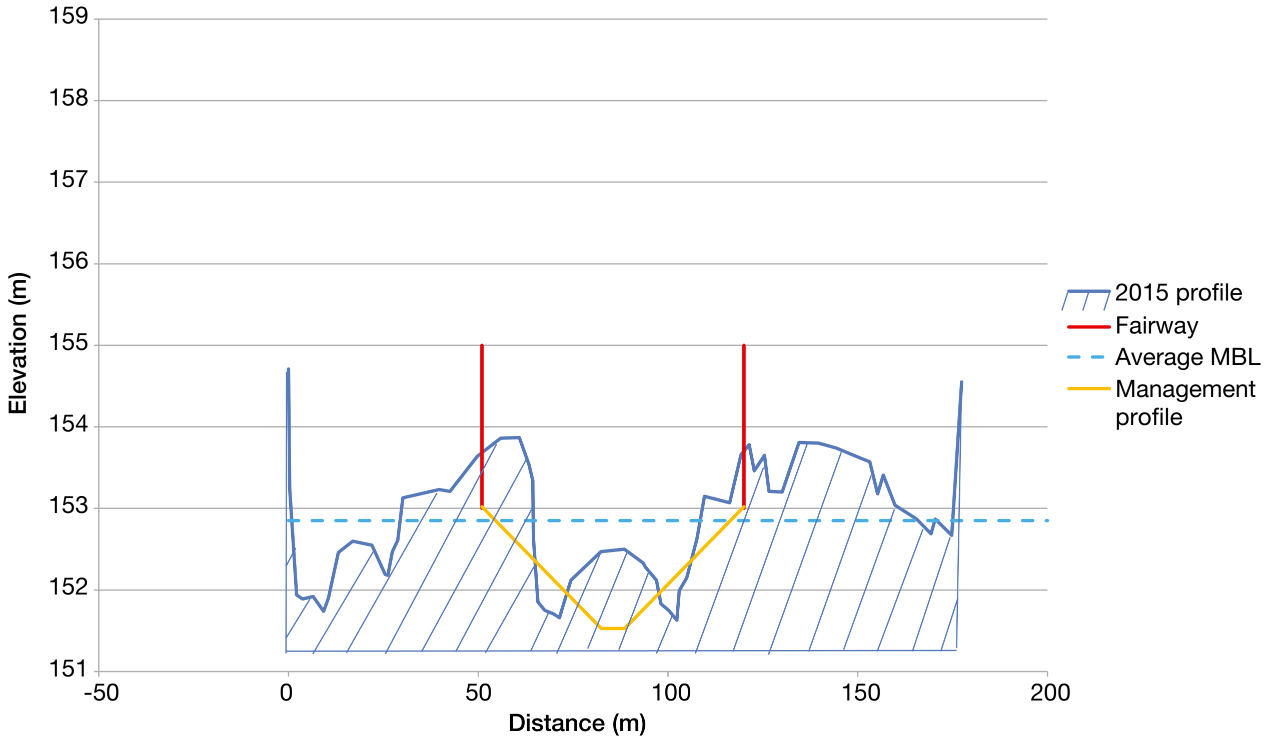

Figure 41. River management profile (Kauru 4) looking downstream

Figure 42. Areas in the Kākaunui and Kauru rivers with management profiles (aerial photography collected in 2013/2014)

Appendix 3. River corridor: Maps

The river fairway and corridor mapping provides guidance for multi-purpose river management, and for the design and implementation of management measures, protection works and in-channel design. When physical works or activities are being considered within the fairway or on the riparian margin, these should be undertaken with reference to the mapped fairway and buffer zones. The method used to define the river corridor is explained in Section 6.

Figure 43. Kākaunui River fairway and corridor Map 1 (aerial photography collected in the summer of 2013/2014)

Figure 44. Kākaunui River fairway and corridor Map 2 (aerial photography collected in the summer of 2013/2014)

Figure 45. Kākaunui River fairway and corridor Map 3 (aerial photography collected in the summer of 2013/2014)

Figure 46. Kākaunui River fairway and corridor Map 4 (aerial photography collected in the summer of 2013/2014)

Figure 47. Kākaunui River fairway and corridor Map 5 (aerial photography collected in the summer of 2013/2014)

Figure 48. Kākaunui River fairway and corridor Map 6 (aerial photography collected in the summer of 2013/2014)

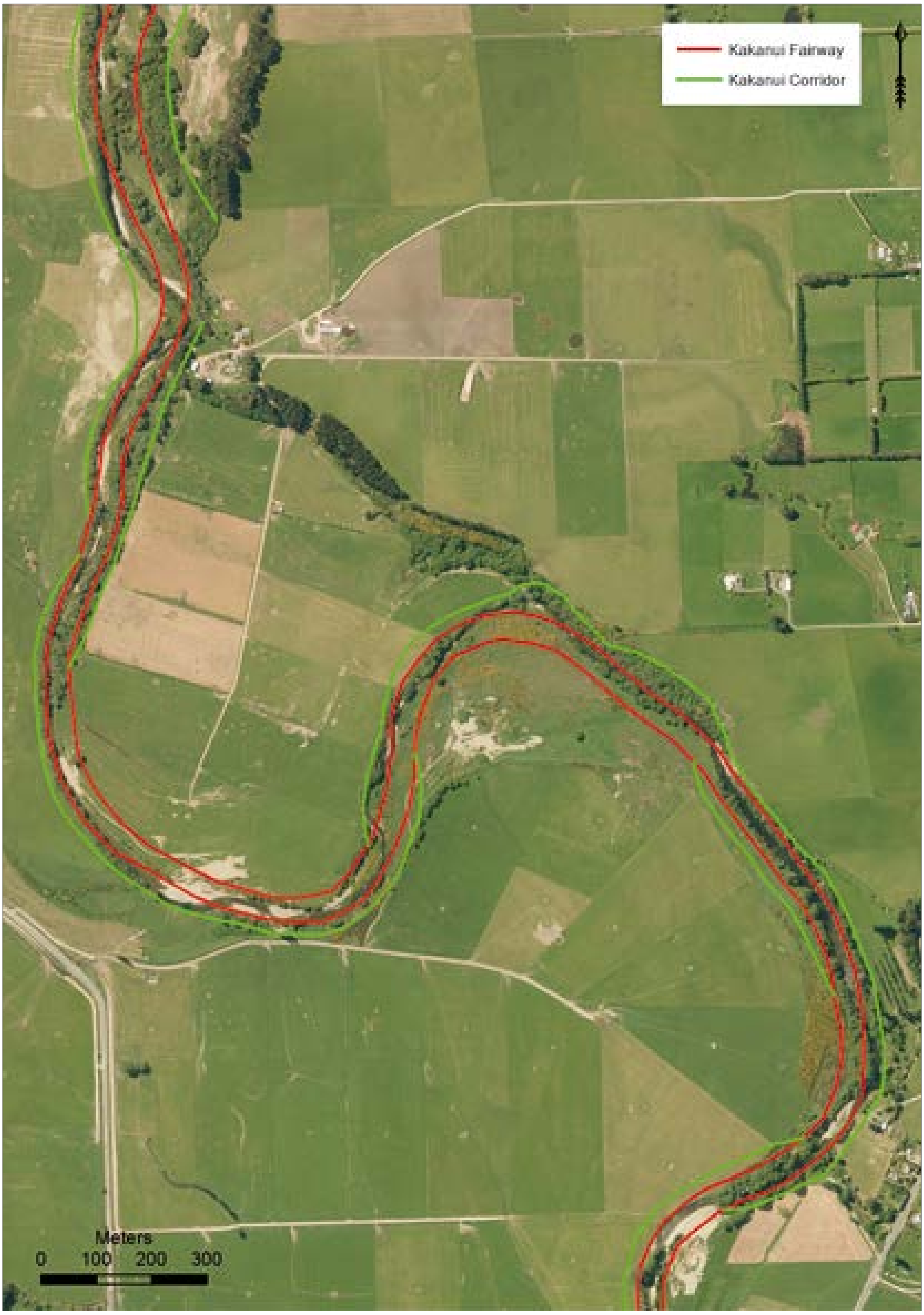

Figure 49. Kākaunui River fairway and corridor Map 6 (aerial photography collected in the summer of 2013/2014)

Figure 50. Kākaunui River fairway and corridor Map 7 (aerial photography collected in the summer of 2013/2014)

Figure 51. Kākaunui River fairway and corridor Map 8 (aerial photography collected in the summer of 2013/2014)

Figure 52. Kākaunui River fairway and corridor Map 9 (aerial photography collected in the summer of 2013/2014)

Figure 53. Kauru River fairway and corridor Map 1 (aerial photography collected in the summer of 2013/2014)

Figure 54. Kauru River fairway and corridor Map 2 (aerial photography collected in the summer of 2013/2014)

Figure 55. Kauru River fairway and corridor Map 3 (aerial photography collected in the summer of 2013/2014)

Appendix 4. Mapped community values

The maps in this section show the location of important values associated with the riverbed and riparian margins, as identified by the community and other stakeholders. The community consultation process is outlined in Section 3.6, Appendix 5 provides a summary of public submissions and Appendix 6 provides actual comments and summarised feedback from landowners and stakeholders.

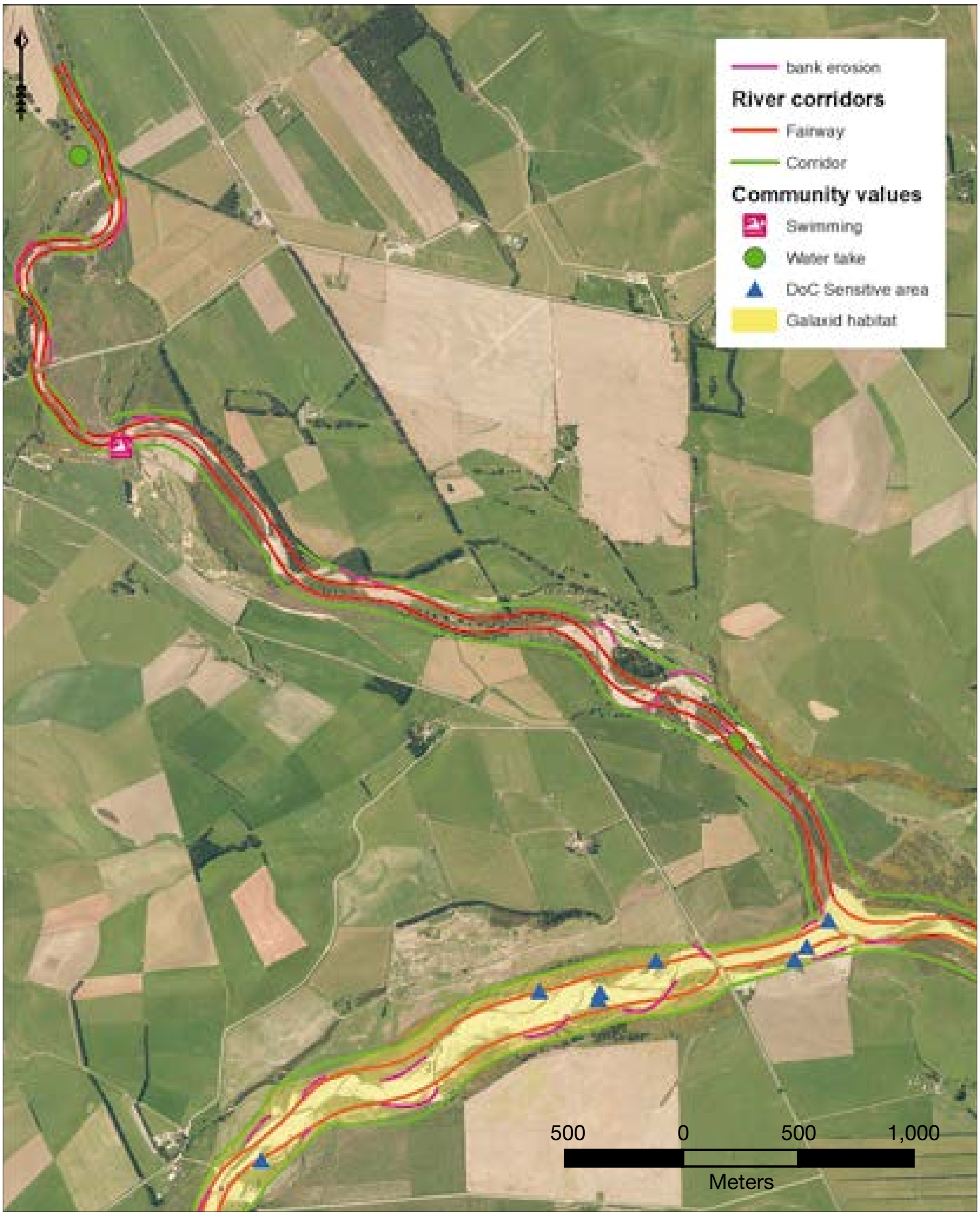

Figure 56. Mapped community values in the Kākaunui River Map 1 (aerial photography collected in the summer of 2013/2014)

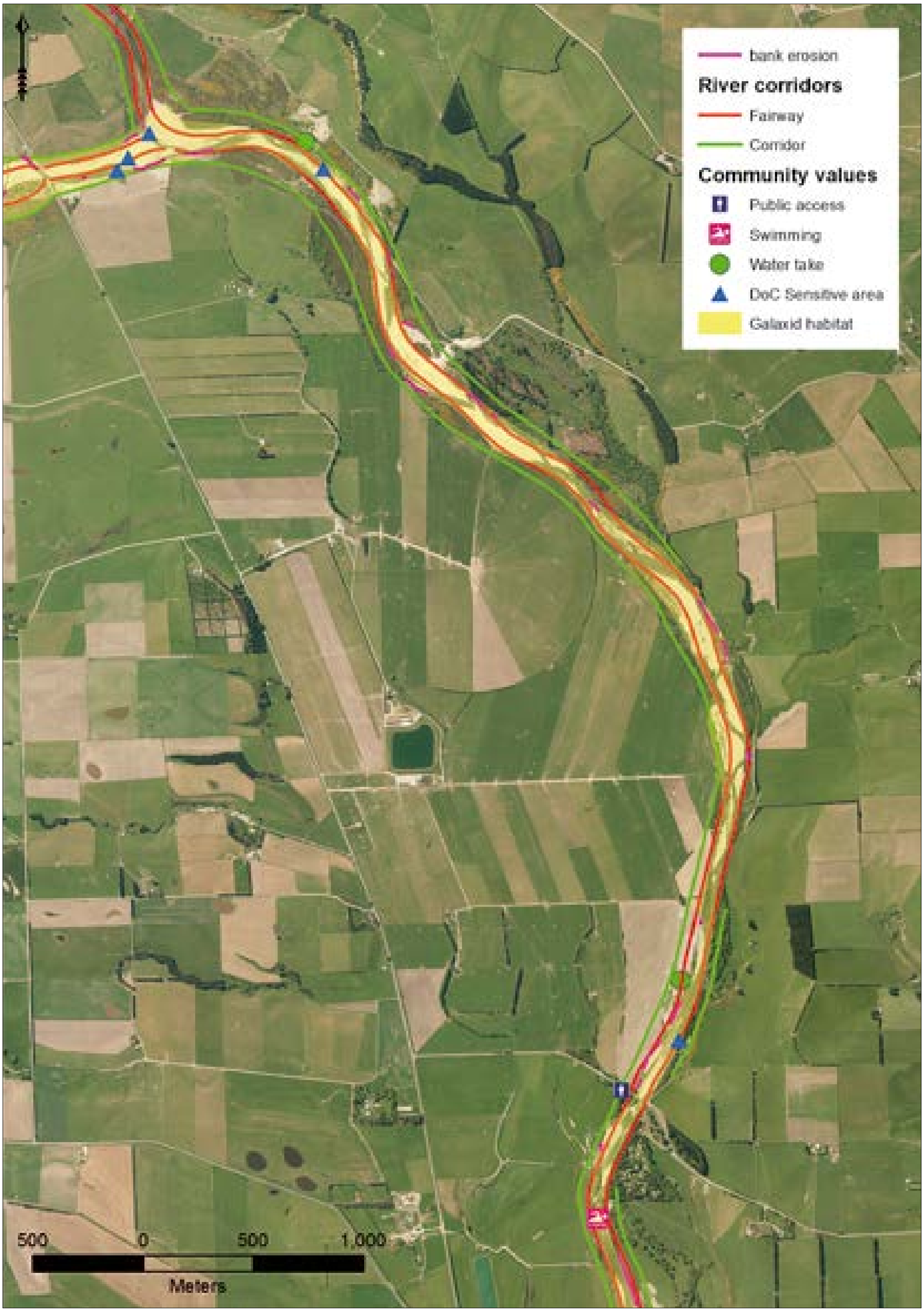

Figure 57. Mapped community values in the Kākaunui River Map 2 (aerial photography collected in the summer of 2013/2014)

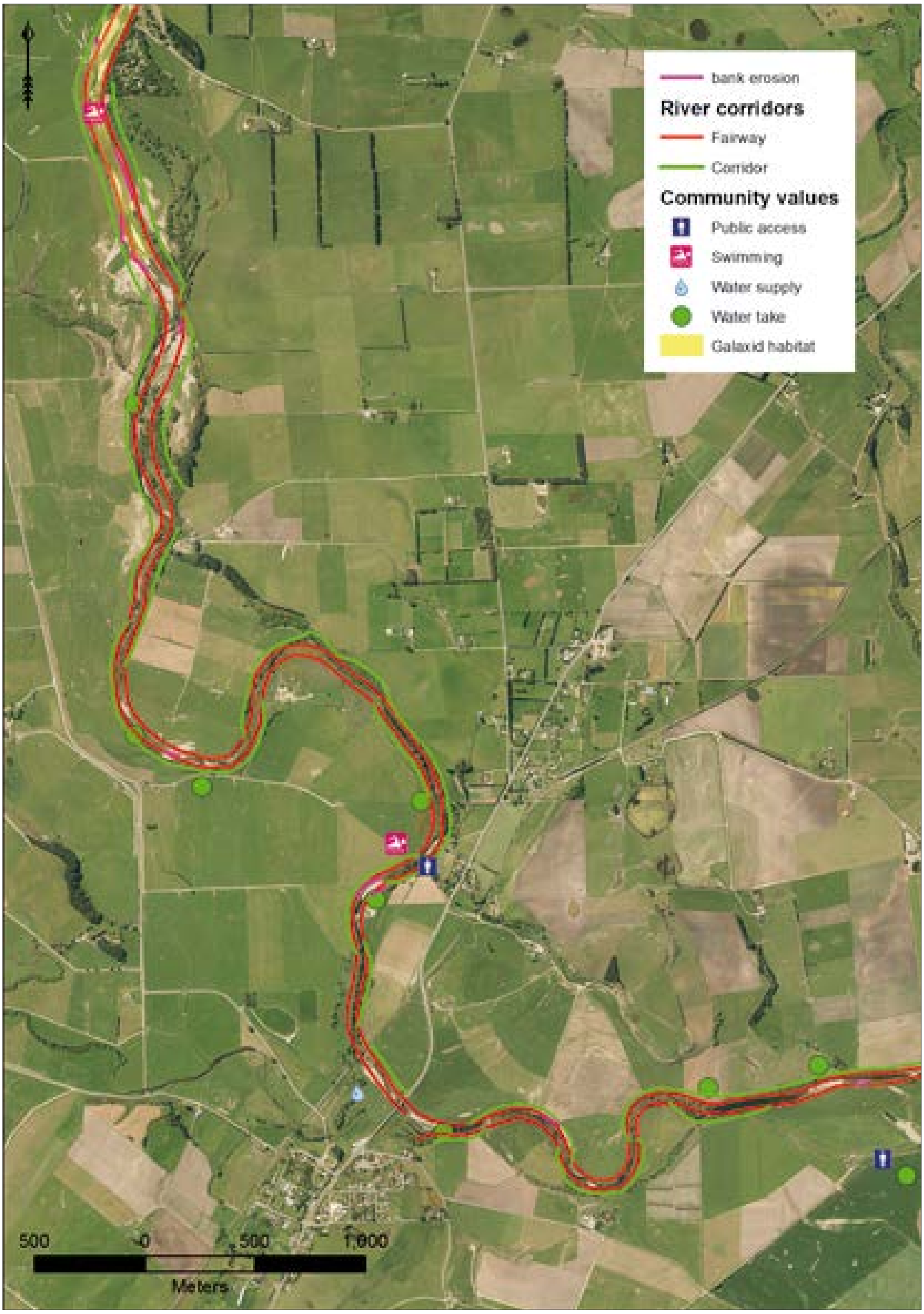

Figure 58. Mapped community values in the Kākaunui River Map 3 (aerial photography collected in the summer of 2013/2014)

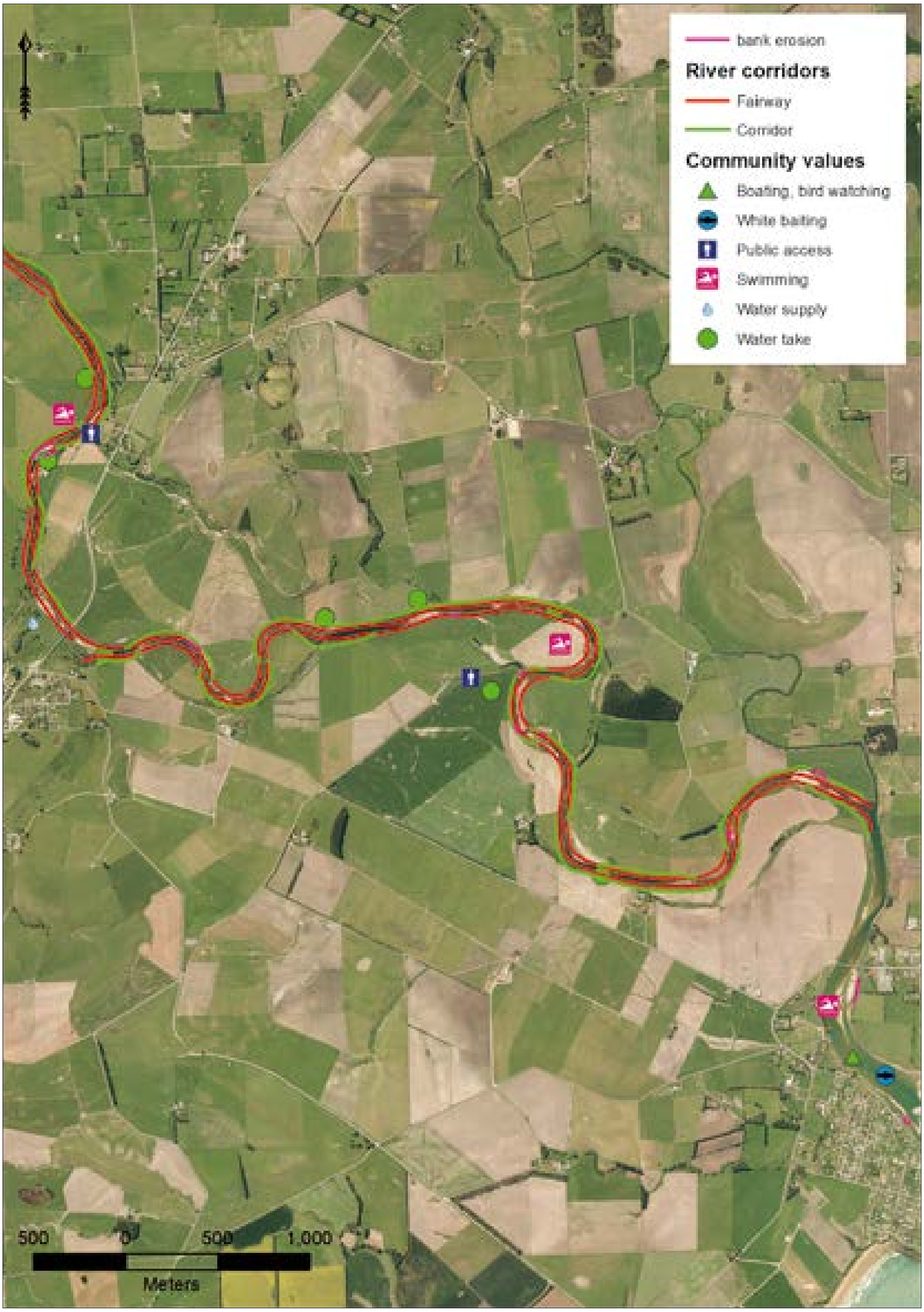

Figure 59. Mapped community values in the Kākaunui River Map 4 (aerial photography collected in the summer of 2013/2014). Note that the Coastal Marine Area boundary extends upstream as far as the Kākaunui Bridge.

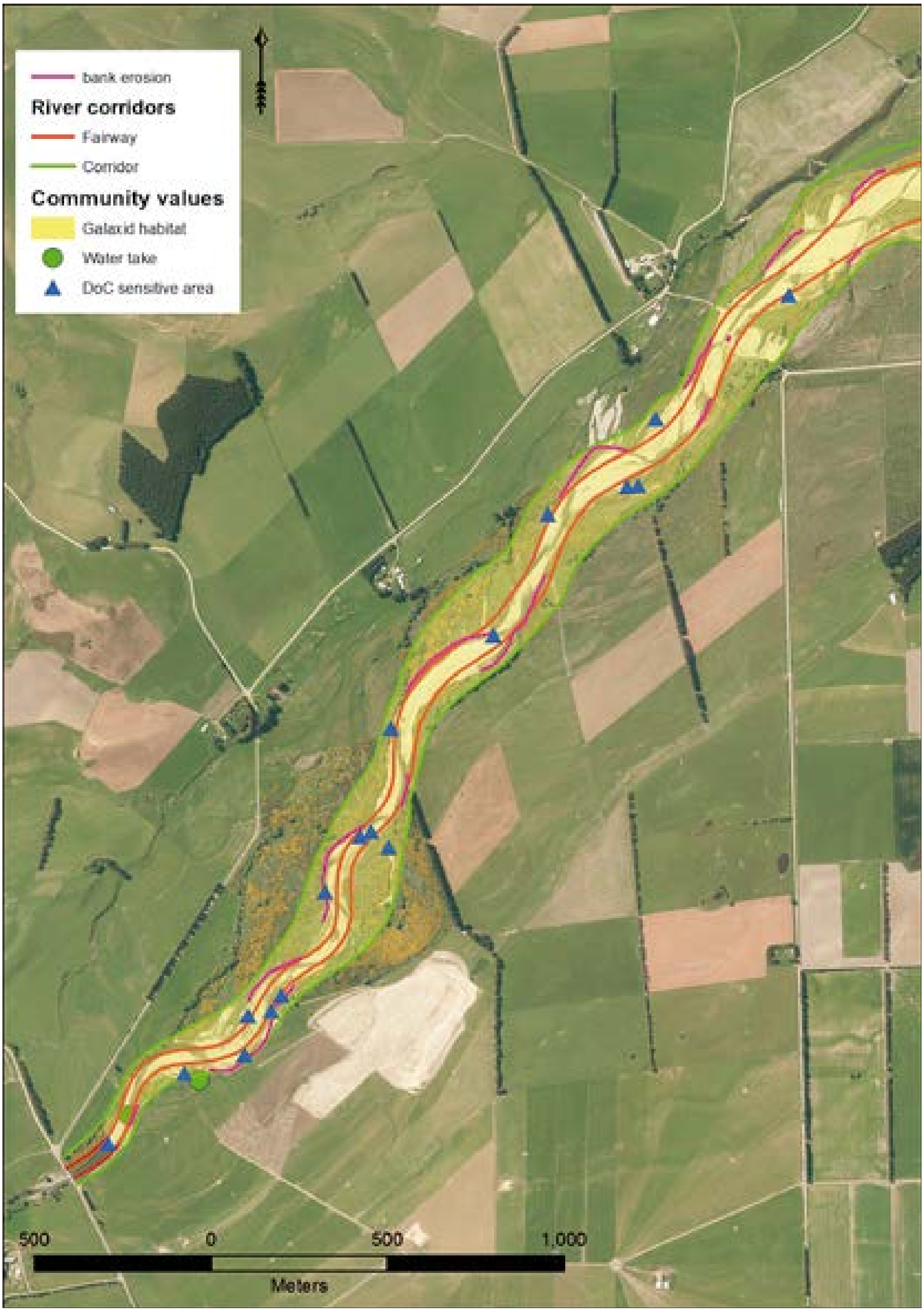

Figure 60. Mapped community values in the Kauru River Map 1 (aerial photography collected in the summer of 2013/2014)

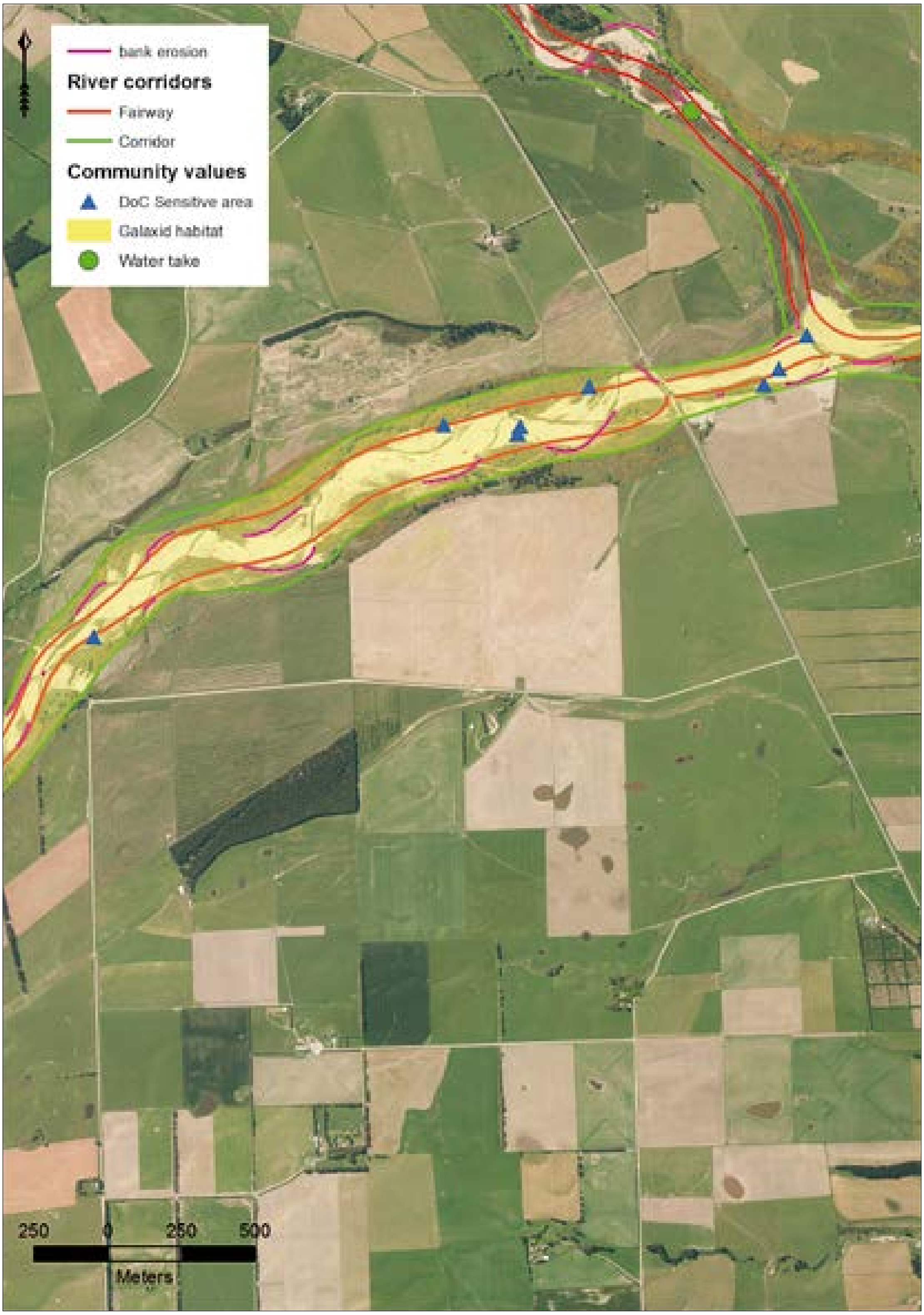

Figure 61. Mapped community values in the Kauru River Map 2 (aerial photography collected in the summer of 2013/2014)

Appendix 5. Community values – public submissions

The community consultation in May/June 2015 included an opportunity for the public to submit on their concerns, as well as a chance to state what they valued about the river and what they would like the strategy to achieve. A diverse range of views and concerns were put forward; some people were concerned that there has been insufficient, or too much, gravel extraction occurring, while others were more concerned with the quality of the water, riparian planting, wildlife habitat, bank erosion, inefficiency of the consenting process, and the mapped river fairways/buffer zones. Numerous submitters emphasised that they were unhappy with the current ORC consenting process for gravel extraction and works on the bed and banks of rivers. There was minimal objection to the proposal to identify buffer zones next to the Kākaunui and Kauru rivers (as discussed in Section 6), although some submitters questioned the width and location of the fairway and buffer zones. There was discussion about what vegetation would work best for the buffer zones (i.e. natives or willows). Several submitters stated that they would like to work collaboratively with the ORC and gravel extractors to complete work in the beds and banks of the Kākaunui and Kauru rivers. A wider catchment approach to management of the Kākaunui and Kauru rivers was discussed in the feedback, as was the use of wetlands and backwaters to mitigate the effects of flooding. One submitter stated that the Kākaunui River had become straighter, less braided and more channelised in recent years. Additional values that were not collected in the initial feedback process (Appendix 6) were also highlighted, such as the river's heritage.

Appendix 6. Community values - feedback from landowners and stakeholder groups

As discussed in Section 3.7.2, discussions were held with landowners and stakeholders in 2014-early 2015. The consultation was framed around two particular topics: i) what concerns they have about the form and function of the Kākaunui and Kauru rivers, and ii) how they would like the rivers to look in the future.

This section provides specific comments, and summarised feedback from landowners, ORC staff, iwi, DoC and Fish & Game, in response to these questions, grouped under four key headings. Some of the key points raised by the community and stakeholders are shown in Figure 62 to Figure 65.

1. The ability of the river to support social, spiritual, recreational and economic values

- A river that returns to being an asset rather than a liability to adjacent landowners (it doesn't cost $$$ in floods).

Want to pass on stories and teach – landscapes – see and understand. Ngai Tahu is a mahinga kai based culture. Children – if they don't have the experience of interacting with the river - you lose a whole cultural identity – if you lose the pieces of the puzzle kids will never be able to play with the puzzle. It's as much about passing on the knowledge as it is as food itself.

- Variety of different habitat – must have variety! Mix of features. Good to have pool or two so we can still have a swim.
- Why does the river need to be modified for just one group – it should be looked after for everyone.
- Good access to the river. Access for elderly. Struggle at Mill Dam at moment but we find a way. Maintain the access points.
- We can ring up and ask – we respect the farmer's property rights.
- A river good for recreational use and clean swimmable water and possibly drink from. Designated areas for recreational activities.
- Supports food gathering
- Amenities: Car parking/toilets provided
- More river use/activities – boats/kayaks
- Access along whole of river – walking.

Characteristics of river differs across length – spawning habitat protected

- Good water quality (in aquifer and surface) and good access – good life supporting capacity and current use – no detrimental effects
- Supports future growth
- Domestic water supplies in Kauru/Windsor – headwaters - supported
- Stock water supplies supported
- No salt water infiltration into groundwater.

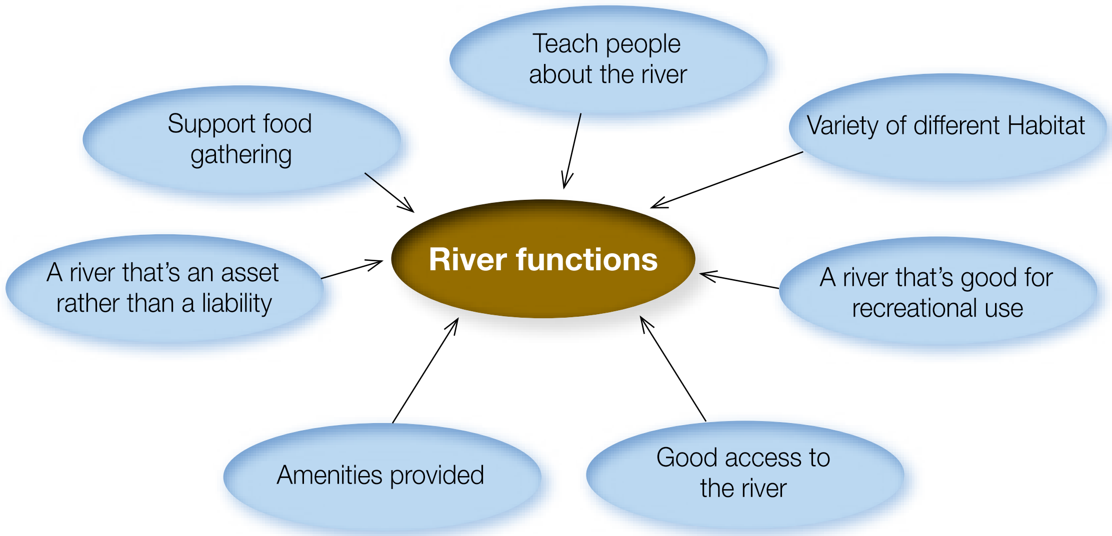

Figure 62. Key points discussed through the consultation relating to river functions.

2. River form: riparian plantings, vegetation and fencing

Like to see more native riparian planting on banks. No willows – natives!

- Lots of infrastructure but no planting.
- Lot of faith in ORC scientists! Would like to say the plantings have function – something tangible. Assurance from ORC technical staff that it serves a purpose.
- Natives plants will help species in the water – and will also get cultural materials (e.g. flax). Access currently – if we want them we'll find them! But don't want to spend petrol to travel for materials and food.
- Iwi see it as: cleans the river. Acts as a filter.

Many views that the riverbanks should be planted with vegetation, managed, with healthy strong trees, willows often mentioned, but also natives and planting for beautification as well as erosion protection.

- Ensuring there is no vegetation in the centre of the river.
- Trees (mix of willows and natives) – planting at right place for river management and naturalised (not straight rows)
- Good shading/habitat/stable banks
- Blue/green corridor – between mountains and sea – wildlife corridor
- Fenced by ORC.

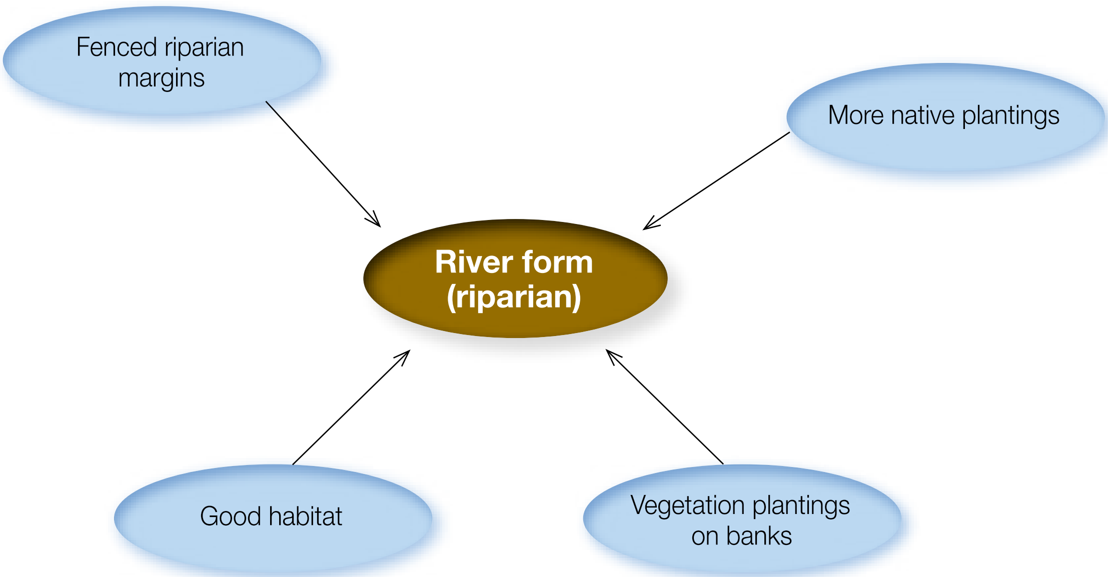

Figure 63. Key points discussed through the consultation relating to river form (riparian margins).

3. River form and function: human modification

3.1 - Responses favouring no/limited engineering work

River straightening etc – completely oppose. It should look natural. Natural is change – let the river do what it naturally does.

- Riffles clean the water – go downstream of riffle.
- It is hard for Whānau to know what is achievable. Everyone hashad a play in the river already. Reduced flows, gravel taken, flood banks constructed. Is anything doable? Not asking to turn back the clock but how far can we go? Explore what is feasible.
- Understand that farmer makes investment in dairy farm – but we are not prepared to have more engineering work.
- Not asking for bridges and other constructions to be removed but not any further engineering.
- A clean slow flowing river.

Clean, nice braids, happy river, has 'mojo' back, happy, filled with life

- Good flow in summer – more natural variation (history of extraction – minimum flow regime)
- Rocks clear of algae (early 2000)
- Abundant fish life
- Water crystal clear.

3.2 – Responses favouring some engineering work

- A river that stays within its banks and on course. Some variation on when this should be expected - at normal events, at high flows, in most flood events.

A deeper river channel that sits below the adjacent land.

- A meandering river within a reasonable channel.

3.3 – Responses favouring considerable engineering work

- Would look like Leith – water stays in channel all time – all floods – farm to edge – no erosion
- Not river 'management' – river 'control' – so river predictable.
- Good bridge/road access and river management.

3.4 – Responses wanting to 'turn back the clock'

- No farms/farmers.

Estuary – not green in summer – open during low flows – connected to the sea.

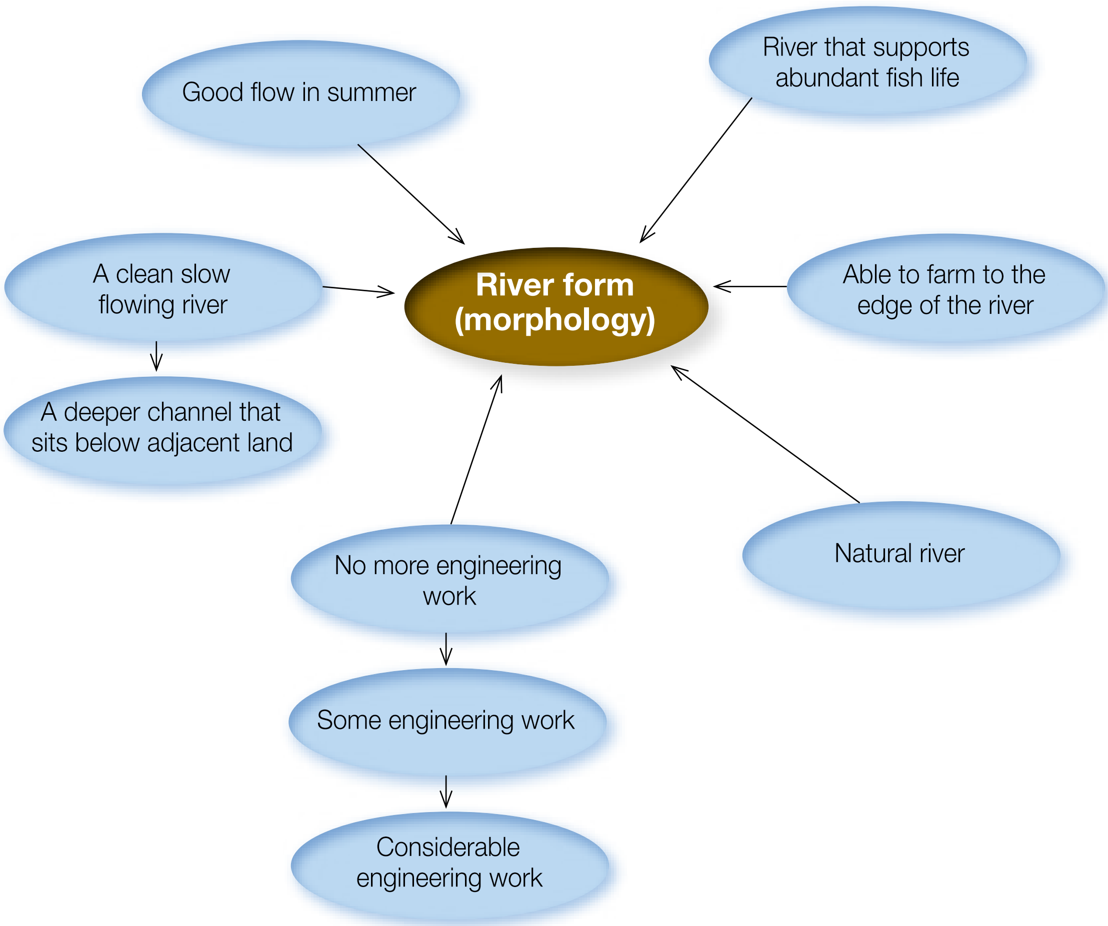

Figure 64. Key points discussed through the consultation relating to the Kākaunui and Kauru rivers form (morphology).

4. The Kākaunui and Kauru riverbeds as a gravel resource

Understand where the whitebait actually live and how they have survived regardless of activities in the river over time.

- Ensuring that there is a sustainable gravel resource for use by the community.
- Being able to act on a global consent.
- Geological formation? Kauru has basalt – quite unique
- Valuable gravel resource – aggregate – available for commercial/community use.
- There has to be a change in thinking and direction from ORC Engineering Staff to take into account the devastation and damage that is occurring during every current flood event. If this requires a change at policy level or governance level within ORC then please list this as one of the main objectives of this review – to make the overall system manageable.

It was mentioned previous ORC river engineers including David Knowles had a **practical approach to managing these rivers and was able to react with targeted extraction and bank reinstatement after each event enabling better management of difficult areas in the river and a common sense approach to extraction over all years – not just the wet ones.**

- This is a low cost, practical, easy to manage approach to doing something positive with the problems and issues that we now have with both extraction and bank reinstatement being possible and largely being organised between the gravel extractor and the landowner – **all we require is consent to be able to undertake this type of work.**
- It is hard enough to get even low volume extraction consent at present (some taking a number of years) let alone obtaining consent to re-channel rivers closer to the centre line and to extract gravel from below water level to be able to achieve this. In the practical world this work isn't hard to do – just difficult and expensive to get consent for. Part of this would also include reinstating eroded banks as was carried out in past decades usually with long term success.

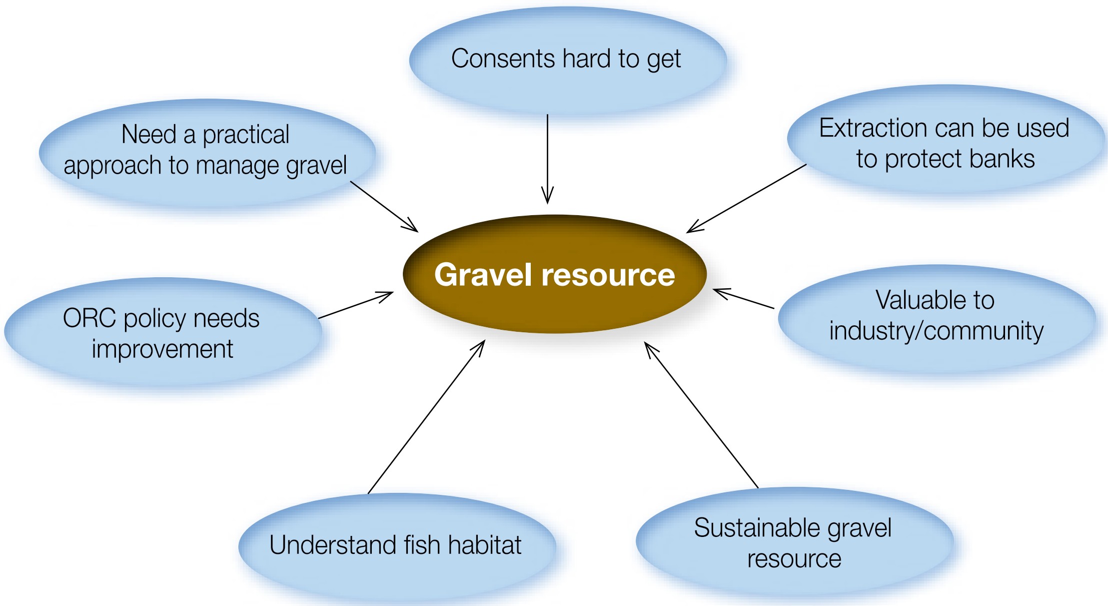

Figure 65. Key points raised through consultation relating to using the riverbed as a gravel resource

Appendix 7. Longitudinal profiles

Rivers generally increase in size (width/depth) and flow downstream as they receive additional flow from tributary waterways. This is the case with the Kākaunui and Kauru rivers, which change from small waterways in the Kākaunui Mountains to larger rivers close to the coast/confluence.

The longitudinal profiles of the Kākaunui and Kauru rivers display the typical concave shape, with steeper areas in the upper catchment and a shallower profile closer to their termination (Figure 66, Figure 67). The longitudinal profiles vary over time in response to several factors, including: discharge, sediment (size and location), flow resistance, velocity, width, depth and slope (Leopold et al., 1964). The longitudinal profile of the Kākaunui and Kauru rivers will change over time due to the factors listed above. It is difficult to describe what the 'natural form' of the longitudinal profile of the two rivers is; however, events causing negative changes (e.g. excessive gravel removal) in the longitudinal profile should be discouraged.

Sediment accumulates in channels, due to several factors, such as where a change to a shallower grade allows velocities to slow down; this allows sediment to drop out of suspension where it rests on the bed of the channel and adjacent berm areas. The main section of the Kauru River where shallower grades allow sediment to become deposited is downstream of the Kākaunui Valley Road Bridge, to the confluence with the Kākaunui River. In the Kākaunui River, areas of natural gravel accumulation occur at the confluence with the Kauru River, and at Robbs Crossing.

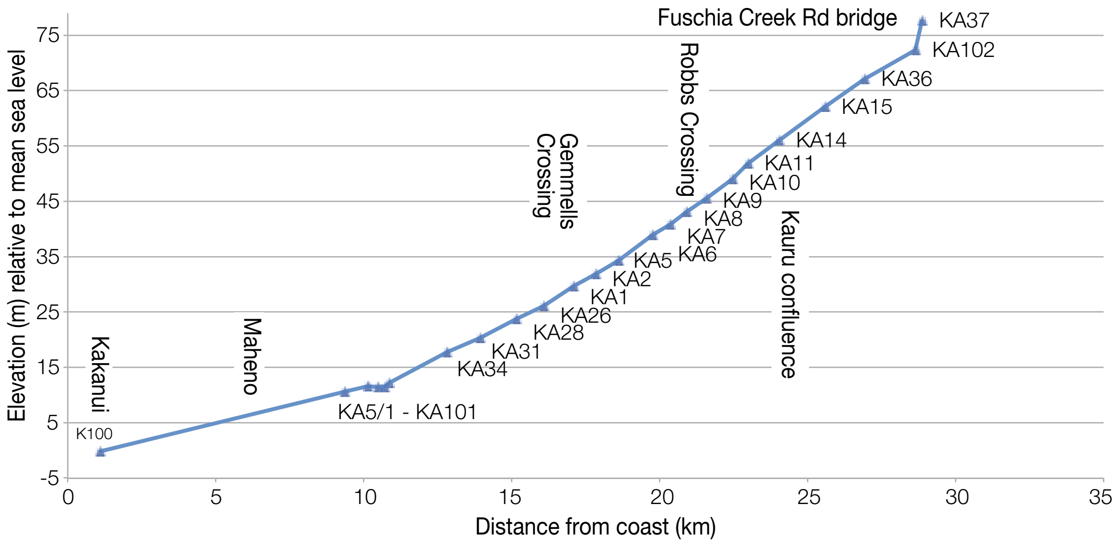

Figure 66. Longitudinal profile of the Kākaunui River (using the 2012 survey)

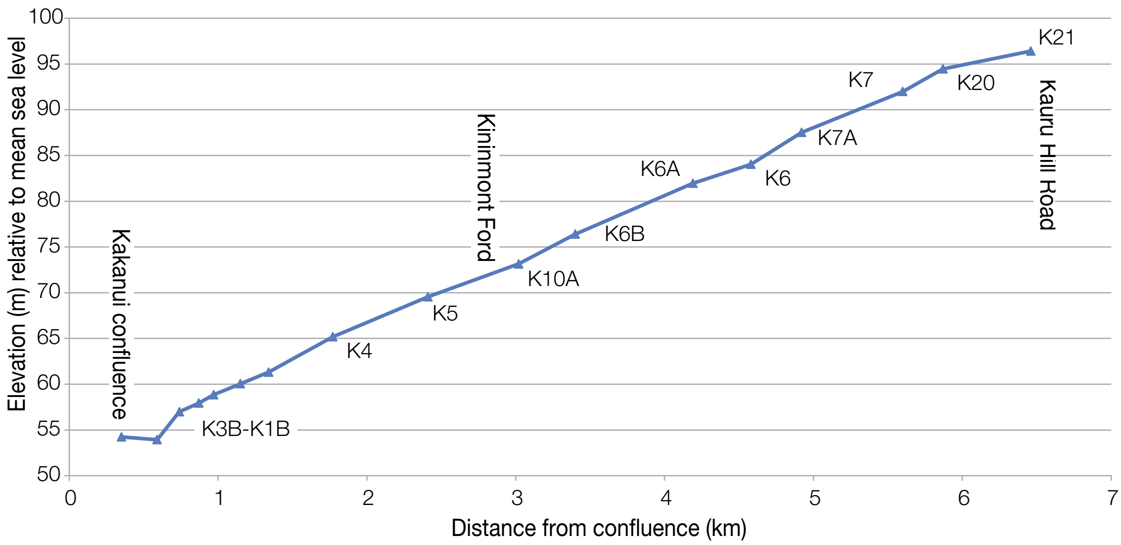

Figure 67. Longitudinal profile of the Kauru River (using the 2013 survey)

Appendix 8. Planting guide

Benefits of riparian planting[20]

The benefits of well-planned and well managed riparian planting areas on farms are considerable, and include:

- increasing the quality and health of waterways
- increasing the ability to filter nutrients before they reach waterways – Nitrogen, Phosphorus, and bacteria/viruses e.g. E.Coli
- reducing sediment runoff
- reducing soil erosion of banks in waterways
- providing shade, which reduces waterway temperatures and shelter for stock
- minimising stock losses as animals are excluded by fences from riparian strips
- increasing biodiversity – aquatic life, native plants, birds and insects
- improving recreational opportunities (e.g. fishing)
- enhancing and beautifying the river margins.

Using trees to stabilise stream banks[21]

Exotics

The most effective trees for stream bank erosion control are exotic willows and poplars. These are planted as stakes (less than 1 m high) or poles (1.5 – 3 m in height). Avoid invasive spreading species, such as crack willow, weeping willow, silver poplar and all non-sterile tree and shrub willows. Before planting fast growing trees, consider their longer-term maintenance needs.

Winter is the best time to plant these species before stakes or poles sprout new growth. Plant about a third of the length below ground. On waterlogged ground, you can force them in by hand. On firm ground, you may be able to sharpen poles at one end and drive them in with a rammer or use a post auger. Stakes can be planted by putting them into a hole made with a length of reinforcing rod or similar. The most important thing is to make sure stakes and poles are firmly planted.

Guide to planting willow poles

Storage

It is recommended that poles are planted as soon as possible following delivery. Poles can be stored for a few weeks in water, stand up in a water trough or pond/creek. The bottoms of the poles should be kept wet to keep them alive and absorbing water. Poles should be stored away from stock.

[20] Adapted from KCCP planting guide (2015)
[21] Adapted from ORC (2005)

Planting

Poles should ideally be planted on the outside of river bends, or sections of river where erosion is occurring. Plant poles in rows with 2 – 3 m spacing between them. Poles need to be planted 300-500 mm deep. Try and plant down to ground water level. Either a crow bar, post-hole borer or tractor forks/digger with a spike can be used to make a hole in the ground that the pole can be dropped into, and then packed firm.

Looking after plantings

Fence planting off from stock to protect plants; plant protectors can also be purchased and can help give protection. It is recommended that poles are watered the day after planting and at least once a week during dry weather until they are established.

To stabilise banks:

✓ pair-plant along straight reaches – one tree on one bank, one tree on the opposite bank, five to seven meters apart.

✓ plant at two to three metre spacing at critical points, such as the outside of the bends where erosion is the greatest.

✘ avoid planting on the inside of bends – soil builds up rather than erodes here, so trees will trap sediment and force current against the outer bank.

✘ avoid planting narrow channels where trees might impede floodwaters.

By the time trees are four- or five-years old, there will be a solid mass of roots along the bank. At 10 to 20 years, trees can be thinned to 10 to 12 metre spacing, but no wider. If you use sleeves on poles to protect the willows and poplars, sheep can be grazed around the trees from the time they are planted.

Natives

Planting natives for bank stability will enhance the natural biodiversity of your riparian margin and provide habitat for invertebrates and birds. While exotic tree species are proven to stabilise banks, new research shows that native trees, such as ribbonwood, cabbage tree and pittosporum species, are suitable for bank stabilisation. These species are deep rooting, with a good root spread. Planting native species alongside exotics will help to maintain a mostly native planting on your banks. When planting natives for bank stabilisation, plant at 1.5 – 3 metre spacing.

Appendix 9. Threat status of native fish and birds

Table 6. Native fish present in the Kākaunui and Kauru rivers, with their threat status (Goodman et al. 2014)

Super-category	Threat Status	Common name	Scientific name
Threatened	Nationally critical	Lowland longjaw galaxias	*Galaxia cobitinis*
	Nationally vulnerable	Lamprey	*Geotria australis*
At risk	Declining	Longfin eel	*Anguilla dieffenbachia*
		Torrentfish	*Cheimarrichthys fosteri*
		Koaro	*Galaxias brevipinnis*
		Inanga	*Galaxias maculatus*
		Canterbury galaxias	*Galaxias vulgaris*
		Bluegill bully	*Galaxias hubbsi*
		Redfin bully	*Gobiomorhus huttoni*
Not threatened		Shortfin eel	*Anguilla australia*
		Upland bully	*Gobiomorphus breviceps*
		Common bully	*Gobiomorphua cotidianus*
		Giant bully	*Gobiomorphus gobioides*

Table 7. Native birds present in the Kākaunui and Kauru rivers, with their threat status (Robertson et al., 2012)

Super-category	Threat Status	Common name	Scientific name
Threatened	Nationally critical	Black stilt	*Himantopus novaezelandiae*
	Nationally vulnerable	Banded dotterel	*Charadrius bicinctus bicinctus*
At risk	Declining	White fronted tern	*Sterna striata striata*
		South Island pied oystercatcher	*Haematopus finschi*
Not threatened		New Zealand kingfisher	*Todiramphus sanctus vagans*
		Shining cuckoo	*Chrysococcyx lucidus lucidus*
		Grey warbler	*Gerygone igata*

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