Pomahaka River morphology and riparian management strategy

Version 1.0 – May 2016

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Overview

The Pomahaka River morphology and riparian management strategy has been prepared by the Otago Regional Council (ORC), with input from the local community, to help protect the recreational, cultural and ecological values of the Pomahaka riverbed, and to enable long-term sustainable use of the land that borders the river. The strategy, as summarised in the two diagrams overleaf, 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 Pomahaka River catchment consider, and give effect to, the principals, 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 that do influence river management activities[1] 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 the 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,[2] and will help to set priorities and work programmes 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.

[1] Including the Local Government Act (in regards to funding considerations), and the Resource Management Act (in regards to environmental effects)

[2] In particular, staff with responsibilities for river and waterway management and natural hazards

Pomahaka 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 on the riparian margins of the Pomahaka River.

Vision

- The long-term sustainable use and enjoyment of the Pomahaka River and its 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 river's values and features to be utilised, preserved and enhanced.

Otago Regional Council

Pomahaka River morphology and riparian management strategy - overview

Objectives & associated activities (these are further refined in Section 8 - implementation)

Objective 1. To recognise and characterise natural river processes.	Objective 2. To equip the community to live with the effects of changes in river morphology.	Objective 3. To enable sustainable gravel extraction.	Objective 4. To promote activities that enhance the natural character and enjoyment of the river.
• 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.	• Promote land-use practices and the placement of assets that 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 that are of high value to the community and iwi.	• 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.	• Provide maps showing the location and characteristics of features that 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 white-baiting 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 riverbeds occur as a result of natural processes that are often uncontrollable, and also from human intervention. The Pomahaka riverbed is an integral part of the wider Pomahaka River catchment (Figure 1). The Pomahaka riverbed is part of a dynamic river system, and has 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[3] 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 New Zealand, Department of Conservation (DoC), Clutha District Council (CDC), 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. As a result, changes in the position and form of the riverbed can cause issues for landowners and other river users. The Pomahaka River is valued as a recreational, commercial, and cultural resource e.g. picnicing, swimming, fishing, and farming (Gregory, 2014).

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

The strategy's key objectives are to:

- Recognise and characterise the natural river and catchment processes that occur in the Pomahaka River
- 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 changes 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 the results are:

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

- A visually appealing river system
- A habitat that supports existing wildlife, fish, and preferred plant species
- Limited effects on assets as a result of flood events
- Resilient infrastructure (roads, bridges, water supply)
- Continued use of the river for recreational activities.

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 in the Pomahaka River catchment consider, and give effect to, the principles, objectives, and actions listed in the strategy.

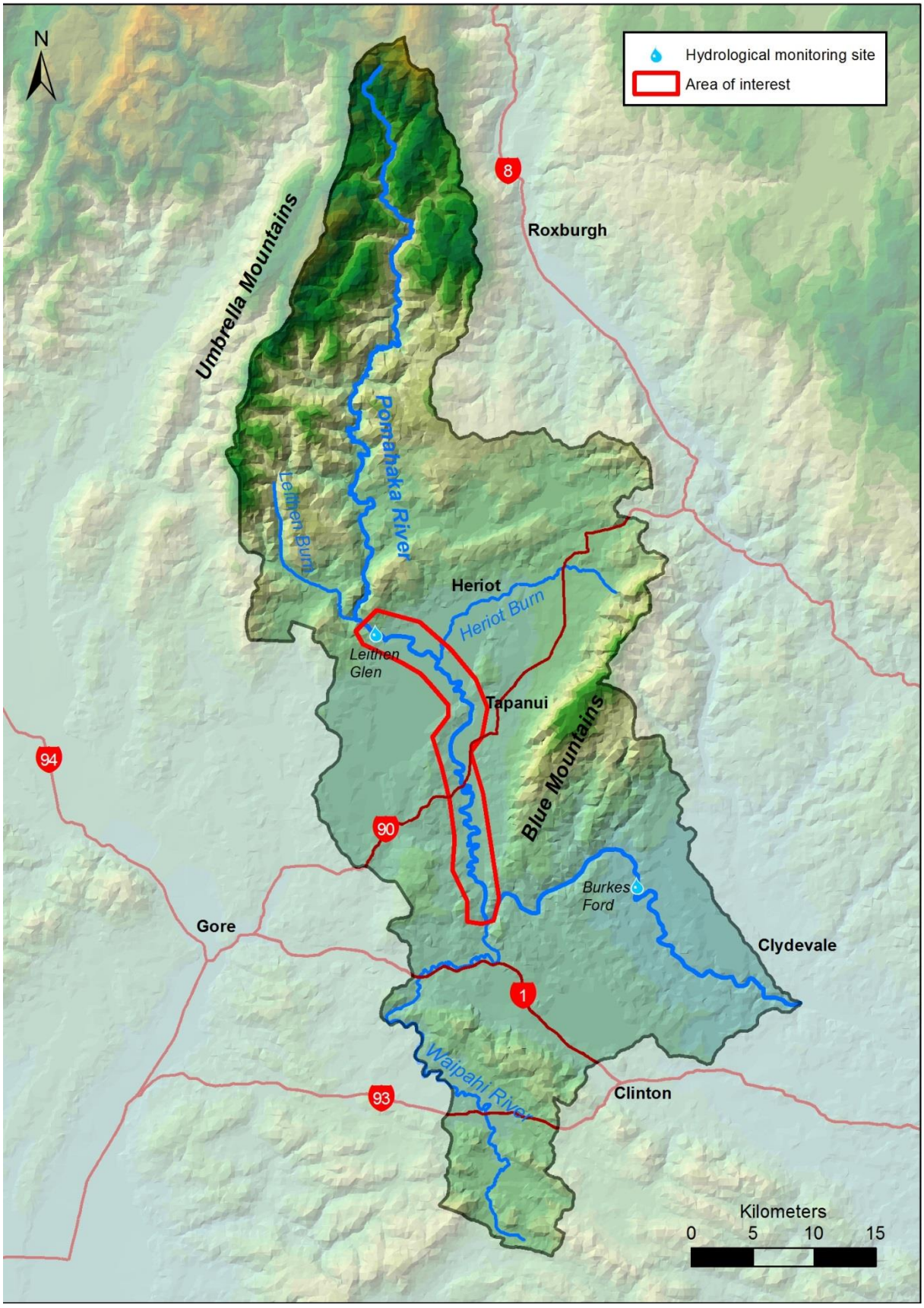

Figure 1. **Pomahaka River catchment boundary, showing main tributaries and the area of interest**

Figure 2. **Examples of changes in channel morphology. Top: bank erosion downstream of the Greenvale Road bridge (November 2015); bottom: bank erosion at Camperdown Bend (August 2015)**

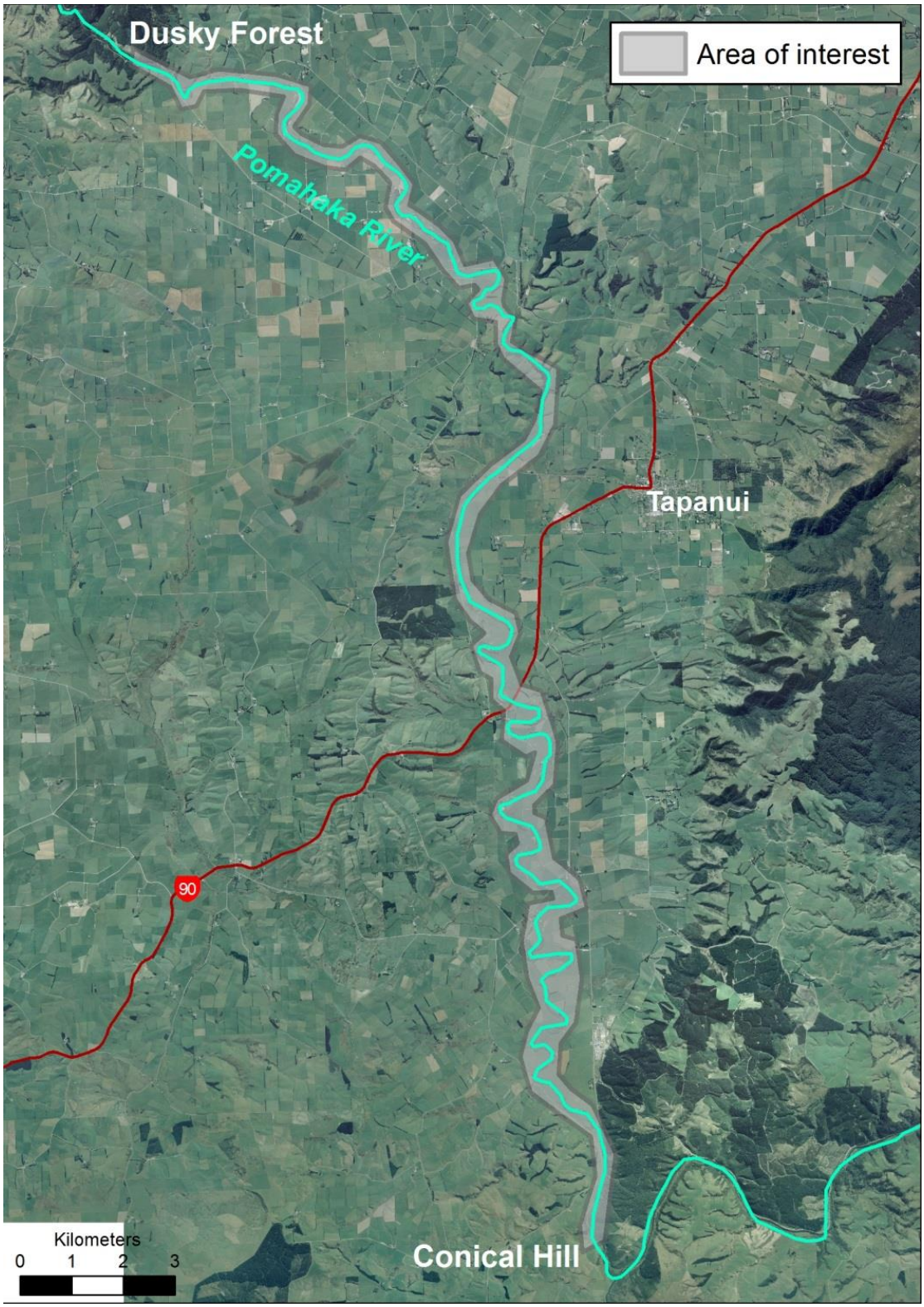

Figure 3. **Map showing the reach of the Pomahaka River, to which this strategy applies**

2. Scope

2.1. Study reach

The geographical scope of the strategy is the reach of the Pomahaka River between Dusky Forest and Conical Hill (Figure 3). Activities that occur in the upper catchment of the Pomahaka River and in other tributary streams may have an effect on the study reach. The upper reaches and tributary streams were not investigated in this report, as most concerns previously raised by the community were located in the study reach. The focus was therefore on this location. Other areas in the Pomahaka River catchment may also experience problems and issues associated with river processes; however these are not examined here.

2.2. Risk

The 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 study reach of the Pomahaka River. However, it is acknowledged that heavy rainfall events may lead to a range of other risks, including widespread flooding and surface runoff.

There are several other environmental issues and hazards in the Pomahaka River catchment. These include natural hazards such as seismic activity, as well as 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 Pomahaka River. Guidance and regulations relating to other issues can be obtained from the ORC.[4]

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,[5] 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 river 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.

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

[5] Including additional understanding gathered during future flood events

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:

- 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.
- A facilitated process to coordinate activity and work towards achieving the principals and objectives outlined in the strategy.

3. Environmental setting

The natural and social settings of the Pomahaka River 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 reach of the Pomahaka River, to which this strategy applies, is located on the two floodplains between Dusky Forest and Conical Hill. Sediment has been eroded from the hill catchments upstream of the study area and has been subsequently deposited by fluvial processes to create the wide, flat floodplain within which the river sits. The geology of the two floodplains is described as gravel and sandy gravel consisting of late Quaternary (2.5 million years before present) age river and alluvial fan deposits (Figure 4, Figure 5) (Turnbull & Allibone, 2003). The surrounding hills are made up of semischist and metasandstone of the Caples terrane from the Permian period (299 to 252 million years before present) (Turnbull & Allibone, 2003). The Tapanui floodplain also contains Tertiary (25 million years before present) sediments and volcanic outcrops (Turnbull & Allibone, 2003).

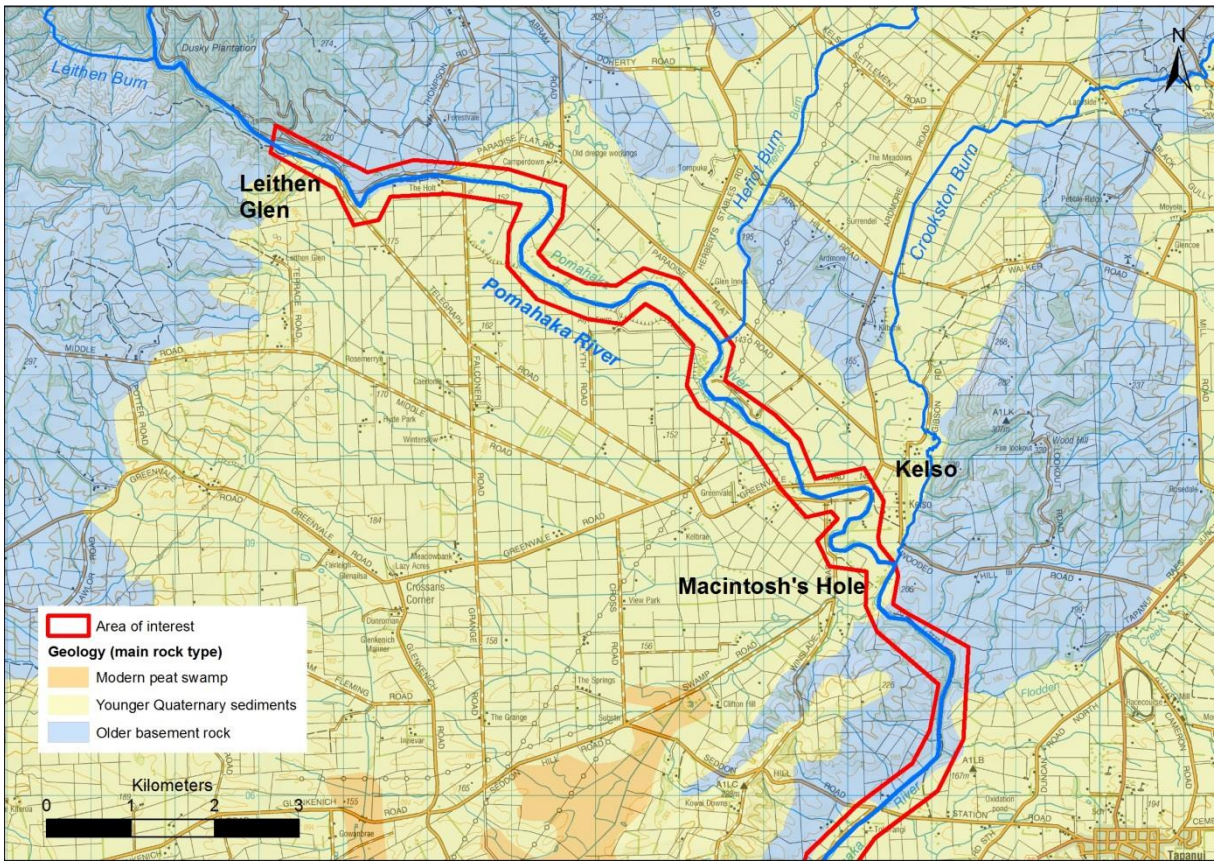

Figure 4. **Geological map showing the reach of the Pomahaka River between Dusky Forest and Kelso Gorge**

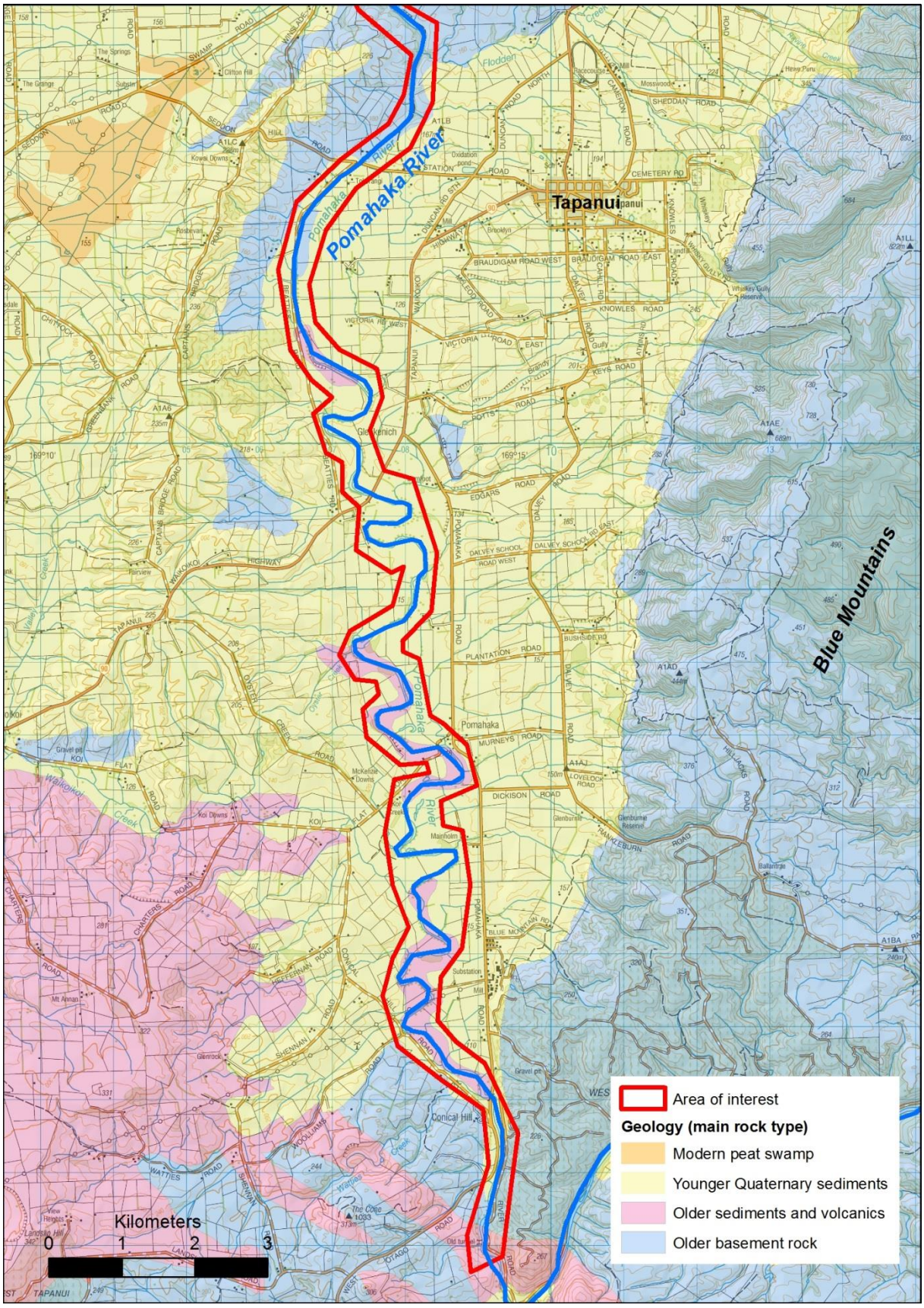

Figure 5. **Geological map showing the reach of the Pomahaka between Kelso Gorge and Conical Hill**

3.2. Geographical setting

The Pomahaka River catchment is located in southwest Otago and has a total catchment area of 2060 km^2 (ORC, 2007), with several tributaries including the Waipahi River, Heriot Burn, Flodden Creek, and the Leithen Burn. The Pomahaka River catchment contains a diverse range of topography from high altitude mountainous terrain in the upper catchment to rolling hill country and wide floodplains in the lower catchment. The upper reaches of the Pomahaka River originate in the Umbrella Range (west of Roxburgh township) (Figure 1). The Pomahaka River flows south from the Umbrella Range until it emerges from the steeper upper catchment (downstream of Dusky Gorge) at Leithen Glen and heads east onto a wide floodplain. The river then enters the gorge downstream of Kelso (Figure 3) and flows south (past the township of Tapanui), entering another gorge at Conical Hill before heading east along the base of the Blue Mountains, where it then joins the Clutha River/Mata-Au about 6 km southeast of Clydevale.

In the study reach, the Pomahaka River is joined by four main tributaries: the Heriot Burn, Crookston Burn, Flodden Creek, and Waikoikoi Creek. Land-use in the study area is mainly high intensity dairy farming, with smaller farms and higher stocking rates than in the upper catchment (ORC, 2010).

Figure 6. Upper Pomahaka River catchment (November 2015)

3.3. Meteorological setting

The Pomahaka River catchment is located on the east coast of the South Island, within the Clutha District. Flood events in the Pomahaka River catchment are generally caused by heavy rain over a day or longer, due to persistent southeasterly conditions that can be coupled with snow melt in the spring and early summer (ORC, 2007).

The nearest long-term automatic rain gauges are located at Moa Flat, Piano Flat, and Waikaia. Annual average and peak 24 hour 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 the upper Pomahaka River catchment

Hydrological monitoring site (rain) (date record commences)	Annual average rainfall (mm)	Peak 24 hour rainfall (mm)	Date of peak 24 hr rainfall
Pomahaka at Moa Flat (1988-2015)	838	86	22-23 February 2012
Waikaia River at Piano Flat (1977-2016)	959	103	16-17 January 1980
Wendon Valley at Waikaia (1988-2016)	873	101	20-21 January 2005

3.4. Hydrological setting

Information on river flow is available from two long-term monitoring sites. The Leithen Glen and Burkes Ford recorders have been operating since 1992 and 1961 respectively. The ten largest flows on record for these sites are shown in Figure 7 and Figure 8. The Pomahaka River can rise rapidly during flood events, with a rate of rise greater than 150 m^3 per hour observed. Average velocities observed at these sites range from 2 to 3 m/sec, with velocities likely to be higher in the steeper, more confined sections of the Pomahaka River.

Table 2. Summary of hydrological information for sites within the Pomahaka River catchments

Hydrological monitoring site (river flow) (date record commences)	Maximum observed flow (m^3/sec) (date occurred)	Annual flood (2.3 year return period) (m^3/sec)	Median flow (m^3/sec)
Pomahaka at Leithen Glen (1992-2016)	476 (23 Feb 2012)	166	8.3
Pomahaka at Burkes Ford (1961-2016)	1157 (17 Jan 1980)	292	17.6

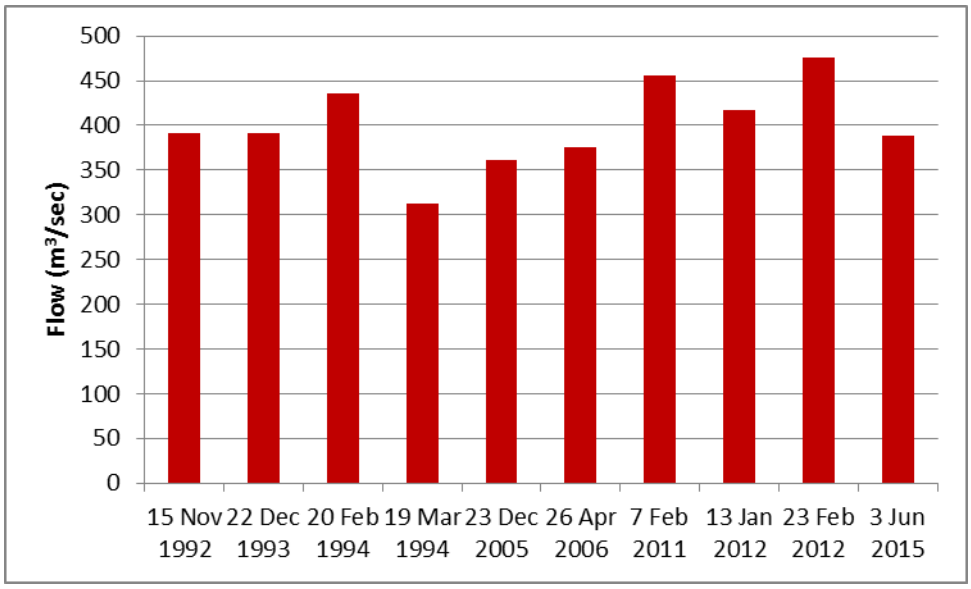

Figure 7. **Ten highest flows in the Pomahaka River at the Leithen Glen recorder, since records began in June 1992**

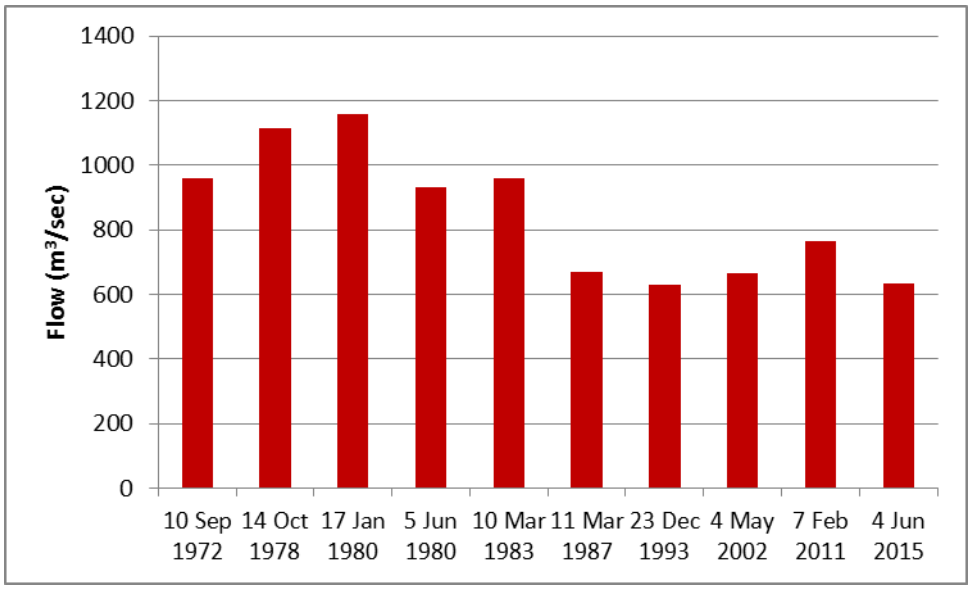

Figure 8. **Ten higest flows in the Pomahaka River at the Burkes Ford recorder, since records began in August 1961**

3.5. Flooding

Changes in the morphology of the Pomahaka River channel are, in part, driven by the hydrological characteristics of the river, including the magnitude and frequency of flood flows. Between 2010 and 2015 there were four flood events in the study area that ranked in the top ten largest flood events at the Leithen Glen flow recorder (Figure 7). The Pomahaka River has experienced large flood events in the past, with the January 1980 event being the largest on record at the Burkes Ford flow recorder (Figure 8) as well as recent events such as June 2015 (Figure 10). The January 1980 event caused significant damage to the township of Kelso where the gorge downstream of the town caused the water to back up and pond in the area for two days (ORC, 1999) (Figure 9). The township of Kelso was located in the lower reaches of the floodplain (upstream of the Kelso Gorge) but was relocated in the early 1980s

due to the effects of numerous floods (ORC, 1999). The mapped flood hazard area for the Pomahaka River, Heriot Burn, and Crookston Burn can be seen in Figure 11. Flooding in the Kelso floodplain reach can be severe due to the Kelso Gorge restricting the escape of floodwaters. Figure 12 shows the mapped flood hazard area for the Pomahaka River and Waikoikoi Creek for the Tapanui floodplain.

Figure 9. **Pomahaka River in flood (17 January 1980), looking downstream above the town of Kelso (location shown in Figure 11)**

Figure 10. **Pomahaka River in flood (4 July 2015), looking upstream from above the Greenvale Road bridge (location shown in Figure 11)**

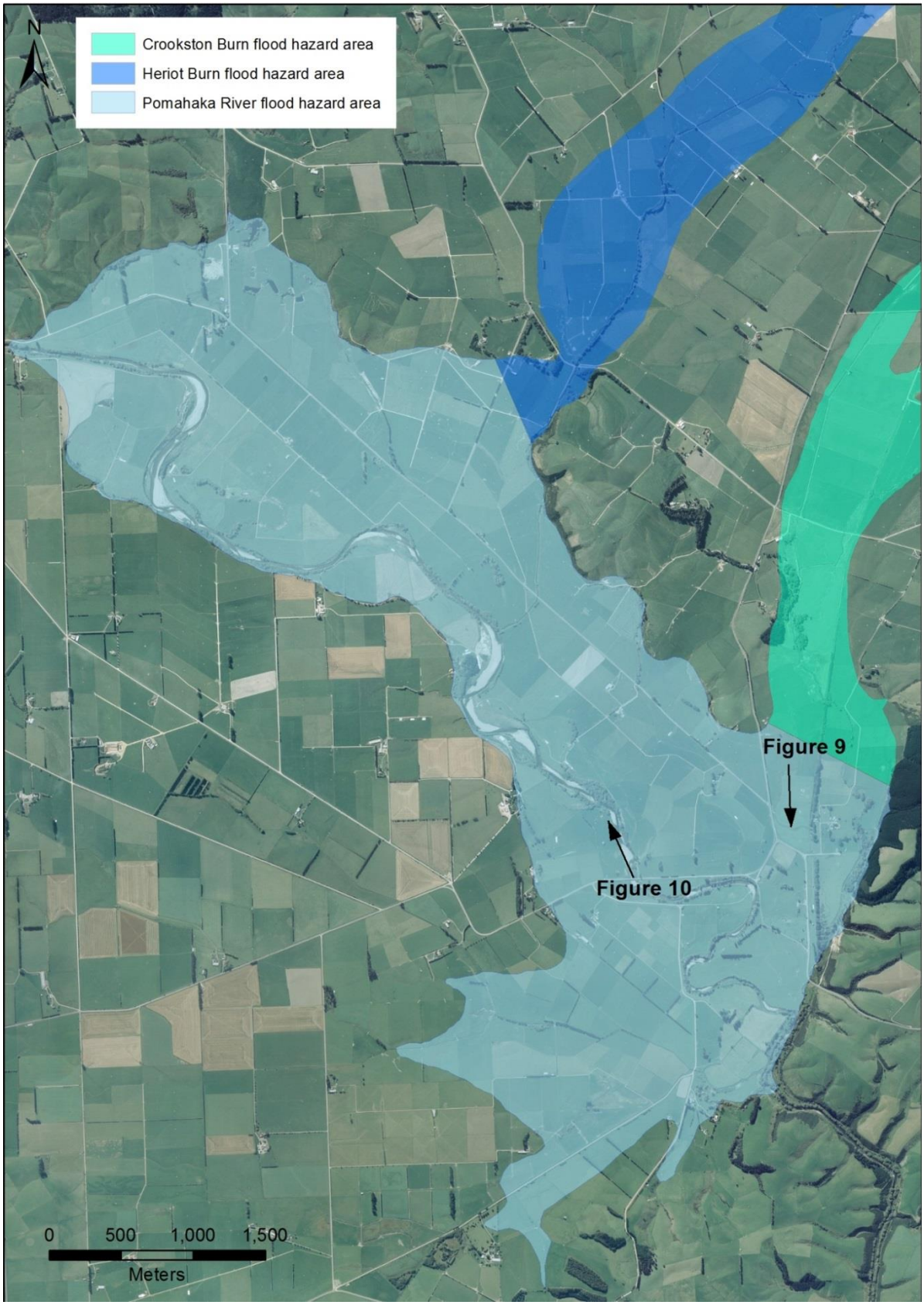

Figure 11. Pomahaka River flood hazard area extent (Kelso floodplain) (ORC, 1999)

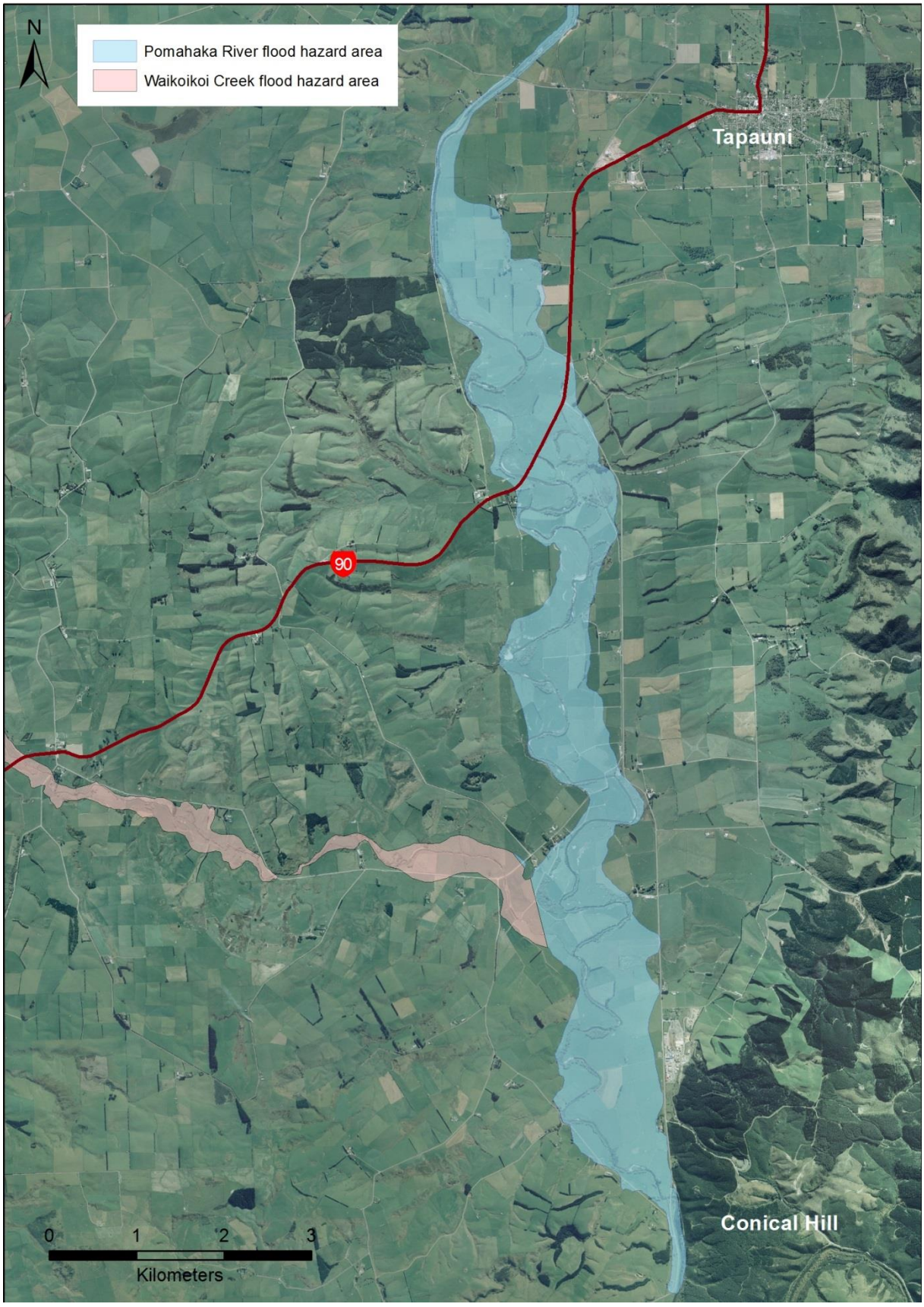

Figure 12. **Pomahaka River flood extent (Tapanui floodplain) (ORC, 1999)**

3.6. Riverbed morphology

The active channel of the Pomahaka River is a dynamic system where flood events and sediment transport regularly cause changes in riverbed morphology. 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 timeframes. Human activities, such as gravel extraction and physical works, can also result in significant morphological change, particularly near these works, but they can 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 analysis. Reports summarising these investigations were published in 2004, 2010, and 2016 (ORC, 2004, 2010, 2016).

Observations of the Pomahaka River in 2015 by ORC staff helped to reinforce the findings of previous investigations, in particular:

- The riverbed changes between stable reaches with riparian planting 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 MBL while other parts have experienced a decrease in recent times (2010 to 2015)
- There are several locations where bank erosion is ongoing that are located outside the ORC cross-section network.

A comparison between aerial photography collected in 1944/1946, 1954, and 2006 further highlights the dynamic nature of the Pomahaka River (Figure 13). In some places the active river channel has changed positions and eroded into farmland, while in other places the channel movement has allowed land to become farmable. More back waters were present in the Pomahaka River in 1944/1946 compared to 2006, as well as larger areas of gravel accumulation (Figure 14, Figure 15).

A comparison of cross-sections dating back to 1988 also highlights the dynamic nature of the riverbed, and shows how the channel moved laterally in some locations and more confined and deeper in other locations (Figure 16, Figure 17).

Figure 13. **Pomahaka River - top 1944/46, bottom 2006**

Figure 14. **Comparison of the Pomahaka River between 1944/1946 and 2006 between Camperdown Bend and the Greenvale Road bridge (aerial photograph collected in 2006)**

Figure 15. **Comparison of the Pomahaka River between 1954 and 2006 below the SH90 bridge (aerial photography collected in 2006)**

Figure 16. Pomahaka River cross-section P51A (looking downstream)

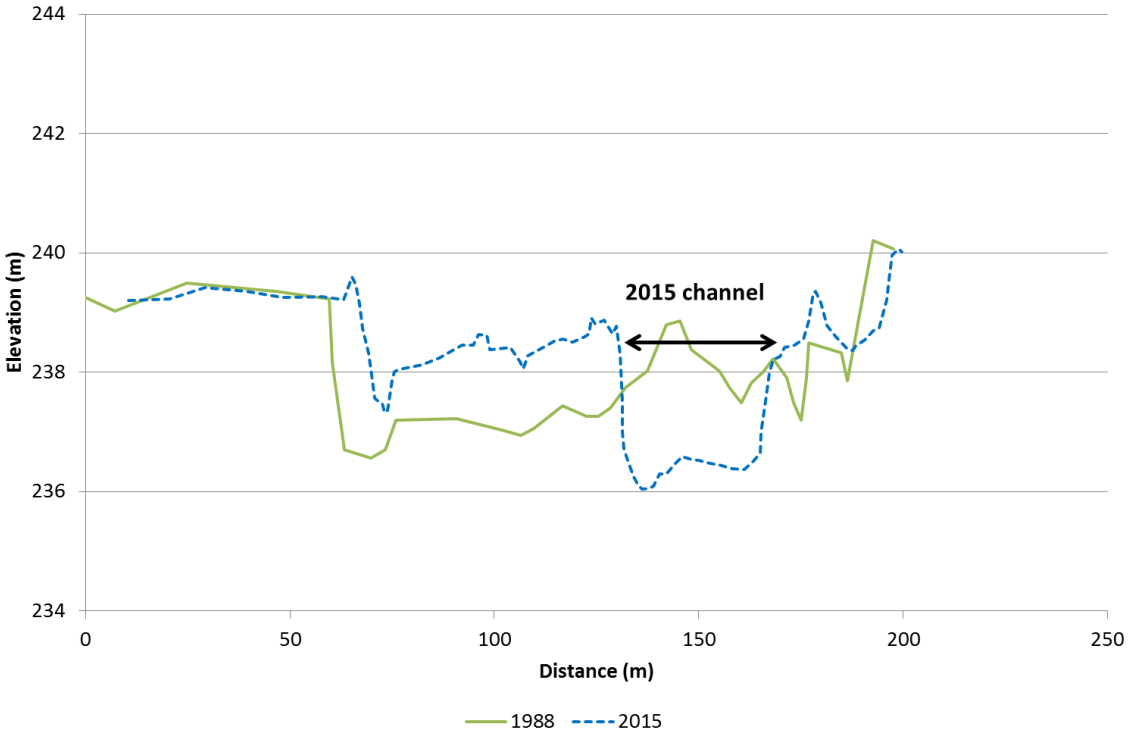

Figure 17. Pomahaka River cross-section P52A (looking downstream)

3.7. 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 Pomahaka River 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 13). This has resulted in a narrowing (or in some cases, complete removal) of the riparian margin that separates the active river fairway from land that is used for farming, or which accommodates community infrastructure. Previous ORC reports have identified that channel widening by bank collapse and erosion are processes that continue to occur in the Pomahaka River (ORC, 2010). 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, thereby protecting against gravity collapse of undercut banks.

Other indirect benefits of riparian plantings include trapping nutrients and fine sediment, shade, shelter and filtering qualities for the aquatic eco-system, as well as 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).

4. Values

Information on the values that the community and stakeholders have for the Pomahaka River was collected through community meetings and collecting feedback (Appendix 4). The Pomahaka River fulfils a number of important roles within the community at a local, district, and regional scale. These roles include (but are not limited to):

- A source of water for irrigation, stock, and people
- A source of gravel for roading and construction purposes
- For recreational purposes, including swimming, kayaking, walking, fishing, hunting, boating, picnicing and camping (e.g. Leithen Glen, Macintosh's Hole picnic area)
- 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.
- Historical sites such as the Kelso flood monument.

The below sections discuss the ecological, community, and Māori cultural values that are held for the Pomahaka River. Limited information was provided/collected on the spatial location of the values discussed and presented by the community and stakeholders. The lack of geographical information on the values discussed in this strategy therefore means all values should be considered whenever activities are planned for the beds and banks of the Pomahaka River at any location.

4.1. Ecological values

Fish

The Pomahaka River provides an important habitat for a range of native and exotic freshwater species. There are ten species of fish (four introduced and six native species) and one species of freshwater crayfish present within the catchment. The introduced species include brown trout (*Salmo trutta*), chinook salmon *(Oncorhynchus tshawytscha)*, rainbow trout *(Oncorhynchus mykiss)*, and perch (*Perca fluviatilis)*. Freshwater mussels (*Hyridella menziesi*) were once abundant in the Pomahaka River but are now uncommon.

Native species include non-migratory galaxiids, common bully (*Gobiomorphus cotidianus*), upland bully (*G. breviceps*), lamprey (*Geotria australis*), longfin eel (*Anguilla dieffenbachii*), shortfin eel (*A. australis*), and crayfish (*Paranephrops sp*.). Longfin eels, lamprey, and galaxiids are threatened species.

Brown trout are the most common species within the catchment.

The Pomahaka River supports a regionally important brown trout fishery. The national angler survey for previous years (Table 3) shows that there has been a decline in the use of the Pomahaka River for angling activities. This may be due to factors such as low flows, riparian management, and poor water quality in tributary streams.

Table 3. **Angler effort in the Pomahaka River catchment (angler days +/- standard error) based on the national angler survey (Unwin, 2009)**

River	Angler usage (angler days +/- SE)		
	1994/1995	2001/2002	2007/2008
Pomahaka	6780 +/- 1210	6000 +/- 1440	3630 +/- 970

Birds

The wider Pomahaka River environment provides habitat for a range of exotic and native bird species that nest or feed in the riverbed and its margins, including mallard, grey duck, paradise shelduck, New Zealand shoveler, pukeko and Canada geese. The threatened mohua is found in relatively high numbers in the Blue Mountains. In addition the Blue Mountains have very good numbers of other native forest birds such as falcon, bellbird, kereru, grey warbler, rifleman, fantail and shining cuckoo.

4.2. Community

To help identify aspects of the wider river environment that is important to the local community, ORC consulted with a wide range of stakeholders in 2016. These included landowners, local iwi, Fish & Game New Zealand, Department of Conservation (DoC), and CDC.

The values that the community and other stakeholder groups identified with the Pomahaka River environment and its form and function are summarised in the box below. Other values that the local community raised included using the river for canoeing as well as having good swimming holes throughout the catchment.

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 management, including planting (both native vegetation and willows) where appropriate.

- The river should support recreational activities such as swimming, fishing, and picnicing
- Regionally important brown trout fishery
- Important habitat for native fish (longfin eel, lamprey, galaxiids)
- The habitat of existing wildlife must be maintained and enhanced
- Access must be able to continue
- 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
- Infrastructure (eg, roads, bridges and water takes) is resilient and able to be quickly reinstated following flood events.

4.3. Māori cultural values

The Pomahaka River is significant to local iwi for mahika kai and other cultural values and is a Statutory Acknowledgement area under the Ngai Tahu Claims Settlement Act 1998 (Schedule 52), providing for the special association of Ngati Mamoe and Ngai Tahu kainga (settlements) in the Catlins and Tautuku areas, with the river. 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 who have gone before and those to follow.

Ngai 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.

4.4. Gravel extraction

The removal of gravel from the riverbed of the Pomahaka River has occurred for many decades, with extracted material generally used for farm laneways, roading, and construction. Gravel extraction typically occurs from locations where sediment accumulates e.g. 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.

Gravel extraction rates have previously exceeded the natural replenishment rates of the Pomahaka River (ORC, 2004). High rates of gravel extraction may have led to bed degradation and bank erosion in some areas of the Pomahaka River (ORC, 2004, 2006). In 2004 the ORC instigated a gravel management plan, which restricted the amount of gravel that was allowed to be removed from the Pomahaka River. In 2006 the ORC reviewed and modified the management plan to allow minor and selective gravel extraction to occur where it can be shown to be a necessary component of erosion risk management in the Pomahaka River. Gravel that is removed from the Pomahaka River system in excess of the natural replenishment rate can lead to issues at downstream locations, such as undermining of river protection works and other assets (e.g. water intakes, bridges, and roads) as well as increased bank erosion and bed degradation.

Gravel extraction within the study reach has been occurring over several decades. Significant commercial extraction occurred during the 1980s and 1990s. Between 1984 and 2004 about 264,000 m^3 of gravel was extracted at an average annual extraction rate of 12,700 m^3 (ORC, 2010). Between 2010 and 2015, 12,206 m^3 of gravel was removed from the Pomahaka River system (based on returns from consented gravel extraction). Currently a total of 2,500 m^3 per year of gravel is consented to be removed from the Pomahaka River, from one extraction location (about 1.5 km upstream of the Greenvale Road bridge) to a given management profile.

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). 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 Pomahaka River are insufficient to maintain the profile of the surveyed reaches. The Pomahaka River is currently experiencing a short-term trend of stability (no large scale aggradation or degradation), however it is still experiencing longterm degradation and ongoing bank erosion.

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 Pomahaka River. 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

ORC will investigate the possibilities, benefits, and legality of a consent held by the ORC to allow for the management of gravel extraction and river management activities in the Pomahaka River (Leithen Glen to Conical Hill). ORC will aim to use the consent to enable landholders to achieve river management objectives i.e. to help mitigate bank erosion/scouring or excessive gravel accumulation.

5. Legislative context

The manner and degree to which the issues in the Pomahaka River 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 Pomahaka River to ORC or CDC. 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 Pomahaka River. 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. 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 Pomahaka River. Any activities in or on the bed and banks of the Pomahaka River 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 that do influence river management activities 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.

6. 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 Pomahaka River, 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 clear and consistent communication between the ORC and other parties
- 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 recognition of the kaitiaki responsibilities of the local iwi.

Principle 2: Plan ahead

Ensure that:

- There is clear and consistent communication between the ORC and other parties
- There is an adaptive approach to river management that will allow for the dynamic nature of the Pomahaka River
- 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:

- There is clear and consistent communication between the ORC and other parties
- Activities are managed in a way that results in:

- A habitat that supports existing wildlife, fish, and suitable plant species
- 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.

7. River form and habitat enhancement

7.1. 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 Pomahaka River between Dusky Forest and Conical Hill (Williams, 2016, 2016). An example is shown in Figure 18, 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 19.

ORC will work towards maintaining the Pomahaka River to the mapped corridor lines in the study reach 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 discussed in Section 4). Maintenance work undertaken in the Pomahaka River (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 Pomahaka River, e.g. Figure 18. 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 Pomahaka River. In these situations the 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.

Figure 18. **Pomahaka River mapped fairway deviating from the current channel alignment (aerial photography collected in 2006)**

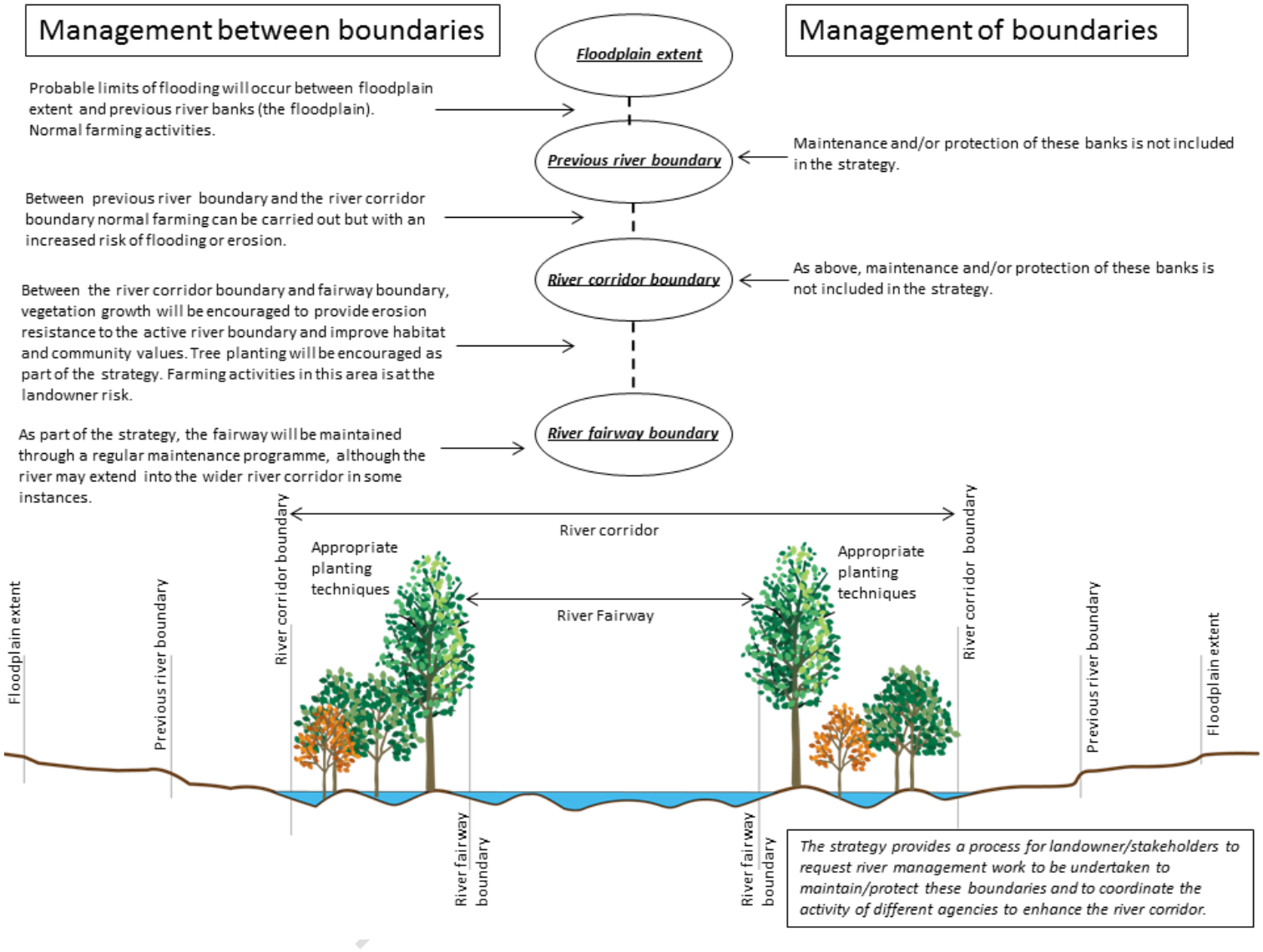

Figure 19. **Policy diagram for management of river boundaries and appropriate land-use on floodplain areas of the Pomahaka River**

7.2. Riparian plantings

As identified in Section 3.7, careful management of riparian margins is key to achieving positive river management outcomes. In addition, one of the key values identified by the community and stakeholders was that they would like to see additional planting and management of riparian plantings included in the strategy as a means of improving the amenity and habitat values of the Pomahaka River, and to help to reduce the effects of erosion (Section 4). The principles identified in Section 6 reflect the importance of sustainable river management and enhancing the natural environment.

Research (Slui, 1991; Phillips & Daly, 2008) shows that to achieve bank protection, the Pomahaka River riparian margins 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, while also 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 Pomahaka River 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 (see Appendix 2).

7.3. 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 6. The tables below highlight the actions that should be undertaken to maintain and enhance the values associated with the Pomahaka River, 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 key actions 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 Pomahaka riverbed, 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 activities for the community, stakeholders, and ORC. It is therefore recommended that people who live, work, or play within the Pomahaka River catchment consider and give effect to the principles, objectives and actions listed in this strategy.

Due to the dynamic nature of the Pomahaka River, 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 Pomahaka River (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	
	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	CDC	Long-term (5-10 years)	Incorporate into future revisions of CDC District Plan
	Identify mechanisms to modify/protect roading assets that consider natural river processes	Roading infrastructure is resilient	CDC	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 2
	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
	Provide information on the Regional Plan: Water permitted activity rules	The community is enabled to complete activities that manage the effects of bank erosion and other river management issues	ORC	Ongoing	Information on permitted activities to be provided to the community at any opportunity
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 Pomahaka River is 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 2016 and 2019 included in Appendix 1
	Physical works by landowners and other agencies to address river management issues	The Pomahaka River is 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 information discussing the 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	Values discussed in Section 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. Enable sustainable gravel extraction for river management benefits					
	ORC will investigate the possibilities, benefits and legal ramifications of holding a consent to extract gravel	Gravel extraction is completed in a sustainable manner	ORC	Feb 2017 (to inform the 2017/18 draft Annual Plan)	
3.2. Identify areas where gravel extraction may affect community values					
	Provide information discussing the importance of community/stakeholder values	Extraction is undertaken in a manner that does not compromise features of the location that are of high value to the community	ORC and the community	Completed	Values discussed in Section 4. These may be modified or adjusted as part of future reviews of this strategy

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	Values discussed in Section 4. These may be modified or adjusted as part of future reviews of this strategy
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 2
4.3. Provide access for fishing activities and habitat for fish					
	Planting work that facilitates fishing activities and enhances fish habitat	The Pomahaka River supports a regionally important sports fishery, and important populations of native fish (including threatened and endangered 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 Pomahaka River supports a regionally important sports fishery, and important populations of native fish (including threatened and endangered species)	ORC, extractors and landholders	Ongoing	See Objective 3 also

	Encourage the creation of additional public access points	River-access opportunities are increased	ORC, CDC, landowners	Ongoing	Covered in CDC District Plan (Rule FIN.8)
4.4. Adequate pest and weed control activities					
	Landowners (including LINZ) and other stakeholders work collaboratively to manage pest species	The Pomahaka River fairway and riparian margin are relatively free of pest species	Landowners, stakeholders, ORC	Ongoing	
4.5. Discourage dumping, and arrange the regular collection of rubbish					
	Collection of rubbish through regular/routine work at key locations (Leithen Glen). Signs warning of penalties for rubbish dumping to be erected if issues persist.	Improved visual amenity and enjoyment of recreational areas	CDC	Ongoing	
4.6. Protect and enhance the natural character of the Pomahaka River					
	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& support from other agencies	Ongoing	

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

Five locations within the mapped 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. These locations are shown on Figure 20 and Figure 21. These priority locations have been determined using the latest information available (November 2015) about specific locations that are experiencing river management issues. ORC intends commencing work at these locations during the 2016/2017 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 2018/2019). Ongoing maintenance may also be required at some of these locations into the future.

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 Pomahaka River will need to consider the following:

- The principles outlined in Section 6
- The location and width of the natural river corridor and active fairway as described in Section 7, and other natural river processes as described in the strategy
- The objectives and associated activities listed in Section 7.3. 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 that are of high value to the community)
- The ecological, community and Māori values discussed in Section 4.

The increased program of work in the Pomahaka River by ORC will result in increased costs for the Clutha Special Rating District (SRD). Revenue from rates within the SRD is projected to increase from $265,000 in 2016/17 to $310,000 in 2019/20, in order to fund additional in-stream work required to meet community river management expectations.

The anticipated budget for river management operations (physical works) in the Clutha SRD until 2019/20 is shown in Table 5 below. This shows that $230,000 is budgeted for this work during the 2016/17 year, up from $167,000 in 2014/15. This budget is not solely for the Pomahaka River and includes other rivers in the Clutha District.

The dynamic nature of the Pomahaka River and the inability to predict the timing or consequences of future flood events in the Clutha District means there is a risk that this additional funding for river management work may still be insufficient. As noted above, all ratepayers within the Clutha District contribute towards the Clutha SRD.

Table 5. ORC river management budget for the Clutha District

Year	ORC river management (operation) budget
2014/15	$167,000
2015/16	$218,000
2016/17	$230,000
2017/18	$229,000
2018/19	$235,000
2019/2020	$241,000

Planned river maintenance work – Pomahaka River

A. Work at this location will involve moving gravel to maintain the active channel fairway, and planting to limit bank erosion (Figure 20).

B. Work at this location will involve moving gravel to maintain the active channel fairway, and planting to limit bank erosion (Figure 20).

C. Work at this location will involve moving gravel to maintain the active channel fairway, with the potential to create a new secondary channel (Figure 20).

D. Work at this location would involve channel reshaping to maintain the active channel fairway and planting to limit ongoing bank erosion. Due to the scale of work required at this location it will likely be an ongoing process over several years (Figure 20).

E. Work at this location would involve channel reshaping and moving the channel to maintain the active fairway and planting to limit ongoing bank erosion. Due to the scale of work required at this location it will likely be an ongoing process over several years Figure 21).

Camperdown Bend is an area that has experienced river management issues in the past and is likely to experience issues into the future. The ORC does not currently have a plan to deal with this location due to budget constraints and the size of the issue, however ORC is aware of the location and will continue to monitor it into the future.

Figure 20. **Priority locations for operations work - 1**

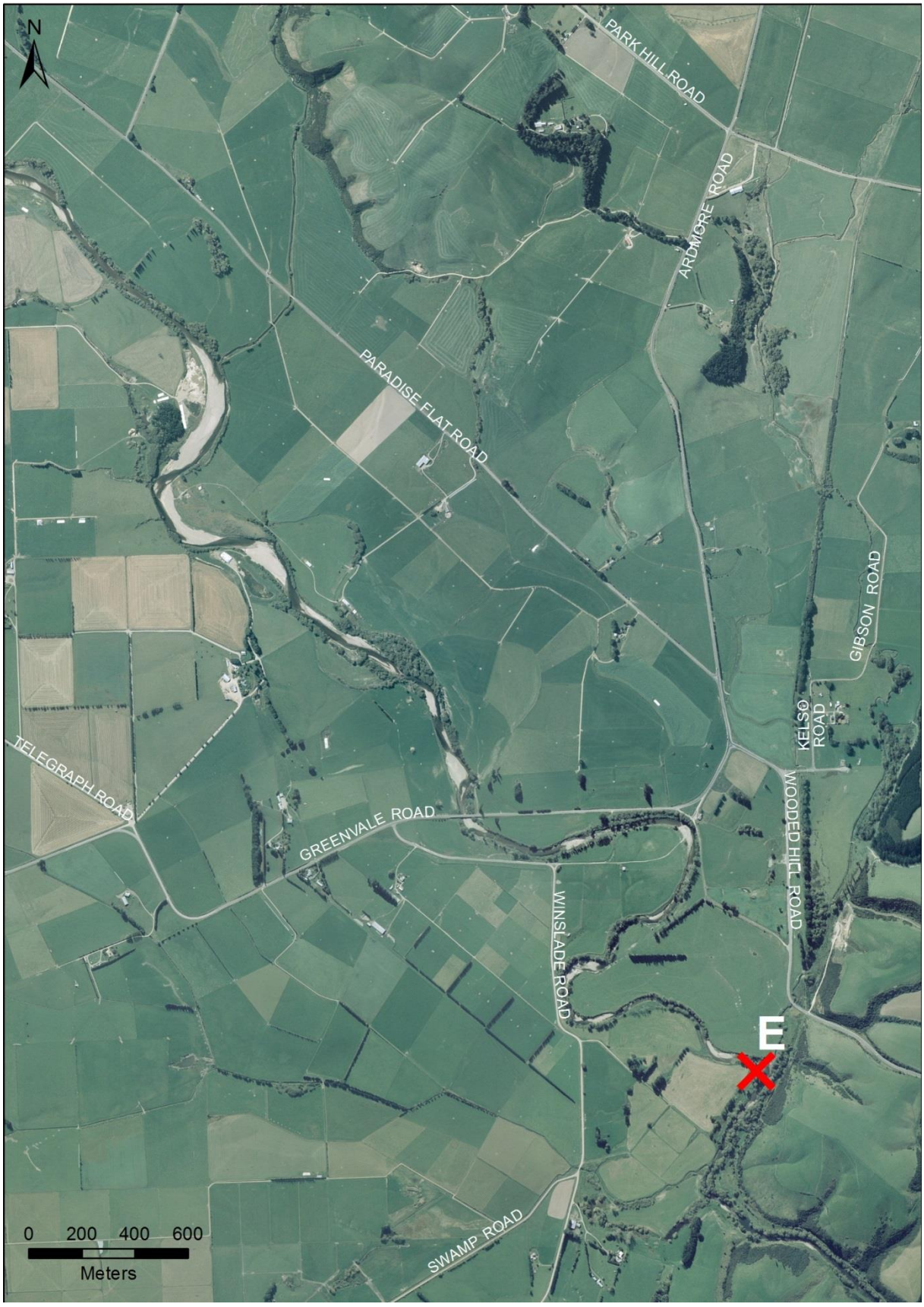

Figure 21. **Priority locations for operations work - 2**

Appendix 2. Planting guide

Benefits of riparian planting[6]

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 from riparian strips by fences
- Increasing biodiversity – aquatic life, native plants, birds and insects
- Improving recreational opportunities (e.g. fishing)
- Enhancing and beautifying the river margins.

Both native and exotic species can be suitable for riparian planting. The species to be used will depend upon many factors, including environmental factors (exposure, soils, etc.) but also the width of the riparian strip, the height of plantings that is desired, and personal preference.

Using trees to stabilise stream banks[7]

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.

[6] Adapted from KCCP planting guide (2015)

[7] Adapted from ORC (2005)

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, standing 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.

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[8]

There are many advantages of utilising native plants. These include:

- Enhancing natural character and landscape values
- Forming a habitat corridor and potentially ecological linkage in the catchment
- Restoration of rare riparian forest (and other habitats)
- Creating/enhancing habitat for native birds and invertebrates (including pollinators)

[8] Information on native planting and previous Pomahaka River catchment vegetation provided curtesy of DoC

- Restoration or enhancement of threatened plant habitats
- Do not grow as high or require maintenance (e.g. pruning or thinning)
- Self-regenerating and maintaining.

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.

Tables 6 through 9 list suitable native vegetation to plant in the Pomahaka catchment, including trees, shrubs, tussock, and rare species.

Original Pomahaka catchment vegetation cover

The vegetation that originally occurred at a site is a reflection of a range of site conditions, particularly climate, soils, and flood regime, however historical events may also affect plant distribution.

The upper catchment of the Pomahaka River (i.e. above Leithen Glen but also in the hill country immediately below Kelso) is believed to have been dominated by beech forest. Silver beech was, and remains, the most common species; however red beech and mountain beech were also present.

The alluvial flats between Leithen Glen and Kelso, and between the junction of the Flodden Burn and Conical Hill, would probably have been dominated by podocarp forest, predominantly kahikatea, totara and matai, with pokaka and other species. However the riparian fringe of the river would likely have contained a ribbonwood – kowhai forest. Both of these forest types are now rare, with few examples remaining on the alluvial flats.

Table 6. Suitable native species for the Pomahaka catchment (trees)

Common name	Scientific name	Mix of plants[9]
Black mapou/kohuhu	Pittosporum tenuifolium	major
Lemonwood	Pittosporum eugenoides	major
Lowland ribbonwood	Plagianthus regius	major
Narrow-leaved lacebark	Hoheria angustifolia	major
South island kowhai	Sophora microphylla	major
Cabbage tree	Cordyline australis	major
Broadleaf	Griselinia littoralis	moderate
Marbleleaf	Carpodetus serratus	moderate
Manuka	Leptospermum scoparium	moderate
Chatham Island akeake	Olearia traversii	moderate
hybrid olearia	Olearia x dartonii	moderate
Silver beech	Lophozonia (Nothofagus) menziesii	major
Red beech	Fuscospora (Nothofagus) fusca	moderate
Mountain beech	Fuscospora (Nothofagus) cliffortioides	moderate
Kahikatea	Dacrycarpus dacrydioides	minor
Mountain totara	Podocarpus hallii	minor
Matai	Prumnopitys taxifolia	minor

[9] The major, moderate or minor is intended to direct the numbers/mix of plants used in a riparian/restoration planting. Therefore the bulk of the plants would compose the 'major' species, with some of the 'moderate' species and only a few of the 'minor' species. The species mix may be in the order of 10 of a 'major' species to 5 of a 'moderate' species to 1 of a 'minor' species.

Table 7. Suitable native species for the Pomahaka catchment (shrubs)

Common name	Scientific name	Mix of shrubs
Mingimingi	Coprosma propinqua	major
A coprosma	Coprosma dumosa/tayloriae	moderate
A coprosma	Coprosma rigida	moderate
Koromiko	Hebe salicifolia	major
Cottonwood	Ozothamnus vauvilliersii	moderate
Weeping mapu	Myrsine divaricata	minor

Table 8. Suitable native species for the Pomahaka catchment (tussock and tussock-like plants)

Common name	Scientific name	Mix of tussock and tussock like plants
Ballerina sedge	Carex secta	major
Toetoe	Austrodieria (Cortadieria) richardii	major
Lowland flax	Phormium tenax	major
Red tussock	Chionochloa rubra ssp. cuprea	moderate

Table 9. Suitable native species for the Pomahaka catchment (rare species)

Common name	Scientific name	Status
Pomahaka tree daisy	Olearia fimbriata	Nationally vulnerable
Hector's tree daisy	Olearia hectorii	Nationally endangered
Linear-leaved tree daisy	Olearia lineata	At risk: declining
Fragrant tree daisy	Olearia fragrantissima	At risk: declining
Bloodwood	Coprosma wallii	At risk: declining
Teucridium	Teucridium parvifolium	At risk: declining

General planting tips

- The wider the riparian strip that is created and planted, a wider range of benefits will be achieved.
- Riparian strips can be of variable width dependent upon site factors such as access for machinery, height above the river (and flood levels), topography, and soils. An example being that wet areas or depressions behind a river bank or levee should be included, as sediments and nutrients may leak into the river.
- Habitat strips/wildlife corridors need to be wider than 5 m (ideally at least 8 m) in order to incorporate the equivalent of three rows of plantings.
- Plantings can be either in rows or randomly scattered to give a more natural appearance. The scattering of plants and natural appearance is more important for restoration plantings and Habitat strips/wildlife corridors.
- Closer plant spacing will provide greater mutual shelter, and so achieve faster growth, however will require more plants and therefore greater cost. They may also require some thinning later. This balance needs to be considered.
- When planting natives for bank stabilisation, plant at 1.5 – 3 metres spacing.
- Additional advice on your site may be available from ORC, DoC, local nurseries, websites and publications.

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 7.1.

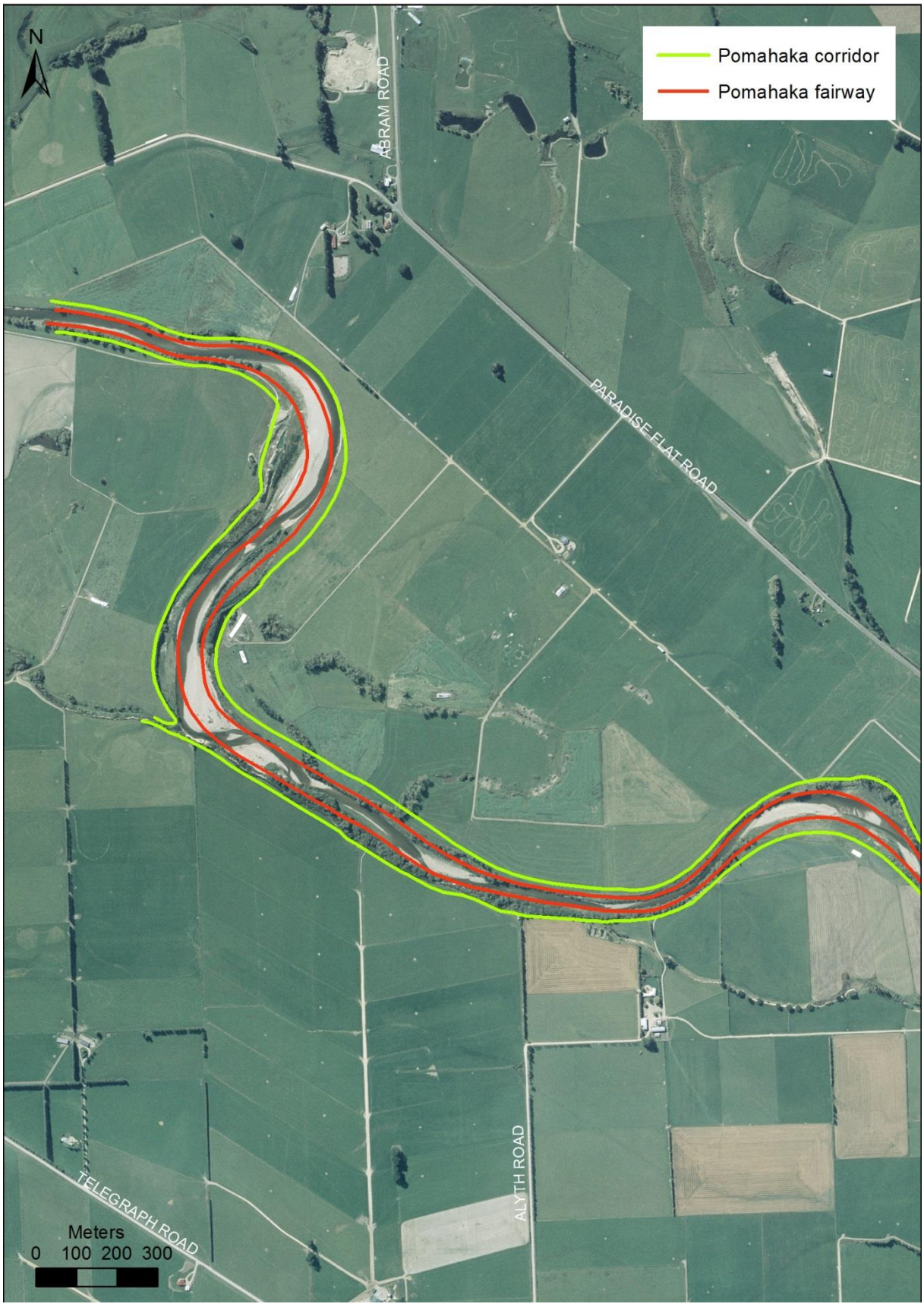

Figure 22. **Pomahaka River fairway and corridor Map 1 (aerial photography collected in 2006)**

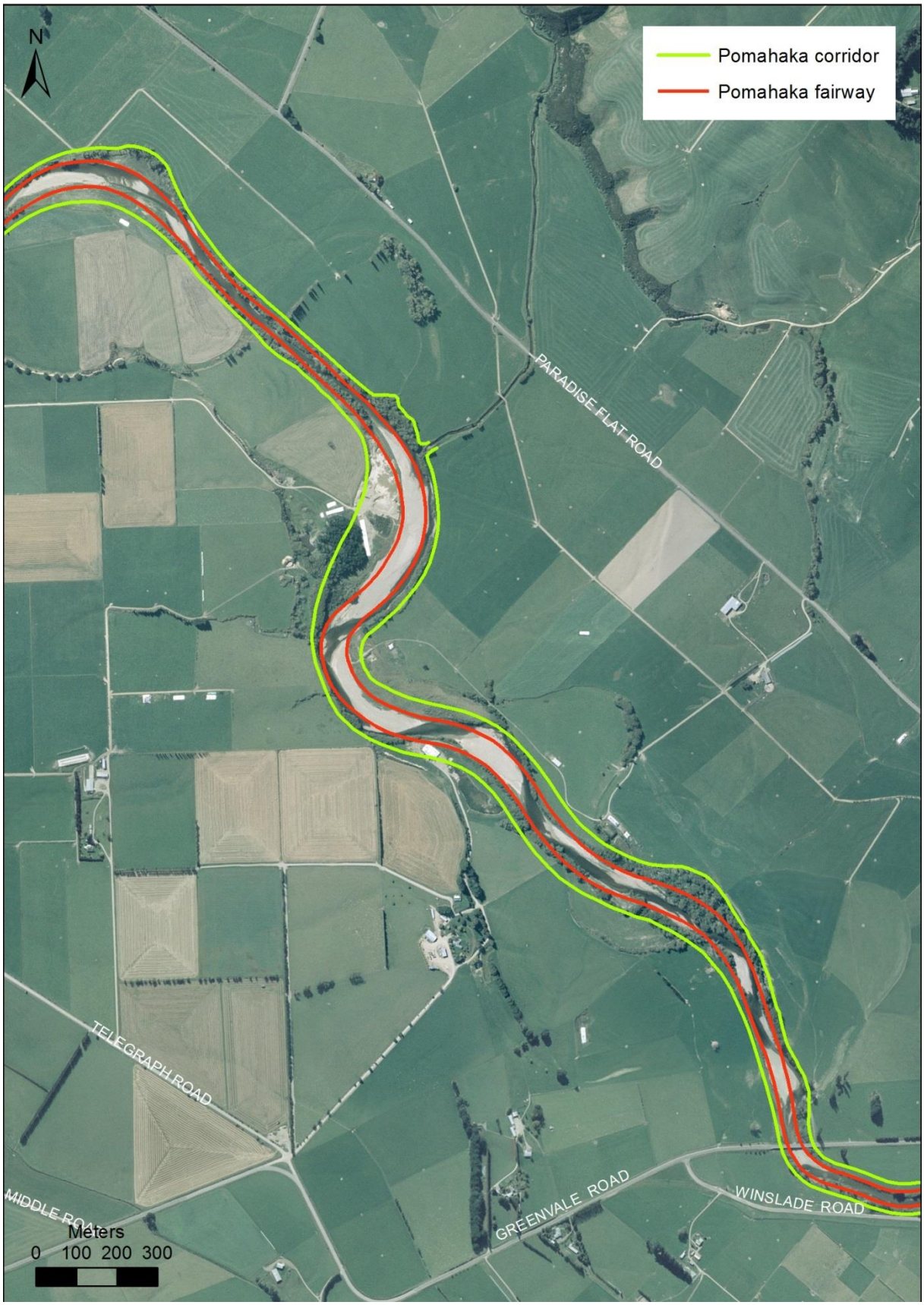

Figure 23. **Pomahaka River fairway and corridor Map 2 (aerial photography collected in 2006)**

Figure 24. **Pomahaka River fairway and corridor Map 3 (aerial photography collected in 2006)**

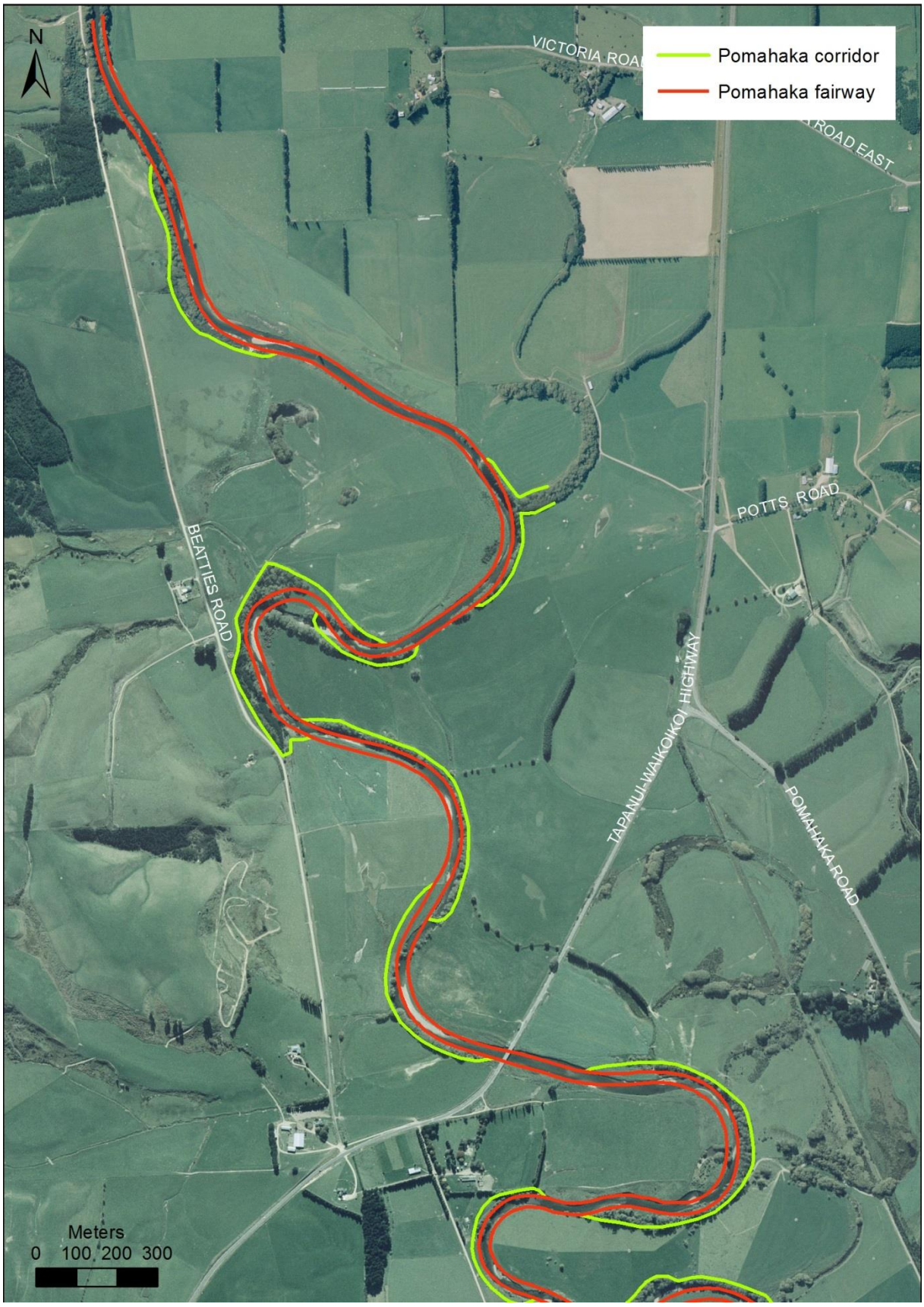

Figure 25. **Pomahaka River fairway and corridor Map 4 (aerial photography collected in 2006)**

Figure 26. **Pomahaka River fairway and corridor Map 5 (aerial photography collected in 2006)**

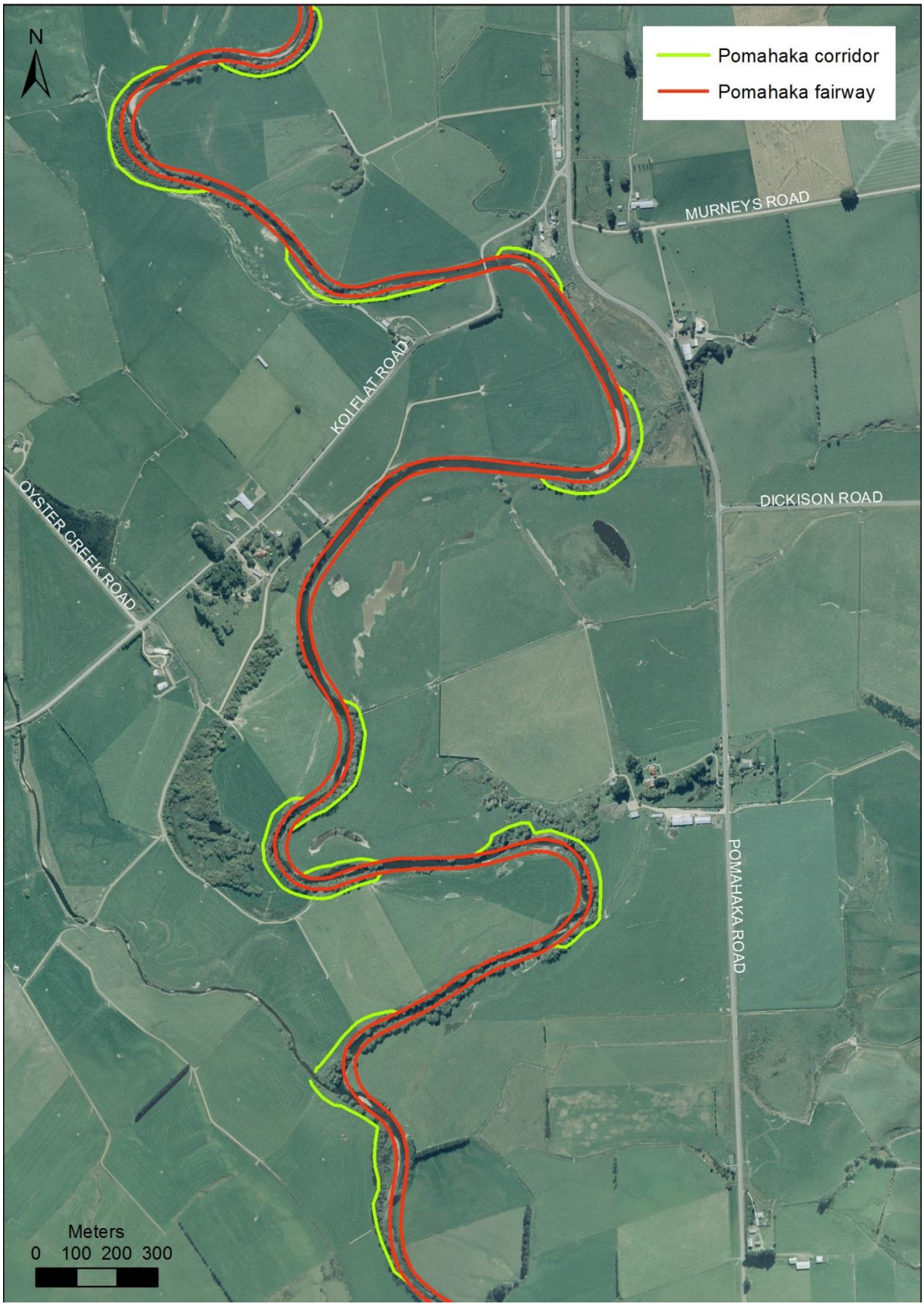

Figure 27. **Pomahaka River fairway and corridor Map 6 (aerial photography collected in 2006)**

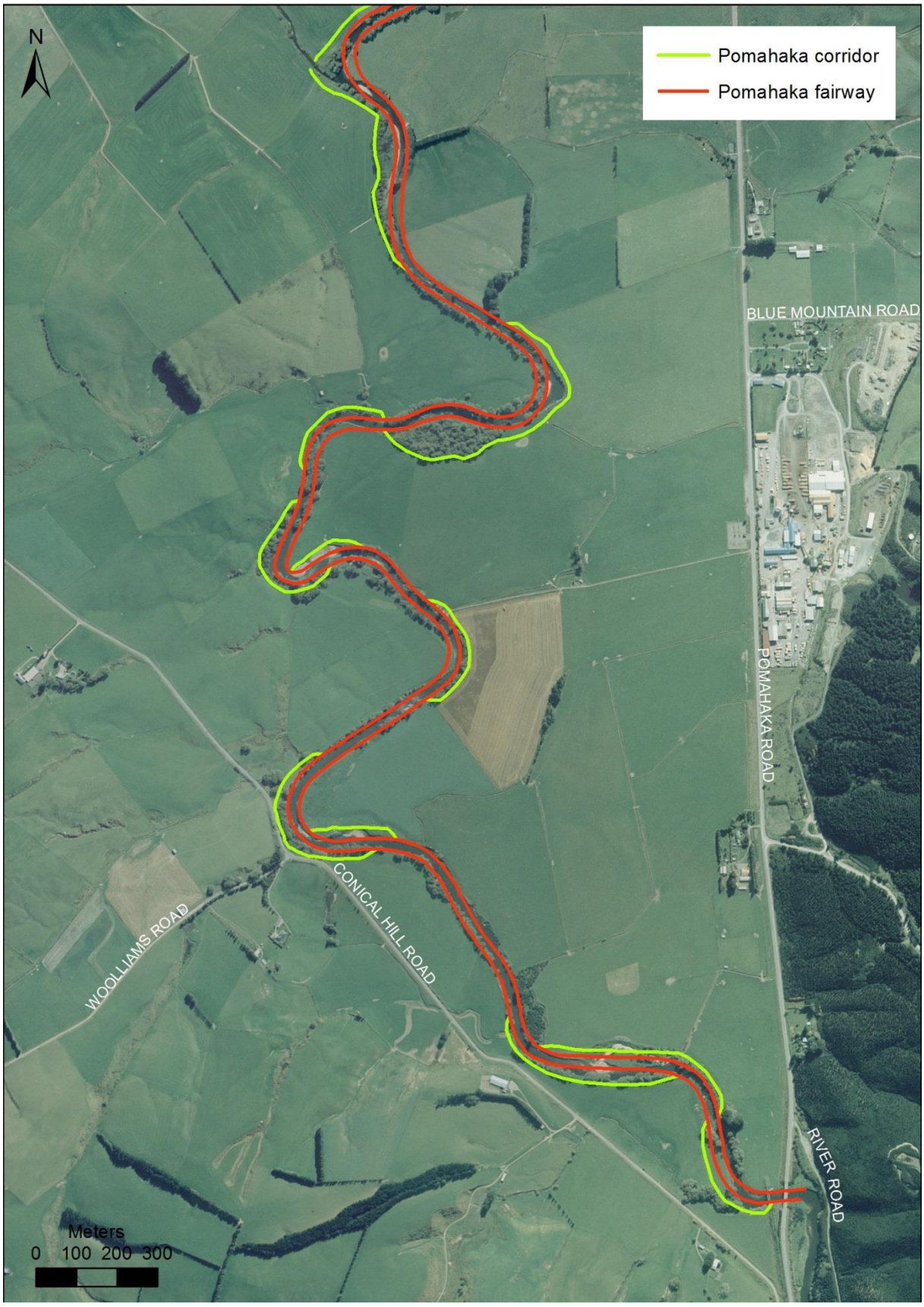

Figure 28. **Pomahaka River fairway and corridor Map 7 (aerial photography collected in 2006)**

Appendix 4. Community consultations - public submissions

The community consultation undertaken from March to April 2016 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 range of views and concerns were put forward: some people were concerned about riparian vegetation maintenance, gravel build up and bank erosion, while other parties were concerned about habitat enhancement, ongoing public access and clarity around the Regional Plan, Water permitted activity rules. An ongoing topic raised at the public meetings was with regard to the difficulty and cost associated with obtaining resource consent to extract gravel. The community also discussed the importance of being able to protect their own land. Limited submissions were received by the ORC on the proposed strategy, with all submitters supporting the values gathered by the ORC and the direction and process that the ORC is taking with the strategy.

Appendix 5. Reference list

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