Living Manuherekia
Willow Management Strategy

Ministry for the Environment

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Executive summary

The Manuherekia Catchment is one of the Ministry for the Environment selected exemplar catchments – these are priority catchments across New Zealand in need of support to address a decline in environmental quality and the consequences for the environmental, cultural, social, and economic wellbeing of the associated communities.

As part of the exemplar catchment project, an Integrated Catchment Enhancement Plan (ICEP) action plan was developed for the catchment. The ICEP was developed based on a stocktake of information and community engagement to identify a vision and aspirations for the catchment. These are supported by actions that will have effect on the ground, including 'quick win' projects to galvanise effort and kickstart the process.

Seventeen actions have been identified and prioritised in the ICEP. The development of a willow management strategy was identified as a quick win priority project based on the following benefits that relate to several of the aspirations:

- It was a priority for almost all stakeholders consulted.
- Increased flow - volume.
- Improved flow - reduced obstruction in streams.
- Improved access to and visual connection with the river.
- Improved recreational/amenity value.
- Improved biodiversity - wetland restoration and where willows are replaced with native riparian species.
- Several sub catchment groups have identified specific areas to target removal.

Further consultation was carried out to understand perspectives on willow management as part of this project – this highlighted the variety of objectives associated with willow control work – including enhancing habitat for freshwater species, improving water quality, improving landscape values and amenity, as well as improving instream flows (refer to Section 7).

This strategy has been developed to give effect to these aspirations/objectives. After identifying areas where willow control would support one or more of these aspirations/objectives, we used a matrix analysis to help prioritise these areas, by assessing which aspirations would be addressed and to what degree. This resulted in the following management areas being identified for willow control work - in order of priority based on the matrix analysis (used in Section 8):

- Thomsons Creek (upstream of Mawhinney Road)
- Poolburn Gorge
- Alexandra willow jungle
- Omakau willow jungle
- Dunstan Creek
- Lauder Creek
- Chatto and Young Hill Creeks
- Ida Valley lowlands
- Above Falls Dam and headwaters arising in Hawkdun Range (down to SH85)

- Little Valley
- Manorburn
- Ida Valley wetlands
- Significant wetlands
- Manuherekia River main stem
- Home Hills
- Dip Creek
- Rough Ridge headwaters.

These areas are shown in the map below.

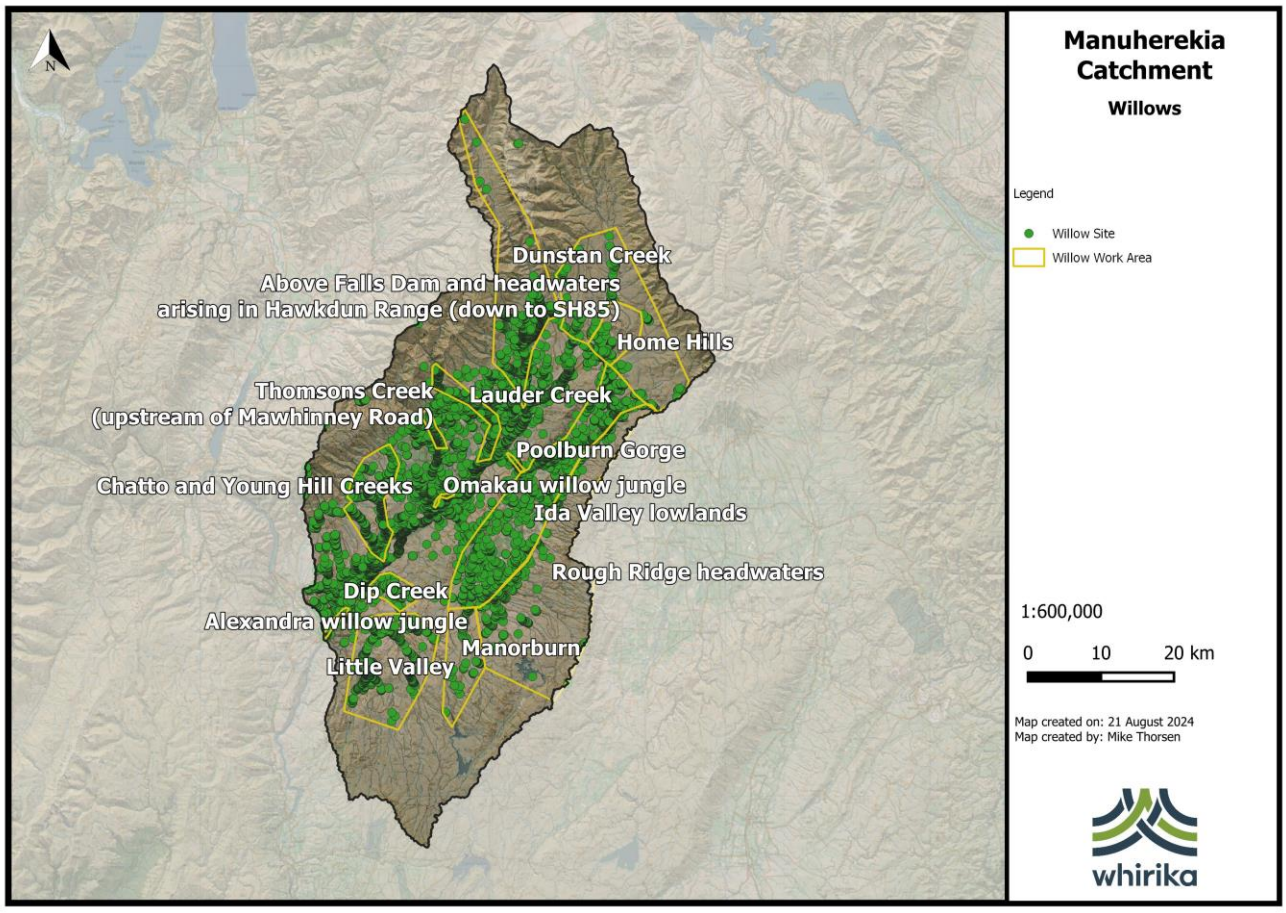

Figure A: Location of willow work areas listed identified as a priority. Manuherekia main stem work area not mapped for clarity. Significant wetland work areas are mapped separately (refer to Figure 7).

It is important to note that this strategy has been developed at a catchment scale, which means that site specific assessments have not been carried out – practical considerations such as land owner consent or site access will need to considered, and may impact feasibility and selection of sites. The relationship between willows and flood management is addressed only at a high level, based on existing information held by the Otago Regional Council (ORC) – no flood modelling or assessment has been carried out as part of this project. Site specific factors, flood risks and the relative importance of an aspiration may result in divergence from the prioritisation of sites identified in the matrix.

Willows are managed by a variety of agencies, depending on the status and ownership of the land (e.g., road reserve, marginal strip or privately owned) and the nature of the issue being addressed. An overview of the roles played by various agencies is provided in Section 3. One of the main reasons for willow control work (including planting) by councils and other government agencies is to address flooding and erosion. In practice the ORC has primary responsibility for willow management for flood management purposes, and its river engineers should be contacted to discuss any proposed willow control work to ensure any work does exacerbate flood risks.

The issues and benefits of willows in riparian areas are addressed in Section 4. There is evidence to suggest that willows are high-water use species and may have noticeable impact on instream flows, particularly where they are instream, within a wetland or along the water's edge.

Removing willows, even though it is removing exotic invasive and unwanted plants, may result in some adverse effects to the riparian zone and/or in-stream habitat in the short-term e.g., other weeds may invade and dominate. Depending on the objective of willow removal, it may be appropriate to plan for site restoration (such as native planting) while in other cases staged and/or selective willow removal may be appropriate e.g., this may be an appropriate method for transition/restoration of native vegetation as it would incur less ecological disruption and would promote native understorey if present. (Refer to Section 5.5).

If multiple sites are identified for willow removal on LINZ and DOC managed land, it will be necessary to obtain a community agreement from DOC and/or an access letter from LINZ (refer to Section 3.5 to 3.7). If other nearby catchment groups are also engaged in willow removal work, draw on their experience with these agencies, or consider working jointly to obtain these approvals.

The method of willow removal requires a site-specific assessment to minimise any potential adverse effects of removal. It also depends on access to the site, the size/age of the willows and the size of the infestation, as well as any landowner preferences. It is important to talk to ORC river engineers and to get an experienced contractor on site to understand how willows should be removed. Section 5 outlines options for willow removal.

Willow control work which will result in the disturbance of the bed of a waterway, or which will result in a noticeable increase in local sedimentation in the waterway will require consent from the ORC (refer to Section 6). This means that mechanical removal away from the bank of a waterway and spraying of willows are often permitted activities. Rules around willow removal may change as a result of the Land and Water Regional Plan, so it is important to check this with the ORC.

Contents

1 Introduction

The Ministry for the Environment (MfE) has identified priority catchments across New Zealand in need of support in addressing a decline in environmental quality and the consequences for the environmental, cultural, social, and economic wellbeing of the associated communities. The Manuherekia Catchment, located in Central Otago, is one of the selected exemplar catchments.

A cornerstone of the exemplar catchment model approach is that it is located outside of the regulatory framework and is driven by the people who live, work, and play in these catchments. The approach aims to empower communities and give effect to their very real interest in the improved and sustained health of these catchments.

As part of the exemplar catchment project, MfE initiated and funded the development of an Integrated Catchment Enhancement Plan (ICEP) action plan for the Manuherekia catchment. The ICEP action plan has been developed on the basis that the Manuherekia Catchment Group (MCG) will take responsibility for hosting and implementing the ICEP (although this had not been confirmed at the time it was written). MCG has approximately 700 members from throughout the catchment.

The ICEP was developed based on a stocktake of information and community engagement to identify a vision and aspirations for the catchment. These are supported by actions that will give on the ground effect, including 'quick win' projects, to galvanise effort and kickstart the process.

Crack willow (Salix x fragilis) is noted as a significant invasive species within the catchment. In addition to this species there are other problematic exotic tree species that occupy similar areas and can also be problematic. This includes other willow species (golden willow, bitter willow, osier, grey), alder, and grey and necklace poplar. These species have been included in this plan, but their relative abundance in the Manuherekia Catchment is not known and they have not been specifically mapped. From visual observations it appears that golden and crack willow are the most common species in the Manuherekia Catchment.

Aspirations identified in the ICEP are shown below (excerpts only, except where aspirations are particularly relevant to willow management):

- Local history is appreciated and protected.
- Abundant native biodiversity - Manuherekia is alive with the sounds of nature. We see, smell and hear an increased diversity of native flora and fauna, including birds, insects, fish, frogs and reptiles (skinks and lizards). Our diverse native habitat, including riparian and biodiversity corridors, supports and enriches our native flora and fauna. We actively manage our plant and animal pests. The natural ecosystem is treasured and protected, and all native living things are thriving and respected.
- Preserving our natural landscape - The rugged beauty of our natural landscape is treasured and protected. The rugged beauty of our natural landscape is treasured and protected. Our rivers,

streams, rocks, craggy hills and mountain ranges are interspersed with tors, shrublands, tussock grasslands and dryland forests. The landscape's spectacular beauty is enhanced by the climate and seasonality; hot and dry in summer, cold and frosty with snow covered ranges in winter. Development and growth occur in appropriate areas, and we take care to retain our wide-open spaces. The air is fresh and clean. Stars are visible in a big night sky free from light pollution. We value the peace, natural silence and seclusion. We feel a sense of belonging in our landscape.

- Exploring our environment - Our unique landscape is our backyard playground. The water, rocks, snow, bush and trails are easily accessible for all recreational activities.
- Farming is part of our future.
- Vibrant and thriving local economy.
- Sense of community - everyone has a friend nearby.
- The river is there for everyone.
- Walking together.

Seventeen actions have been identified and prioritised in the ICEP. The development of a willow management strategy was identified as a quick win priority project based on the following benefits that relate to several of the aspirations:

- It was a priority for almost all stakeholders consulted.
- Increased flow - volume.
- Improved flow - reduced obstruction in streams.
- Improved access to and visual connection with the river.
- Improved recreational/amenity value.
- Improved biodiversity - wetland restoration and where willows are replaced with native riparian species.
- Several sub catchment groups have identified specific areas to target removal.
- There are no barriers to commencing with several sub aspects of the action – notably mapping, which is the first and fundamental step to developing a strategy and Action Plan for willow management across the catchment.

This strategy has been developed to give effect to this as a priority project identified in the ICEP.

2 Willows – in Aotearoa and the Manuherekia

Willows are a large genus (*Salix*) of woody plants, comprising some 400 – 500 species with natural distribution in the northern hemisphere. Willows exhibit many different forms, ranging from large trees to dwarf shrubs, and inhabit a wide range of habitats, including high-disturbance habitats such as

mountain screes, arctic regions and floodplains. Willows are deciduous and dioecious (i.e. there are male and female plants).

Willows have an immense capability for interspecific crossing, largely due to flexible pollination by insects as well as long-distance dispersal of airborne seeds (Marinček et al., 2023; Vašut et al., 2024). Hybridization can boost genetic variance and consequently hybrids might be capable of inhabiting different ecological niches than their parental species.

Crack (*Salix* x *fragilis,* a hybrid of *S. alba* and *S. euxina*), golden willow (*Salix alba* var. *vitellina*) and grey (pussy) willow (*S. cinerea*) are the three most commonly used species for riverbank protection in New Zealand, and as a consequence are the most widespread willows in New Zealand. Willows were introduced to Aotearoa/New Zealand in the 1800s with early European settlement, primarily for planting of wet areas for soil reclamation. They are well adapted to the New Zealand climate and found both in wetter areas around rivers stabilising riverbanks as well as in drier soils, and they counter steep land soil erosion. Observations by community members indicates that willows were planted in the Manuherekia in the 1900s and have spread throughout the catchment in the last 50 or so years.

The distribution of willow species within the Manuherekia catchment is not known, but from informal surveys as part of this project, most willow along rivers and streams appears to be crack willow, with weeping willow and tortured willow present in some areas near farm ponds as a result of deliberate plantings. A small grove of what appears to be osier (*Salix viminalis*) is being used to stabilise a road bank near Lauder. This lower-growing species is known to colonise river gravels in the Hawke's Bay, and so may pose a similar risk here. A small, but actively spreading, grove of willow-like grey poplar (*Populus* x*canescens*) is present near Chatto where it appears to be spreading along a bank. Necklace poplar (*Populus deltoides*) is actively seeding into gravel flats of the Manuherekia River near Becks, something this species is prone to doing. Golden willow appears to be rare in this catchment, but is becoming increasingly common around Queenstown.

It may be that only male plants of crack willow are present in Aotearoa/New Zealand, and these are likely to belong to a single clone, although crack willow has frequently been crossed with other willow species (Webb et al., 1988). Though sexually infertile, crack willow spreads via transport (by water or by storm winds) of the brittle and easily broken shoots that are extremely easily grown on almost any substrates. It is likely that most willows spread in this fashion, but the fragile branches of *Salix euxina* make crack willow particularly problematic. Grey willow, on the contrary, has freely seeding populations in New Zealand, and has been spreading both via wind-borne seeds and broken shoots.

Attributes such as the ease of propagation, hybridisation and adaptation to a wide range of environments especially where disturbance is high and/or frequent (e.g. braided river beds) has enabled willows (crack and grey willows) to spread quickly and extensively in New Zealand, and less than 20 years after their introduction they had already become problematic in New Zealand (Webb et al., 1988).

Landowners, land managers and councils continue to use willows primarily as soil stabilisation tool. Breeding (hybridisation) programmes are funded by public sectors to produce new cultivars/hybrids that

are better fit for purpose[1]. Simultaneously, there are many groups and agencies in New Zealand who have programmes and/or funds to remove willows that are causing problems (Phillips 2008).

Both crack and grey willows are listed by the Ministry of Primary Industries on the National Pest Plant Accord (NZPPA) list, which means they cannot be traded. Consequently, most regional councils include these species in their respective regional pest management plans. In Otago, willows are identified as an 'organism of interest' and are included in ORC's surveillance and monitoring program (refer Section 3.4 below). If these plants are found to be problematic, regional councils are the first points of contact to determine the status of these species and responsibility for control and/or advice on control (MPI, 2020).

Strategy to control and manage willow invasion varies on a site-basis (Wagenhoff & Young, 2013). However, initial and crucial steps are to understand the issues and determine the outcomes sought. To help understand the issues, site attributes (including area of control), target willow species, existing biodiversity values associated with willows (e.g. known birds roosting within willows), and possible invasion pathways (prevailing winds, river flow direction), and receiving environment help inform the issues to be addressed. Determining outcomes will inform required actions, funding needs, risks and assumptions, and timeframe.

Factors specific to the Manuherekia that are relevant in considering willow management in this catchment include:

- Annual rainfall of the catchment is 400 – 500 mm (one of the driest areas in Aotearoa/New Zealand).
- The catchment is home to non-migratory galaxiid fish species.
- Water quality of the rivers/stream in the catchment is generally good but there are specific locations where NESFM limits are not met.
- Temperatures appear to currently limit willow establishment above 500 m above sea level (but this upper limit is likely to increase in a rapidly warming climate).

3 Roles and responsibilities

Willows are managed by a variety of agencies, depending on the status and ownership of the land (e.g., road reserve, marginal strip or privately owned) and the nature of the issue being addressed. An overview of the roles played by various agencies is provided below.

One of the main reasons for willow control work (including planting) by councils and other government agencies is to address flooding and erosion. Willows are being used for this purpose as a cost-effective method of stabilising erosion-prone riverbanks. Councils are increasingly focussed on using lower-risk willow species for this purpose.[2]

[1] Such as the New Zealand Poplar & Willow Research Trust (https://www.poplarandwillow.org.nz/).
[2] https://icm.landcareresearch.co.nz/knowledgebase/publications/public/Willows_survey_report_2008.pdf

3.1 Flood Management

Regional and district councils are responsible for reducing the impact of flooding under a suite of legislation, including the Resource Management Act 1991, the Local Government Act 2002 and the Soil Conservation and Rivers Control Act 1941.

For example, The Soil Conservation and Rivers Control Act 1941 (SCRCA) includes provisions for regional councils to prevent damage by erosion and protection of property from flood damage. This act allows regional councils to maintain and improve watercourses to avoid flooding and erosion, and the power to plant trees for soil conservation purposes.

Both regional and district councils have functions relating to the avoidance or mitigation of natural hazards under the Resource Management Act. District councils have powers under the Local Government Act 2002 to manage infrastructure to disposing of stormwater.

3.2 Broader functions of regional councils impacting willow management

In addition to flood management, regional councils have other functions that can relate to willow management.

Under s30 of the RMA, regional council functions include:

- controlling the use of land for:
- the purpose of maintaining and enhancing ecosystems in water bodies
- the avoidance or mitigation of natural hazards
- in relation to any bed of a water body, the control of the introduction or planting of any plant for a range of purposes including maintaining or enhancing water quality, or the avoidance or mitigation of natural hazards
- the establishment, implementation, and review of objectives, policies, and methods for maintaining indigenous biological diversity.

On this basis, willow planting and removal is managed through the Otago Regional Council's Regional Plan Water. Rules relating to willow planting and removal are outlined in Section 6 below.

3.3 Biodiversity

The function in Section 30 of the RMA relating to indigenous biological diversity was added by a 2003 amendment to the Act and may require proactive intervention to achieve *maintenance* of indigenous biological diversity.

In addition to Section 30 of the RMA, Section 14 of the Local Government Act 2002 (LGA) sets out a series of principles which local authorities must act in accordance with. Section 14(h) specifies that, in taking a sustainable development approach, local authorities shall take into account matters including the need to maintain and enhance the quality of the environment.

The ORC's approach to biodiversity is set out in its 2018 Biodiversity Strategy.

Otago Regional Council's Biodiversity Strategy 2018

The ORC's Biodiversity Strategy 2018 identifies how ORC will add value and strategic leadership to the biodiversity initiatives of communities and other organisations in Otago.

This includes Outcomes such as

- Outcome 1 - All indigenous species and ecosystems that support them are maintained.
- Outcome 2 - Threatened indigenous species and ecosystems that support them are actively protected and enhanced.

Actions outline how ORC will support stakeholders and communities to achieve these outcomes including for example by providing expert advice to community groups. This strategy does not include the ORC undertaking direct actions (such as willow removal) to enhance biodiversity. This means that this plan is unlikely to result in direct management of willow management for a biodiversity purpose by the ORC.

3.4 Weed Management

3.4.1 Otago Regional Pest Management Plan 2019-2029

Regional councils have a mandate under Part 2 of the Biosecurity Act 1993 to provide regional leadership in activities that prevent, reduce, or eliminate adverse effects from harmful species present in their region. The ORC Regional Pest Management contains the framework to manage or eradicate specified organisms in the Otago region.

Willow (Salix spp.) are not identified as a pest under this plan but are instead identified as an 'organism of interest'. Section 70(2)(d) of the Biosecurity Act provides for the specification of 'any other organisms intended to be controlled' but not accorded pest status. There are many organisms not classified as pests that are capable of causing adverse effects, particularly to biodiversity values. A number pose a sufficient future risk to warrant being watch-listed for ongoing surveillance or future control opportunities. These organisms have been categorised as 'Organisms of Interest' (OOI). OOIs are not accorded pest status but future control of them could arise, for example through site-led programmes. A review of the Plan may be necessary to include them as pests. However, OOIs may be controlled in other ways in accordance with the Biosecurity Strategy.

Willows are included in the ORC's surveillance and monitoring program. Under this programme ORC is to undertake monitoring and surveillance activities to measure the progress made in managing pests and may also include monitoring organisms of interest in and any other organisms that may present a threat to the region. However, no active monitoring is currently being undertaken by the ORC.

3.5 LINZ managed land including pastoral land

The Crown owns approximately 1.2 million hectares of Crown pastoral land, largely within the South Island high country, including within this catchment. This Crown land is mostly leased out for pastoral farming. Under the Crown Pastoral Lands Act 1998, leaseholders have the right to graze the land along with some permitted activities including exotic pest plant control, minor soil disturbances (including to remove tree stumps), burning slash within existing cultivated paddocks and riparian planting using indigenous species sourced from local seeds (Section 8 and Schedule 1AB, Part 1).

While Toitū Te Whenua Land Information New Zealand (LINZ) can suggest a farm plan to progress issues like weed control, there is no clear requirement under the Crown Pastoral Land Act for pastoral leasees to undertake willow control work.

LINZ is also responsible for administering and managing a range of Crown owned lands (under the Lands Act 1948 and Public Works Act 1981).

LINZ does not have an active management plan for willows as they are not a species required to be controlled under Regional Pest Management Plans. In isolated cases, LINZ will undertake works on willows where they are still low in density and their spread could have a significant impact on biodiversity in a high value area.

3.6 DOC managed land

The Conservation Act sets out the Department of Conservation's (DOC) functions. Its functions include managing land held under the Act for conservation purposes and preserving indigenous freshwater fisheries, and protecting recreational freshwater fisheries and freshwater fish habitats. DOC can develop conservation strategies for the integrated management of land – these plans (or the Minister) can direct the preparation of conservation management plans for particular areas. The Act also sets out different types of protected areas, and the purpose for which they are to be managed e.g. amenity areas shall be managed so indigenous natural resources are protected (Section 23A).

One conservation strategy of relevance is the Department of Conservation Strategic Plan for Managing Invasive Weeds (DOC, 1998) – this has the goal of maintaining or improving the integrity and sustainability of all natural areas that are important for natural heritage conservation, and the long-term survival of native species. Invasive weeds are defined as 'plants that can significantly and adversely affect the long-term survival of native species, the integrity or sustainability of natural communities, or genetic variation within indigenous species' (p1).

This plan notes the impacts of weeds on biodiversity and ecosystems. Crack and grey willow are identified as having major impacts in freshwater wetlands by choking water bodies, lowering water levels and shading out other species. Relevant objectives include minimising numbers or containing distribution of significant new invasive weeds where feasible (weed-led control programmes) and protecting sites that are important to our natural heritage, (site led programmes) and set out factors to consider when prioritising programmes.

3.7 Permissions from LINZ and DOC

Where willow removal is proposed on land managed by LINZ or DOC, permission will need to be obtained for the work from these agencies.

Willow removal work within LINZ managed land generally requires an access letter through the LINZ applications team for permission to undertake the works, this is the process to ensure that all necessary parties are notified and that works are done consistently and the site left in a tidy condition etc.[3]

Any willow management work within public conservation land or marginal strip managed by the Department of Conservation requires approval from the local operations manager. Permission can be in the form of a community agreement which allows groups to carry out broad scale work such as weed control or pest management within DOC managed land – this could apply to a whole catchment. Community agreements will be subject to conditions and requirements such as how the willow removal work was to be carried out, health and safety and notifying DOC about the timing and location of works. Alternatively, permission can be provided through a letter of authority from the operations manager – this might be more relevant for site specific work.

4 Impact of willows

To inform the development of this willow management strategy, a literature review of the following aspects of willows was undertaken and is presented here.

- Review national and international literature on willow water uptake.
- Review national literature on the benefits and issues of willows.
- Review published (and unpublished information where necessary) on best approach to transition from willow- to native-dominated riparian vegetation.

On considering the above aspects, related questions have been included in this review:

- Does removal of willow improve the flow?
- Does removal of willow benefits instream habitat?
- What does restoration need to account for?
- Do amenity/recreational values increase with removal of willow (as a tree)? People's perception of a tree vs perception as unwanted objects.

[3] The form to request access from LINZ can be found at: https://www.linz.govt.nz/resources/form/application-interest-crown-land-lease-licence-or-access

4.1 Extent of willows in the Manuherekia Catchment

The extent of willows in the catchment has been to assist with decisions on management options. This process used the point cloud data generated by recent LiDAR mapping. The vertical discrepancy between the portion of the point cloud representing the ground surface and the portion representing tree canopy was identified. A minimum difference of 5 m between these horizontal strata was used to produce an initial map of polygons representing cover in the catchment by trees greater than 5 m tall. Areas of commercial forest and wind breaks were removed using the mapped extent of the plantation forest in the national Land Cover Database (version 5) and then each remaining polygon was manually inspected and recorded as willow or not. This resulted in 15,620 polygons totalling 1,199 ha being identified as predominantly consisting of willow (Figure 1).

Most of the willows mapped are greater than 10 m in height and represent long-established plants. The historic rate of increase in willow extent is likely to be slow, but colonisation of new land is likely to continue at ever-increasing rates.

Willow regrowth is notably more common in areas of disturbed riverbank and braided riverbed such as the Blackstone Hill area. It is thought that the majority of the 1,199 ha of willow infestation is a result of spread from willows originally used for riverbank stabilisation. It is possible that over 90% of the willow area is actually of weedy origin and thus represents a considerable loss of land to infestation by a weed species.

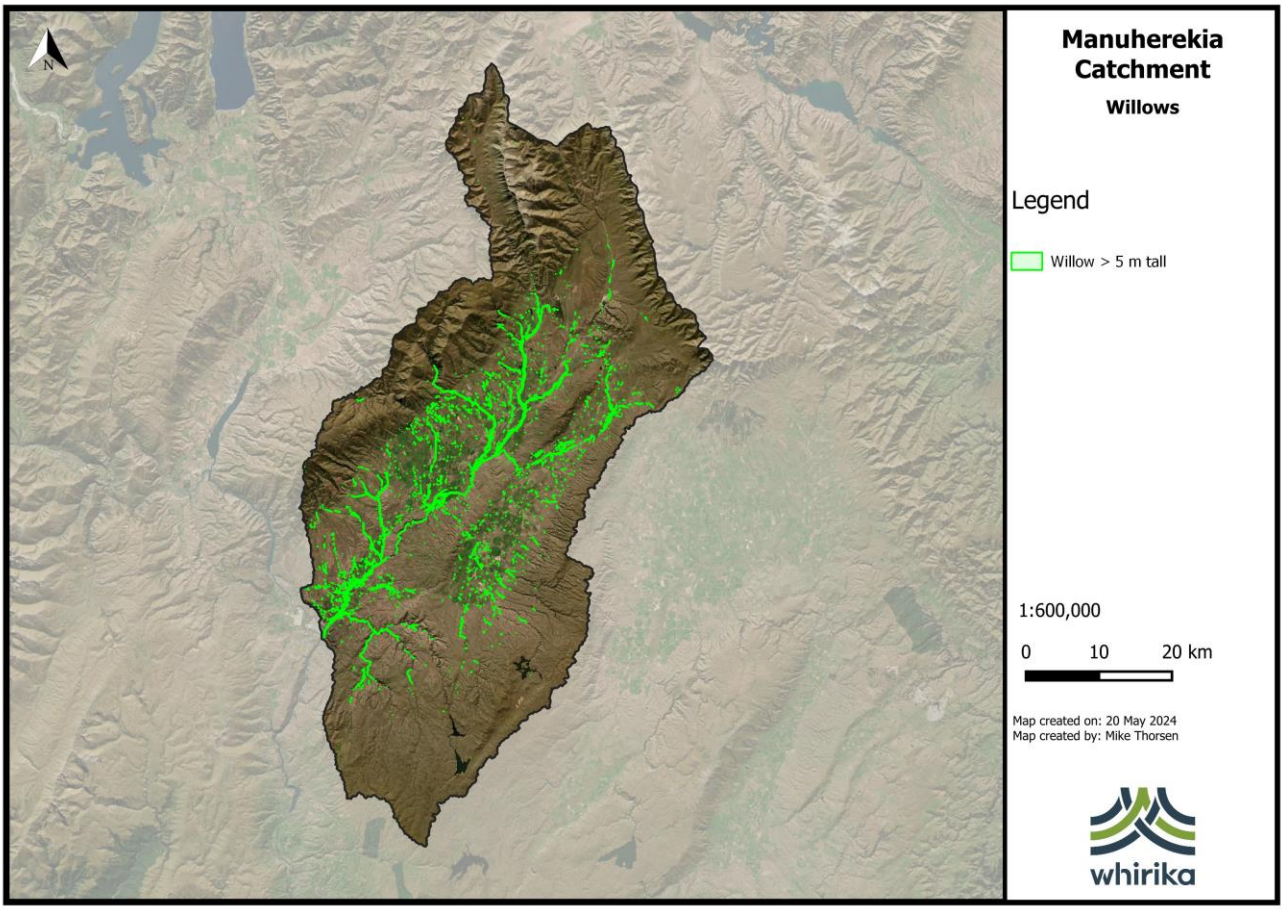

Figure 1. Extent of willow > 5 m tall within the Manuherekia Catchment identified from evaluation of LiDAR point cloud data.

4.2 Willow water consumption

There is very little published information on willow water consumption in the Aotearoa/New Zealand context, and even less information on the impact of removal on instream flow. There is, however, more information to establish the fact that invasive species, including willows, have the tendency to exploit natural resources such as water and light more than native plants, due to their ability to colonise and establish in a non-native environment rapidly (Cavaleri et al., 2014; Crooks, 2002).

On reviewing published information from countries where willows are recognised as major weeds, while it is dependent on abiotic factors, there is evidence to suggest that willows are high-water use[4] species. Their water consumption rate is even larger[5] where there is unlimited access to water, such as in-stream, water's edge of a riparian zone, or in a freshwater wetland, compared to the consumption rate of willows growing on dryland with limited access to water (Doody et al., 2011; Doody & Benyon, 2011; Dudley et al., 2019). Taller willows (20 m high) have much higher water consumption than shorter (trimmed, 10m high) willows.

Thus, extensive planting of willows (and poplars, which is another genera with similar ecological traits) would likely result in reduced drainage to stream flow and aquifer recharge, reduced peak flows, and springs and ephemeral streams may dry up sooner and for longer during summer conditions (Hall et al., 1998), potentially reducing summer flows by 50% in some situations.[6]

4.3 Would willow removal result in more water in the landscape?

This question will have different answers depending on the purpose of willow removal.

If water salvation (defined as increased water available **for human or environmental beneficial use** as a consequence of vegetation and land cover change resulting from removal or reduction of introduced vegetation) is the purpose of the willow removal, targeting willows which grow in areas with unlimited access to water, such as in-stream or riverine wetlands, would increase the likelihood of an increase to instream flow. Removing willows in the riparian zone where access to water (including sub-surface flow) is limited may not result in a change instream flow.

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[4] Dudley et al (2019) estimated the annual evapotranspiration of the following riparian vegetation: i) tall (>20 m) willow riparian forest (1393 mm); ii) short (<10 m) willow riparian forest (1331 mm); iii) grass (638 mm); iv) Typha-dominant wetland (1231 mm); v) native riparian planting (663 mm); vi) open water (1220 mm).

[5] Doody & Benyon (2011) reported that annual cumulative water use (evapotranspiration) by in-stream willow (2410 mm) was significantly higher than willows on dryland (553 mm). Annual evapotranspiration of open water was estimated to be 1472 mm, which is slightly less than that of in-stream willow.

[6] https://niwa.co.nz/lakes/freshwater-update/freshwater-update-77-june-2018/use-stable-isotopes-rainfall-and-rivers-explain-pathways-and-speed-water and https://onlinelibrary.wiley.com/doi/abs/10.1002/eco.1930

If willows are to be replaced with native vegetation, willow removal would likely result in a substantial increase of water availability for the native vegetation replacing the willow. New Zealand plant species are likely to be more water conservative than invasive exotic plant species as the former rarely demonstrate the 'invasiveness' in their natural environment but instead co-exist with other species and may disappear or become less dominant as the forest succession proceeds (McAlpine et al., 2008). In this situation, willow removal may not have direct impact on the stream flow, although it may result in increased aquifer recharge as New Zealand plants are relatively shallow rooted compared to willows and poplars (Cavaleri et al., 2014; Doody et al., 2011; Dudley et al., 2019).

Water salvage for human uses versus water salvage for broader ecological benefits are two different things. If willows are removed and water availability for indigenous species are increased, that will have cascade benefits in long-term ecohydrological processes and biodiversity. A desirable outcome must be defined so that willow removal is targeted to achieve that outcome.

4.4 Willow's other impacts on waterbodies

Willows in New Zealand are ecological engineers which have the ability to alter the physical nature of ecosystems. In the riverine environment, willows can not only change the flow rates, regimes, composition and structure of riparian vegetation, but can also alter the nutrient cycles, trophic interactions, primary productivity, fire regime, stream-channel geomorphology, and other aspects of ecohydrology where willow has invaded.

A non-exhaustive summary of reported impacts of willow invasions is provided below (Crooks, 2002; Doody et al., 2011; Lester et al., 1994, 1996; Poff et al., 1997; Serra et al., 2013; Vilches et al., 2023; Zukowski & Gawne, 2006):

- Deep and dense root systems form thickets and allows encroachment of trees across stream beds as the roots trap sediments. Water movement is slowed and may be diverted around dense thickets, altering stream morphology, and causing stream bank erosion as water is diverted outside the natural stream channel.
- Reductions in water quality are likely, due to flow reduction via relatively larger water consumption (as compared to native species) coupled with large autumn flushes of organic matter (deciduous leaves) which can rapidly decompose in the aquatic system.
- Leaching of chemicals, such as cyanidins and delphinidins, into the aquatic system from decomposing willow detritus may adversely impact on the activities of in-stream fauna.
- Large willow canopies create significant seasonal shading when located within water bodies, reducing the amount of solar radiation reaching the stream. While this may be beneficial to many waterways in Aotearoa/New Zealand today, significant seasonal fluctuation in solar radiation is a significantly altered state from the seasonally-stable light regime associated with native riparian or instream vegetation.
- Willows are reported to inhibit growth of understory species and biodiversity along colonised stream and river reaches due to their heavy shading during the growing season, although

conversely willows further from the water's edge can provide a nursing function for native understorey vegetation. This nursing function will be discussed in section 5.5.

4.5 Benefits and issues

Benefits and issues of willows identified in published and unpublished information are summarised in Table 1. It should be noted that Table 1 is not an exhaustive list of issues or benefits, and that mana whenua perspectives are addressed separately in Section 7.1.

Table 1. Benefits and issues of willows

In relation to/ In context of	Benefits	Issues
Indigenous biodiversity (terrestrial)	• Nursing effect for native plants' early establishment stage (Forbes, 2017) • Food source for some indigenous fauna • Ecological stepping stone (for mobile fauna) • Habitats (e.g. roosting) (Edgeley & O'Donnell, 2004)	• Dominates/supress/outcompete indigenous flora and ecosystems, inhibiting native species to recolonise • Cause direct loss of breeding and foraging habitats of shorebirds (Maloney et al., 1999) • Can only provide limited food and habitat (it is not primary/the most favourable food or habitat for most of NZ indigenous species) (Mander et al., 1998; Wagenhoff & Young, 2013) • Root structure does not provide as heterogenous habitats as indigenous vegetation does • Creates mono-culture vegetation which is susceptible to pests such as giant willow aphid
Indigenous biodiversity (aquatic, incl. ecohydrology)	• Creates buffer for rivers/streams from land use activities • Filters land-borne contaminants from surface and subsurface flows • Provides bank stability by forming thick root mats and consolidating soils • Shading • Provide habitat heterogeneity for macroinvertebrate, fish and birds	(Summarised from sections 4.1 and 4.4) • High water consumption especially with unlimited access to water, resulting in loss of water from waterbodies/catchment • Channel clogging by thick root mats • Modification of channel morphology – reduced velocity, channel diversion • Increased erosion associated with channel modification • Water quality reduction via large inputs of rapidly decomposing organic matter in autumn • Sedimentation (smaller average particle size trapped in root mats)

In relation to/ In context of	Benefits	Issues
		• Impacts on aquatic species (macroinvertebrates, fish) via leaching of chemicals
Climate	• Carbon sequestration • Regulate ambient temperature, benefiting urban environment to mitigate heat island phenomenon	• Indirect adverse effect on climate by influencing ecohydrology of indigenous ecosystems, increasing vulnerability of indigenous ecosystems to climate change.
Social	• Shading – ameliorate ambient temperature in a built/urban or modified environment and provide shade for stock • Provide some protective function for the community on flood plains and areas along waterways from flooding • In some settlements, seasonal display of trees (e.g. autumn leaves) may be perceived as notable features by people[7] • Willow sawfly larvae seasonal food source for trout	• Willows and other invasive weeds which often co-dominate in willow riparian forest are perceived negatively • Willow die-back caused by willow sawfly is perceived negatively • Willows from upstream will cause willow infestation downstream, affecting downstream community
Economic	• Provide some protective function for agricultural activities on flood plains and areas along waterways from flooding and protection of productive land and infrastructure located near erodible banks • Provides limited wood materials (e.g. timber, biofuel[8]) • Occasional source of fodder (for livestock) when no other food source available	• Significant cost to the nation to control willows • Willows are affected by willow sawflies, which result in cost of replanting • Willow can be the major source of woody debris in extreme weather events, causing infrastructure and property damage, especially large woody debris from deteriorating (or unhealthy or weakened) trees can collect against bridges and cause damming

[7] Consulting with the community about willows and will control will be important. https://caws.org.nz/old-site/awc/1996/awc199613791.pdf

[8] Rigorous growth and coppicing behaviour of *Salix* species could be taken advantage for its use as bioenergy fuels https://www.soils.org/news/science-news/shrub-willow-bioenergy-crop/

5 Willow Control and Removal

5.1 Approval to control and remove

Before any willow removal project a site-specific assessment is important to consider whether willows are providing bank stability that is important to protect infrastructure (See Section 5.3) or where removal debris may provide a downstream hazard (Section 5.4). Willow removal works that result in disturbance or alteration to the bed of a waterway or which may result in sediment or herbicide entering a waterway may need consent from ORC before proceeding (refer to Section 6). Landowner approval is required before removing willows and landowners will generally want to know the reason for willow removal, how the willow will be removed, and how this will affect their land.

5.2 Removal and control methods

A number of techniques are available to kill or remove willows. All techniques have their advantages and disadvantages, and it is important to consider these when selecting the appropriate technique for killing and removing willow. For any technique it is important to consider how this can be done safely and what personal protective equipment and other health and safety measures are needed. Eye protection is a must when injecting or spraying herbicides.

Adult willows can be killed through either drilling a c. 15 mm diameter hole into the trunk or up-angled cutting through the bark using a hatchet or chisel, at 100 mm intervals around the trunk, or by frilling (cutting through the bark [but not ringbarking the plant]), at around waist height and filling each of the holes/cuts with 10 ml undiluted glyphosate with colouring agent or cut using a tree injector or drenching gun. Death of the tree usually occurs within 1-3 months and resprouting is minimal (and resprouting usually indicates insufficient injections around the trunk).

Smaller stems should be cut off near ground level using loppers and herbicide paste applied to the cut stump. This technique is one of the cheaper methods to kill willow but can be difficult where willows are in wetlands deeper than easy wading or where trees have a large number of low hanging branches and dead material making it difficult to physically reach the trunk. Every stem emerging from the ground needs to be treated. The frilling technique is a faster method but may be less effective on larger trees. These techniques cannot be applied during winter when metabolic activity in the plant is very low.

Young willows or isolated trees not growing over water can be controlled by spraying with glyphosate at a concentration of 12.5 ml/l and a penetrant, or metsulfuron-methyl at a concentration of 5g/10L, or triclopyr triethylamine at label rate, once leaves have emerged. The use of surfactants (spreaders) and penetrants increases the efficacy of the spray.

Young willows (up to 15 cm diameter) also can be chemically ringbarked by spraying the basal 40-50 cm using a low-pressure (20 – 40 psi) stream (to minimise splashing) of 1-part Grazon (triclopyr

butoxyethylester) mixed with 4-parts basal oil or diesel. Plants can take 18 months to die using this technique.

Aerial application of herbicide is the most cost-effective method for large infestations. This use may require a consent from the ORC (refer to Section 6). Aerial application frequently also leads to some damage to other vegetation at the site and some native plant species (such as the sedge pukio *Carex secta*) can be accidentally killed. Triclopyr triethylamine and metsulfuron–methyl are less damaging to grass-like plants. Both can be transported via the root system and affect nearby trees and can cause death of trees planted in revegetation projects if planted too soon after herbicide application.

Control of willows using spray usually takes just over a year as there is usually a need to treat surviving or resprouting plants. It is also advisable to check a site 5 years after treatment as any willow seedlings will have grown and become visible.

It is usually considered most appropriate to kill trees before removal as almost all living fragments of crack willow (and other willow, alder, or poplar species) are capable of resprouting if in contact with the ground. Cut stumps of live plants are also very prone to resprouting unless the margin of the cut (the bark contact zone) is pasted with herbicide.

Removal of willow (if required: see Section 5.4) is best undertaken once all individuals in the infestation are dead to prevent generating live fragments that will grow into new trees.

Live willows in paddocks can be felled and fed to stock which will strip it of leaves and smaller twigs. It can then be burned once dry.

Isolated trees and young willows less than 5 m tall are best left standing once dead as they will break down over time.

Stands of large trees in areas where there is concern that debris could be a flood hazard should be felled once dead and either chipped on site (some machines can chip standing trees) or hauled away from the site. Hauling requires heavy machinery and should only be operated by qualified persons. The hauled material can be piled and when dry burned on site or left to rot. The cut stumps should be left in the ground where they will gradually decay. This will minimise damage to riverbank stability.

An option for trees close to settled areas is to cut the trunk and larger branches into rounds and supply these as firewood.

Willows situated close to Alexandra could be chipped and provided to Pioneer Energy’s wood chip stockpile.

It is not recommended to haul plants bodily from the ground as this creates considerable damage to riverbanks. However, this technique can be used for willows in paddocks.

5.3 Retaining beneficial willows

Willow stands can ameliorate (or exacerbate) flood effects and therefore where there is a potential impact on flood management it is important to consult with ORC river engineers before proceeding. Some willows (both planted and wilding) are important for maintaining river bank stability and therefore should not be removed without consultation with ORC river engineers. These areas are shown in Figure 2 and Figure 3. In general, willows on outside bends of waterways, or upstream of infrastructure such as bridges should be assessed for their role in providing flood mitigation prior to removal.

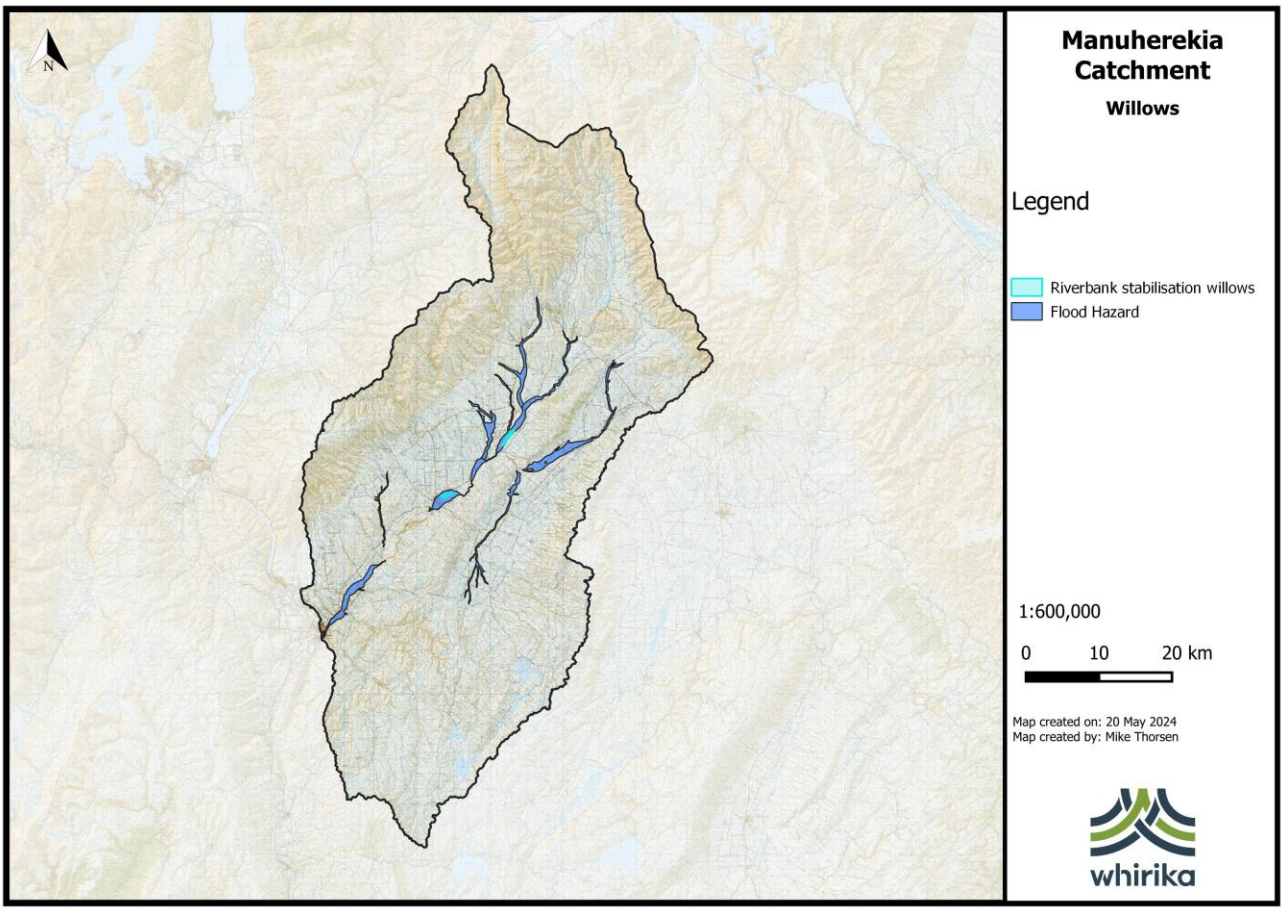

Figure 2. Extent of flood hazard and location of willows important for riverbank stabilisation.

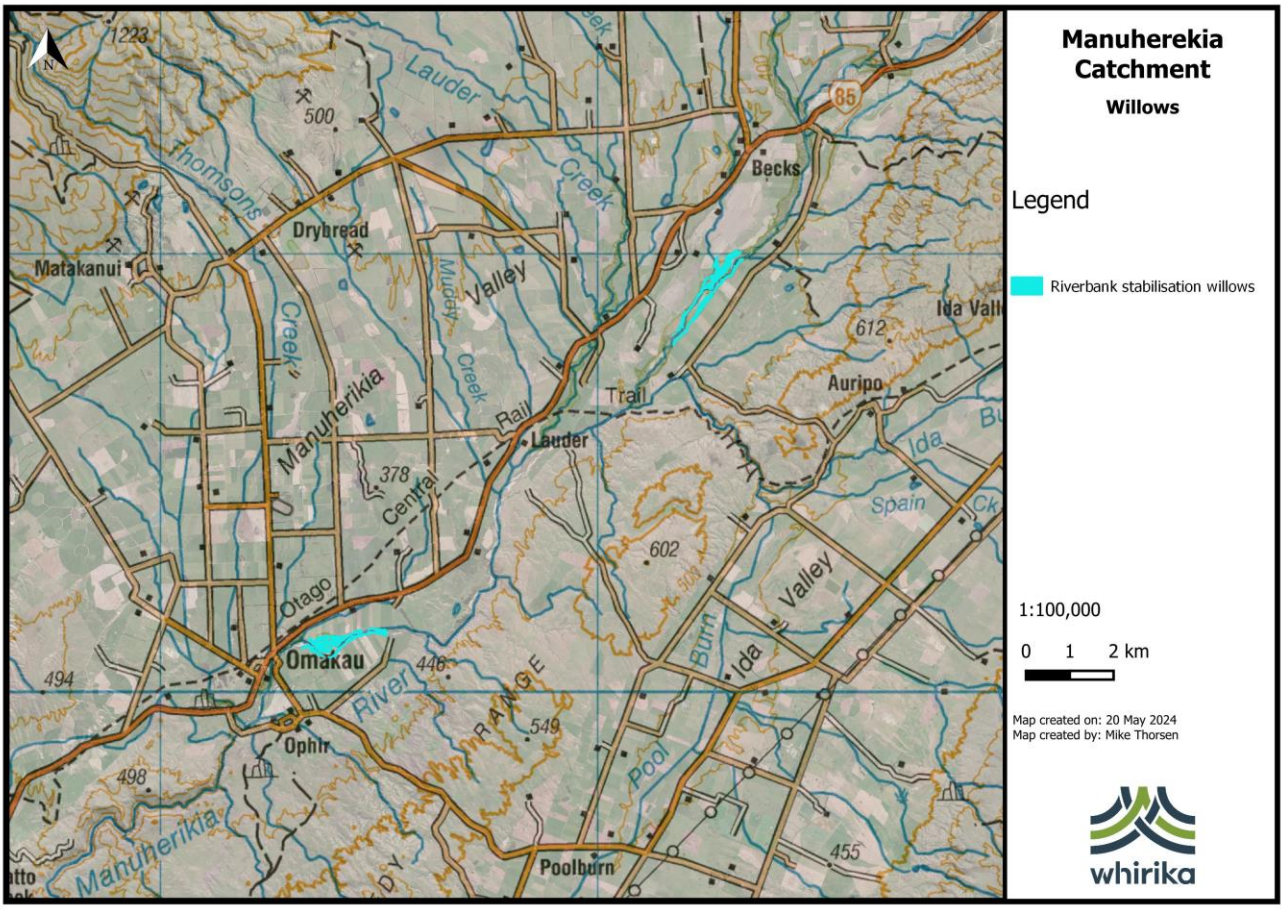

Figure 3. Closer view of location of willows planted in the Manuherekia Catchment by ORC for riverbank stabilisation purposes.

5.4 Willow debris

Some willow removal methods can also create quantities of dead willow branches of a size that if transported downstream in a flood event they individually or as a raft can pose a risk to infrastructure (bridges, water intake structures) and recreational users. For this reason, removal of willow trunks and large branches from the flood zone of larger waterways should occur within one year of a willow control programme targeting groups of trees. It is advisable to remove large willows from the flood plain of waterways of a size greater than River Order 4 and should be considered for waterways of a River Order 3.[9] These areas are shown in Figure 4.

[9] River Order is a measure of the size of a water way. River Orders start at 1 (the headwaters) and increase by 1 when they are joined by another waterway of the same or greater size. The Manuherekia River at Alexandra has a River Order of 7.

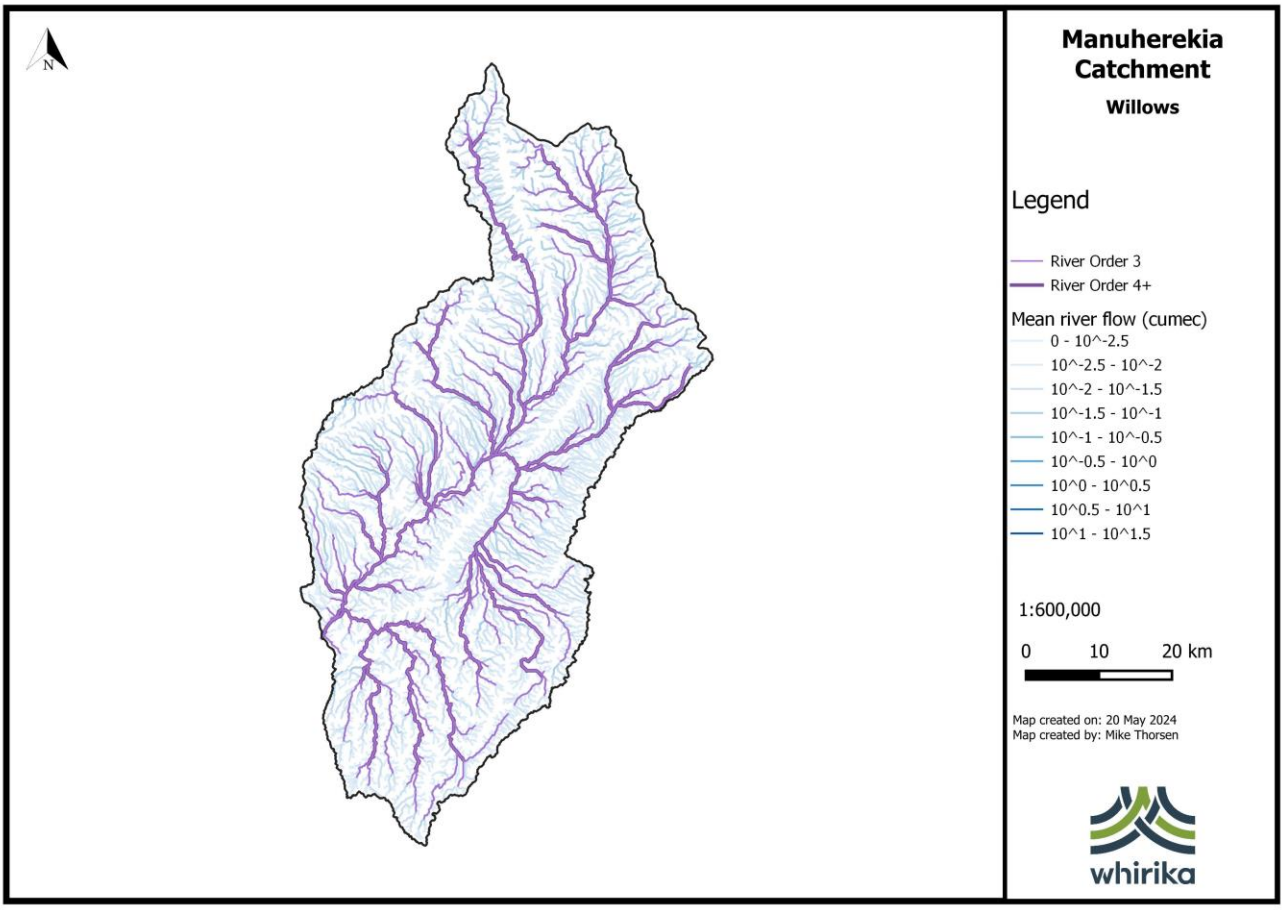

Figure 4. Mean waterway flows (in logarithmic scale) and extent of waterways of a size greater than River Order 3.

5.5 Restoration methods

As mentioned in section 4.3, it is important to clarify the 'purpose' of the willow removal (e.g. water salvage for human use versus water re-allocation to native ecosystem). Once that is clarified, optimum restoration method is likely to vary depending on the site, i.e. site-specific planning is likely to be required.

This section assumes that the target state after willows are removed is a riparian zone dominated by native vegetation that is not subject to grazing, harvest or any other economic activities.

Removing willows, even though it is removing exotic invasive and unwanted plants, may result in some adverse effects (described below) to the riparian zone and/or in-stream habitat in the short-term. The method of removal should, therefore, focus on how to make the transition while minimising these effects.

From an ecological perspective, a transitional restoration method is likely to be the preferred restoration pathway rather than a conventional blanket removal of willows followed by native planting. Broad characterisation of the potential adverse effects of willow removal and methods to avoid and/or mitigate them are provided below, based on published (Forbes, 2017; GWRC, 2021; Hashiba & Millar, 2023; Zukowski & Gawne, 2006) and unpublished information:

Potential effects on willow removal on channel morphology:

- It is generally site-specific and hard to predict, and although removal is positive for most situations, removal may cause erosion if willows (to be removed) grow on the riverbed where there is a change in gradient. In this situation, leaving their root mats in place may be a better option.
- Removal of willows from the bank is beneficial as it will prevent further changes in stream morphology. However, the removal method should aim for minimum disturbance to banks and the instream bed, such as drill & fill herbicide application so roots are intact for a while, or removal in sections along streams at any one time.

On water quality:

- Removal of whole willows including root mats may lead to pulse release of large quantities of sediment trapped in root mats, which may have adverse impacts on instream organisms. Removal method where root mats are left intact for a while (e.g. drill & fill, cut & paste) may be a better option to minimise the short-term impacts
- Dense and mature willows significantly reduce the availability of light to banks and watercourses while providing no or limited shading during winter months. This may cause site-specific responses to in-stream metabolisms and primary production, which are one of the main drivers of water quality (e.g. oxygen availability).
- Shade from mature stands of willow has an influence on water temperature, hence removal will have impact on water temperature. In areas susceptible to high solar radiation and drought and/or for small streams, staged and well-timed (e.g. avoid low flow months) removal of willows coupled with establishment of native vegetation may be better options whereby native plantings have some protective shade in summer and streams are not exposed to significantly higher solar radiation.
- Removal of willows will result in removal of willow leaf litter input into the waterway, which in turn reduces high nutrient pulses and overall nutrient levels in stream in the long term, especially in small streams. However, this may also mean that food availability for invertebrates and fish may also be reduced until alternative vegetation is established. Therefore, a staged removal (e.g. removal in sections of the riparian zone) coupled with establishment of native vegetation may be a better option at sites with an important population of non-migratory galaxiid fish.

On other riparian vegetation:

- Removal of willows may promote other weeds to invade and dominate.

- If there is an existing native vegetation understorey, removal of willows can also expose them to high solar radiation and temperature, which may lead to short-term negative impacts such as plant desiccation or mortality of these native plants.
- While an increase in the water table is positive, an acute change in water table depth and ecohydrology may affect existing native vegetation.
- Staged and/or selective willow removal may be a better method for transition/restoration of native vegetation as it would incur less ecological disruption and would promote native understorey if present.

On aquatic fauna:

- Willow removal would change habitat conditions (light, temperature, foliage and habitat, organic input) for aquatic fauna. Whether the impact is positive or adverse depends on the site (such as climate, ecohydrology, riparian vegetation) and the species of interest.
- Where restoration of indigenous ecosystems is the outcome sought, removal of willow should be implemented, which may result in short-term negative change in aquatic fauna (especially in relation to increase in light and water temperature, reduced organic matter, and sediment release) but would have positive influence on them in long term.
- However, an acute change in in-stream condition, especially increase of summer water temperature, would likely to be detrimental to aquatic fauna, especially where there is little riparian vegetation other than willow forest. Staged removal of willows in sections or in patches coupled with restoration/establishment of native vegetation to replace willow vegetation, is therefore a better method of willow removal. Keeping the root zone intact for the short-term may also be beneficial in avoiding acute/sudden change in instream condition.

Where the invasion pathway of willows is clear, e.g. crack willows spreading from upstream to downstream, removal should be started upstream and progress downstream, or according to the direction of the invasion pathway.

If removal of willows from water's edge is not possible (such as being restricted under regional council's flood protection scheme), native species, especially those that are 'typical' components of the riparian vegetation of the site in question, can be planted in areas set back from water bodies behind the 'live edge' (or buffer) of willows where groundwater is still shallow. Alternatively, mixed planting of willows by creating strips or blocks of native planting into willows could be considered, especially where there is moderate to low erosion risk and good soil.

Finally, success of restoration is also heavily influenced by other aspects such as site accessibility and resource availability (funding). These aspects should be considered from the beginning so that efforts of removal, however small or large, produce the desired outcome.

6 Is consent required for willow management?

Willow planting and removal is managed through the ORC's regional plan. In many cases willow removal will not require a consent, depending on whether the removal results in disturbance to the bed[10] of a water body or whether the work results in contaminants entering a water body e.g. herbicide or sediment. At the time of writing the Regional Plan: Water was still the operative plan containing rules relating to willow removal. The ORC is currently developing a draft Land and Water Regional Plan which would replace the Regional Plan: Water. Limited detail about proposed rules in the draft Land and Water Regional Plan is available at this stage, however consultation material indicates a similar or potentially or permissive approach to the operative Regional Plan: Water. Rules in the operative plan are outlined below.

Willow removal which will result in the disturbance of the bed of a waterway, or which will result in a noticeable increase in local sedimentation in the waterway will require consent.

- Disturbance of the bed of a waterway – discretionary activity requiring consent under Rule 13.5.3.1. Bed disturbance is defined as: Any activity which affects the bed or bank of a water body and includes any excavation, dredging, drilling, tunnelling, and any widening, deepening or altering of the course of the water body.
- Discharge of sediments into waterway from willow removal:
- Permitted activity if conditions of Rule 12.C.1.1 can be met, including that there is no conspicuous change in colour or visual clarity in the waterway.
- Otherwise the discharge will require consent as a restricted activity under Rule 12.C.2.1.

Use of herbicide or pesticide for willow removal:

- Discharge of pesticide to land is a permitted activity if the conditions of Rule 12.B.1.2 can be met including that there is no direct discharge of the pesticide to water in any water body, drain, water race, the pesticide is authorised for use in New Zealand and there is no damage to fauna, or New Zealand native flora, in or on any Regionally Significant Wetland.
- Discharge of herbicide where it may enter water is a permitted activity if the conditions of Rule 12.B.1.3 can be met including all reasonable measures are taken to minimise any direct discharge of the herbicide to water in any water body, drain, water race, and providing notice to those taking water.
- Aerial discharge of a pesticide to land where it may enter water is a permitted activity if the conditions of Rule 12.B.1.4 can be met including that the all reasonable measures are taken to prevent any discharge of the pesticide within 20 metres of water in any water body, drain or

[10] The bed of a water body includes the space of land which the waters of the river cover at its fullest flow without overtopping its banks (refer Section 2 of the Resource Management Act).

water race, the pesticide is authorised for use in New Zealand and there is no damage to fauna, native flora or any Regionally Significant Wetland.

- Otherwise the use of herbicide or pesticide will require a consent as a discretionary activity under Rule 12.B.4.2 or 12.B.4.3.

Note also that there is a permitted activity rule for planting willow for the purpose of managing flooding and erosion:

- Planting any plant, including willows, within the bed of a waterway to manage flooding or erosion, or to restore habitat, is a permitted activity, with the exception of Crack Willow Salix fragilis or Grey Willow Salix cinerea, or pest plants listed in the Pest Management Strategy. (Rule 13.6.2.1).

The ORC carries out willow control work under a consent held by the ORC – this may be used for willow work across the region (known as a 'global permit/consent'). Previously groups or private landowners have sometimes been authorised by the ORC to undertake willow control under this consent. The current ORC is due for replacement, and is unlikely to be able to be used by other parties – in part because of the increase in interest in willow control work in many of the catchments across Otago, but also because of the need for the ORC to ensure any work carried out under its global consent is entirely consistent with it.

7 Local considerations

7.1 Mana whenua perspective

Kāi Tahu whānui, represented by Kā Papatipu Rūnaka and Te Rūnanga o Ngāi Tahu, comprise people of Kāi Tahu, Ngāti Māmoe and Waitaha descent, who hold manawhenua over an area that includes the entire Otago region. The four Papatipu Rūnaka of Otago are:

- Te Rūnanga o Moeraki
- Kāti Huirapa Rūnaka ki Puketeraki
- Te Rūnanga o Ōtākou
- Hokonui Rūnanga.

Planning and strategy documents developed by Te Rūnanga o Ngāi Tahu and Kā Papatipu Rūnaka provide an indication of the values of mana whenua when considering pest plant management.

7.1.1 Kāi Tahu ki Otago Natural Resource Management Plan (2005)

The four Papatipu Rūnaka developed the Kāi Tahu Ki Otago Natural Resource Management Plan (2005). This is the principal planning document for Aukaha, a consultancy service acting on behalf of Kā Papatipu Rūnaka. This document also provides information, direction and a framework to achieve a greater understanding of the natural resource values, concerns and issues of Kā Papatipu Rūnaka and the associated whānau and rōpū of the Otago Region.

The underpinning philosophy of the plan is 'ki uta ki tai' /mountains to the sea – this emphasises holistic management of the interrelated elements within and between catchments, from the air and atmosphere to the land and the coastal environment. The over-arching principles governing this document include that of manawhenua, kaitiakitaka (guardianship, care, and wise management) and the protection of Mauri, or the protection of the life-giving essence of an ecosystem.

A number of issues, objectives and policies within the plan also provide an indication of the values and perspectives of Kā Papatipu Rūnaka that should be taken into account in relation to willow management. These emphasize (amongst other aspects, and within a holistic framework) the critical important of wai māori (fresh water), wāhi tapu (sacred places), cultural landscapes, biodiversity and mahika kai (food gathering places and resources) to Kā Papatipu Rūnaka.

Issues identified for wai māori include the indiscriminate use of chemicals for weed control, impacts of willow removal on water quality, water temperature and mahika kai habitat, as well as the lack of proper riparian management throughout an entire catchment. (refer issue 5.3.2)

The following objectives and policies should also be taken into account in relation to willow management.

5.3.3 Wai Māori General Objectives
i. The spiritual and cultural significance of water to Kāi Tahu ki Otago is recognised in all water management.
ii.The waters of the Otago Catchment are healthy and support Kāi Tahu ki Otago customs.

5.3.4 Wai Māori General Policies
Willow Removals:
46.To require before and after photos of the site that show the work carried out.
47.To require willow debris be stockpiled out of the flood plains.
48.To require that any bed disturbance is limited to the extent necessary to remove the vegetation and that all reasonable steps are taken to minimize the release of sediment to water.
49.To require that trees are removed only on a selective basis and not from both sides of the river at once.
50.To require that the consent holder will carry out ongoing maintenance by managing re-growth so that future disturbance of the beds and banks is minimised.
51.To require re-planting of locally-sourced indigenous plants.

Indigenous biodiversity loss, loss of indigenous flora and fauna remnants are identified as issues, along with the impacts of land management, development and pests and weeds on mahika kai and indigenous biodiversity. Threats to native flora and fauna, such as feral and domestic cats, rats, stoats and ferrets, and invasive weeds, are noted as largely not being addressed in any co-ordinated manner (refer 5.5.2).

Mahika kai and biodiversity objectives seek protection, restoration and enhancement of biodiversity and mahika kai sites (refer for example 5.5.3). Policies include protecting and enhancing existing wetlands, supporting the reinstatement of wetlands and the promotion of catchment-based management programmes and models, such as Ki Uta Ki Tai (refer 5.5.4).

The issues, objectives and policies indicate potential support for careful removal of willows to enable biodiversity and mahika kai enhancement.

7.2 Community and Stakeholder Perspectives

Community feedback was sought via a drop-in session as well as by inviting emails or phone calls. The drop-in session was held on 24 April 2024 in Omakau, with advertising via social media and emails. Input was also received from Manuherekia Catchment Group and Ida Valley Catchment Group representatives.

Several participants noted the spread of willows in the catchment – including that the river used to be visible from the road alongside the Manuherekia 50 years ago, but that now you can only see willows. Several participants were supportive of willow removal.

Benefits of willows were noted including:

- Providing shade, including for stock
- Potentially improving water quality by reducing nutrient losses and sediment inputs
- Provides habitat for deer, which is beneficial for hunters

Issues noted with willows:

- Willow leaf litter cause adverse effects on water quality
- Reduction in water yields – removal of willows has resulted in observed increases in flow in tributaries
- Reservoir of pests such as rabbits and possums
- Flow backs up behind willows and spills onto/floods surrounding land, especially in tributaries

Feedback was provided about the potential approach to willow management in the catchment:

- Start in the upper reaches and in tributaries
- Start in the head waters of the catchment and working downstream over time
- Get rid of willows at or above Falls Dam
- Protect the conservation estate but do so holistically e.g. wider biodiversity and ecosystem outcomes rather than just looking at willows
- Don’t get rid of willows to allow for an expansion of grazing
- Consider other pests, including weed control after willow removal
- Looking at restoration after willow removal
- Possibly look at thinning or managing them
- Willows are taking off along fenced off waterways in the catchment. e.g. Becks Creek area
- Continued willow management (e.g. spraying) is required after removal

Particular locations identified for willow removal:

- Within the Poolburn gorge – an assessment of willow removal (including how it would be undertaken and effects on instream values) has been undertaken for the Ida Valley Catchment Group (McMurtie & James, 2024). This assessment provides a site-specific assessment of willow removal impacts on freshwater ecology.
- Above Falls Dam and along the Manuherekia River below the dam wall down to the confluence with Dunstan Creek – (feedback in support of this was provided by an adjacent landowner)
- Finish the removal of willows from the bottom of Māori Creek
- Around Omakau and Alexandra - this was referred to as a 'willow jungle'
- At the Ophir breakout channel
- Within the gorge on the Manuherekia River below Omakau
- Lauder Creek – there is likely to be landowner support for removal on at least 2 properties.

Particular locations identified for leaving willows:

- On some outside bends at various locations
- Willows have been planted in two locations for bank protection and remediation (by the ORC):
    - upstream from Omakau
    - off Blackstone Hill Runs Road

Other feedback noted that willows dominate the riparian margins stopping native species establishing, interrupt the natural flow of rivers and streams and extract a significant amount of water through transpiration. However, there was a desire to see willow management as part of a comprehensive plan of riparian restoration including replanting in appropriate species and fencing from stock, at least cattle. Removing willows from the headwaters of sub-catchments such as the Manorburn was seen as an effective starting point on the basis that those areas are lightly stocked and, provided follow up willow control is carried out, were seen as likely to transition to native vegetation without riparian fencing and planting.

Otago Fish and Game (OFG) endorsed the controlled removal of willows from the catchment, on the basis that the cleared areas are replanted with native species indigenous to riparian margins. Willow removal provides an opportunity to enrich the inherent attributes and ecological balance of the Manuherekia catchment. Given the scale of potential willow removal in the catchment, site specific discussions with OFG are recommended. OFG provided the following high-level input:

- Systematic removal of willows upstream from catchments to prevent reinvasion downstream, with replanting of native plants to provide habitat and erosion protection. Replanting with natives along riparian margins will also assist with improving water quality and increase native biodiversity.
- Evaluate each catchment's fishery value and assess the impact of willow removal on spawning habitat and fishery.
- Consider the impact on waterfowl and waterfowl hunters in willow removal planning. Willows serve as valuable cover and breeding habitat for waterfowl. Sites where willows are removed

should be replanted with native species to replace lost habitat. Consultation with hunters who have stands in affected areas is necessary to minimize disruption, especially around gamebird hunting season.
- Incorporate a long-term weed maintenance into the program.
- Planting plans for sites where willows are removed should include provisions for access along riparian margins.
- Recognise Dunstan Creek as a significant site for fishing and spawning.
- Consult with Fish and Game on work programs to identify sites and mitigation strategies.
- Utilise native species for flood protection where feasible and transition to natives under designated willows to facilitate future removal of willows for flood-prone sites. If native plants are not feasible due to cost or time constraints, consider planting new varieties of willows less likely to self-establish as replacements.

7.3 Council perspectives

ORC staff (river engineer and freshwater ecologist) provided input on willow management in the Manuherekia in relation to flood management and the protection or enhancement of instream values. Input included particular locations identified for leaving willows in place, or removing them, as outlined below and in Figure 5.

Areas where willows should be left in place:

From a flood management and mitigation perspective:

- on some outside bends at various locations
- willows have been planted in two locations for bank protection and remediation (by the ORC):
    - upstream from Omakau
    - off Blackstone Hill Runs Road

From an ecological perspective:

- Dunstan Creek – Willows provide habitat for trout, with this creek being a fishery of national importance. It may be better to thin willows out rather than remove them.
- Thomsons Creek – total willow removal upstream of Mawhinney Road to enhance galaxiid habitat, keep willows that are located downstream of Mawhinney Road (but upstream of weirs), as the holes and pools created by these willows provide eel habitat, however tidy up willows in this stretch that have fallen over or are at risk of falling over.[11]
- Could do a tidy up (willows falling over).
- Assess Chatto Creek to see whether willows are providing habitat values.

Removal for ecological perspective:

[11] P. Ravenscroft, ORC, personal communication - note that advice on specific locations in this area should be confirmed with P. Ravenscroft on site.

- Remove any willows above Falls Dam as soon as possible, so that they don't spread and the natural values in this area are retained.
- Along the mainstem below Falls Dam Mainstem down to the confluence with Dunstan Creek.
- Thomsons Creek – remove willows upstream of Mawhinney Road, to enhance galaxiid habitat.
- Remove willows in higher elevation areas.

Ecologically, willows removal should support succession of desired plant species, potentially through transitional planting. Willow might also be managed by thinning them out in some sites.

Central Otago District Council has limited budget to carry out vegetation removal – manages willows primarily to support road safety e.g. within 20m of the centre of bridges for visibility and so that willow leaves don't degrade the surface of the bridge. Would be happy to see increased management of willows throughout the catchment, as long as debris is kept away from flood waters to avoid damage to private and public infrastructure.

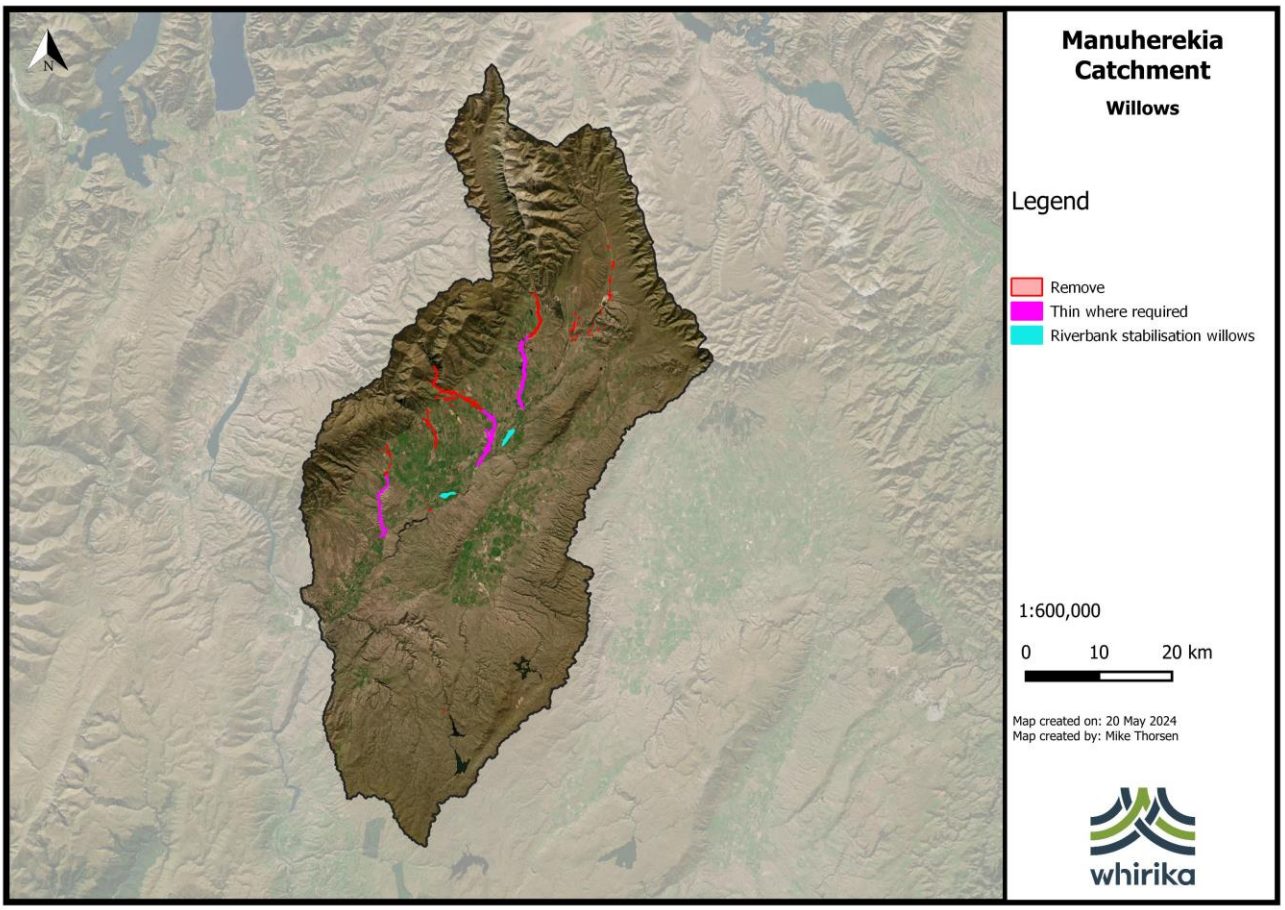

Figure 5. Locations of willows identified by ORC as a priority for removal or thinning to enhance non-migratory galaxid habitat or to retain for riverbank stabilisation purposes.

8 Strategic Approach to willow management in the Manuherekia

8.1 Strategic Options

A strategic approach for willow management across a catchment should respond to clearly stated issue/s and/or outcome/s. At present there are a range of issues and outcomes sought, as can be seen from the Manuherekia ICEP action plan, with no prioritisation of issues or aspirations.

Willow management was selected as a priority focus area in the ICEP action plan because of the potential to address a number of issues and work towards a number of aspirations – this is certainly true for willow removal at different sites (in that willow removal at different sites will address different issues). In some cases, willow removal from a particular site may address multiple issues/aspirations, depending on how removal occurs and how the site is restored/managed after removal.

A matrix approach is utilised below to highlight the range of different issues and outcomes that may be addressed at particular sites, to help prioritise site selection. This matrix is intended as a guide for initial site selection - further investigation of these sites will be necessary, as there are a range of other considerations that will impact feasibility and outcomes. These more practical, often interlinked considerations include:

- All sites need to be checked for impact on flood risk (flood risk was outside of the scope of this assessment, and is not included in the matrix below)
- Landowner approval – landowner support where a site is privately owned can simplify a process considerably, while obtaining approvals from agencies such as LINZ and DOC can take considerable time.
- Community buy-in - there may be strong support from willow removal at a particular site.
- Method of removal required, and complexity involved e.g. access to site, size and density of trees.
- Consent requirements (and associated costs and complexity).
- Budget constraints and the cost of removal at particular sites.
- Visibility – doing work on sites may meet many of the criteria but could be hidden from view - there can be benefits in carrying out work with higher public visibility – can lead to uptake by other community members, buy-in from community.

The matrix in Table 2 provides an overview and prioritisation of potential sites for willow removal when assessed against the objectives in this strategy. Discussion of willow removal to achieve key objectives is outlined in more detail in the following sections and include:

- Total removal of willows from riparian and wetland areas of the catchment (with potential increase in water yield, biodiversity enhancement).
- Total/near total removal of willow from sub-catchments/stream catchments (with potential increase in water yield, biodiversity enhancement).

- Changing flood behaviour (based on observations only, as the scope of this project has not included a flood risk assessment).
- Removal from high importance biodiversity areas.
- Transition to community resource (recreation, amenity, connection to river).
- Improving willow and river management
- Rectifying emerging issues.

Table 2. Strategic overview of value of outcomes from potential willow work areas in the Manuherekia Catchment. Work areas ranked in probable value earned in undertaking the project. Note that this matrix does not consider flood risk/benefit of willow management as it was outside of the scope of this assessment. See Figure 6 for location and extent of work areas.

Type of area/ site	Wetland/ riparian biodiversity	In-stream biodiversity	Increasing instream flows	Community use / connection	Amenity Values	Learnings	Value[12]
Thomsons Creek (upstream of Mawhinney Road)	Moderate	High	High	High	Moderate	Moderate	15
Poolburn Gorge	Moderate	Moderate	Low	High	High	High	14
Alexandra willow jungle	Moderate	Low	Low	High	High	High	13
Omakau willow jungle	Moderate	Low	Low	High	High	High	13
Dunstan Creek	Moderate	High	High	Moderate	Low	Moderate	13
Lauder Creek	Moderate	Moderate	High	Moderate	Low	Moderate	12
Chatto and Young Hill Creeks	Moderate	Moderate	High	Moderate	Low	Moderate	12

[12] Sum of priority scores

Type of area/ site	Wetland/ riparian biodiversity	In-stream biodiversity	Increasing instream flows	Community use / connection	Amenity Values	Learnings	Value[12]
Ida Valley lowlands	Moderate	Moderate	High	Moderate	Moderate	Low	12
Above Falls Dam and headwaters arising in Hawkdun Range (down to SH85)	High	High	Moderate	Low	Low	Low	11
Little Valley	High	High	Moderate	Low	Low	Low	11
Manorburn	High	High	Moderate	Low	Low	Low	11
Ida Valley wetlands	High	Moderate	Low	Moderate	Low	Low	10
Significant wetlands	High	Moderate	Low	Low	Low	Low	9
Manuherekia River main stem	Low	Low	Moderate	Moderate	Moderate	low	9
Home Hills	Moderate	Moderate	Low	Low	Low	Low	8
Dip Creek	High	Low	Low	Low	Low	Low	8

Type of area/ site	Wetland/ riparian biodiversity	In-stream biodiversity	Increasing instream flows	Community use / connection	Amenity Values	Learnings	Value[12]
Rough Ridge headwaters	Moderate	Moderate	Low	Low	Nil	Low	7

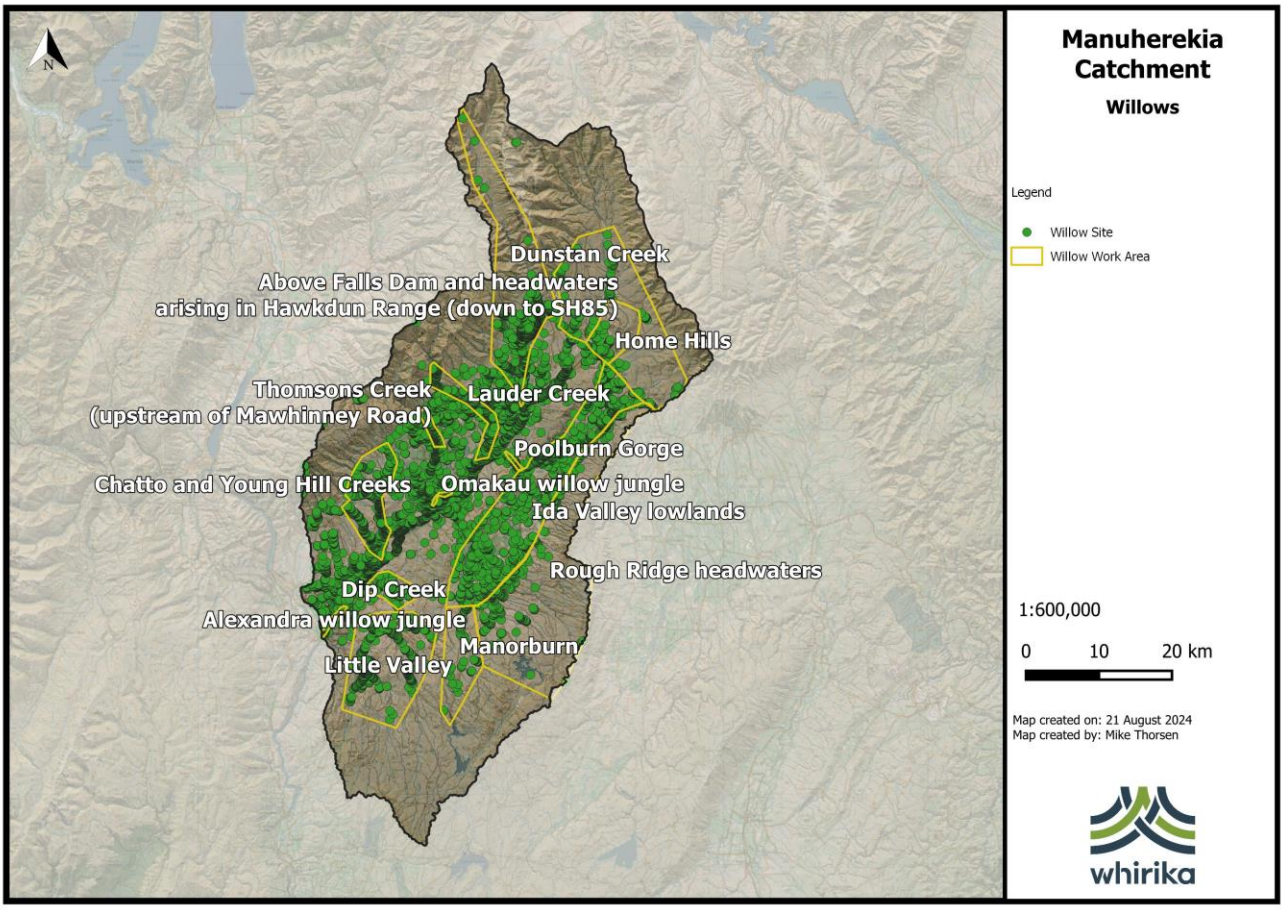

Figure 6. Location of willow work areas listed in Table 2. Manuherekia main stem work area not mapped for clarity. Significant wetland work areas are mapped as 1a in Figure 7.

8.2 Objective A: Total removal of willows from riparian and wetland areas of the catchment

Total removal of willows from the riparian and wetland areas of the Manuherekia Catchment excepting areas where willows are required to maintain bank stability would be a large and long-term project that would only be considered if there are clear outcomes from pursuing this option.

The strongest driver for pursuing this objective is to increase water quantity throughout the catchment, although the potential increase resulting from removal of riparian willows is not known, and difficult to estimate based on the currently available science.

Therefore, the first step in considering this option would be to commission research on the effect of willow removal to both in-stream and subsurface flows relative to both an unvegetated river margin and a restored native riparian forest. If this research shows that there is merit in removing willows then a coordinated willow removal plan should be developed based on this document, a lead agency identified, resources assigned (possibly through a targeted rate), and implementation of a biosecurity programme to ensure that willows and other weeds do not return (or are removed soon after they return).

8.3 Objective B: Total/near total removal of willow from sub-catchments/stream catchments.

Removal of willow from sub-catchments could provide possible increases in water quantity, plus also biodiversity benefits (these benefits would depend on which sub-catchment is involved). The feasibility of removing willows from a sub-catchment will be dependent on the agreement and motivation of the landowners in that catchment. There are few technical limitations to removal of willows at sub-catchment scale and the largest barrier is cost, which is strongly dependent on the extent of the infestation and the method of removal.

The lowest cost removal technique is aerial spraying and leaving dead trees to naturally break up. This may need to be undertaken in a stage manner (working from upstream down) to reduce the amount of debris from dead trees (breakdown debris) flowing down waterways.

Initially this breakdown debris will mostly be small, but later (years 3 onwards) it will increasingly include larger branches that fall from the trunk. A programme of removal by whole tree excavation (together with root mass) using an excavator, winching/moving trunks onto the riparian area outside of flood zone is possible but is only possible at sites where heavy machinery can access and also would cause considerable disturbance to the stream bank and stream bed. Felling and then winching the trees reduces this disturbance, but increases the cost and, if done more than a year or so post poisoning, has further safety implications around felling under a canopy of dead branches.

If willows are being retained at sites in the catchment for purposes such as stream bank stabilisation or as shade for stock then surveillance is needed to remove any new willows originating from retained trees.

8.4 Objective C: Changing flood behaviour

Willows can affect flood behaviour through hydraulic damming, particularly in areas of dense tall trees and even more so if there is a high component of tree fall at the site or upstream (which is swept into standing trees creating a ‘beaver dam’) causing flooding of upstream pasture. The Poolburn Gorge is one area where this is thought to occur. Areas with similar physical characteristics (but less extensive willow infestation) are Lauder Gorge and the entrance to the Tiger Hill gorge.

Another area of concern is the bend in the Manuherekia River which is showing signs of accelerated bank erosion on the TLHS which could allow the Manuherekia to revert to an old bed which would put areas of Ophir township at risk. This bend is being actively planted with willows, but removal of willow on the river bank and flats opposite may assist the river in straightening its course.

8.5 Objective D: Removal from high importance biodiversity areas

8.5.1 Priority 1a to 1c - wetlands

Willow can have a detrimental effect on some important elements of biodiversity. In particular willows can transform wetlands as they can inhabit all areas of wetlands and shade out the lower-growing indigenous vegetation. For this reason, removal of willows from wetlands, especially Regionally Significant wetlands is the highest priority under this option. The willows along Hill's Creek and Gorge Creek fit here as the bed of these creeks appear to have a range of natural vegetation, including probable wetlands. These willows have been given a priority of 1c.

The locations of Priority 1 willows are shown in Figure 7, Figure 8, Figure 9. Priority 1a willows cover c. 7.4 ha and are located at the head of the lower Manorburn Dam, at the base of Long Gully near Alexandra, and near the Poolburn Reservoir. Priority 1b willows cover 26.7 ha and are located along Crawford Hills Road, lower Springvale Creek, in the mid-reaches of Moa Creek, in the southern Ida Valley, at Falls Dam, near Hills Creek, on a tributary of Pleasant Valley Creek, and in upper Williamsons Creek. Priority 1c willows cover 14.2 ha in the Hills and Gorge Creek areas of the Ida Valley.

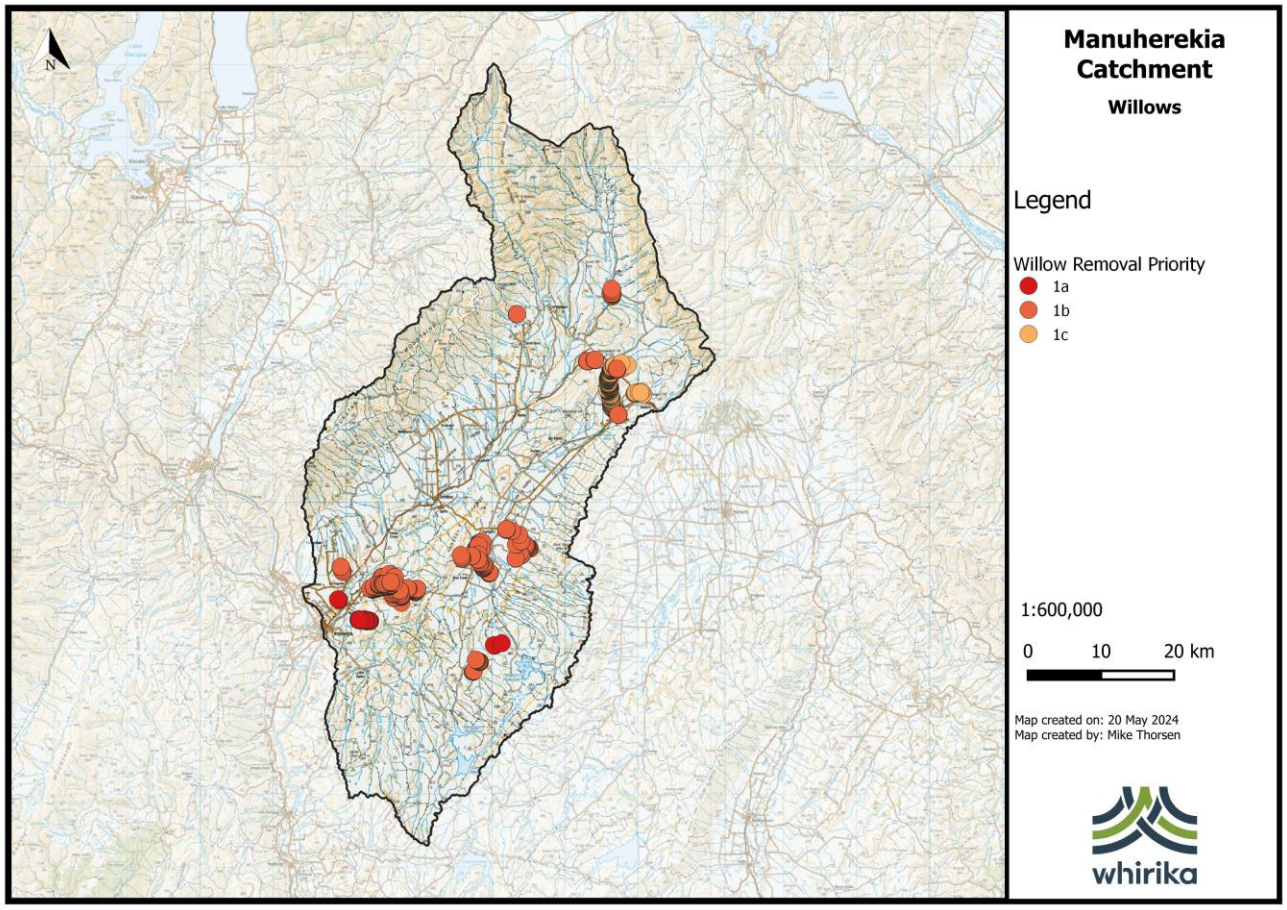

Figure 7. Location of Priority 1 willow infestations.

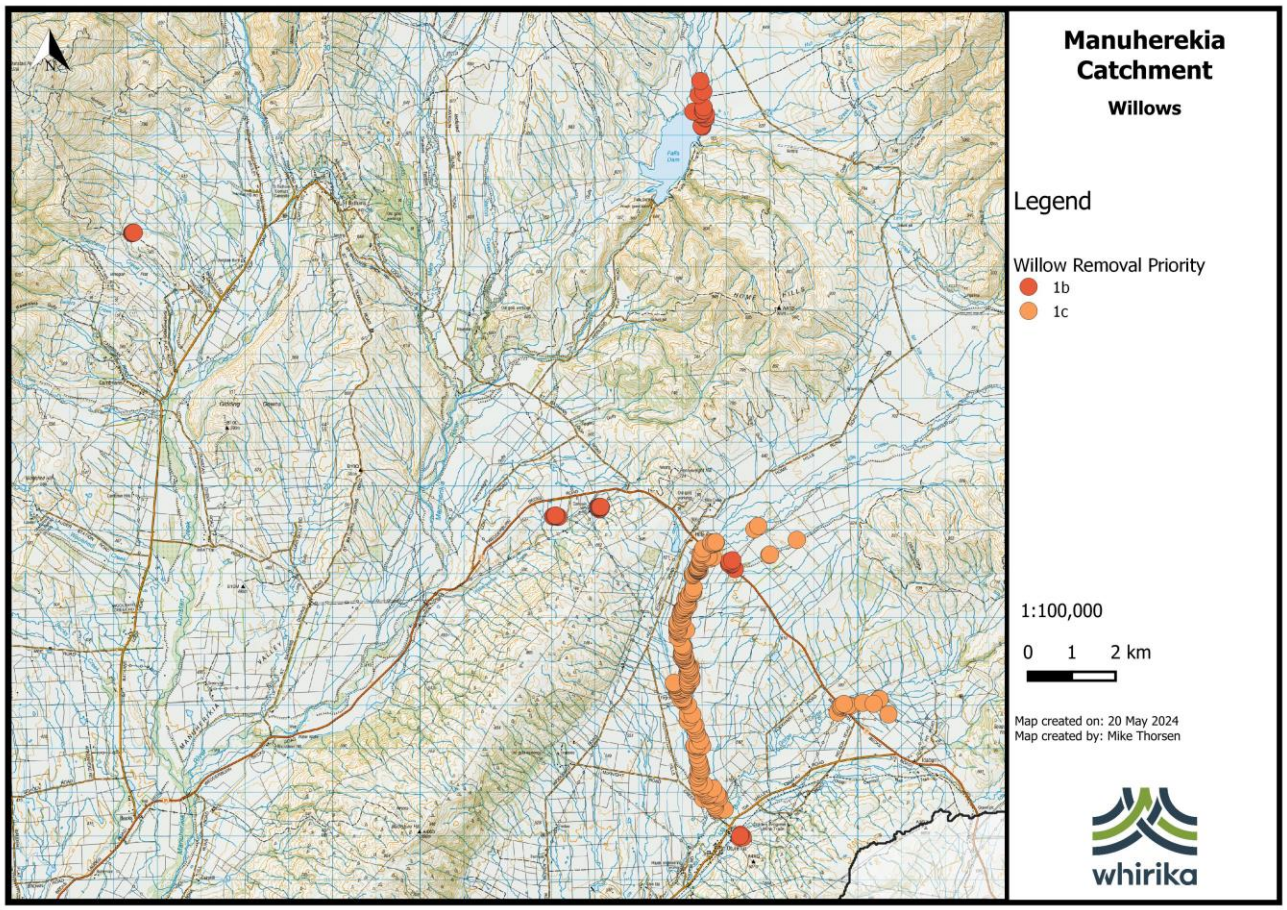

Figure 8. Closer view of Priority 1 willows in the northern area of the Manuherekia Catchment.

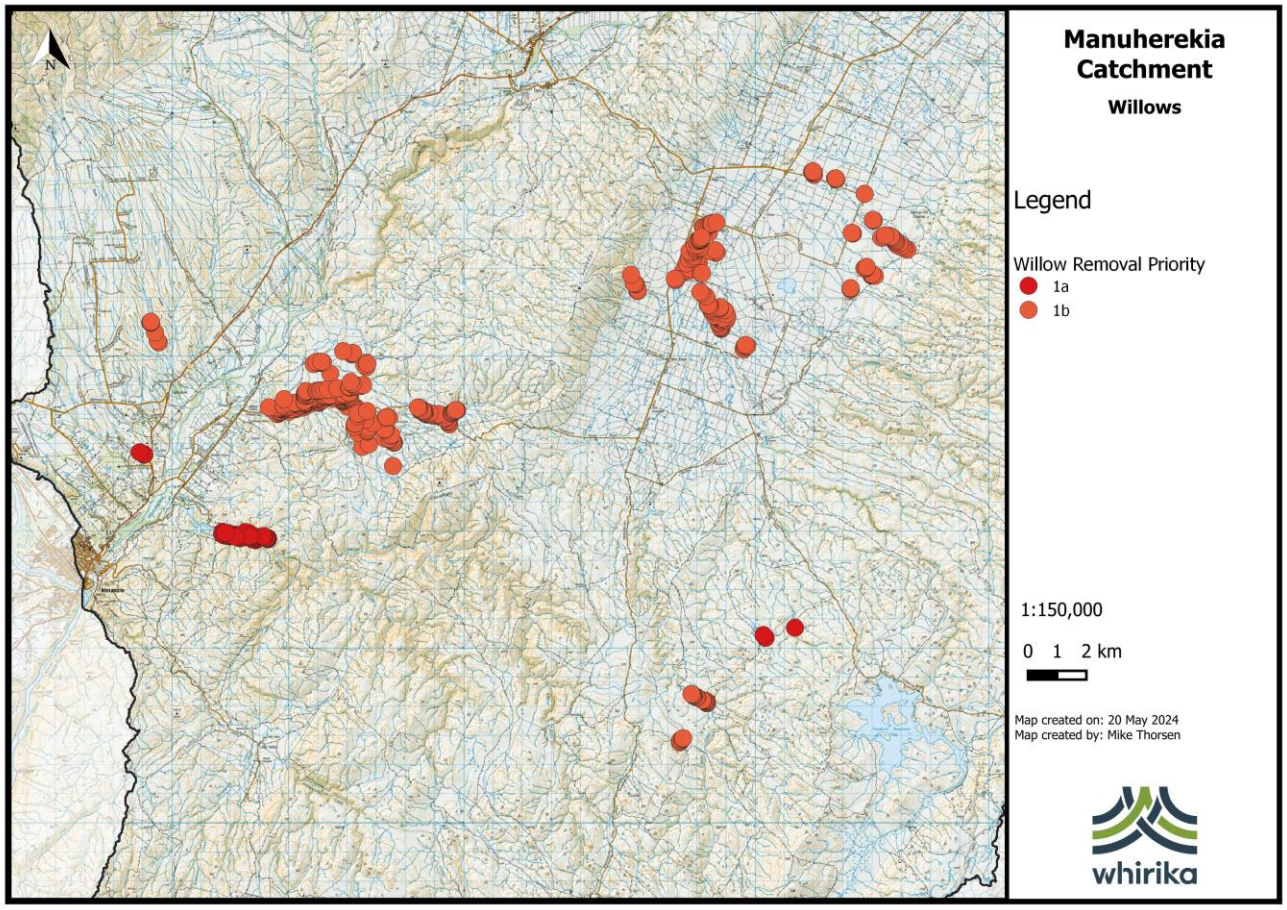

Figure 9. Closer view of Priority 1 willows in the southern area of the Manuherekia Catchment.

8.5.2 Priority 2a & 2b - higher elevations

Willows along the open banks of upland waterways displace indigenous shrublands and tussocklands and shade out herbaceous riparian vegetation. Seasonal willow litterfall also changes local instream phytoplankton and invertebrate communities. Willow spread reduces with increased elevation and spread seems to be limited above 600 m a.s.l. However, under an increasingly warmer climate the upper elevation at which willows thrive will also increase. The higher elevation areas are where much of Otago's biodiversity remains and therefore the spread of willows in these areas would become an issue. For this reason, removal of willows from higher elevations is the next highest priority. The willows in the area upstream of Alexandra to Ranfurly road and St Bathans is the higher priority due to the abundance of biodiversity values in this area and have been given a priority of 2a.

The locations of Priority 2 willows are shown in Figure 10. Priority 2a willows cover c. 4.8 ha and are located in the Home Hills, Johnstone Creek, upper Manuherekia River above Falls Dam, near the Scandinavian Water Race, Dunstan Creek and in two areas of the upper Ida Burn. Priority 2b willows cover c. 29.5 ha mainly on the western slopes of the Rock and Pillar Range, in Speargrass and Bickerstaffe Creeks in Little Valley, in Dip Creek and sites on the Raggedy Range (particularly in the

vicinity of the Ida Valley - Omakau Road and in Lauder Creek, upper Thomsons Creek, Welshmans Gully and Shepherds Creek of the Dunstan Mountains.

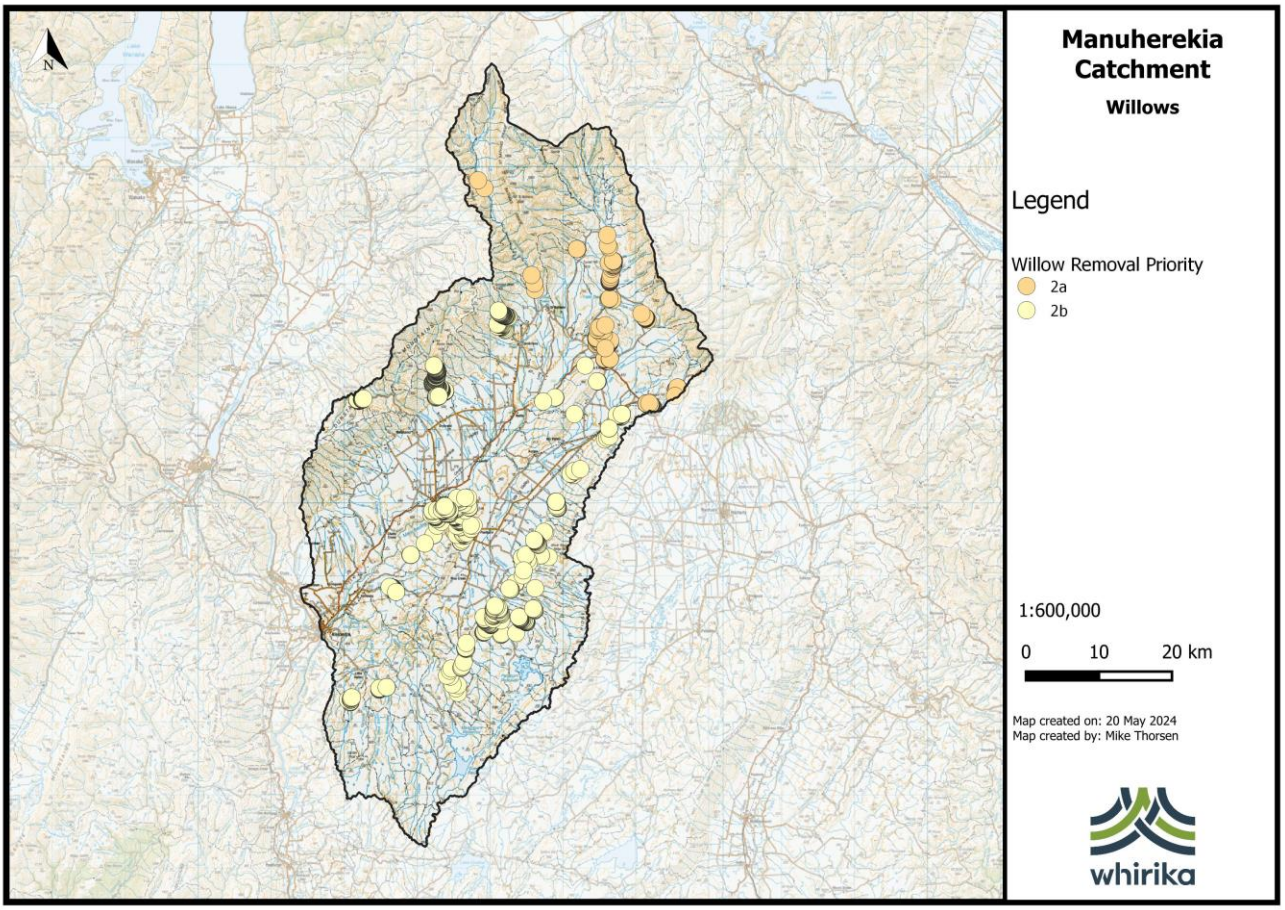

Figure 10. Location of Priority 2 willow infestations.

8.5.3 Priority 3 - riparian areas, forests and shrublands within protected areas

Reducing the impact of willow on riparian areas, forests and shrublands within protected areas (Department of Conservation administered reserves and covenants and Queen Elizabeth II Covenants) is the next highest priority. This will require a site-by-site evaluation in conjunction with QEII and the Department of Conservation.

The locations of Priority 3 willows are shown in Figure 11. Priority 3 willows cover c. 383 ha and are located at multiple locations along the Central Otago Rail Trail, along the Manuherekia River and Ida Burn, around St Bathans and Cambrians, and in the Manor Burn catchment. Important sites from a biodiversity perspective are likely to be those in the Manor Burn Catchment, Noones Road, The Ida Valley Tail Race Reserve, sites on the Ida Burn, Fiddlers Flat Conservation Area, lower Reaches of Dunstan

Creek, Matakanui Conservation Area and Galloway Conservation Area. No willows were mapped as occurring on QEII Covenants.

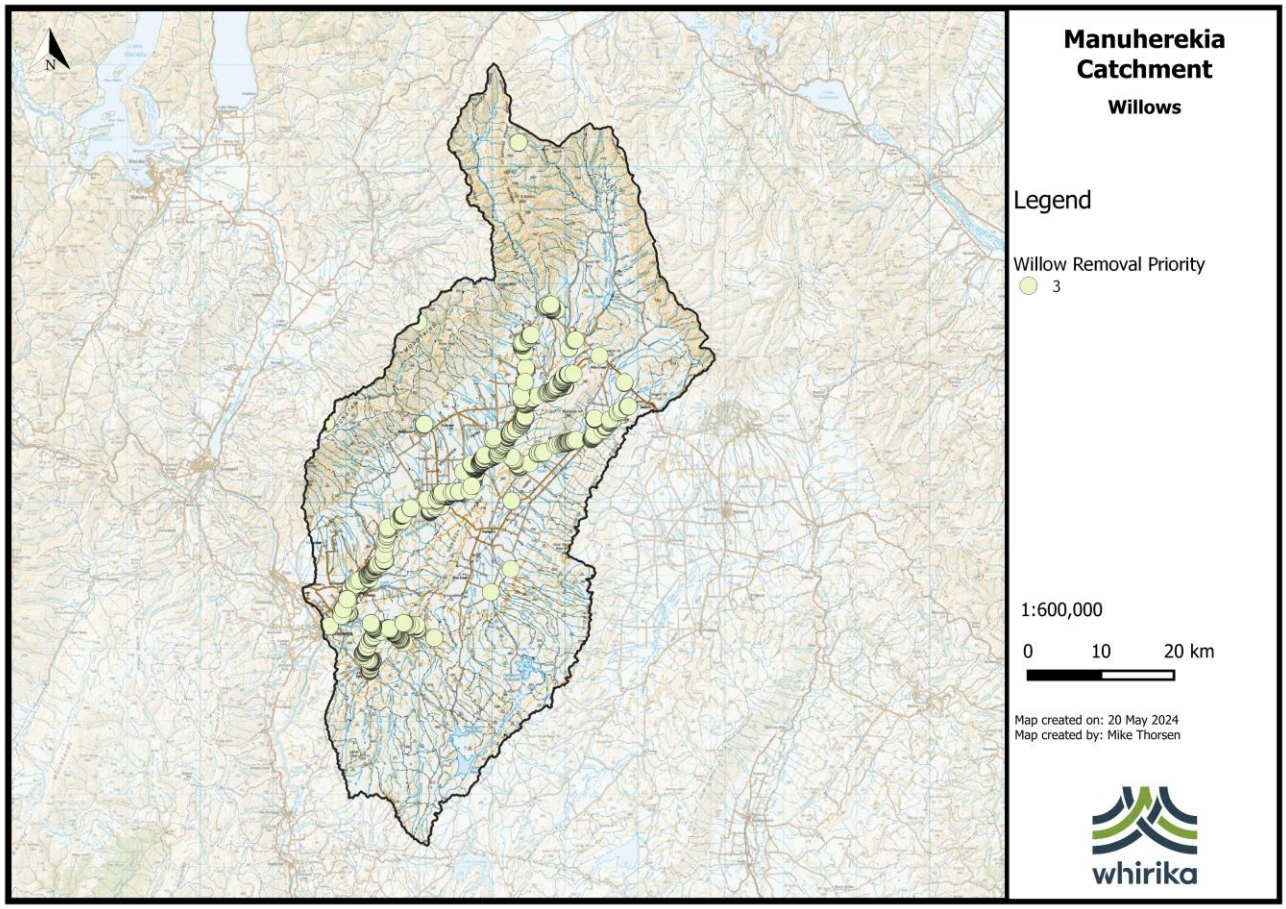

Figure 11. Location of Priority 3 willow infestations.

8.5.4 Priority 4 – significant natural areas and important biodiversity sites

Reducing the impact of willow on important sites such as significant natural areas (SNA) or other important biodiversity site (such as a Naturally Uncommon Ecosystem or habitat of freshwater fish) outside of the protected area network helps maintain the natural value of these sites and is the next highest priority. No willows have been mapped within an SNA that have not been mapped as part of a higher priority. Several areas have been identified by the ORC where willow removal would be advisable to enhance native fish populations. These areas total 46.4 ha and are located at Fiddlers Flat, Station Stream, mid reaches of Dunstan Creek, Lauder Creek area, Thomsons Creek and Chatto Creek as well as Ophir Bridge (Figure 12).

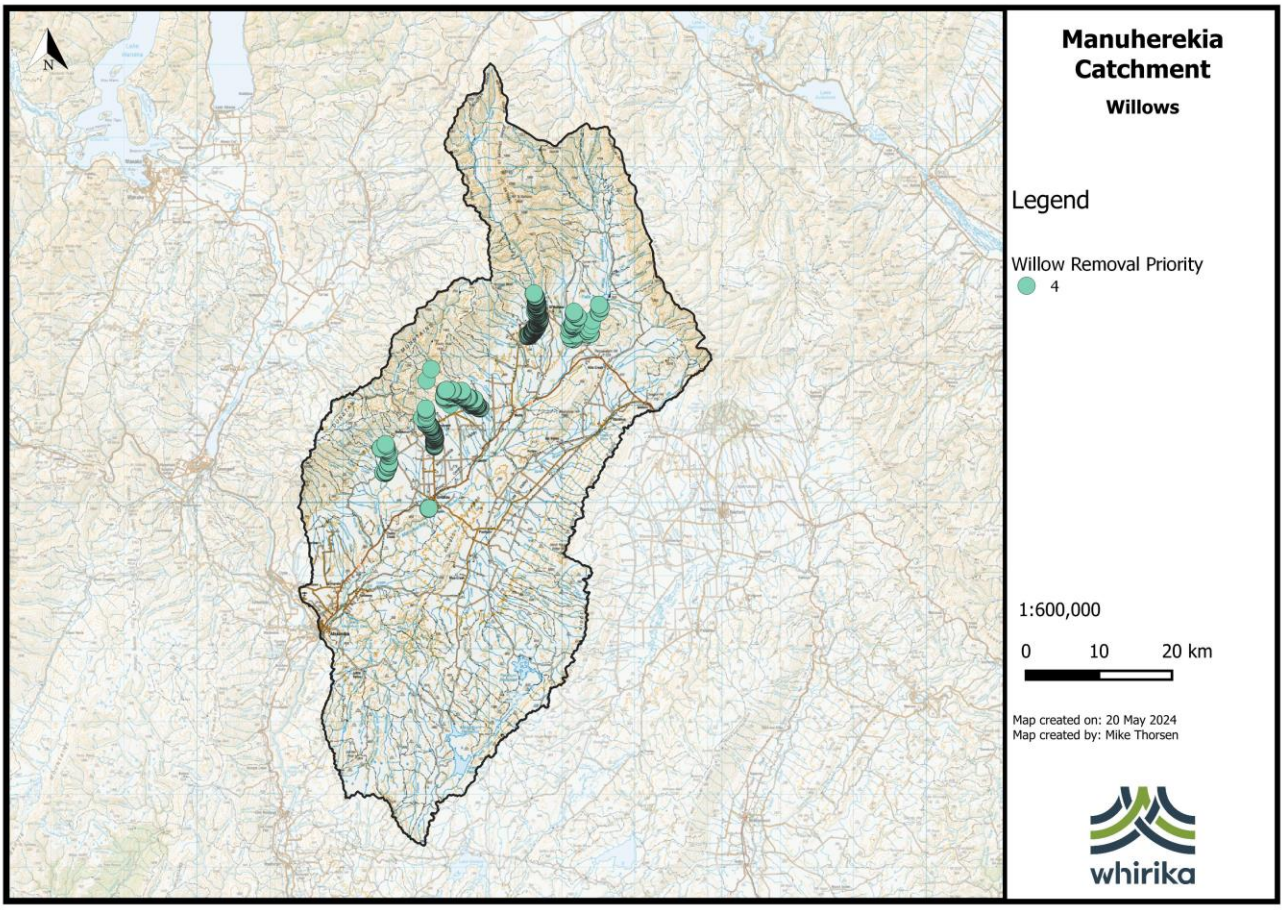

Figure 12. Location of Priority 4 willow infestations.

8.5.5 Priority 5 – Crown Pastoral Land

Crown Pastoral Lease is land leased from the land and is managed, on behalf of all New Zealand, to maintain its biodiversity values. For this reason, willows within natural areas on Crown Pastoral Land is the next highest priority. This will require a site-by-site evaluation in conjunction with the lessee and Land Information New Zealand.

The locations of Priority 5 willows are shown in Figure 13. Priority 5 willows cover c. 24.8 ha and are located mainly on Dunstan Burn, Mt St Bathans, Moutere Station, Galloway Station, Little Valley, Mount Campbell, and Matangi Pastoral Leases.

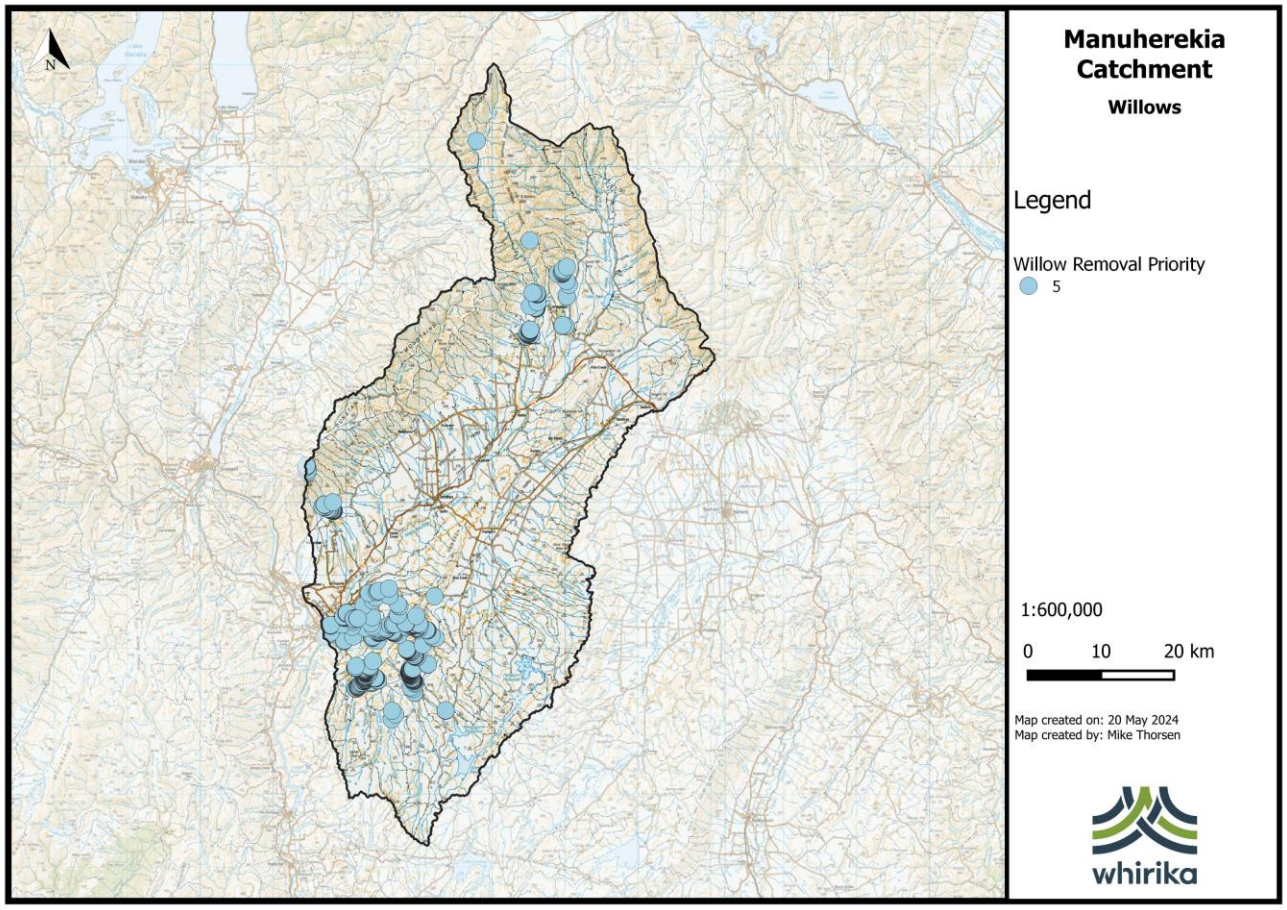

Figure 13. Location of Priority 5 willow infestations.

8.6 Objective E: Transition or removal for recreational and amenity purposes

Shaded recreation areas are a scarce resource in sun-blasted Central Otago. The willow jungles on the banks of the Manuherekia River at Omakau and Alexandra are a recreational resource that could be transformed into a valued recreational resource with added biodiversity value by transitioning the existing willow jungle into indigenous forest (kānuka, kowhai and totara mainly) by under planting the willows and then sequentially kill individual willow trees and leave these standing excepting where they overhang a recreation asset such as a track or building.

Willow removal within the Poolburn Gorge has been identified by the Ida Valley Catchment Group as a priority site to improve amenity (including visibility of the river) and potentially also improving access to the river within the gorge. A site-specific assessment of willow removal impacts on freshwater ecology has been undertaken for the gorge (McMurtie & James, 2024) – this also highlighted the need for a planting plan for the area after removal, and weed and pest management.

It is likely that other areas can also be transitioned into a more biodiverse natural area, either through transitioning or by clearing and replanting. These areas will be selected on the basis of landowner demand.

8.7 Objective F: Learnings - improving willow and river management

Willows are increasingly seen as a problem in New Zealand catchments, especially in drier eastern areas and those with braided river types. There is an emerging body of information on the impacts of willows (both positive and negative) and how willows and rivers are managed for multiple outcomes including community resilience, economic return, cultural and amenity value and for protecting and enhancing biodiversity.

The Manuherekia River catchment is one of the Ministry for the Environment's Exemplar Catchments created to showcase methods for improving water quality. Aspects of the willow removal programme that have the ability to showcase new approaches are removing willow from difficult terrain in the Poolburn Gorge, removal of establishing willow and willow-like tree species, transitioning willow 'jungle' to native riparian forest, and measuring improvement in water quantity following removal of willow infestation.

8.8 Objective G: Rectifying emerging issues

During this project two areas of willow and willow-like tree infestation were identified that will be likely to affect waterways through congestion of historically open riverbed areas and riparian areas. A small grove of what appears to be osier (*Salix viminalis*) is being used to stabilise a road bank near Lauder. This lower-growing species is known to colonise river gravels in the Hawke's Bay (and probably elsewhere). A small, but actively spreading, grove of willow-like grey poplar (*Populus* x*canescens*) is present near the Chatto Creek confluence with the mainstem where it appears to be spreading along a bank. Necklace poplar (*Populus deltoides*) is actively seeding into gravel flats of the Manuherekia River near Becks, something this species is prone to doing.

These populations are currently small enough to make removal feasible. Removing the necklace poplar infestation should also include identifying the adult seed source trees and removing these. A watching brief should be kept on the use of Osier (and the similar bitter willow) in the catchment and their use should be discontinued and any plants removed if it is showing signs of spreading from the current planted area.

9 Getting Started

Based on the information in this document, working through the questions below will assist in planning and undertaking willow removal work.

What is the objective/issue you are addressing?

Being clear on the objective or issue you want to address will help determine what to prioritise. There may be several objectives/issues, and in some cases willow removal from a particular site may addresses multiple objectives/issues (refer to Sections 1, 4.5 and 8).

Is it safe to remove willows?

Consider whether willows are providing bank stability that is important to protect infrastructure (See Section 5.3) or where removal debris may provide a downstream hazard (Section 5.4).

What is your plan for the site after willow removal?

Removing willows, even though it is removing exotic invasive and unwanted plants, may result in some adverse effects to the riparian zone and/or in-stream habitat in the short-term e.g., other weeds may invade and dominate. Depending on the objective of willow removal, it may be appropriate to plan for site restoration (such as native planting) while in other cases staged and/or selective willow removal may be appropriate e.g., this may be an appropriate method for transition/restoration of native vegetation as it would incur less ecological disruption and would promote native understorey if present. (Refer to Section 5.5).

Who is/are the landowners?

If the land is privately owned, you will need landowner agreement and buy-in to the project. Work with the landowner to draw on their local knowledge and understand their preferred approach to willow removal.

If multiple sites are identified for willow removal on LINZ and DOC managed land, work to obtain a community agreement from DOC and/or an access letter from LINZ (refer to Section 3.5 to 3.7). If other nearby catchment groups are also engaged in willow removal work, draw on their experience with these agencies, or consider working jointly to obtain these approvals.

How should the willows be removed?

This requires a site-specific assessment to minimise any potential adverse effects of removal. It also depends on access to the site, the size/age of the willows and the size of the infestation, as well as any landowner preferences. Start by talking to the ORC river engineers and getting an experienced contractor on site to understand how willows should be removed. You can also talk to other catchment groups who have carried out willow removal.

Young willows or isolated trees may be hand sprayed or drilled (refer Section 5.2), while aerial application of herbicide (by helicopter or drone) is the most cost-effective method for large infestations. Spraying before mechanical removal is carried out as living fragments of crack willow (and other willow, alder, or poplar species) are capable of resprouting if in contact with the ground.

Stands of large trees in areas where there is concern that debris could be a flood hazard (refer to Section 5.4.) should be felled once dead and either chipped on site (some machines can chip standing trees) or hauled away outside of the flood zone. Ideally this should occur within one year of spraying to prevent dead trees or branches becoming debris.

Will the work require consent?

Willow removal which will result in the disturbance of the bed of a waterway, or which will result in a noticeable increase in local sedimentation in the waterway will require consent (refer to Section 6).

This means that mechanical removal away from the bank of a waterway and spraying of willows are often permitted activities.

Once the method of removal has been identified talk to the ORC to check whether consent is required. Rules around willow removal may change as a result of the Land and Water Regional Plan, so it is important to check this with the ORC.

Planning and resourcing the work

Once prioritisation of objectives have been clarified by the Living Manuherekia project, a management plan can be used to guide the actions required for each of the management areas.[13]

Resourcing of the work (particularly at scale across the catchment) will likely require commitment from local and regional council. An example of such a scheme is Environment Canterbury's River berm transition programme.[14]

[13] See for an example: https://www.hurunui.govt.nz/repository/libraries/id:23wyoavbi17q9ssstcjd/hierarchy/Support_Services/Strategies/Waipara%20River%20Management%20Strategy%202012

[14] https://www.ecan.govt.nz/your-region/your-environment/river-and-drain-management/climate-resilience-and-flood-protection-funding/regionwide-planting-and-berm-transition/

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