MAHINGA KAI AND ECOLOGICAL RESTORATION PLAN – MCKINNONS CREEK, RANGITATA RIVER, SOUTH CANTERBURY

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Lower reach of McKinnons Creek, South Canterbury. 8 July 2021

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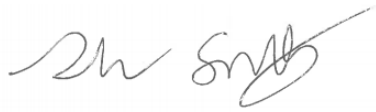

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1. INTRODUCTION

The Rangitata River and its catchment have been identified as a priority under the Department of Conservation Nga Awa source to sea restoration programme[1]. The programme will provide a multi-agency approach to managing the Rangitata River. The agencies involved include the Department of Conservation, Te Rūnanga o Arowhenua, Fish and Game – Central South Island Lakes, Ashburton District Council, Timaru District Council and Environment Canterbury and they have formed a steering group (the Rangitata Steering Group) to oversee the restoration work. The Rangitata Steering Group has identified six sites within the lower Rangitata River catchment as initial priorities for restoration, and commissioned Wildland Consultants Ltd to develop high level ecological and mahinga kai restoration plans for these sites.

This report provides a restoration plan, to be implemented over a four-year timeframe, for the McKinnons Creek site. This stream is a spring-fed tributary situated on the south side of the Rangitata River, approximately two kilometres upstream from the river mouth/hapua. Wildlands has prepared similar plans for the five other Rangitata sites: Coldstream 1, Coldstream 2, Rangitata Hāpua, Ealing Springs, and the main stem of the Rangitata River.

2. SITE GOALS

Overarching project goals and objectives are needed to provide guidance for the ecological restoration of McKinnons Creek. The goals below align with broader overarching goals identified by the Rangitata Steering Group.

2.1 Ecological restoration project goals

- To implement a robust ecological restoration plan that will increase the mauri and ecological integrity of the vegetation and habitat types within the McKinnons Creek site.
- To increase the diversity and abundance of indigenous plant and animals that are important mahinga kai resources at McKinnons Creek.
- To improve the water quality within McKinnons Creek, and maintain this standard in the longer term.
- The integral role that Te Rūnanga o Arowhenua play as kaitiakitanga over the Rangitata River is respected and incorporated in the restoration plan and project.

2.2 Ecological restoration project objectives

By the end of the four-year timeframe of the project, the following will be achieved:

- Detailed ecological surveys have been completed and there is a high degree of understanding regarding the ecological values that are present at the site.

[1] See: https://www.doc.govt.nz/our-work/freshwater-restoration/nga-awa/

- The southern section of the site is fenced and is free of livestock. Negotiations regarding the northern section of the site have been completed and restoration actions are being implemented.

- Feasibility planning for restoring natural riparian features and wetlands (e.g. the installation of weirs and earthworks to create additional riparian wetlands) has been undertaken and where possible, has been implemented.

- The southern section of the site has been planted in indigenous vegetation. This will include vegetation types such as lowland podocarp forest that are rare on the lower Canterbury Plains, as well as those that provide mahinga kai resources for Te Rūnanga o Arowhenua.

- The main threats at the site (e.g. livestock, pest plants and animals) have been identified and are being actively managed in restoration areas in cost effective ways.

- All sources of water pollution (e.g. dairy effluent, sediment run-off) have been identified and mitigation actions are being implemented along the length of the project site.

- At least one presently absent Mahinga kai species has been translocated to the site following Department of Conservation protocols and Te Rūnanga o Arowhenua tikanga.

- Ongoing management decisions are informed by a robust monitoring programme that is implemented at appropriate timeframes.

- The ecological importance of the site is highlighted to the wider community through public engagement (e.g. volunteer planting days, website updates).

3. SITE VISIT

Ecological and mahinga kai values, threats and restoration opportunities that are present at McKinnons Creek were identified by the Rangitata Steering Group and provided as written summaries.

Additional information was gathered during a site visit and meeting on 8 July 2021. Participants included two Wildlands ecologists, representatives from the Department of Conservation, Te Rūnanga o Arowhenua, and Environment Canterbury. The purpose of the meeting was to discuss the key attributes and opportunities for restoration at McKinnons Creek. Only the large wetland and downstream reach were visited. McKinnons Creek was not surveyed during the site meeting but vegetation types and habitats, potential restoration areas, and pest plants were mapped on aerial photos. The vegetation and habitats within unsurveyed areas were mapped using recent aerial photos and Google Earth imagery.

4. SITE DESCRIPTION

McKinnons Creek consists of a spring-fed stream situated on the south bank of the Rangitata River about two kilometres from the mouth (Figure 1). The stream is *c*.500 meters in length and flows in a south to south-east direction though two irrigated dairy farms. Land tenure is a mix of grazing concession (Department of Conservation) and private land. A salmon hatchery is located at the mouth of the creek near the confluence with the Rangitata River. The potential restoration site extends from the salmon hatchery to the spring at the head of the creek.

5. ECOLOGICAL VALUES

5.1 Vegetation and habitat types

Seven vegetation and habitat types were identified during the site visit. Further field surveys are needed to identify additional vegetation and habitats, and the species they contain at the site. The vegetation and habitat types are listed below, and further descriptions are provided in Appendix 1.

1. Indigenous shrubland and sedgeland.
2. Crack and grey willow forest.
3. Poplar/willow treeland.
4. Exotic scrub and shrubland.
5. Exotic grassland.
6. Stream.
7. Ponds.

5.2 Notable habitat

Spring-fed streams are important aquatic habitats in braided river systems. They seldom flood and therefore have greater algal and aquatic plant growth, which supports higher overall biodiversity (Instream 2019). This habitat type is relatively rare in the lower Rangitata River catchment.

5.3 Notable flora

McKinnons creek appears to retain a low diversity of indigenous plant species. As such, no notable indigenous plant species were recorded at the site during the site visit. However, due to the limited area surveyed during the site inspection, it is still possible that Threatened or At Risk[1] indigenous plant species may still persist at the site.

5.4 Avifauna

Twenty-eight indigenous and 15 exotic bird species were recorded on eBird within 10 kilometres of the McKinnons Creek site (species listed in Appendix 2). Two species listed as Threatened (as per Robertson *et al*. 2021) have been recorded near the mouth of the Rangitata River: tara piroe/black-fronted tern (C*hlidonias albostriatus*;

[1] As per de Lange *et al*. (2018).

Threatened – Nationally Endangered), and taranui/Caspian tern (*Hydroprogne caspia*; Threatened – Nationally Vulnerable). These species will predominantly utilise the braided river area. A further nine species that are listed as At Risk have been recorded near the site: tūturiwhatu/banded dotterel (*Charadrius bicinctus bicinctus*; At Risk – Declining), tōrea/South Island pied oystercatcher (*Haematopus finschi*; At Risk – Declining), torea pango/variable oystercatcher (*Haematopus unicolor*; At Risk – Recovering), tara/white-fronted tern (*Sterna striata striata*; At Risk – Declining), tarāpuka/black-billed gull (*Larus bulleri*; At Risk – Declining), tarāpunga/red-billed gull (*Larus novaehollandiae scopulinus*; At Risk – Declining), karuhiruhi/pied shag (*Phalacrocorax varius varius*; At Risk – Recovering), little shag (*Phalacrocorax melanoleucos brevirostris*; At Risk – Relict) and kawau/black shag (*Phalacrocorax carbo novaehollandiae*; At Risk – Relict). South Island pied oystercatcher and black shag are likely to be present, at least periodically, at the McKinnons Creek site. Variable oystercatcher, red-billed gull, white-fronted tern, and pied shag are highly unlikely to be seen within the McKinnons Creek site. Banded dotterel and black-billed gull may periodically use pastoral land to forage, and banded dotterel may breed in short grassland (Heather & Robertson 2015).

Although matuku/Australasian bittern (*Botaurus poiciloptilus;* Threatened – Nationally Critical), koitareke/marsh crake (*Porzana pusilla affinis*; At Risk – Declining), and pūweto/spotless crake (*Porzana tabuensis*; At Risk – Declining) were not detected in the eBird search, these species may be present in the peripheral wetland areas. These species are highly cryptic and difficult to detect. They are sparsely yet widely distributed in wetlands that have areas of raupō (*Typha orientalis*), *Carex* and reed beds (Heather & Robertson 2015).

5.5 Freshwater fauna

A search of the NZFFD and associated literature (Bonnett 1986) found records for four indigenous fish species from McKinnons Creek (threat status as per Dunn *et al*. 2018):

- Common bully (*Gobiomorphus cotidianus*; Not Threatened).
- Longfin eel (*Anguilla dieffenbachii*; At Risk – Declining).
- Shortfin eel (*Anguilla australis*; Not Threatened).
- Giant bully (*Gobiomorphus gobioides*; At Risk – Naturally Uncommon).

Fish and Game monitoring have recorded two additional species in recent years:

- Kanakana/lamprey (*Geotria australis*; Threatened – Nationally Vulnerable).
- Black Flounder (*Rhombosolea retiarii*; Not Threatened).

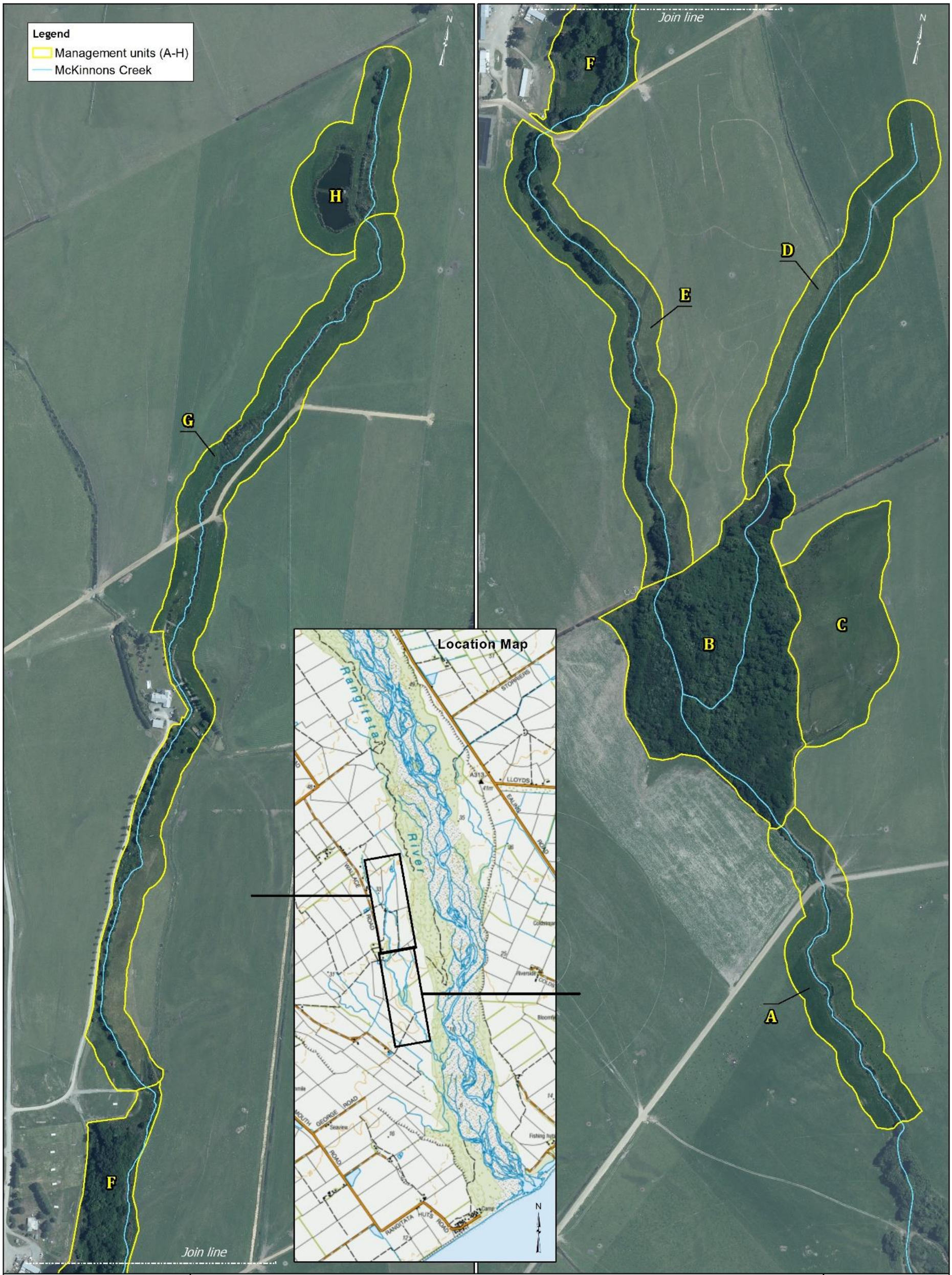

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Figure 1. Management units at McKinnon's Creek, Rangitata River, South Canterbury

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6. CULTURAL VALUES

6.1 Significant sites

Kawauraki, a significant cultural site, is located at the headwater spring of McKinnons Creek.

6.2 Mahinga kai species

Te Rūnanga o Arowhenua identified five indigenous and one exotic plant, one indigenous bird, three freshwater fish, and one indigenous freshwater mussel species as significant mahinga kai resources that could be restored or reintroduced at McKinnons Creek. These species are listed in Appendix 3. Testing of mahinga kai to ensure safety should be conducted before harvest (e.g. heavy metal contamination of freshwater mussels or watercress).

7. ECOLOGICAL THREATS

7.1 Changes in hydrology or channel modification

Protecting and maintaining the hydrodynamic integrity and connectivity are critical to maintaining the freshwater values of McKinnons Creek. Primary threats to these include changes in water flow from water extraction or altered rainfall, direct modification of the channel (i.e. from drainage and infilling), pollution from adjacent agricultural land, and changes in hydrology and dynamics from pest plants.

McKinnons Creek is protected from direct modification of the channel or reduction in flow under the Rangitata River Water Conservation Order (2006). However, drains in the adjacent pastural land have the potential to adversely affect the overall hydrology of the creek and wetlands within the system. There is a lack of knowledge regarding the upstream linkages of the McKinnon's Creek system, and it is possible that water extraction and changes in land use within the broader Rangitata River catchment may adversely affect water flow within McKinnons Creek in the future.

7.2 Water quality

Water quality in the McKinnons Creek system reflects the impact of effluent and fertiliser runoff from adjacent agricultural land (Instream 2019). Monthly water quality monitoring undertaken by Environment Canterbury indicates low dissolved reactive phosphorus (DRP) concentrations, but very high concentrations of nitrogen and elevated *E. coli* (*Escherichia coli*) counts (Instream 2019; Table 1). Fine sediment inputs have also increased. Spring-fed streams are particularly susceptible to fine sediment deposition and land runoff, because they lack regular floods to flush out sediments (Instream, 2019). Most nutrient and sediment inputs are from non-point sources, with only one known point source discharge, a water race that runs from a dairy shed on the upstream reach. In addition, the elevated nitrogen levels and the lack of stream shading are likely contributing to the growth of aquatic weeds, which may result in episodic releases of sediments during heavy rain events.

Table 1: Water quality in the McKinnons Creek system (data sourced from LAWA, 2022).

Water Quality Indicator	Five Year Median	State	Trend
E. coli	210n/100ml	In the worst 50% of all sites; Attribute Band D	Likely improving
Suspended fine sediment (clarity)	5.17 metres	In the best 25% of all sites; Attribute Band A	Not assessed
Suspended fine sediment (turbidity)	0.4 NTU	In the best 25% of all sites	Likely degrading
Total nitrogen	4.6 mg/L	In the worst 25% of all sites	Very likely improving
Total oxidised nitrogen	4.5 mg/L	In the worst 25% of all sites	Very likely improving
Dissolved inorganic nitrogen	4.505 mg/L	In the worst 25% of all sites	Very likely improving
Ammoniacal nitrogen	0.005 mg/L	In the best 25% of all sites; Attribute band A (toxicity)	Very likely improving
Nitrate nitrogen	4.5 mg/L	In the worst 25% of all sites; Attribute Band C (toxicity)	Very likely improving
Dissolved reactive phosphorus	0.0059 mg/L	In the best 50% of all site; Attribute Band A	Very likely degrading
Total phosphorus	0.008 mg/L	IN the best 25% of all sites	Not assessed

7.3 Low habitat diversity and barriers to indigenous fish migration

McKinnons Creek contains good habitat for freshwater fish; however, the lack of mature riparian vegetation means that the habitat complexity (i.e. large stable woody debris, shading, refugia) is low. This is of particular importance for long- and shortfin eels, and for reducing the predation risk to all indigenous fish species. In addition, the culvert situated below the large willow wetland is a barrier to fish passage and should be remediated or replaced. Replacement would also reduce the risk of bankside erosion, as the existing culvert is considerably smaller than the stream width. Any other structures upstream would likely have similar impacts on fish movement and stream integrity.

7.4 Predation of indigenous fish by introduced fish species

Predation is a threat to indigenous fish, although there is uncertainty regarding the degree of impact in the Rangitata River (Instream, 2019). Species present in McKinnons Creek can coexist with salmonoids[1], but are vulnerable to predation. This is particularly important for smaller indigenous fish species (i.e. bullies) or the juvenile stages of larger species. As such, predation may limit the reintroduction of some species, in particular freshwater crayfish (*Paranephrops zealandicus*).

[1] Salmonoids include salmon (*Oncorhynchus* spp. in New Zealand) and trout (*Salmo* spp., *Oncorhynchus* spp., and *Salvelinus* spp.).

7.5 Environmental pest plants

Environmental pest plants[1] are a primary threat to indigenous vegetation and habitats, and the indigenous fauna species they support at the site. In addition, environmental pest plants at McKinnons Creek will directly compete with restoration plantings, inhibit the recruitment of indigenous seedlings and saplings, and act as a propagule source for nearby areas. Nine environmental pest plants were recorded during the brief site visit (listed in Appendix 4). These species, and any other species of environmental pest plants that are located at the site in the future, should be controlled on an ongoing basis. Four of the environmental pest plant species recorded at the site are included in the Canterbury Regional Pest Management Plan 2018-2038 (Environment Canterbury 2018).

7.6 Pest animals

Introduced mammal species are likely negatively impacting indigenous vegetation and the population density and persistence of terrestrial indigenous vertebrate and invertebrate species at the site. This is a cumulative pressure given indigenous fauna are restricted at this site by habitat availability. Specifically, the pest animals may be having the following impacts:

- Rats (*Rattus* spp.), mustelids (*Mustela spp.*), feral cats (*Felis catus*), and brushtail possums (*Trichosurus vulpecula*), and European hedgehogs (*Erinaceus europaeus*) are likely to be negatively impacting the population density and persistence of terrestrial indigenous fauna. Brushtail possums can also negatively impact indigenous vegetation.

- Rabbits (*Oryctolagus cuniculus cuniculus*), hares (*Lepus europaeus*), possums, rats, and mice (*Mus musculus*) may be impacting indigenous flora at the site.

- Feral pigs (*Sus scrofa*), feral goats (*Capra hircus*), and deer (most likely red deer; *Cervus elaphus scoticus*) may periodically occur within the corridor of the Rangitata River, and therefore may access the McKinnons Creek site. Pigs can cause considerable damage to the margins of wetlands and streams, while goats and deer are capable of causing the localised decline of palatable indigenous plant species.

7.7 Livestock

Livestock that access the waterways and wetland at the site could potentially browse and trample indigenous vegetation, as well as introduce sediments and faeces to waterbodies.

7.8 Climate change

NIWA climate change modelling predicts that the eastern South Island will have progressively hotter, dryer summers over the next 35 years due to global climate change (Macara 2020). This could potentially decrease the quality of riparian and wetland habitat by increasing frequency of drought stress, which may further reduce the

[1] Pest plant species that are known to have demonstrable negative impacts.

diversity of indigenous plant and animal species at the site. Addressing climate change implications for McKinnons creek is beyond the scope of the restoration plan, although any actions to improve ecological resilience will likely confer improved capacity to accommodate climate change impacts, at least over short-medium time scales.

The following reports provide a starting point for longer-term climate change resilience planning for McKinnons creek:

- Macara G. *et al.* 2020: Climate change projections for the Canterbury Region. *NIWA Client Report No. 2019339WN*. Prepared for Environment Canterbury. 156 pp.

- Awatere S. *et al*. 2021: He huringa ahuarangi, he huringa ao: A changing climate, a changing world. 2021. *Manaaki Whenua Client Report*. Prepared by for Nga Pae o te Maramatanga. 61 pp.

8. MANAGEMENT ACTIONS

The following sections outline management actions[1] required to achieve the goals and objectives listed in Section 2. They encompass the entire site which is split into management units, and are presented in order of priority. Therefore if funding is limited and time is constrained, actions can be scaled back or selected habitats prioritised. Management actions targeting indigenous aquatic values, water quality, enhancement of wetland and riparian habitats, weed control, and plantings to establish propagule supplies of indigenous species characteristic of spring-fed stream environments are priorities. A workplan summarising the priority management actions, and areas, is presented in Appendix 7.

8.1 Fence off stream margins and wetlands, implement pest plant control, and undertake restoration plantings to improve water quality

Riparian margins and wetlands should be fenced off, pest plants controlled, and restoration plantings undertaken. As far as negotiations with grazing lease-holder/landowners allow, the restoration plantings should aim to establish a dense cover of indigenous vegetation, beginning with the stream margins below the main wetland (Management Unit B in Figure 1, and Restoration Area 5 in Figure 3). Taller trees and shrubs should be planted along streams to reduce aquatic weed growth and improve indigenous fish habitat. However, low stature plants are required under the arcs of centre pivot irrigators.

Fenemor and Samarasinghe (2020) recommend a minimum riparian setback width of at least 10 metres on land with slope <10° to achieve ecologically significant reductions in nutrient and contaminant inputs and improvements in shading and water body temperatures. Where possible, wider setbacks would allow a greater balance of ecosystem functions i.e. habitat provision, connectivity, resistance to weed invasion. Narrower setbacks will still achieve some improvements in water quality and habitat

[1] Resource consent are required for some proposed actions within this site.

where wider setbacks do not have landowner support. Therefore, a minimum setback of not less than 5 metres is recommended.

Within the two wetlands at the site, crack willow should be controlled in a staged manner, beginning in the upstream areas first to reduce the downstream invasion of willow propagules. All mature individuals of grey willow should be controlled throughout the wider site as a priority to prevent in-site seed sources. Control to low-levels should be the goal in the first instance as reinvasion from wind-blown seed is possible requiring ongoing control. If control to low-levels is achieved, focus could be shifted to whether eradication is feasible.

While out of scope, the learnings from willow control and wetland enhancement in the restoration site could be applied downstream at the hatchery.

Areas of indigenous reedland, sedgeland, rushland, and kahikatea forest should be incorporated within the restoration areas to create a matrix of different habitats for indigenous fauna (e.g. raupō reedlands for the Threatened–Nationally Critical Australasian bittern (*Botaurus poiciloptilus*). Species selection and planting guidelines are provided in Appendix 5.

8.2 Remove barriers to fish migration and improve instream habitat

Undertake a survey for barriers to fish passage along the length of the stream system at the site and replace or reposition the culvert below the southern wetland.

Increase the diversity of habitats for indigenous freshwater fish and invertebrates within streams by adding dead wood (large logs, piles of smaller logs) of non-invasive tree species or areas of boulders (as per Richardson and Taylor 2002). Depending on the overall structure of the in-stream structures, these sites may provide roosting areas for duck and shag species.

8.3 Protect the headwater spring and overall stream hydrology

Threats to the headwater spring and stream need to be determined through a survey of the upper reaches of McKinnons Creek. This survey should include an assessment and mitigation plan for any sources of pollution (principally from dairy effluent).

Undertake earthworks to form streamside wetlands and seasonally inundated areas in sections of the stream that have been channelised. Water levels in wetlands could potentially be raised by installing weirs that do not inhibit indigenous fish migration.

8.4 Undertake environmental pest plant management

Both crack willow and grey willow should be controlled to low levels at the site, with consideration given to eradication if feasible. Many of the other environmental pest plants such as elderflower (*Sambucus nigra*) and Scotch broom (*Cytisus scoparius*) occur in low densities and could be eradicated.

8.5 Undertake pest animal control

Monitoring should be conducted at the site to determine the fauna values and pest animal species that are present and the likely impacts these pests are having on indigenous fauna. Rabbits and hares are likely to damage restoration plantings and should be controlled when the plants are young. In addition, rabbit proof fences could be incorporated into fence designs to protect restoration plantings. Possums should be controlled if they impact plantings of palatable indigenous plant species as they mature and when fully established.

8.6 Undertake vegetation and fauna surveys

An indigenous fish and macroinvertebrate survey is needed to document their diversity within McKinnons Creek. Likewise, a bird survey should be undertaken to determine the species that are present at the site. Acoustic monitoring of the two wetlands should be carried out to determine whether cryptic wetland bird species such as Australasian bittern are present.

Additional surveys are needed to map the vegetation and habitats, pest plant populations, and record indigenous and exotic plant species at the site. In addition, restoration sites for mahinga kai species should also be identified.

8.7 Develop site- and species-specific restoration plans

The results of the fauna and vegetation surveys should be used to inform species- and site-specific restoration plans. The species-specific plans should target Threatened and At Risk species (e.g. kākahi/freshwater mussel, *Echyridella menziesii*; At Risk – Declining as per Grainger *et al*. 2018; kanakana/lamprey, *Geotria australis*; Threatened – Nationally Vulnerable) and should be guided by Department of Conservation translocation protocols and the tikanga of Te Rūnanga o Arowhenua.

8.8 Implement engineering solutions to manage point discharges

Management of the point source discharge from the dairy shed on the upstream race is required for long term improvements in water quality. A feasibility assessment of possible engineering solutions to manage nutrient and sediments inputs is required and should be undertaken in collaboration with the land managers if possible. Options may include diversion of any discharge into soakage ponds/filtering wetlands, with possible opportunities for dual habitat creation.

8.9 Management units

To facilitate the timely implementation of management actions we have broken the wider site into eight management units (Figure 1). Section 9 provides specific actions for each management unit. Section 12 provides a suggested four-year workplan to achieve these actions.

9. SPECIFIC MANAGEMENT ACTIONS REQUIRED WITHIN THE MANAGEMENT UNITS

Table 2: Management actions required within each of the eight management units at the McKinnons Creek site.

Management Unit	Size (ha)	Current Vegetation and Habitat Type	Intended Vegetation and Habitat Type	Suggested Management Actions
A	2.8	Exotic grassland, exotic and indigenous shrubland.	Dryer areas: Dryland indigenous forest, scrub and shrubland. Riparian margins and riparian wetlands: Indigenous riparian forest, flaxland, sedgeland and rushland.	• Fence stream margins. This may require moving existing gates • Replace or realign the culvert within the management unit • Control pest plants prior to undertaking restoration plantings • Plant drier areas with indigenous forest and scrub species that are capable of surviving droughts (see Appendix 5). • Plant riparian margins with indigenous riparian and wetland tree, shrub, flax, sedge and rush species (see Appendix 5). • Wetlands on riparian margins should be planted with harakeke and raupō. • Any areas that overlap with centre pivot irrigation systems should be planted with lower stature indigenous vegetation. • Monitor for and undertake pest animal control, if needed (see Section 10). • Add large woody debris or rocks to increase fish habitat complexity.
B	6.7	Crack and grey willow forest (wetlands), exotic scrub and shrubland, and pond	Dryer areas: Dryland to seasonally inundated indigenous forest, scrub and flaxland. Wetland areas: Kahikatea forest, raupō reedland, harakeke flaxland, and wī-pūrei and swamp sedge rushland and sedgeland.	• Undertake fence repairs, if required • Undertake a feasibility assessment for installing a weir at the southern end of the wetland to raise wetland water levels. • Control crack and grey willow in a staged manner. • Plant drier areas with indigenous forest and scrub species that are capable of surviving seasonal flooding (see Appendix 5). • Plant wetland areas with kahikatea forest, raupō, harakeke, and indigenous sedges and rushes (see Appendix 5). • Mass plantings of raupō should be established at the southern end of the wetland to filter water, provide mahinga kai resources, and as habitat for indigenous fauna. • The margins of the stream and pond in the northeast section of the unit should be planted with harakeke, wī, pūrei and swamp sedge (see Appendix 5). • Monitor for and undertake pest animal control, if needed (see Section 10). • Undertake survey for additional barriers to fish passage (e.g., culverts, pipes) and remove or replace.

Management Unit	Size (ha)	Current Vegetation and Habitat Type	Intended Vegetation and Habitat Type	Suggested Management Actions
C	3.2	Exotic grassland	Dryer areas: Dryland indigenous forest, scrub and shrubland. Riparian margins and riparian wetlands: Indigenous riparian forest, flaxland, sedgeland and rushland	• Install perimeter fence to exclude livestock • Plant drier areas with indigenous forest and scrub species that are capable of surviving droughts (see Appendix 5). • Plant riparian margins with indigenous riparian and wetland tree, shrub, flax, sedge and rush species (see Appendix 5). • Wetlands on riparian margins should be planted with harakeke and raupō. • Monitor for and undertake pest animal control, if needed (see Section 10).
D	3.3	Exotic grassland, exotic and indigenous shrubland.	Dryer areas: Dryland indigenous forest, scrub and shrubland. Riparian margins and riparian wetlands: Indigenous riparian forest, flaxland, sedgeland and rushland.	• Fence stream margins. This may require moving existing gates • Control pest plants prior to undertaking restoration plantings • Plant drier areas with indigenous forest and scrub species that are capable of surviving droughts (see Appendix 5). • Plant riparian margins with indigenous riparian and wetland tree, shrub, flax, sedge and rush species (see Appendix 5). • Wetlands on riparian margins should be planted with harakeke and raupō. • Any areas that overlap with centre pivot irrigation systems should be planted with lower stature indigenous vegetation. • Monitor for and undertake pest animal control, if needed (see Section 10). • Add large woody debris or rocks to increase fish habitat complexity. • Undertake survey for additional barriers to fish passage (e.g., culverts, pipes) and remove or replace.
E	3.9	Crack and grey willow forest (wetlands), exotic scrub and shrubland, and exotic grassland	Dryer areas: Dryland indigenous forest, scrub and shrubland. Riparian margins and riparian wetlands: Indigenous riparian forest, flaxland, sedgeland and rushland.	• Fence stream margins. This may require moving existing gates • Control pest plants prior to undertaking restoration plantings • Plant drier areas with indigenous forest and scrub species that are capable of surviving droughts (see Appendix 5). •]Plant riparian margins with indigenous riparian and wetland tree, shrub, flax, sedge and rush species (see Appendix 5). • Wetlands on riparian margins should be planted with harakeke and raupō. • Any areas that overlap with centre pivot irrigation systems should be planted with lower stature indigenous vegetation. • Monitor for and undertake pest animal control, if needed (see Section 10). • Undertake survey for additional barriers to fish passage (e.g., culverts, pipes) and remove or replace.

Management Unit	Size (ha)	Current Vegetation and Habitat Type	Intended Vegetation and Habitat Type	Suggested Management Actions
F	2.9	Crack and grey willow forest (wetlands), exotic scrub and shrubland, and exotic grassland	Dryer areas: Dryland to seasonally inundated indigenous forest, scrub and flaxland. Wetland areas: Kahikatea forest, raupō reedland, harakeke flaxland, and wī-pūrei and swamp sedge rushland and sedgeland.	• Install a perimeter fence, if required • Control crack and grey willow in a staged manner. • Plant drier areas with indigenous forest and scrub species that are capable of surviving seasonal flooding. • Plant wetland areas with kahikatea forest, raupō, harakeke, and indigenous sedges and rushes (see Appendix 5). • Mass plantings of raupō and harakeke should be established in open, shallow areas of the wetland to filter water, provide mahinga kai resources, and as habitat for indigenous fauna. • Monitor for and undertake pest animal control, if needed (see Section 10). • Add large woody debris or rocks to increase fish habitat complexity. • Undertake survey for additional barriers to fish passage (e.g., culverts, pipes) and remove or replace.
G	6.6	Indigenous shrubland and sedgeland, poplar/willow treeland, exotic scrub and shrubland, and exotic grassland	Dryer areas: Dryland indigenous forest, scrub and shrubland. Riparian margins and riparian wetlands: Indigenous riparian forest, flaxland, sedgeland and rushland.	• Fence stream margins. This may require moving existing gates • Control pest plants prior to undertaking restoration plantings • Plant drier areas with indigenous forest and scrub species that are capable of surviving droughts (see Appendix 5). • Plant riparian margins with indigenous riparian and wetland tree, shrub, flax, sedge and rush species (see Appendix 5). • Wetlands on riparian margins should be planted with harakeke and raupō. • Any areas that overlap with centre pivot irrigation systems should be planted with lower stature indigenous vegetation. • Monitor for and undertake pest animal control, if needed (see Section 10). • Add large woody debris or rocks to increase fish habitat complexity. • Undertake survey for additional barriers to fish passage (e.g., culverts, pipes) and remove or replace. • Undertake feasibility assessment to manage point discharges from dairy shed and implement if possible.

Management Unit	Size (ha)	Current Vegetation and Habitat Type	Intended Vegetation and Habitat Type	Suggested Management Actions
H	2.3	Indigenous shrubland and sedgeland, crack and grey willow forest (wetlands), and ponds	Dryer areas: Dryland indigenous forest, scrub and shrubland. Riparian margins and riparian wetlands: Indigenous riparian forest, flaxland, sedgeland and rushland.	• Fence stream margins. This may require moving existing gates • Control pest plants prior to undertaking restoration plantings • Plant drier areas with indigenous forest and scrub species that are capable of surviving droughts (see Appendix 5). • Plant riparian margins with indigenous riparian and wetland tree, shrub, flax, sedge and rush species (see Appendix 5). • Wetlands on riparian margins should be planted with harakeke and raupō. • The margins of the ponds should be planted with harakeke, sedges and rushes (see Appendix 5). • Any areas that overlap with centre pivot irrigation systems should be planted with lower stature indigenous vegetation. • Monitor for and undertake pest animal control, if needed (see Section 10). • Add large woody debris or rocks to increase fish habitat complexity. • Undertake survey for additional barriers to fish passage (e.g., culverts, pipes) and remove or replace.
Total	**31.7**			

10. MONITORING

Monitoring should be regularly undertaken at the site to inform and improve the implementation of management actions and measure restoration success. The monitoring should be carried out throughout the four-year project and continued on an ongoing basis thereafter. Monitoring should be more frequent immediately after implementation to track changes in response to restoration to the point where the site stabilises to a restored state, after which monitoring frequency could be reduced.

Photopoints

Photos taken at specific points and at set timeframes, are an efficient way to monitor gross changes in vegetation composition and structure within a defined viewpoint. It is recommended that at least ten photopoints are established at the site. The location of each photopoint should be recorded with a handheld global positioning system (GPS). A compass should be used to gauge a bearing to the center of the frame of the photopoint. The photos should then be printed to provide a reference for future revisits. The photopoints should be resampled every year in sites where frequent management actions are occurring (e.g. ongoing pest plant control).

Pest Plants and Restoration Plantings

Monitoring operations should be undertaken at least every three months during the growing season to track the proportions of pest plants killed via control work and the survival rates of restoration plantings. Walk through transects should be established through the two larger wetlands and along stretches of riparian margin to provide ongoing monitoring of management operations. The results of this monitoring should be used to improve management decisions regarding factors such as herbicide choice and the density and species selection of future restoration plantings.

Natural and Reintroduced Populations of Threatened Species

All populations of naturally occurring and reintroduced threatened species should be regularly monitored to build a better understanding of their habitat requirements, determine the limitations to restoration success, and identify future management actions. The monitoring regime will vary by species and should be undertaken by biologists who have experience working with the target species.

Pest Animals

Small mammal predators (rats, mustelids, cats and possums) should be monitored if surveys indicate that there are populations of vulnerable indigenous fauna species at the site. Rabbits, hares and possums should be monitored prior to and after restoration plantings are established. All pest monitoring should follow the best practice guidelines provided on the Bionet website (https://www.bionet.nz/library/).

Water Quality Testing

Fish and Game undertake biannual water quality monitoring above and below the hatchery downstream. Environment Canterbury also monitor water quality at Wallaces

Bridge. This sampling should continue over the long term to determine whether the management actions are improving water quality. Water should be sampled at the same locations at least once every two years.

11. CONSTRAINTS

The successful ecological restoration of McKinnons Creek is potentially constrained by a number of factors. These constraints, and their potential solutions, are outlined in Table 3.

Table 3: Potential constraints and solutions for the ecological restoration of the McKinnons Creek site.

Potential Constraint	Potential Solutions
Lack of ongoing funding beyond the four-year timeframe	• Begin applying for further funding within the first two years of the project • Hire a dedicated project manager to successfully implement the project • Widely publicise the work of the project to build a profile and community support
Ongoing declines in water quality due to effluent and nutrient runoff	• Monitor water quality on an ongoing basis • Identify and mitigate future sources of pollution on an ongoing basis
Ongoing environmental pest plant invasion	• Undertake ongoing pest plant control • Ensure maintenance teams are experienced and follow best practice protocols • Where feasible, undertake restoration in the wider area • Undertake ongoing pest plant monitoring to improve the efficiency and effectiveness of control efforts (see Section 9 below)
Failure of restoration plantings	• Only contract reputable native plant nurseries who have a track record of growing high quality plants • Ensure planting teams are experienced and follow best practice protocols • Undertake regular maintenance of plantings in the first year after planting • Undertake regular monitoring to inform ongoing restoration actions (see Section 9 below)
Failure of species reintroductions	• Seek the advice of technical experts to ensure reintroductions follow best practice guidelines • Undertake regular monitoring to inform future reintroduction efforts • Undertake regular monitoring following species reintroductions to determine ongoing management actions (see Section 9 below)
Changes in surrounding land tenure leading to restricted site access	• If applicable, establish easements to access the full extent of the site • Formally protect the site through a covenant (if applicable and practical) • Maintain good relationships with neighbouring landowners
Changes in hydrology due to water extraction and climate change	• Undertake hydrodynamic studies to determine the source and threats to the headwater spring if these haven't already been completed. • Ensure that any future land development does not exceed unsustainable water extraction rates. • Implement the management actions outlined in this report

12. TIMELINE AND INDICATIVE COSTS FOR THE IMPLEMENTATION OF MANAGEMENT ACTIONS

The following workplan relies on further negotiations with landowners being completed in 2022. The control of environmental pest plants within Management Unit B is staged over three years within this timeline but, could be undertaken over a shorter timeframe. In addition, the maintenance of the restoration plantings should be continued beyond the four-year timeframe of the plan. Cost estimates for hydrological surveys and pest animal control have not been included.

Table 4: Workplan and indicative costs for McKinnons Creek.

Management Unit	Management Action	Timing	Price Estimate
Year 1			
All management units	Establish photopoints where ecological restoration will occur	October 2021-May 2022	$1,500
	Vegetation and habitat mapping, bird survey, and detailed restoration plan	October 2021-May 2022	$5,000
	Freshwater fauna survey (including survey of fish barriers)	November 2021-April 2022	$7,000
	Baseline water quality testing (if not already being undertaken)	Two times during first year (winter and summer)	$3,500
A	Replace or reposition culvert	October 2021-May 2022	$15,000
B	Undertake a feasibility study and install weir at southern end of main wetland	October 2021-May 2022	$30,000
A, B and C	Habitat improvement for fish/riparian wetland earthworks	October 2021-May 2022	$20,000
A, B (part of) and C	Order eco-sourced plants and planting materials (plant guards etc.)	October 2021	$290,000
A, B and C	Fence installation and repairs	October 2021-April 2022	$40,000
A, B (part of) and C	Initial control of pest plants	October 2021-April 2022	$6,000
A, B (part of) and C	Site preparation	April 2022	$10,000
A, B (part of) and C	Planting of dryland and riparian margin areas	May-June 2022	$63,500
A, B (part of) and C	Planting of wetland areas and riparian wetlands	September-October 2022	$63,500
D-H	Further negotiate restoration areas with landowner	Ongoing	$1,000
All management units	Undertake an initial feasibility study for the reintroduction of a mahinga kai species (or multiple species)	Ongoing	$5,000

Management Unit	Management Action	Timing	Price Estimate
Year 2			
B (part of), D, E, F, and infill planting sites for A and C	Order eco-sourced plants and planting materials (plant guards etc)	October 2022	$468,000
D, E, F, G, H	Habitat improvement for fish/riparian wetland earthworks	October 2022-April 2023	$25,000
D, E, F, G, H	Fence installation and repairs	October 2022-April 2023	$105,600
B (part of), and D, E, F (if fencing complete)	Undertake pest plant control within unit	October 2022-April 2023	$7,000
A, B (part of) and C	Maintenance of Year 1 plantings	October 2022	$12,500
A, B (part of) and C	Maintenance of Year 1 plantings	December 2022	$12,500
A, B (part of) and C	Maintenance of Year 1 plantings	March 2023	$10,500
B (part of), D, E, F, and infill planting sites for A and C	Site preparation	April 2023	$8,000
B (part of), D, E, F, and infill planting for A and C	Planting of dryland and riparian margin areas	May-June 2023	$99,000
B (part of), D, E, F, and infill planting for A and C	Planting of wetland areas and riparian wetlands	September-October 2023	$99,000
Year 3			
All management units	Ongoing water quality testing (if not already being undertaken)	Two times during year (winter and summer)	$3,500
	Reintroduce one or more mahinga kai species and undertake ongoing monitoring	October 2023-April 2024	$10,000
B (part of), G, H, and infill plants for D, E, F,	Order eco-sourced plants and planting materials (plant guards etc)	October 2023	$421,000
B (part of)	Undertake pest plant control within unit	October 2023-April 2024	$6,000
A, B (part of) and C	Maintenance of Year 1 plantings	October 2023	$12,500
A, B (part of) and C	Maintenance of Year 1 plantings	December 2023	$10,500
A, B (part of) and C	Maintenance of Year 1 plantings	March 2024	$10,500
B (part of), D, E and F	Maintenance of Year 2 plantings	October 2023	$22,800
B (part of), D, E and F	Maintenance of Year 2 plantings	December 2023	$22,800
B (part of), D, E and F	Maintenance of Year 2 plantings	March 2024	$20,800

Management Unit	Management Action	Timing	Price Estimate
B (part of), G, H, and infill plants for D, E, F	Site preparation	April 2024	$16,000
B (part of), G, H, and infill plants for D, E, F	Planting of dryland and riparian margin areas	May-June 2024	$94,000
B (part of), G, H, and infill plants for D, E, F	Planting of wetland areas and riparian wetlands	September-October 2024	$94,000
Year 4			
All management units	Resample photopoints	October 2021-May 2022	$1,000
Infill plants for G and H	Order eco-sourced plants and planting materials (plant guards etc)	October 2024	$23,000
A, B (part of) and C	Maintenance of Year 1 plantings	October 2024	$10,500
A, B (part of) and C	Maintenance of Year 1 plantings	December 2024	$10,500
A, B (part of) and C	Maintenance of Year 1 plantings	March 2025	$8,000
B (part of), D, E and F	Maintenance of Year 2 plantings	October 2024	$22,800
B (part of), D, E and F	Maintenance of Year 2 plantings	December 2024	$20,800
B (part of), D, E and F	Maintenance of Year 2 plantings	March 2025	$20,800
B (part of), G and H	Maintenance of Year 3 plantings	October 2024	$19,500
B (part of), G and H	Maintenance of Year 3 plantings	December 2024	$19,500
B (part of), G and H	Maintenance of Year 3 plantings	March 2025	$17,500
Infill plants for G and H	Site preparation	April 2025	$2,500
Infill plants for G and H	Planting of dryland and riparian margin areas	May-June 2025	$8,000
Infill plants for G and H	Planting of wetland areas and riparian wetlands	September-October 2025	$8,000
Total			**$2,344,900**

13. CONCLUSIONS

McKinnons Creek is an ecologically and culturally important spring-fed stream system located near the lower Rangitata River. The primary threats to the system are from agricultural land use, both through past vegetation clearance and conversion to dairy, and associated declines in water quality. While its extant values are in a degraded condition, the site retains a high degree of landscape and hydrodynamic intactness and provides important habitat for native fish.

In order to meet the Rangitata Steering Groups overarching goals of improving water quality, species recovery, habitat enhancement, and identification of opportunities for restoring mahinga kai resources at McKinnons Creek, ecological values, threats and management actions have been identified. These include fencing the site to exclude livestock, ongoing pest plant control, and undertaking restoration plantings. Implementing these management actions will greatly enhance the ecological integrity and mauri of McKinnons Creek, and ensure that the site provides mahinga kai for Te Rūnanga o Arowhenua for future generations.

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VEGETATION AND HABITAT TYPES RECORDED AT MCKINNONS CREEK, RANGITATA RIVER

The vegetation and habitat types recorded at McKinnons Creek during the July 2021 site visit are listed below. The distribution of these vegetation and habitat types at the site is illustrated in Figure 2.

1. Indigenous shrubland and sedgeland

Areas of what appears to be indigenous shrubland and sedgeland occur along the margins of McKinnons Creek in the northern half of the site. These riparian margins appear to contain pūrei (*Carex secta*) and harakeke (*Phormium tenax*); however, may also contain indigenous and exotic shrub species, as well as exotic grass species. An area of ecological restoration planting has recently (planted in April 2019) been undertaken around the headwater spring at the site by volunteers from the McKinnons Creek Hatchery[1]. It is possible that additional areas have been planted within this vegetation type.

2. Crack and grey willow forest

The two main wetlands at the site contain forest comprising crack willow (*Salix* x*fragilis*) and grey willow (*S. cinerea*). The areas of the larger southern wetland that were visited contained blackberry (*Rubus fruticosa*) and harakeke on the wetland margins, as well as occasional tī kōuka (cabbage tree, *Cordyline australis*). Areas of the willow understorey contained scattered saplings of indigenous karamū (*Coprosma robusta*), kōhūhū (*Pittosporum tenuifolium*) and mikimiki (*Coprosma* spp). Indigenous ferns were also present within the understorey and included little hard fern (*Blechnum penna-marina*), swamp kiokio (*Blechnum minus*) and pūnui/prickly shield fern (*Polystichum vestitum*).

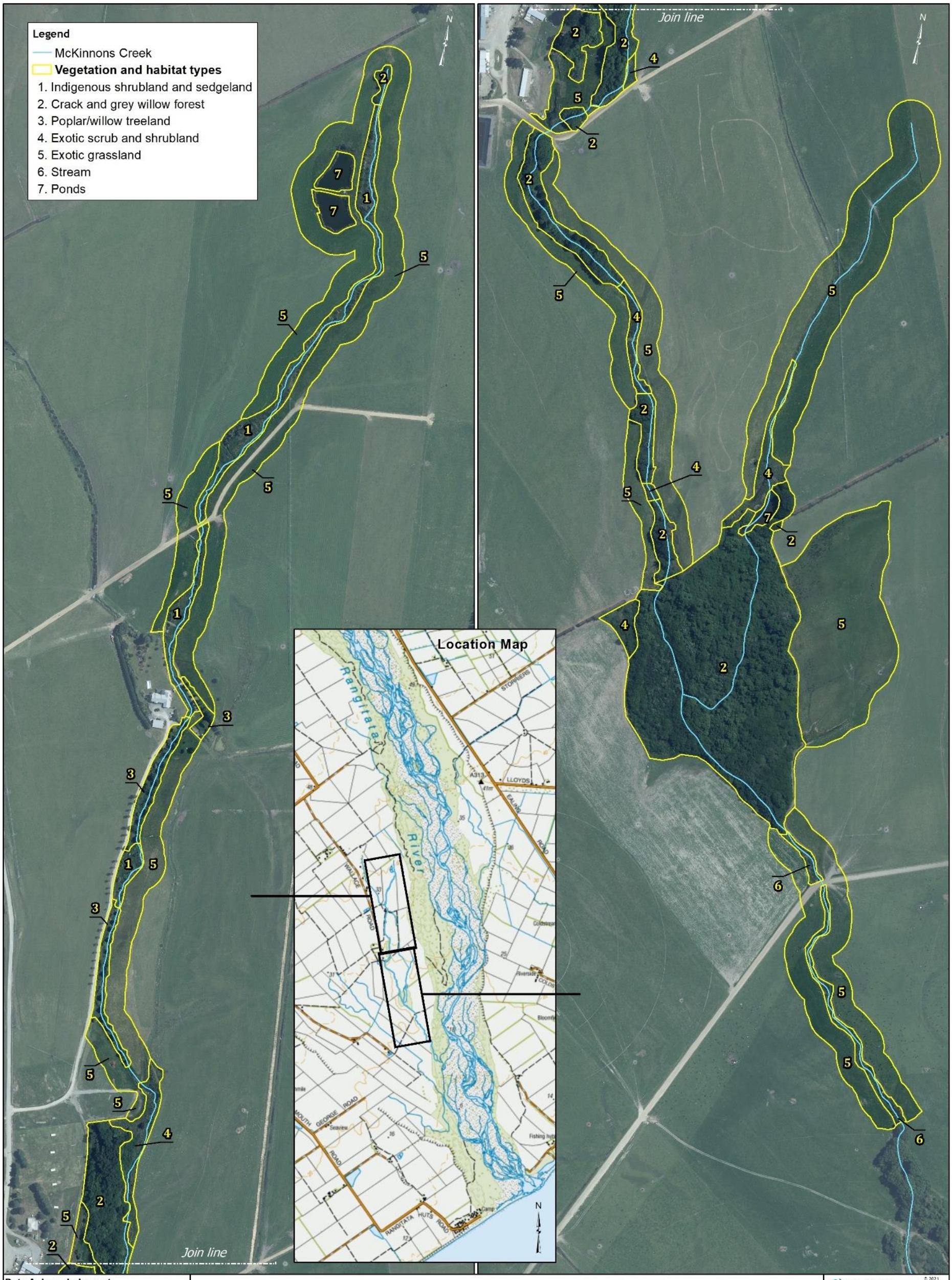
3. Poplar/willow treeland

Areas of what appears to be poplar (*Populus* sp.) and willow treeland occurs along the margins and immediately adjacent to McKinnons Creek shortly north of the northern willow wetland. These areas of treeland contain an understorey of exotic grassland and what appears to be patches of indigenous sedgeland.

4. Exotic scrub and shrubland

What is believed to be exotic shrubland occurs along sections of stream margin north of the main wetland. These areas likely contain blackberry, gorse (*Ulex europaeus*) and grey willow. These areas of shrubland may also contain indigenous species such as harakeke and pūrei. Restoration plantings may have been undertaken in some sections of the shrublands.

[1] Source: http://www.mckinnonscreek.co.nz/latest-news/archives/04-2019



Data Acknowledgment
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Figure 2. Vegetation and habitats at McKinnon's Creek, Rangitata River, South Canterbury

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Wildlands
www.wildlands.co.nz, 0508 WILDNZ

Scale: 1:4,500
Date: 23/09/2021
Cartographer: FM
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5. Exotic grassland

Large areas of the site contain exotic grassland. These include many of the riparian margins and the area of pasture immediately east of the main wetland. The riparian margins below the main wetland that were viewed during the site visit contained grassland that primarily comprises ryegrass (*Lolium perenne*). Areas of shrubland comprising blackberry and gorse, with scattered grey willow, harakeke, pūrei and tī kōuka occur along the stream margins.

6. Stream

The main stream at the site is approximately 3.3 kilometres long. A branch of the main stream extends *c*. 800 metres north of the main wetland in the southern half of the site. Aquatic plants are present within the stream and include monkey musk (*Erythranthe guttata*).

7. Ponds

Two adjoining ponds are located at the northern end of the site adjacent to the headwater spring. A third pond occurs near the northeast margin of the large willow wetland.

APPENDIX 2

AVIFAUNA SPECIES RECORDED ON EBIRD THAT OCCUR WITHIN A 10 KILOMETRE RADIUS OF MCKINNONS CREEK, RANGITATA RIVER

Scientific Name	Common Name	Threat Classification[1]
Indigenous		
Anas gracilis	Grey teal	Not Threatened
Anas rhynchotis	Australasian shoveler	Not Threatened
Aythya novaeseelandiae	New Zealand scaup	Not Threatened
Charadrius bicinctus bicinctus	Banded dotterel	At Risk – Declining
Chlidonias albostriatus	Black-fronted tern	Threatened-Nationally Endangered
Circus approximans	Swamp harrier	Not Threatened
Cygnus atratus	Black swan	Not Threatened
Egretta novaehollandiae	White-faced heron	Not Threatened
Haematopus finschi	South Island pied oystercatcher	At Risk – Declining
Haematopus unicolor	Variable oystercatcher	At Risk-Recovering
Himantopus himantopus leucocephalus	Pied stilt	Not Threatened
Hirundo neoxena neoxena	Welcome swallow	Not Threatened
Hydroprogne caspia	Caspian tern	Threatened-Nationally Vulnerable
Larus bulleri	Black-billed gull	At Risk – Declining
Larus dominicanus dominicanus	Southern black-backed gull	Not Threatened
Larus novaehollandiae scopulinus	Red-billed gull	At Risk-Declining
Morus serrator	Australasian gannet	Not Threatened
Phalacrocorax carbo novaehollandiae	Black shag	At Risk – Relict
Phalacrocorax melanoleucos brevirostris	Little shag	At Risk – Relict
Phalacrocorax melanoleucos melanoleucos	Little pied shag	Non-resident Native – Vagrant
Phalacrocorax varius varius	Pied shag	At Risk-Recovering
Porphyrio melanotus	Pūkeko	Not Threatened
Rhipidura fuliginosa fuliginosa	South Island fantail	Not Threatened
Sterna striata striata	White-fronted tern	At Risk-Declining
Tadorna variegate	Paradise shelduck	Not Threatened
Todiramphus sanctus vagans	New Zealand kingfisher	Not Threatened
Vanellus miles novaehollandiae	Spur-winged plover	Not Threatened
Zosterops lateralis lateralis	Silvereye	Not Threatened
Exotic		
Alauda arvensis	Skylark	Introduced and naturalised
Anas platyrhynchos	Mallard	Introduced and Naturalised
Branta canadensis	Canada goose	Introduced and naturalised
Carduelis carduelis	Goldfinch	Introduced and naturalised
Carduelis chloris	Greenfinch	Introduced and naturalised
Columba livia	Rock pigeon	Introduced and naturalised
Cygnus olor	Mute swan	Introduced and naturalised

[1] As per Robertson *et al*. (2021).

Scientific Name	Common Name	Threat Classification[1]
Emberiza citronella	Yellowhammer	Introduced and naturalised
Fringilla coelebs	Chaffinch	Introduced and naturalised
Gymnorhina tibicen	Australian magpie	Introduced and naturalised
Passer domesticus	House sparrow	Introduced and naturalised
Prunella modularis	Dunnock	Introduced and naturalised
Sturnus vulgaris	Starling	Introduced and naturalised
Turdus merula	Blackbird	Introduced and naturalised
Turdus philomelos	Song thrush	Introduced and naturalised

APPENDIX 3

POTENTIAL MAHINGA KAI RESOURCES THAT COULD BE ESTABLISHED AT MCKINNONS CREEK, RANGITATA RIVER

Species	Common Name	Threat Status	Mahinga Kai Resource
Plant			
Cordyline australis	Tī kōuka, cabbage tree	Not Threatened	Numerous medicinal, food, fibre uses[1].
Coriaria spp.	Tutu	Not Threatened	Used in medicine, beverages, dyes and crafts. Almost all parts of plant are toxic[1].
Nasturtium officinale	Kōwhitiwhiti, watercress	Introduced and Naturalised	Edible leaves, used medicinally for headaches[1].
Phormium tenax	Harakeke, flax	Not Threatened	Numerous medicinal, food, fibre, dyes, and construction uses[1].
Pteridium esculentum	Rārahu, bracken	Not Threatened	Numerous medicinal, food, hunting, and construction uses. Young fronds contain carcinogens[1].
Typha orientalis	Raupō, bullrush	Not Threatened	Numerous medicinal, food, hunting, and construction uses[1].
Birds			
Anas superciliosa	Pārera/grey duck	Threatened – Nationally Vulnerable	Food[2]
Freshwater fish			
Anguilla dieffenbachii	Tuna, longfin eel	At Risk – Declining	Food[3]
Anguilla australis	Tuna, shortfin eel	Not Threatened	Food[3]
Geotria australis	Piharau/kanakana, lamprey	Threatened – Nationally Vulnerable	Food[4]
Freshwater invertebrate			
Echyridella menziesii	Kākahi, freshwater mussel	At Risk – Declining	Mussel flesh used as food and medicine. Shells used as tools[5].

1. Further information at (requires a search of individual plant species): https://maoriplantuse.landcareresearch.co.nz/WebForms/default.aspx
2. Source: Phillips (1947).
3. https://niwa.co.nz/our-science/freshwater/tools/kaitiaki_tools/species/tuna
4. https://niwa.co.nz/our-science/freshwater/tools/kaitiaki_tools/species/piharau
5. https://niwa.co.nz/our-science/freshwater/tools/kaitiaki_tools/species/kakahi#:~:text=Traditionally%2C%20they%20were%20collected%20throughout,as%20a%20rongo%C4%81%20or%20medicine).

ENVIRONMENTAL PEST PLANTS OBSERVED AT AND NEAR MCKINNONS CREEK, RANGITATA RIVER

Scientific Name	Common Name	Status in the RPMP[2]
Acer pseudoplatanus	Sycamore	Not listed
Clematis vitalba	Old man's beard	Sustained Control
Cytisus scoparius	Scotch broom	Sustained Control
Rubus fruticosus	Blackberry	Organism of Interest
Salix cinerea	Grey willow	Not listed
Salix xfragilis	Crack willow	Not listed
Sambucus nigra	Elderflower	Not listed
Populus nigra[1]	Black poplar	Not listed
Ulex europaeus	Gorse	Sustained Control

1. Black poplar (*Populus nigra*) has been planted along farm fencelines as a windbreak. Controlling plants of this species will require consultation with the neighbouring landowner.
2. As outlined in the Canterbury Regional Pest Management Plan 2018-2038.

GUIDELINES FOR PLANTING AND MAINTAINING INDIGENOUS PLANT SPECIES AT MCKINNONS CREEK, RANGITATA RIVER

OVERVIEW

The following section provides an overview of the management actions required for the successful planting and establishment of indigenous species at McKinnons Creek.

SPECIES SOURCES AND SELECTION

- All indigenous plant species should occur naturally in similar sites within the Low Plains Ecological District.
- All plants should be sourced from the Low Plains Ecological District genetic stock or from nearby ecological districts and should generally have been grown from seed to maximise potential genetic diversity.
- A range of indigenous species with different attributes were identified for the plantings (listed in Table 1-3). These include:
  - Trees that will form a mature canopy.
  - Fast growing early successional species.
  - Shrubs that will provide diversity in the understorey.
  - Raupō, harakake and a range of sedges and rushes for planting on riparian margins and in wetlands.
  - Mahinga kai species.
  - Nationally Threatened/At Risk (as per de Lange *et al.* 2018) and locally uncommon species, to enhance conservation values. A number of nationally threatened species such as hook grass (*Carex strictissima*) and swamp nettle (*Urtica perconfusa*) have been included. The historical distribution of these species is not known with certainty, but it is very likely they were more widely distributed in the ecological district prior to European colonisation.
  - Vigorous indigenous species that will quickly colonise the planting areas (e.g. toatoa, *Haloragis erecta*; karamū; and koromiko, *Veronica salicifolia*).
  - Fleshy-fruited species, to provide food for indigenous fauna and to facilitate their dispersal by birds.

PLANT GRADES

- Planter bag (PB) plant grades (ideally 2/3) should preferably be used for most of the plantings as their stature and robustness reduces their vulnerability to light or incidental browsing by herbivorous animal pests (e.g. rabbits, possums), and they are more resilient to frosts and other environmental extremes.
- PB grade plants should also be used for enrichment plantings.
- Where pre-planting site preparation and post-planting monitoring and maintenance are carried out to a high standard, plants in root trainers (RTs) can be used instead of larger (more costly) plants in individual PBs.

PLANT SPACINGS

- Plant trees at 1.5 - three metre spacings (depending on species).
- Plant shrubs one to two metre spacings (depending on species).
- Sedges, rushes and grasses should generally be planted at 0.5 metre spacings with the exception of species such as pūrei, swamp sedge and toetoe (*Austroderia richardii*) which should be planted at 1 metre spacings.
- Plants should be set back from stock fences by 1.5 metres to prevent livestock browse.

SITE PREPARATION PRIOR TO PLANTING

- Planting areas should be prepared in mid to late autumn, ideally four to six weeks prior to planting. Individual planting sites should have vegetation cover reduced by spraying 0.4 metre round areas with 10% glyphosate in water.
- Herbicide should be applied by a qualified applicator (Growsafe and Approved Handler certified).
- It is important that existing naturally-occurring indigenous vegetation (especially containing Nationally Threatened/At Risk or locally uncommon species) is not adversely affected by the planting programme. Plantings should be integrated with and enhance existing indigenous vegetation as much as possible, therefore no indigenous vegetation should be removed to facilitate planting.

TIMING OF PLANTING

- In dryland areas, timing of planting will be dictated by the rainfall patterns in the intended planting season; however, in general, should be planted from late autumn, once soil moisture levels reach field capacity, through to mid-winter.
- In wetland areas, planting should be undertaken in early-mid spring (September or October, depending on winter rainfall) once standing water in flooded areas has begun to recede. Site visits should be conducted at the wetland restoration areas to determine the timing of planting during the spring when it is planned.

PLANT GUARDS

- In dryland areas, newly-planted trees and shrubs can be decimated by rabbit and hare browse, so protection against browse is critical.
- Individual plant guards should be used to protect each plant if browsing is an issue. They also provide shelter, increased humidity, reduction of moisture loss, and help to prevent unintended herbicide damage.
- Guards should be removed and reused once the foliage of the plants grows out of the top of the guard.

MAINTENANCE OF PLANTS

- In the first 12 months following planting operations, assess plant condition and weed competition every three months.
- For the first two years following planting, plants should be released from environmental weeds a minimum of three times a year by hand weeding or spraying with selective herbicides.
- For up to five years following the planting, further releases from environmental weeds may be required once or twice a year during the growing season by hand weeding or spraying with selective herbicides. When plants are emergent above the surrounding vegetation (typically a grass sward), little further management is required. However, ongoing control of pest plants will be required, particularly before canopy closure is achieved.
- Infill planting to replace plants that have died may be required and should be undertaken during the second or third year after the original planting.

Table 1: Indigenous plant species to be planted within dryland areas at the McKinnons Creek site, Rangitata River.

Scientific Name	Common Name	Conservation Status[1]	Spacing (m)	Percentage (%)	Plants Per Hectare (ha)
Anemanthele lessoniana[1]	Wind grass	Not Threatened	0.5	1	400
Astelia fragrans[1]	Kakaha, bush lily	Not Threatened	2	1	25
Coprosma crassifolia[1]	Thick-leaved coprosma, mikimiki	Not Threatened	1	2	200
Coprosma propinqua[1]	Mingimingi, mikimiki	Not Threatened	1	5	500
Coprosma robusta[1]	Karamū	Not Threatened	1	2	200
Cordyline australis[2]	Cabbage tree, tī kōuka	Not Threatened	2	5	125
Coriaria arborea[1, 2]	Tree tutu	Not Threatened	1.5	2	89
Haloragis erecta[1]	Toatoa	Not Threatened	2	1	25
Hoheria angustifolia	Narrow-leaved lacebark, houhere	Not Threatened	1.5	5	222
Kunzea robusta	Kānuka, rawirinui, kopuka	Threatened – Nationally Vulnerable	1.5	18	800
Leptospermum scoparium var. *scoparium*[1]	Mānuka, tea tree	At Risk – Declining	1.5	18	800
Myrsine australis	Red māpou, red matipo	Not Threatened	1.5	5	222
Myrsine divaricata	Weeping matipo, weeping māpou	Not Threatened	1.5	2	89
Pennantia corymbosa	Kaikōmako, ducks foot	Not Threatened	1.5	2	89
Pittosporum tenuifolium	Kōhūhū, black matipo	Not Threatened	1.5	5	222
Plagianthus regius	Lowland ribbonwood, mānatu	Not Threatened	1.5	5	222
Podocarpus totara	Lowland tōtara	Not Threatened	1.5	5	222
Prumnopitys taxifolia	Matai, black pine	Not Threatened	3	5	56
Pseudopanax crassifolius	Lancewood, horoeka	Not Threatened	2	2	50
Sophora microphylla	Small-leaved kōwhai	Not Threatened	1.5	5	222
Teucrium parvifolium[1]	New Zealand verbena, teucridium	At Risk – Declining	2	2	50
Veronica salicifolia[1]	Koromiko	Not Threatened	1.5	2	89
				100	**4,919**

1 Low stature species for planting under the arc of irrigators.
2 Mahinga kai species.

Table 2: Indigenous plant species to be planted within riparian margins at the McKinnons Creek site, Rangitata River.

Scientific Name	Common Name	Conservation Status[1]	Spacing (m)	Percentage (%)	Plants per Hectare (ha)
Aristotelia serrata	Wineberry, makomako	Not Threatened	1.5	2	89
Austroderia richardii[1]	Toetoe	Not Threatened	1	7	700
Carex buchananii[1]	Cutty grass, matirewa	At Risk – Declining	0.5	5	2000
Carex coriacea[1]	Cutty grass, rautahi	Not Threatened	0.5	2	800
Carex geminata[1]	Cutty grass, rautahi	Not Threatened	0.5	5	2000
Carex maorica[1]	Cutty grass, rautahi	Not Threatened	0.5	2	800
Carex secta[1]	Pūrei, pūkio	Not Threatened	1	5	500
Carex strictissima[1]	Hook grass	Threatened – Nationally Endangered	0.5	5	3000
Carex virgata[1]	Swamp sedge	Not Threatened	0.5	5	2500
Coprosma propinqua[1]	Mingimingi, mikimiki	Not Threatened	1.5	2	89
Coprosma virescens[1]	Mikimiki	Not Threatened	1.5	2	89
Cordyline australis[2]	Cabbage tree, tī kōuka	Not Threatened	1.5	10	445

[1] As per de Lange *et al*. (2018).

Scientific Name	Common Name	Conservation Status[1]	Spacing (m)	Percentage (%)	Plants per Hectare (ha)
Coriaria sarmentosa[1, 2]	Tutu	Not Threatened	1	2	200
Eleocharis acuta[1]	Sharp spike sedge	Not Threatened	0.5	2	800
Griselinia littoralis	Broadleaf, kāpuka	Not Threatened	2	2	50
Haloragis erecta[1]	Toatoa	Not Threatened	2	2	50
Juncus edgariae[1]	Leafless rush, wī	Not Threatened	0.5	5	2000
Juncus pallidus[1]	Giant rush, leafless rush, wī	Not Threatened	0.5	5	2000
Juncus sarophorus[1]	Leafless rush, wī	Not Threatened	2	2	50
Leptospermum scoparium	Mānuka, tea tree	Threatened – Nationally Vulnerable	1.5	10	445
Phormium tenax[1, 2]	Lowland flax, harakeke	Not Threatened	1	7	700
Sophora microphylla	Small-leaved kōwhai	Not Threatened	2	2	50
Teucrium parvifolium[1]	New Zealand verbena, teucridium	Not Threatened	1.5	1	45
Typha orientalis[1, 2]	Raupō, bull rush	Not Threatened	0.5	5	500
Veronica salicifolia[1]	Koromiko	Not Threatened	2	5	125
Total				**100**	**20,0027**

1 Low stature species for planting under the arc of irrigators.
2 Mahinga kai species.

Table 3: Indigenous plant species to be planted within wetland areas at the McKinnons Creek site, Rangitata River.

Scientific Name	Common Name	Conservation Status[1]	Spacing (m)	Percentage (%)	Plants per Hectare (ha)
Austroderia richardii[1]	Toetoe	Not Threatened	1	2	200
Blechnum minus[1]	Swamp kiokio	Not Threatened	0.5	1	400
Carex buchananii[1]	Cutty grass, matirewa	At-Risk Declining	0.5	2	800
Carex coriacea[1]	Cutty grass, rautahi	Not Threatened	0.5	2	800
Carex geminata[1]	Cutty grass, rautahi	Not Threatened	0.5	5	2,000
Carex maorica[1]	Cutty grass, rautahi	Not Threatened	0.5	2	800
Carex secta[1]	Pūrei, pūkio	Not Threatened	1	10	1,000
Carex strictissima[1]	Hook grass	Threatened – Nationally Endangered	0.5	5	2,000
Carex virgata[1]	Swamp sedge	Not Threatened	0.5	5	2,000
Coprosma pedicellata[1]		At Risk – Declining	2	5	125
Cordyline australis	Cabbage tree, tī kōuka	Not Threatened	1.5	5	222
Dacrycarpus dacrydioides	Kahikatea, white pine	Not Threatened	2	15	375
Haloragis erecta[1]	Toatoa	Not Threatened	2	2	50
Juncus edgariae[1]	Leafless rush, wī	Not Threatened	0.5	5	2,000
Juncus pallidus[1]	Giant rush, leafless rush, wī	Not Threatened	0.5	5	2,000
Juncus sarophorus[1]	Leafless rush, wī	Not Threatened	0.5	3	1,200
Leptospermum scoparium	Mānuka, tea tree	Threatened – Nationally Vulnerable	1.5	5	222
Phormium tenax[1, 2]	Lowland flax, harakeke	Not Threatened	1	13	1,300
Typha orientalis[1, 2]	Raupō, bull rush	Not Threatened	0.5	7	2,800
Urtica perconfusa[1]	swamp nettle	At Risk – Declining	1.5	2	89
Total				**100**	**22,383**

1 Low stature species for planting under the arc of irrigators.
2 Mahinga kai species.

[1] As per de Lange *et al*. (2018).

APPENDIX 6

SITE PHOTOGRAPHS

Plate 1: A damp paddock that has been identified as a possible wetland/riparian planting area. This area is located near the southern end of the site. 8 July 2021.

Plate 2: Lower reaches of McKinnons Creek. 8 July 2021.

Plate 3: A culvert located downstream of the large willow wetland. This culvert is likely acting as a barrier for indigenous freshwater fish passage. 8 July 2021.

Plate 4: Exotic grassland and plants of soft rush (*Juncus effusus* var. *effusus*) in Management Unit C. The large willow wetland is in the background. 8 July 2021.

SUMMARY OF MANAGEMENT ACTIONS AND PRIORITIES FOR MCKINNONS CREEK RESTORATION WORK PLAN

Key Objectives and Actions for Management Zones identified in Figure 3:

1. Culvert: Replace or reposition to improve fish passage.

2. Salmon hatchery: out of project scope, learnings from willow control and wetland enhancement in the restoration site could be applied.

3. Riparian restoration area: establish filtering vegetation cover to reduce nutrient and containment inputs and improve instream and riparian habitat.

4. Lower stream: improve instream habitat diversity by the addition of dead wood or areas of boulders. Opportunities for mahinga kai.

5. Kahikatea wetland restoration area: staged control of crack willow, eradication of grey willow, establish indigenous reedland, sedgeland, rushland, and kahikatea forest.

6. Wetland/dryland restoration area: Reintroduce dryland forest species, reintroduce wetland plant species in wetter areas. Funding scope may limit scope of actions here.

7. Headwater spring: identify threats to headwater spring and stream, prepare mitigation plan for any sources of pollution (principally from dairy effluent), implement actions to protect and enhance riparian and instream habitats and water quality.

8. Upper stream and riparian margins: negotiate setbacks with landowners, implement actions (i.e. riparian planting, willow control, improve habitat diversity, wetland creation) as per lower stream and wetland habitats, assess feasibility of earthworks to form streamside wetlands and seasonally inundated areas in sections of the stream that have been channelised, manage point source discharge from dairy shed.

9. Whole area: predator control, control grey willow and other pest plants identified as conservation priorities, monitor, survey for additional threats (i.e. point discharge, pest plant species, barriers to fish passage) and unknown habitats and values, work with Te Rūnanga o Arowhenua to identify and implement other actions to enhance the ecological integrity, mauri and provision of mahinga kai, implement other actions as identified in the Main Stem restoration plans.

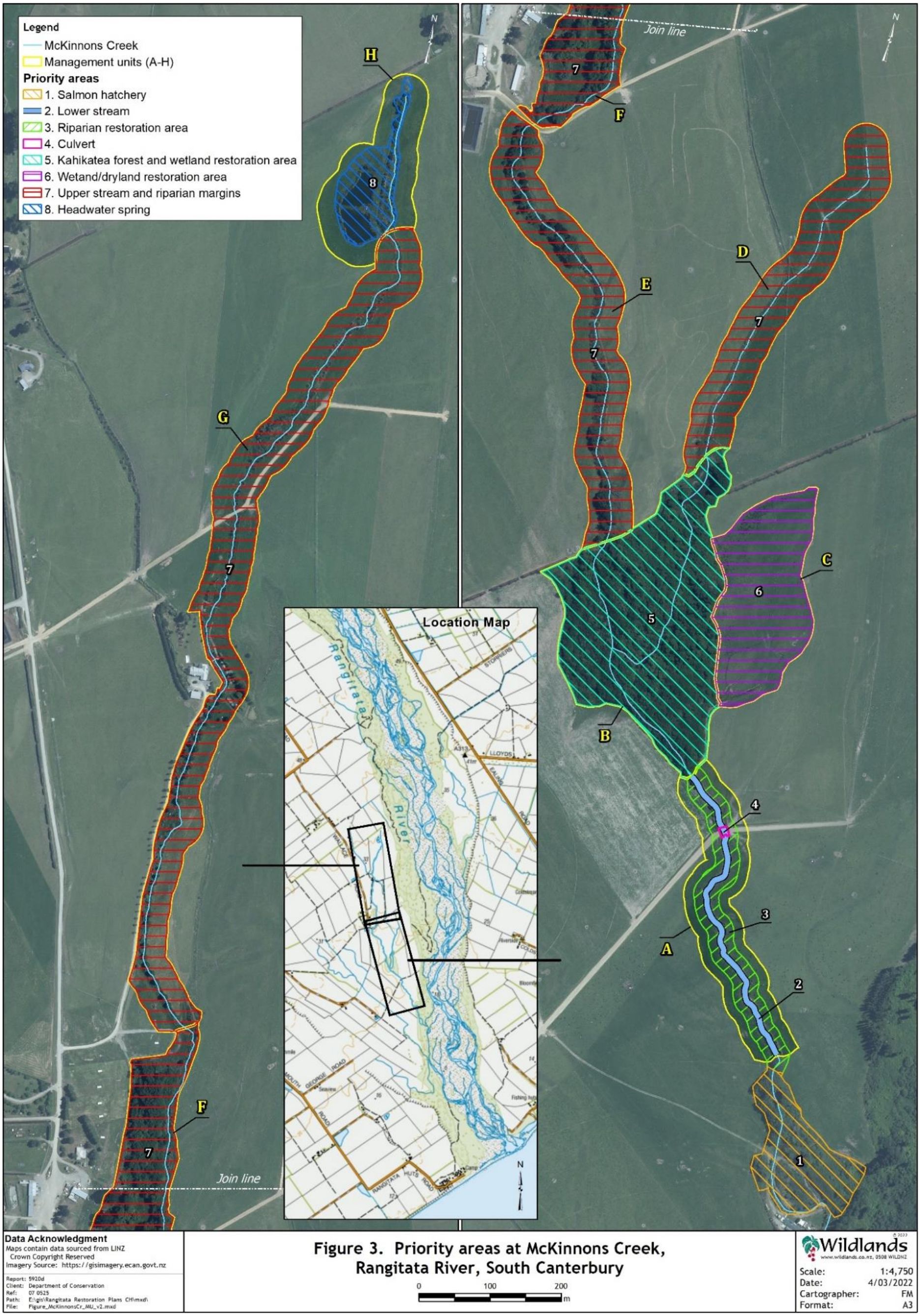

Figure 3. Priority areas at McKinnons Creek, Rangitata River, South Canterbury

Activity/Task	Area/Zone (Refer Figure 3)	Activity Required	Timing	Objective/Reason
Landowner consultation	All zones	Discuss vision for stream, opportunities, plans, and activities permissible in short term, and in medium and long term	ASAP	Establish what restoration activities can be applied to McKinnons stream along its entire length, in the short and medium term, e.g. removal of barriers to fish passage, enhancement. If permissible, treat stream length as a single management zone for in-stream restoration activities.
Freshwater fauna and habitat survey	All zones	Identify to identify and prioritise restoration areas	ASAP	Identify/confirm priority areas, values and opportunities. Threats to the headwater spring and stream need to be determined through a survey of the upper reaches of McKinnons Creek. This survey should include an assessment and mitigation plan for any sources of pollution (principally from dairy effluent).
Undertake pest plant survey at the site	All zones.	This survey will identify all pest plants present and control priorities needed	ASAP	Develop pest plant management plan.
Develop pest plant management plan	Priority sites identified in surveys	Identify all problematic pest plants and priority areas and species for control	After pest plant survey	Pest plants have the potential to modify the functionality of the braided river system, impacting mahinga kai resources, reducing nesting habitat for indigenous birds and inhibit the regeneration of indigenous vegetation. The complete removal of the willows is recommended to be staged over four years.
Refine restoration plan after survey	Lower stream margins / Zone 3 Kahikatea forest & wetlands / Zone 5 Wetlands/dryland forest / Zone 6 (optional, as opportunity allows) Headland spring & selected sites in upper stream / Zone 7 & 8 (optional, as opportunity allows)	Define restoration areas, priorities, plant numbers, and appropriate species list	After surveys	Better defining areas will allow for more accurate plant number calculations – need for ordering eco-sourced plants.
Order eco-sourced plants and planting materials	Lower stream margins / Zone 3 Kahikatea forest & wetlands / Zone 5 Wetlands/dryland forest /	Order eco-sourced plants and planting materials (plant guards etc.) Refer to Appendix 6 table 4 & 5 for suitable planting species.	ASAP after refining restoration plan	Eco-sourcing is important for the local ecological integrity. Eco-sourcing plants can be a long process. Plants need to be ordered as soon as possible. Not all species will need to be guarded.

Activity/Task	Area/Zone (Refer Figure 3)	Activity Required	Timing	Objective/Reason
	Zone 6 (optional, as opportunity allows) Other areas as opportunity allows			
Establish photopoints	All areas	Establish photopoints where ecological restoration will occur.	Prior to restoration	Good monitoring tool to observe progress and help with future restoration projects. Undertake regular monitoring as outlined in Section 10.
Mahinga kai feasibility study	All areas	Undertake an initial feasibility study for the reintroduction of a mahinga kai species (or multiple species).	ASAP - ongoing	Identify opportunities for mahinga kai reintroduction or enhancement with Te Rūnanga o Arowhenua. Develop and implement a management plan for mahinga kai.
Survey of barriers to fish passage	Entire length of stream, or southern stream Zones 2 and 5	Walk through survey to identify existing barriers impeding fish passage up and down the length of the stream.	ASAP, subject to landowner approval in northern section.	Ensure the habitats being restored are accessible to target fish species.
Habitat improvement for aquatic fauna	Entire length of stream, or southern stream Zone 2	Add large woody debris or rocks to increase fish habitat complexity.	ASAP after refining restoration plan, prior to riparian planting, subject to landowner approval in northern section	Increase the diversity of habitats for indigenous freshwater fish and invertebrates within streams by adding dead wood (large logs, piles of smaller logs) of non-invasive tree species or areas of boulders. Depending on the overall structure of the in-stream structures, these sites may provide roosting areas for duck and shag species.
Protection of headwater spring and stream hydrology	Zone 8; all areas	Implement management actions to address threats or opportunities identified during surveys.	After surveys	Protection of headwater stream and stream hydrology critical for long-term habitat provision.
Culvert remediation	Culvert / Zone 4	Replace or remediate culvert to improve fish passage. Undertake survey for additional barriers to fish passage (e.g., culverts, pipes) and remove or replace.	Winter (May-October) 2022 or Summer (November-January) 2023	Culvert is a barrier to indigenous fish passage. Important to avoid critical indigenous fish migration periods.
Barrier remediation	Entire length of stream, or Lower Stream / Zone 2	Remediate other barriers to fish passage identified by barriers survey (if any).	Winter (May-October) 2022 or Summer (November-January) 2023	Additional barriers requiring remediation may be present.
Fence installation and repairs	Zone 3 and 5; Zone 6 if this option is taken; Zone 8 if required.	Install fencing along edge of riparian setback. Complete and repair fencing around	Spring (September - November) 2022	Prevent stock accessing and impacting stream, wetland, and planting areas.

Activity/Task	Area/Zone (Refer Figure 3)	Activity Required	Timing	Objective/Reason
		wetland unit comprising zone 5, as necessary.		
Feasibility study for raising water levels.	Zone 5 and 6	Undertake a feasibility assessment for installing a weir at the southern end of the wetland to raise wetland water levels.	Autumn (April-May) 2022	Enhance wetland habitat. Conduct in consultation with adjacent landowners and leaseholders. Action may not be desirable by Steering group.
Pest plant control	Zones 3 & 5; All areas as access allows.	Spot spray, cut and paste or manual removal of pest plants (Appendix 4), and others detected (pest plant survey, above) depending on extent of exotic species present and their proximity to waterways.	After pest plant management plan has been developed – April 2022 - ongoing	Pest plants have the potential to inhibit the regeneration of indigenous vegetation. Any existing naturally-occurring indigenous vegetation should be identified and flagged (using suitable flagging tape), so as not to be removed, or damaged during pest plant control. Staged control of crack and grey willow.
Planting site preparation	Zone 3 and 5; Zone 6 if this option is taken; Zone 8 if required.	Follow up control of any pest plants that have survived or regenerated following initial control – within planting zones. Spot spray planting sites (0.4 metre round areas with 1% glyphosate or other suitable herbicide depending on target species and time of year).	Mid – late autumn. At least one month prior to planting	This is important for successful establishment of planted species and makes it easier and/or more efficient for planting. **All pest plant control should be undertaken by experienced Growsafe certified operators.**
Planting	Zone 3 and 5; Zone 6 if this option is taken; Zone 8 if required.	Plant and guard species were necessary. Plant at 1 – 1.5 m spacing for shrub/tree species. Refer: Appendix 6, Table 4 – for planting list and specifications.	At least one month after site preparation Spring 2022 – wetland areas Autumn 2022 – dryland areas.	Create a seed source for future natural regeneration, and enhance current habitats. In dryland areas planting should be undertaken from late autumn through to mid-winter. Once soil moisture levels reach full capacity. In wetland areas, planting should be undertaken in early-mid spring (September or October, depending on winter rainfall) once standing water in flooded areas has begun to recede. Planting to follow willow control, and could be staggered along a gradient from drier to wetter, early in the season to later as conditions dictate.

Activity/Task	Area/Zone (Refer Figure 3)	Activity Required	Timing	Objective/Reason
				Any areas that overlap with centre pivot irrigation systems should be planted with lower stature indigenous vegetation.
Planting site maintenance	Zone 3 and 5; Zone 6 if this option is taken; Zone 8 if required.	Spray (Glyphosate) or hand release plants from weeds and pest plants as required.	At least 3-4 visits over Spring-Summer for the first 3 years - after planting. Then ongoing as required until plantings have established.	This is vital for the successful establishment of the planting areas. Invading weeds can quickly establish and complete/outgrown planted species.
Undertake feasibility assessment to manage discharge from dairy shed	Zone 7	Assess options for managing effluent from dairy sheds.	As working relationship with landowner and managers allows.	Management of the point source discharge from the dairy shed on the upstream race is required for long term improvements in water quality.
Fence installation and repairs	Zones 7 and 8	Install fencing along edge of riparian setback. Complete and repair fencing around wetland unit comprising zone 5, as necessary	As working relationship with landowner and managers allows.	Prevent stock accessing and impacting stream, wetland, and planting areas.
Order eco-sourced plants and planting materials	Zones 7 and 8	Order eco-sourced plants and planting materials (plant guards etc.) Refer to Appendix 6 table 4 & 5 for suitable planting species.	As working relationship with landowner and managers allows.	Eco-sourcing is important for the local ecological integrity. Eco-sourcing plants can be a long process. Plants need to be ordered as soon as possible. Not all species will need to be guarded.
Infill planting	Zone 3 and 5; Zone 6 if this option is taken; Zone 8 if required.	Infill planting to replace plants that have died	Second or third year after the original planting.	Required to establish canopy closure.
Pest plant control	Zone 7 and 8	Spot spray, drill, cut and paste or manual removal of pest plants (Appendix 4), and others detected (pest plant survey, above) depending on extent of exotic species present and their proximity to waterways.	As working relationship with landowner and managers allows.	Pest plants have the potential to inhibit the regeneration of indigenous vegetation. Any existing naturally-occurring indigenous vegetation should be identified and flagged (using suitable flagging tape), so as not to be removed, or damaged during pest plant control.
Planting site preparation	Zone 7 and 8	Follow up control of any pest plants that have survived or regenerated following initial control – within planting zones. Spot spray planting sites (0.4 metre round areas with 1%	Mid to late autumn. At least one month prior to planting, as working relationship with landowner and managers allows.	This is important for successful establishment of planted species and makes it easier and/or more efficient for planting. **All pest plant control should be undertaken by experienced Growsafe certified operators.**

Activity/Task	Area/Zone (Refer Figure 3)	Activity Required	Timing	Objective/Reason
		glyphosate or other suitable herbicide depending on target species and time of year).		
Planting	Zone 7 and 8	Plant and guard species were necessary. Plant at 1 – 1.5 m spacing for shrub/tree species. Refer: Appendix 6, Table 2, Table 4 – for planting list and specifications, particularly with regards planting in Management units E, F, and H.	Autumn, at least one month after site preparation, as working relationship with landowner and managers allows.	Create a seed source for future natural regeneration, and enhance current habitats.
Planting site maintenance	Zone 7 and 8	Spray (Glyphosate) or hand release plants from weeds and pest plants as required.	At least 3-4 visits over Spring-Summer for the first 3 years - after planting. Then ongoing as required until plantings have established.	This is vital for the successful establishment of the planting areas. Invading weeds can quickly establish and complete/outgrown planted species.

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