Transforming Lowland Waterway Networks

A Catchment Management Plan for Reimagining the Ararira/LII

Plan prepared by EOS Ecology, Aqualinc & Cawthron

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This **Catchment Management Plan (CMP)** is designed to work in conjunction the **Implementation Guide (IG)**

The **IG** can be downloaded here, or via this QR code.

Contents

Fine sediment from the bed of a drainage channel, one of the issues in the Ararira catchment.

Image source: EOS Ecology

1 Introduction

Much of New Zealand's lowland agricultural land was developed by converting vast areas of forest and wetland into pasture. This was facilitated by digging drainage channels and laying networks of subsurface drains. While this land drainage began in the late 19th century, efforts to convert lowland wetlands to pastoral agriculture were accelerated by government subsidies during the 1950s and 60s. Whilst recognising the indelible effect this has had on our waterway landscape, the resulting drainage schemes are not only essential to some of our most productive land but are steeped in a history of back-breaking pioneering and form part of the cultural identity of many New Zealanders. This tension between seeking productivity and livelihood from the land and the risk of environmental degradation is replicated across the globe.

With their networks of straight lines and deeply incised channels, agricultural drains are often perceived to have low ecological value. However, although drainage 'improvements' tend to lead to declines in other values, such as biodiversity, cultural, and recreational values, these drains still have significant value. They are tributaries of larger river catchments and sensitive receiving environments, and in many areas, they provide the only remaining habitat for our indigenous freshwater flora and fauna. To maintain the drainage function of these waterways, they are regularly maintained, typically through mechanical clearing of sediment and macrophytes. This mechanical clearance removes fauna, destroys habitat, and degrades water quality. With this maintenance typically funded by historic rating structures, there is little funding for, or motivation to adopt innovative techniques that incorporate better environmental or cultural outcomes.

The principles of Te Mana o te Wai recognise the vital importance of freshwater and the connection that all New Zealanders have with freshwater. Te Mana o te Wai is an integral part of the New Zealand Government's *Essential Freshwater* programme, which aims to stop further degradation of our freshwater, to start making immediate improvements to water quality, and to reverse past damage to waterways and ecosystems (Ministry for the Environment, 2022a).

To understand the need for *Essential Freshwater*, as well as the National Policy Statement for Freshwater Management 2020, the Canterbury Water Management Strategy, and the many other documents striving to make a difference to freshwater management, we first need to understand the current state of our freshwater and where we have come from. In a 2017 review of the state of New Zealand's fresh waters, Peter Gluckman, the Chief Science Advisor to the Prime Minister, stated that, "the science is clear—New Zealand's fresh waters are under stress because of what we do in and around them." What causes these environmental stressors is also clear. Land use change brought about by human habitation and food production has profoundly changed the landscape of our watersheds. Deforestation and the loss of vegetative cover, draining of wetlands, and the creation of impervious surfaces in our urban areas has altered the hydrological cycle, with further changes anticipated as the effects of climate change become more evident each year. Urbanisation and agricultural intensification introduce excess sediment, nutrients, faecal waste, heavy metals, pesticides, and other contaminants to our freshwater, degrading both water and habitat quality. Some of the changes to our freshwater environments are insidious and not easily reversible. A 'lag effect' means that we may only now be seeing the effects of degradation that began decades ago; and subsequent improvements, due to more careful environmental stewardship, may not be seen for decades to come. The concept of 'shifting baseline syndrome' is also relevant here. This refers to each new generation accepting the ecological state at the beginning of its generation as the baseline. This allows for gradual environmental degradation through successive generations purely because of changing perceptions of what is considered acceptable. Consequently, we come to regard as pristine an environment that was seen as degraded by our predecessors.

For the most basic of reasons, our continued survival is dependent on water. The ecological state of our water bodies – including oceans, lakes, and rivers – is not just a matter for scientists to worry about. As individuals, communities, and nations, all our futures are inextricably linked to the state of the water on this planet. What is required to achieve the objectives of the *Essential Freshwater* programme are not minor adjustments to business as usual, they are urgent and substantial changes – designed not only to stop further degradation, but to reverse past damage. Therefore, the changes put forward in this Catchment Management Plan (CMP) can no longer be considered optional or aspirational – they must be considered as essential and become the 'new normal'. Now is the time to make a change – to take the opportunity to do things differently and help forge a better future for our environment and tamariki – and we have the knowledge, tools, and indeed desire to start this journey. Some of these solutions could cost more than existing practices, but their multiple benefits can outweigh the purely financial considerations and move the catchment towards a more sustainable future.

Ararira/LII Catchment

The Ararira/LII catchment is a 6,760 ha surface water catchment in coastal mid Canterbury. The waterways of the catchment flow through the heart of the Lincoln township and through rural land before discharging into Te Waihora/Lake Ellesmere, the coastal hāpua (lake-lagoon) (Figure 1). The catchment is the second largest contributor of water to Te Waihora/Lake Ellesmere, second only to the Waikirikiri/Selwyn River catchment (Hamilton *et al*., 2017). At 198 km^2, Te Waihora is Canterbury's largest and New Zealand's fifth largest coastal lagoon. As one of the most polluted coastal hāpua in New Zealand (ranked as NZ's third worst lake for water quality), Te Waihora receives nitrogen and phosphorus loads two to four orders of magnitude greater than all other monitored lakes. With most of the catchment used for intensive agriculture, and the lake level artificially controlled, the lake is now excessively enriched with excess nutrients, high algal biomass, and poor water clarity. Improving the health of Te Waihora is crucial to the long-term health and wellbeing of all those who interact with the lake, and it is expected that improving the health of the waterways of the Ararira catchment will contribute to the greater challenge of improving the health of Te Waihora. The changes proposed for Ararira may also provide the momentum required to initiate change in other catchments and provide an example for others to follow.

Te Waihora/Lake Ellesmere Catchment

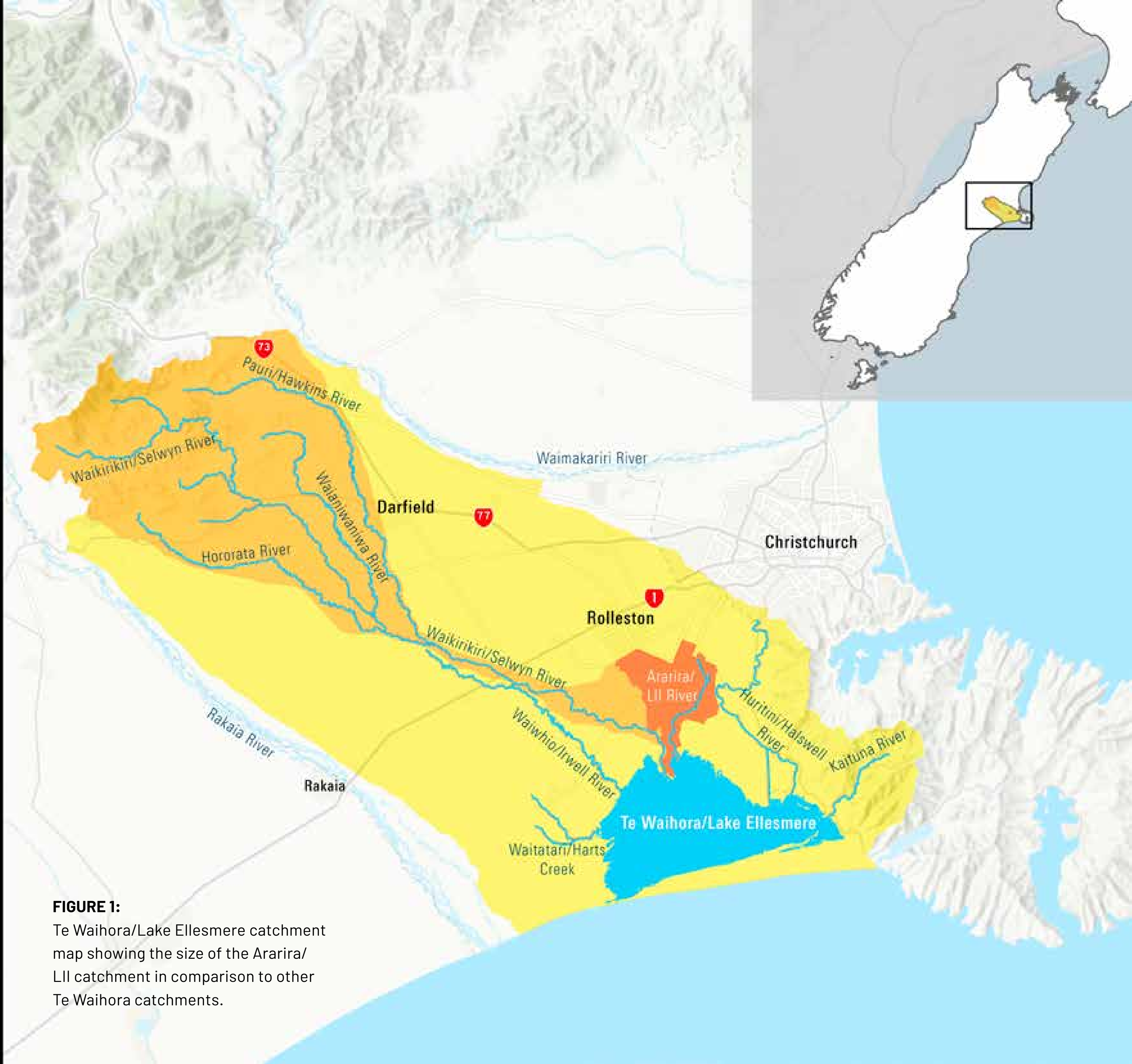


FIGURE 1:
Te Waihora/Lake Ellesmere catchment map showing the size of the Ararira/LII catchment in comparison to other Te Waihora catchments.

Layer source: Major waterways: LINZ, Te Waihora/Lake Ellsemere & Waikirikiri/Selwyn River catchments: Canterbury maps, Ararira/LII River catchment: modified from catchment layer provided by DOC.

Image source: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth © OpenStreetMap contributors.

A Transformative Approach

This document works together with other key resources to provide the roadmap for improving the health of the Ararira catchment waterways for the benefit of future generations.

Project Document Roadmap for Catchment Waterway Improvement

Catchment Management Plan (CMP)

Summary of:

- past & present **state**
- current & future **pressures**
- main **challenges**.

Proposes solutions:

- **Catchment-scale approaches** designed to decrease ongoing impacts of surrounding land use.
- **Toolbox** of proposed interventions to deal with existing state, plus the legacy of past & present drainage/land use practices.

What it does:

Sets out plan to fundamentally change how the drainage network is managed by implementing tools that not only deal with existing challenges, but also enhance the catchments biodiversity & cultural values.

The plan is grounded by the need to continue to provide effective drainage of productive land.

Implementing catchment-scale changes in land/drain management, combined with reach-scale interventions will improve existing condition & reduce catchment pressures. This improves the state of waterways and, ultimately, the receiving environment (Te Waihora/ Lake Ellesmere).

Implementation Guide (IG)

Describes:

- **approaches** for bringing people together to work towards a shared vision for catchments and to evaluate progress
- **financial pathways** to support implementation of the CMP
- **planning/consenting** requirements of the CMPs proposed toolbox
- **phasing of works**.

What it does:

Supports the implementation of the CMP. It is based around a framework of 12 key areas, which recognises a number of key activities that collectively support change. The aim of the IG is to stimulate and support a transparent, neutral, open, inclusive and forward-looking dialogue across SDC, mana whenua, partners and stakeholders to ensure that different activities collectively contribute to realising the bigger picture. In this way it works well with assessing progress towards a shared vision – such as that set out in the CMP.

Tuna/Shortfin eel, an historic mahinga kai species for the area.

Image source: EOS Ecology

2 Vision for the Ararira Catchment

During October 2020, Living Water (DOC/Fonterra Partnership) signed a Memorandum of Understanding with Te Taumutu Rūnanga and Selwyn District Council to redesign the waterway network in the Ararira/LII drainage district. The purpose was to work together to produce a catchment plan for the Ararira that fundamentally changed the way waterways were valued and managed by incorporating ecological and cultural values into the design while also recognising that drainage would remain a key value.

Living Water formed an Ararira drainage redesign Project Team in January 2021, to follow a co-design process, whereby the Project Team (including partners Department of Conservation, Fonterra, Te Taumutu Rūnanga, Selwyn District Council, Environment Canterbury, and the LII Drainage Committee) work together with the Consultant Team (EOS Ecology, Aqualinc Research and Cawthron Institute) to find workable solutions for this catchment.

The Project Team developed a vision and mission statement, to define the purpose and anticipated outcomes of the project. These statements were developed during a values mapping workshop and were aligned with the Te Waihora Co-Governance indicator framework. The framework was developed to help Co-Governors track overall progress towards achieving their vision and strategic priorities for the restoration of the mauri of Te Waihora. Key outcomes that would result from a transformative approach to catchment management were grouped under four key value 'baskets':

1. The mauri and ecosystem health of Te Waihora is restored.
2. Thriving communities – current and future generations are provided for.
3. A healthy Te Waihora supports healthy people.
4. A prosperous land and water-based economy is maintained.

The development of this CMP and its related IG provides the roadmap through which this vision and mission can be achieved, and the key value baskets realised.

Vision Statement

The life force of the Ararira catchment is enhanced by the thriving communities who live within it, and their relationship to land and water, now and in the future.

Mission Statement

We will work together to reimagine the Ararira so that it continues to support thriving and resilient communities while enhancing the mauri of the catchment.

Key Value Baskets

The Mauri & Ecosystem Health of the Lake

- Taonga species returned.
- Native biodiversity.
- A healthy Te Waihora.
- Restore mauri of Ararira LII.
- Ki uta ki tai – mountains to the sea approach to management of all waterways.
- Waipuna health – protecting & valuing springs & natural landscapes.

Thriving Communities – Providing for Current & Future Generations

- Resilient communities.
- Te Waihora lake management.
- Embracing innovation.
- Partnership approaches.
- Community engagement & participation.
- Common 'terminology' reflects values of environment & culture.
- Clear & agreed management strategy for catchment.

A Healthy Lake Supports Healthy People

- Recognising our social history.
- Connected people to land.
- Can swim in LII.
- Recreation & educational opportunities.
- Well-monitored & integrated water quality monitoring.
- Ahi kā – recognising people – past, present & future.

A Prosperous Land- & Water-based Economy is Maintained

- Drainage system that supports social resilience.
- Land use supports people/ communities.
- Regenerative practices for all land use.
- Sustainable economy – includes research farms, etc.
- Reliable rural & urban drainage – protecting productive soils, farms & houses.
- Avoiding flooding & groundwater flooding.

Freshwater springhead in Lincoln township, a water source for the Ararira/LII River.

Image source: EOS Ecology

Past State

PRE 1330 AD
Pre-human Settlement

Prior to human settlement the Ararira catchment was mostly forested in a kahikatea/mataī/totara podocarp forest, with only very small pockets of grassland.

Image source: EOS Ecology

1330 ONWARDS
Māori Settlement

Following the loss of forest habitat, the Ararira catchment became a vast area of wetlands.

Image source: Canterbury Museum

1800 ONWARDS
European Settlement

The wetlands of Ararira were drained and the waterways channelised to make way for arable farming and crop production.

Men digging a drainage ditch in the Kaitaia swamp. Northwood brothers. Photographs of Northland. Image source: Ref: 1/1-010652-G. Alexander Turnbull Library, Wellington, New Zealand. /records/22913942

1860S
Urban Creation

The township of Lincoln was established in the headwaters of the catchment in the 1860s and urban expansion continued at a relatively slow pace through to the 1980s.

The LI River in the newly formed Lincoln township, ca 1880s. Image source: Lincoln & Districts Historical Society

1980S ONWARDS
Urban Growth & Farming Intensification

In recent decades the catchment has seen an intensification of farmland and further urban expansion.

Aerial image source: Robin Smith, DOC

FIGURE 2:
A visual history of the changing states of the Ararira/LII Catchment.

3 State of the Ararira Catchment

3.1 Past State

The Ararira catchment has not always looked as it does today (Figure 2). Prior to Māori settlement, the area would have been cloaked in lowland podocarp forest dominated by kahikatea and mataī, with very little grassland (Figure 3). At the time of European arrival, the southwestern part of the catchment was described as flax and raupō swamp/wetland, while the northwest was grass plains (Figure 4). The eastern part of the catchment supported flax and raupō swamp, but also included areas of grass and flax (Figure 4). The underlying soil types of the catchment illustrate the relationship between the less permeable soils of the lower catchment and the past habitat of vast wetlands in that area (Figure 4). In comparison, the more dry land environment of the upper portion of the catchment is characterised by more freely draining soils (Figure 4). Recent LiDAR data shows the intricate network of waterways and overland flow paths that were an integral part of this landscape prior to human settlement and land drainage (Figure 5).

Following European settlement, the myriad of natural waterways and wetlands in the area were drained, as a network of artificial drainage channels was excavated across the landscape by hand (Figure 2). During the 1890s, drain maintenance was contracted out, with tasks including weed cutting, clearance of stumps and vegetation, and removal of silt from drains (Singleton, 2007). The township of Lincoln was established as an agricultural town in the 1860s, designed around the headwaters of the Liffey River, or LI as it is now known. The availability of fresh running water suitable for establishing a flour mill was an important consideration for the location of the town (Montgomery *et al*., 2017). While around 200 quarter acre sections went up for sale as part of the original layout of the Lincoln township in 1862, the town had only 102 houses and a population of 400 by 1948, and slow urban growth continued through until the 1980s. Since that time, urban development has gained pace, with influences such as the removal of agricultural subsidies, local government reforms, the passing of the Resource Management Act 1991, the dairy boom, and the Christchurch earthquakes all contributing to the urban expansion of Lincoln (Montgomery *et al*., 2017).

Ararira/LII River Catchment
Historic Vegetation Cover

- Coastal salt marsh
- Coastal sand dune
- Grassland/shrubland
- Kahikatea/mataī podocarp forest
- Swamp/wetland
- Totara/mataī podocarp forest
- Dry woodland

- Waterways
- Main roads

N

0 0.5 1 2 Kilometers

Layer source: Vegetation cover: modified using Williams, K (2005) plant groupings from smap soil classification layer provided by LRIS, Waterways: modified from classified drains layer provided by SDC, Ararira/LII River catchment: modified from catchment layer provided by DOC, Roads: LINZ.

Image source: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

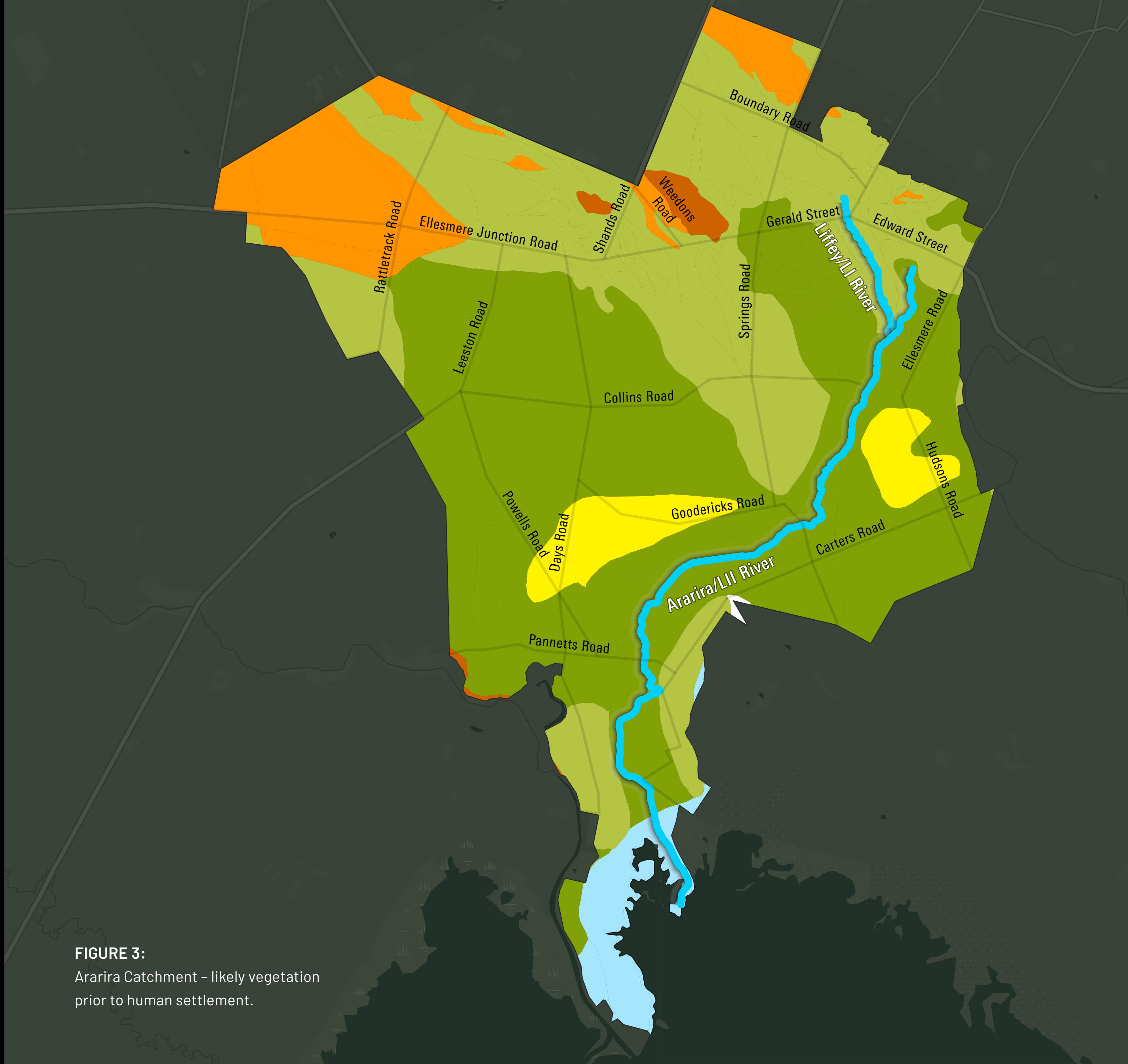


FIGURE 3:
Ararira Catchment – likely vegetation prior to human settlement.

Ararira/LII River Catchment Historic Black Maps Land Cover

- Broken ground
- Bush
- Fern
- Grass
- High water
- Lagoon
- Pond
- Raupo
- River channel
- Rushes & toe toe
- Sand Hill
- Wetland

N

0 0.5 1 2 Kilometers

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: Land cover: modified from Black Maps layer provided by Canterbury Maps, Ararira/LII River catchment: modified from catchment layer provided by DOC.

Image source: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

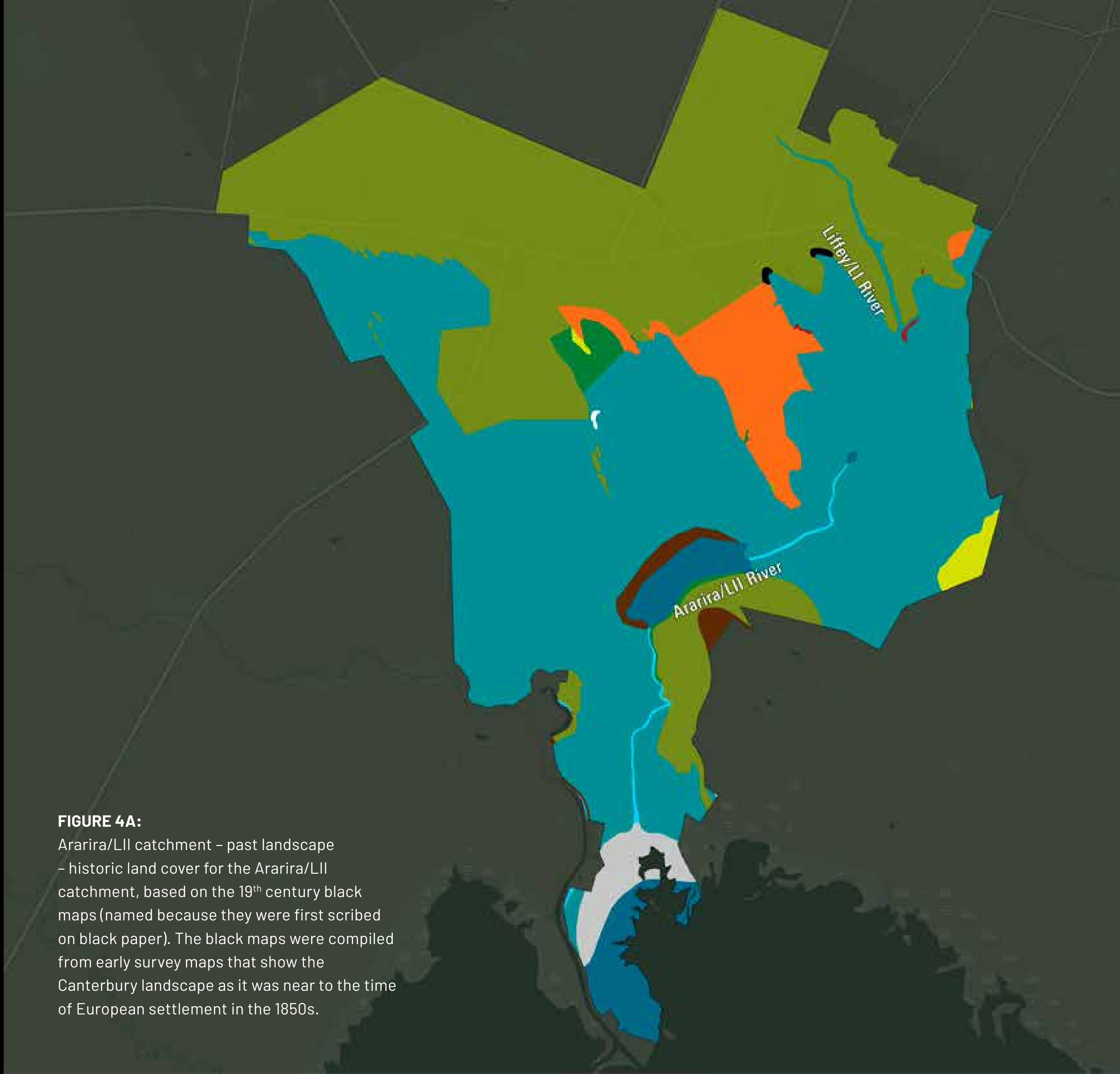


FIGURE 4A:
Ararira/LII catchment – past landscape – historic land cover for the Ararira/LII catchment, based on the 19th century black maps (named because they were first scribed on black paper). The black maps were compiled from early survey maps that show the Canterbury landscape as it was near to the time of European settlement in the 1850s.

Ararira/LII River Catchment Soil Drainage

- Well drained
- Moderately well drained
- Imperfectly drained
- Poorly drained
- Very poorly drained

- Waterways
- Main roads

0 0.5 1 2 Kilometers

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: Soil drainage: Canterbury Maps, Waterways: modified from classified drains layer provided by SDC, Ararira/LII River catchment: modified from catchment layer provided by DOC, Roads: LINZ.

Image source: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

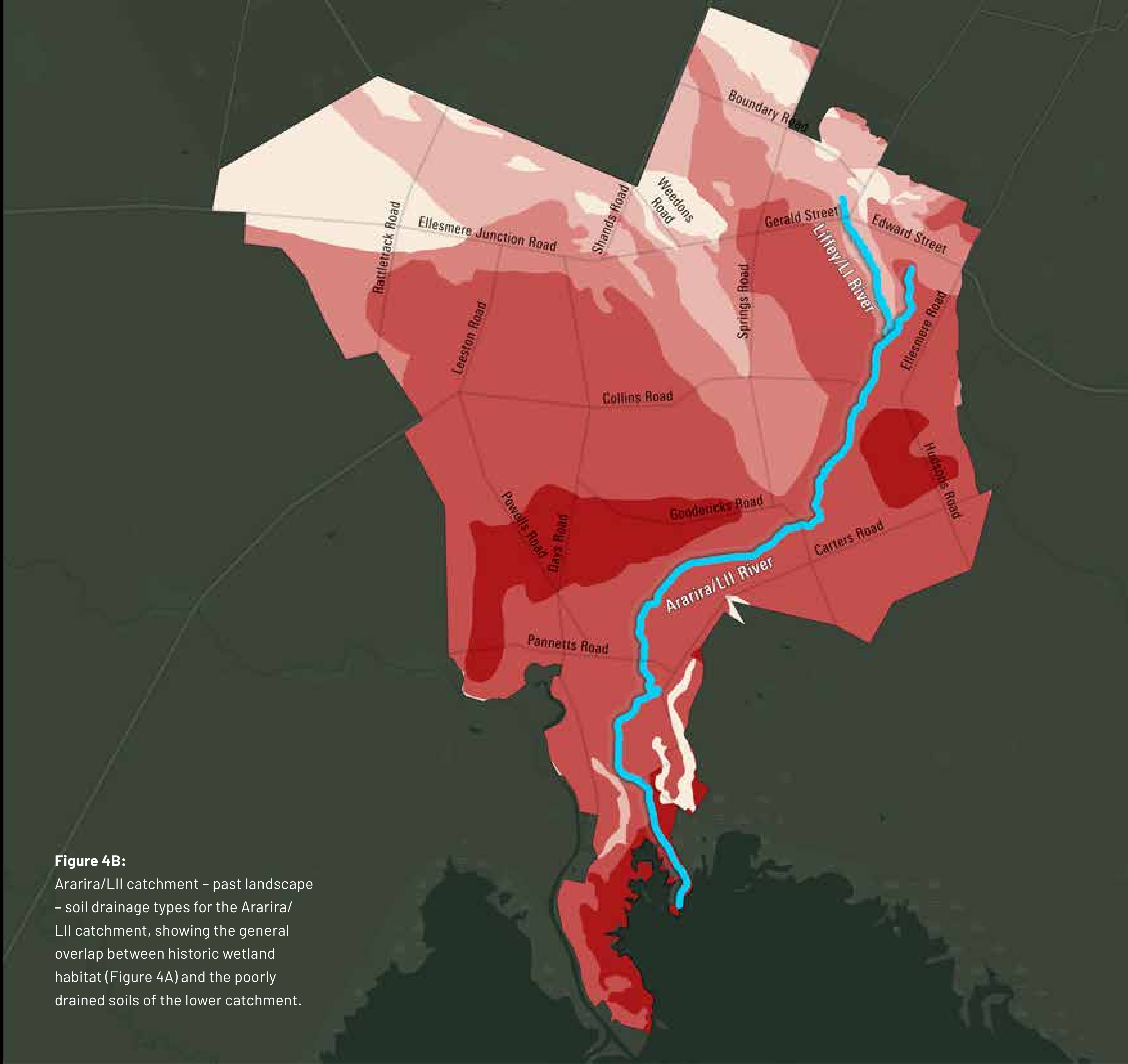


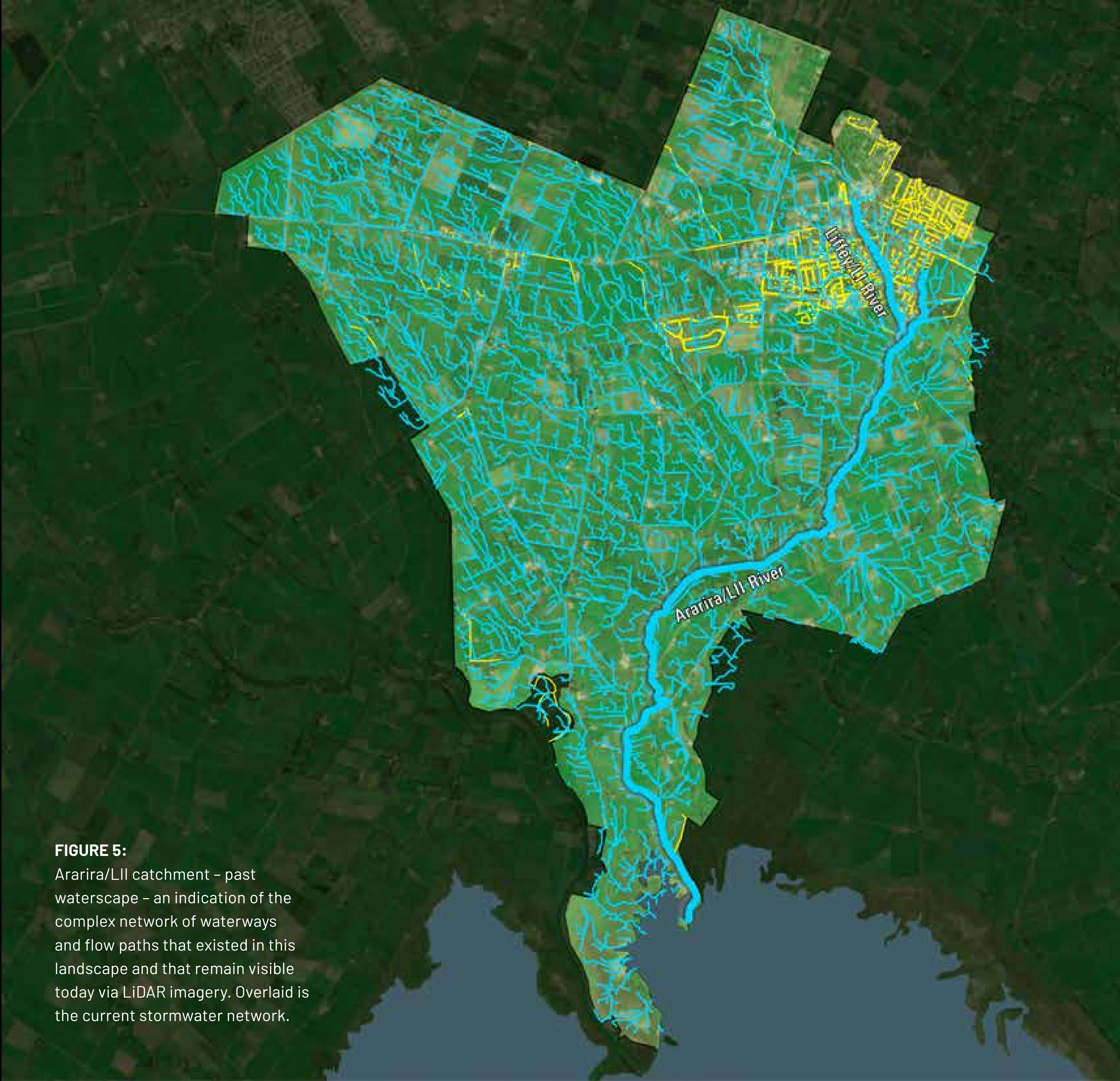
Figure 4B:
Ararira/LII catchment – past landscape – soil drainage types for the Ararira/LII catchment, showing the general overlap between historic wetland habitat (Figure 4A) and the poorly drained soils of the lower catchment.

Ararira/LII River Catchment Waterways & Flowpaths

Overland flowpaths

Stormwater pipes & channels

Waterways



0 0.5 1 2 Kilometers

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: Overland flowpaths: Created by Aqualinc using Canterbury LiDAR 1m DEM provided by LINZ, Stormwater: SDC, Waterways: modified from classified drains layer provided by SDC, Ararira/LII River catchment: modified from catchment layer provided by DOC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors.

FIGURE 5:
Ararira/LII catchment – past waterscape – an indication of the complex network of waterways and flow paths that existed in this landscape and that remain visible today via LiDAR imagery. Overlaid is the current stormwater network.

3.2 Present State

3.2.1 Land Use

The Ararira catchment covers an area of around 6,760 ha of predominantly flat land, including both urban and rural land use. The catchment includes the small town of Lincoln, which is rapidly growing as urban development expands into the surrounding farmland. Lifestyle properties are also scattered throughout the catchment and covering approximately 8% of the land area. However, farming is by far the dominant land use in this catchment, representing around 70% of the catchment area (Figure 6). In contrast, the built-up urban area represents only 6% of the land in the catchment. Several types of farms are represented in the catchment, including dairy, sheep, beef, deer, and horticulture. Dairy farming is the dominant farm type in terms of area covered, with approximately 50% of the catchment identified as being used for this purpose (Living Water, 2022). With the increase in intensive farming in the catchment, there has also been an increase in irrigated land, with around 3,100 ha currently irrigated (based on Dark, 2020). While high producing exotic grassland is the dominant land cover in the catchment, collectively constituting 63% of the land area, a further 26% of the catchment is used for short-rotation cropland. There are also small amounts of exotic forest (0.5%) within the catchment.

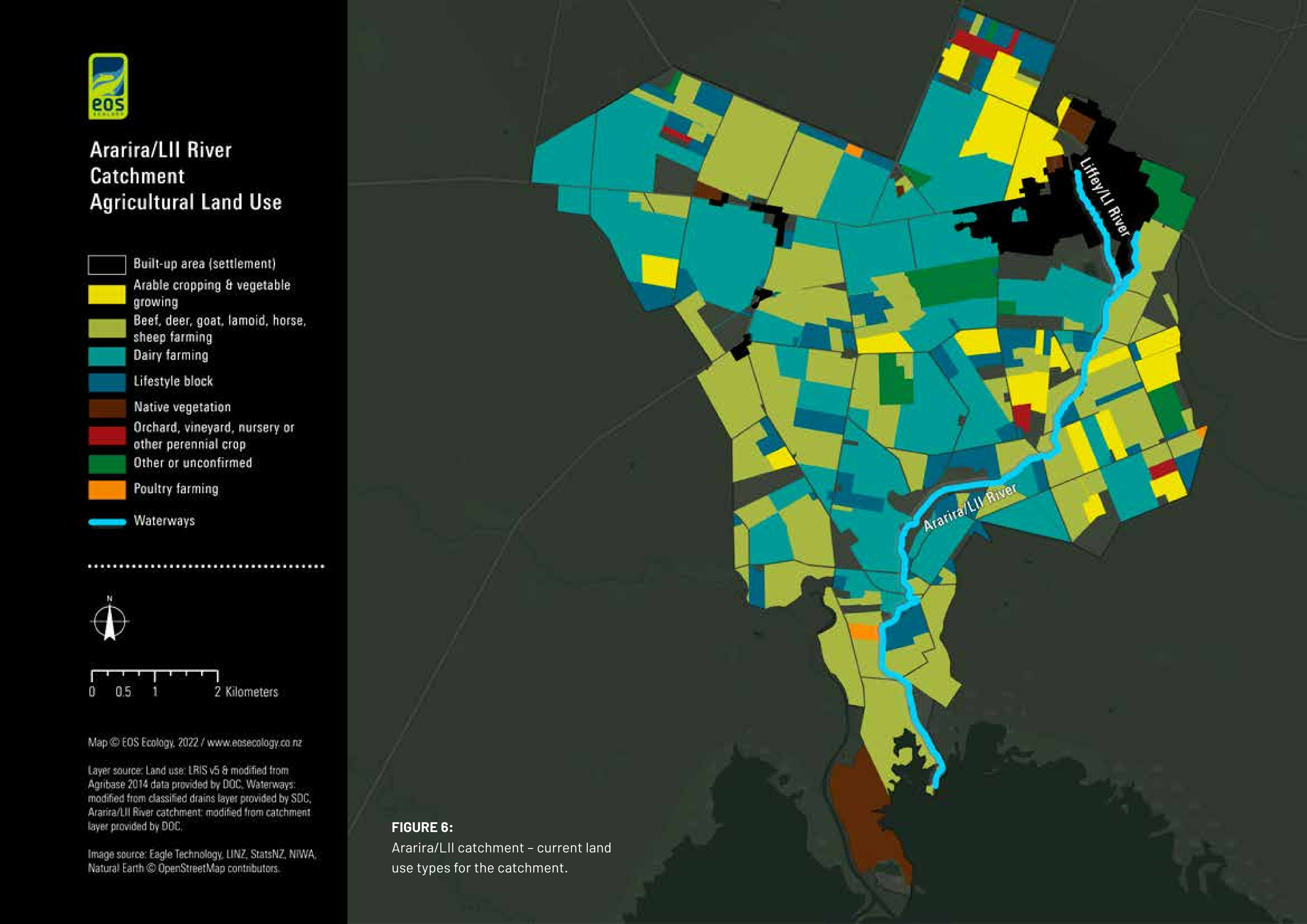


FIGURE 6:
Ararira/LII catchment – current land use types for the catchment.

3.2.2 Waterways & Their Habitat

The Ararira catchment consists of a network of spring-fed waterways and artificial drainage channels, feeding into the mainstem of the Ararira River, which discharges to Te Waihora/Lake Ellesmere. Within the catchment, there are several distinct waterway types and sources of water (Figure 7). The northwestern part of the catchment receives water from the Paparua water race scheme (sourced from the Waimakariri River), whereas the northeastern part of the catchment has the highest density of springs. The drains within the catchment vary in their flow permanence, ranging from ephemeral or intermittent in the upper catchment, to permanent flow further downstream as the drains discharge to the mainstem. The waterway types, and their spatial distribution within the Ararira catchment have been assembled based on existing spatial data, a review of previous catchment studies, discussions with the Project Team, and observations during field visits. The water sources and waterway types are described in more detail in Figure 8.

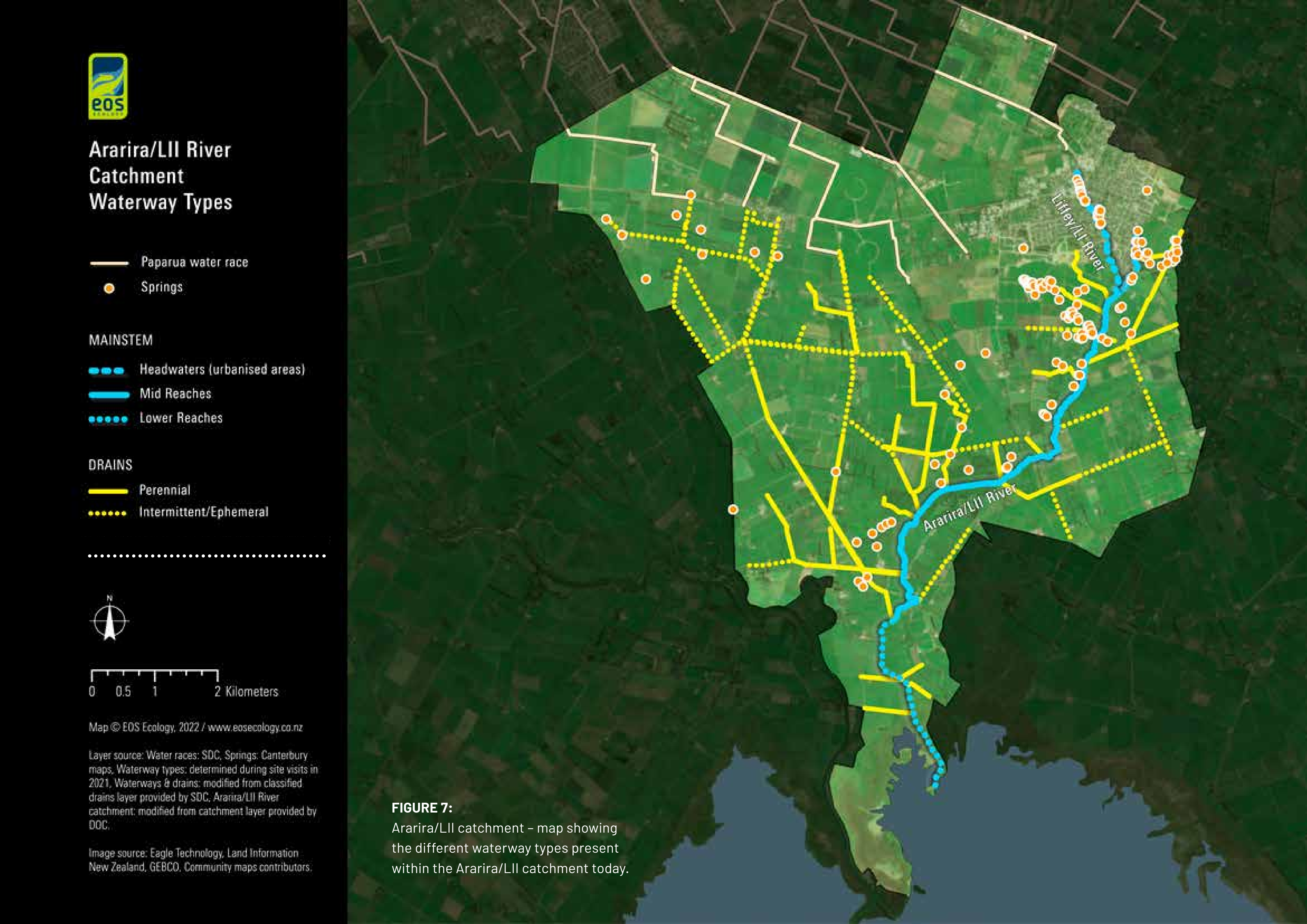


FIGURE 7:
Ararira/LII catchment – map showing the different waterway types present within the Ararira/LII catchment today.

Water Sources

Springs

Two main types of artesian spring are present in the Ararira catchment. These include springs that discharge within the waterways and those that form a springhead on the land. The location of these springs may change over time, in response to weather conditions and irrigation patterns. Springheads are typically visible as wet or muddy areas in otherwise dry land and the water they discharge may follow informal flow paths to the nearest drainage channel.

ISSUES with springs include their potential to contribute fine sediments to downstream waterways, especially when stock are not excluded from accessing springs.

Springs are identified by water bubbles in areas of otherwise still water.

A springhead discharging to a nearby drainage channel.

A small springhead adjacent to an urban development area.

A large springhead within Lincoln township.

Image source: EOS Ecology

FIGURE 8 pages 20–24**:**
Images and descriptions of the different waterway types within the Ararira/LII catchment today.

Informal Flow Paths

These depressions in the landscape are the routes taken by water during and shortly after rainfall. They may be visible as low areas or depressions on the landscape but there is no obvious channel, and they may be difficult to observe during dry weather as the flow is ephemeral. Informal flow paths have been identified using aerial photos and LiDAR as shown in Figure 5.

ISSUES with informal flow paths include their tendency to contribute high levels of fine sediment to nearby drains during wet weather and their widespread distribution in this catchment.

Informal flow paths are low areas or depressions on the landscape and are difficult to observe during dry weather.

During rainfall, water accumulates in depressions and follows informal flow paths to reach nearby drains.
Image: Robin Smith, DOC.

Drain margins may act like a bund, holding back water, which then spills over at the lowest point.
Image: Robin Smith, DOC.

Informal flow paths continue to discharge water to drains following rainfall.
Image: Robin Smith, DOC.

Image source: EOS Ecology unless otherwise stated

Water Race

The water races in this catchment are part of the Paparua Stock Water Race scheme, which sources water from the Waimakariri River. These water races feed into the northwestern part of the Ararira catchment and provide a perennial source of flow to parts of the upper catchment, as well as being a source of water for aquifer recharge. These are typically well defined, straight, channelised artificial waterways, either located on-farm or as roadside waterways.

ISSUES for these waterways include high levels of fine sediment, which may act as a sediment source to the lower catchment.

The lower reaches of some water races are often dry as the water flow diminishes and soaks to ground.

Some water races retain flow in their lower reaches, providing areas of perennial flow in the upper catchment.

Water races may be a source of fine sediment inputs to the catchment.

Drains

Ephemeral/Intermittent

Ephemeral and intermittent drains within the Ararira catchment are typically straight channelised waterways. They may flow during and briefly after rainfall (ephemeral) or more consistently during the wetter seasons of the year (intermittent). These waterways are typically unfenced and while some are located on-farm, many of these are roadside drains. The intermittent drains may have gravel substrate, but this is often embedded within fine sediment.

ISSUES for these drains include fine sediment accumulation, stock access, steep banks, and a lack of space to enable alternative bank treatments.

Ephemeral flow paths are typically straight and may look like grassed swales if they rarely hold water.

An intermittent roadside drain with gravel substrate embedded within fine sediment. Intermittent waterways are typically dry during summer months but flow more consistently during autumn and winter.

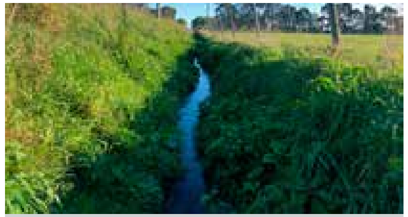
Steep banks and a lack of space for bank reshaping are known issues for intermittent drains.

Perennial

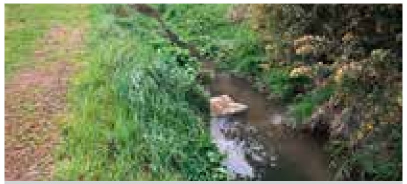
Permanent drains within the Ararira catchment are typically straight channelised waterways. Instream habitat variability is low, with run flow type and soft sediment substrate being dominant for this waterway type, although there are some stretches with faster water velocity and gravel substrate. Where there is little shade, emergent macrophytes are abundant in these waterways. Emergent macrophytes (mainly monkey musk (*Erythranthe guttata*) and water cress (*Nasturtium officinale*)) provide the main instream habitat type in these drains, but these also choke the channels and so are subject to seasonal clearance.

ISSUES for these drains include high sediment inputs, stock damage, steep banks with areas of slumping and instability, and seasonal emergent macrophyte growth.

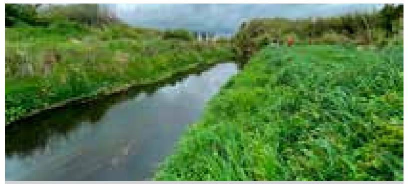
Perennial drains are often fed by spring inputs.



Perennial drains may have steep banks and little space for bank reshaping.



In this roadside perennial drain with little riparian shading, emergent macrophytes have established at the margins.



A deeper perennial drain with abundant submerged macrophytes and no riparian shading.

Image source: EOS Ecology

Mainstem

Headwaters (urbanised area)

The headwaters of the Ararira mainstem are mainly within the urban area of Lincoln. The mainstem and tributaries within the urban area have a relatively natural and sinuous channel form, compared to the artificial drains further downstream. Whilst dry upstream of the town, the mainstem has perennial flow within the urban area and there are areas of gravel substrate, although this may be embedded within fine sediments. There are many in-channel springs contributing to the flow in this area. Instream habitat variability is low, with run flow type dominant. The channel is well shaded in places by exotic canopy trees and as a result, macrophyte cover is variable. Instream and riparian improvements have been implemented in places, as the urban area has been developed.

ISSUES for the mainstem headwaters include a lack of space for substantial riparian planting, and the influence of urban stormwater inputs such as fine sediment and contaminants.

Space for tributaries may be limited within the urban area.

The Ararira mainstem has areas of gravel bed in its urban headwaters, which are well shaded with mature exotic trees.

Instream and riparian improvements have been implemented along with urban development in some areas.

Stormwater infrastructure is conspicuous in the urban environment.

Image source: EOS Ecology

Mainstem continued over page...

Mid Reaches

Downstream of the urban area, the mainstem of the Ararira channel becomes deeper and wider, as perennial drain tributaries join the river. At a landscape scale, the river channel is sinuous, but at the reach scale it has been straightened and channelised over time. With soft sediment substrate dominant, the abundant submerged macrophytes provide the main instream habitat, along with undercut banks. Much of the channel is fenced, but there is little substantial vegetation to provide shade to the channel. Rank grasses are the typical riparian vegetation, with occasional taller native or exotic vegetation present. Ungrazed riparian margins are often very narrow or almost non-existent with fences located on the edge of the banks. Tārerekautuku Yarrs Lagoon is within this section of the river.

ISSUES for the mainstem mid reaches include limited instream habitat diversity, the excessive growth of submerged macrophytes, and the lack of substantial riparian planting.


The Ararira River through Tārerekautuku Yarrs Lagoon.
Right image source: Robin Smith, DOC


Riparian planting on the true right bank of the Ararira River, upstream of Pannetts Road bridge.
Leftl image source: Robin Smith, DOC

Lower Reaches

The lower reaches of the Ararira catchment have similar characteristics to the mid reaches, with a wide, deep channel and a uniformly soft sediment substrate. The river is channelised and distinctly separate from the surrounding wetlands as it discharges to Te Waihora/Lake Ellesmere. The characteristics of this lower part of the river are likely to be influenced by lake levels.

ISSUES for the mainstem lower reaches include limited instream habitat diversity, the excessive growth of submerged macrophytes, and the lack of substantial riparian planting.

The lower reaches of the Ararira mainstem, at Wolfes Road.

The wide and deep channel in the lower reaches of the Ararira mainstem. Riparian vegetation is absent on one side of the river.

Aerial view of the mainstem of the Ararira River, showing the lack of substantial riparian vegetation.
Image source: Robin Smith, DOC

Aerial view upstream from Te Waihora/Lake Ellesmere, showing the lower reaches of the Ararira mainstem and catchment, including Yarr's Flat. Image source: Robin Smith, DOC

Image source: EOS Ecology unless otherwise stated

3.2.3 Freshwater Ecology

Much of what is known about the freshwater ecology of the Ararira catchment comes from recent survey work by the University of Canterbury and Living Water (Harding & Meijer, 2021; Instream Consulting, 2018; Golder, 2015). This work has shown that the ephemeral and intermittent reaches of the catchment support a community of freshwater invertebrates limited to species that are tolerant of poor conditions. Fish are not often recorded in these waterways because of the lack of permanent flow. The permanent drains and mainstem headwaters support a greater diversity of freshwater invertebrates, but the invertebrate community is indicative of poor water quality. There have been 37 freshwater invertebrate taxa (Table 1) as well as 13 fish species recorded from the catchment (Table 2; Figure 9). Only one site in the mid to lower mainstem of the Ararira River has been surveyed for macroinvertebrates, probably because the mid to lower mainstem is largely non-wadeable and unsuitable for typical aquatic invertebrate sampling methodologies. There are also anecdotal accounts of abundant frog populations in the catchment, including within the stormwater treatment systems and some of the permanent drains (Barry Moir & Daniel Meehan, pers. comms.).

Of the ten native fish species recorded from the catchment, īnanga, longfin eel, torrentfish, and bluegill bully have a threat status of *at risk declining*, giant bullies have a threat status of *at risk naturally uncommon,* lamprey is *threatened nationally vulnerable*, whereas the other native fish species in the catchment are considered *not threatened* (Dunn *et al*., 2017). Although the New Zealand Freshwater Fish Database (NZFFD) records the presence of torrentfish in the Ararira mainstem, this is an incidental record, as the catchment is unlikely to have sufficient fast flowing habitat to support a self-sustaining population of this species. Similarly, a survey by Taylor & Marshall (2018) provides the only record of bluegill bully for the catchment and suitable habitat for this species is very limited within the catchment. Two pest species have been recorded in the catchment, including goldfish and rudd. Introduced brown trout also occur throughout the catchment and support a locally popular fishery.
In the Ararira catchment, the diversity of migratory fish species with short life cycles (such as īnanga, which only live for 1–2 years) could be affected by when the Te Waihora/Lake Ellesmere outlet is open. For example, in 2021 an extensive īnanga survey by University of Canterbury found very few īnanga populations anywhere in the Te Waihora catchment, which was attributed to the lake only being open once that year (Mike Hickford, University of Canterbury, pers. comm.).

TABLE 1:
Summary of aquatic invertebrates found today in the Ararira/LII catchment waterways (based on surveys by Harding & Meijer, 2021; and Instream Consulting Limited, 2018).

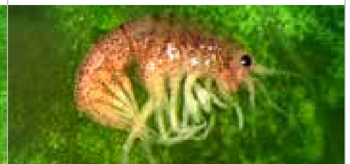
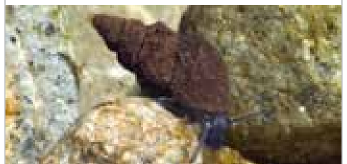
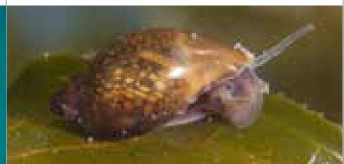
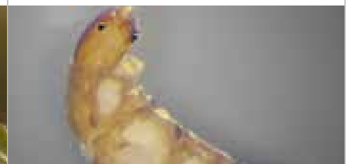
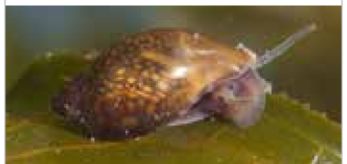
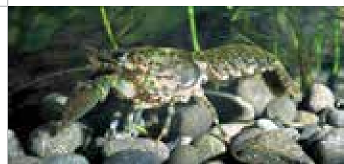
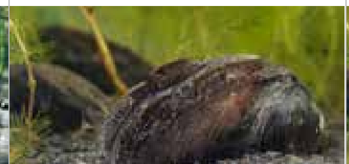
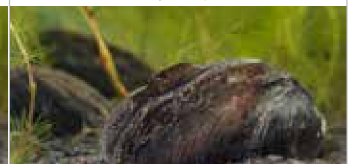
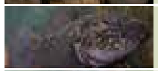
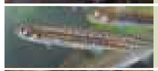
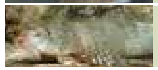
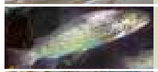
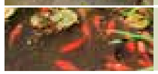
	Drains		Mainstem		
	Ephemeral/Intermittent	Perennial	Headwaters	Mid Reaches	Lower Reaches
Average species diversity	Taxa richness ~ 12	Taxa richness ~ 14	Taxa richness ~ 19	Insufficient data	Taxa richness = 24 (one survey site only)
Average MCI/QMCI Scores	MCI 76 / QMCI 3.6	MCI 69 / QMCI 3.9	MCI 74 / QMCI 4.0		MCI 71 / QMCI 4.4
Three most abundant taxa	 *Potamopyrgus antipodarum*	 *Potamopyrgus antipodarum*	 *Potamopyrgus antipodarum*		 *Paracalliope* sp.
	 *Physa* sp.	 *Oxyethira albiceps*	 *Paracalliope* sp.		 *Potamopyrgus antipodarum*
	 *Ostracoda*	 *Physa* sp.	 *Orthocladiinae*		 *Physa* sp.
Mega invertebrates present			 Waikōura/Freshwater crayfish	 Kākahi/Freshwater mussel	 Kākahi/Freshwater mussel

Image source: EOS Ecology

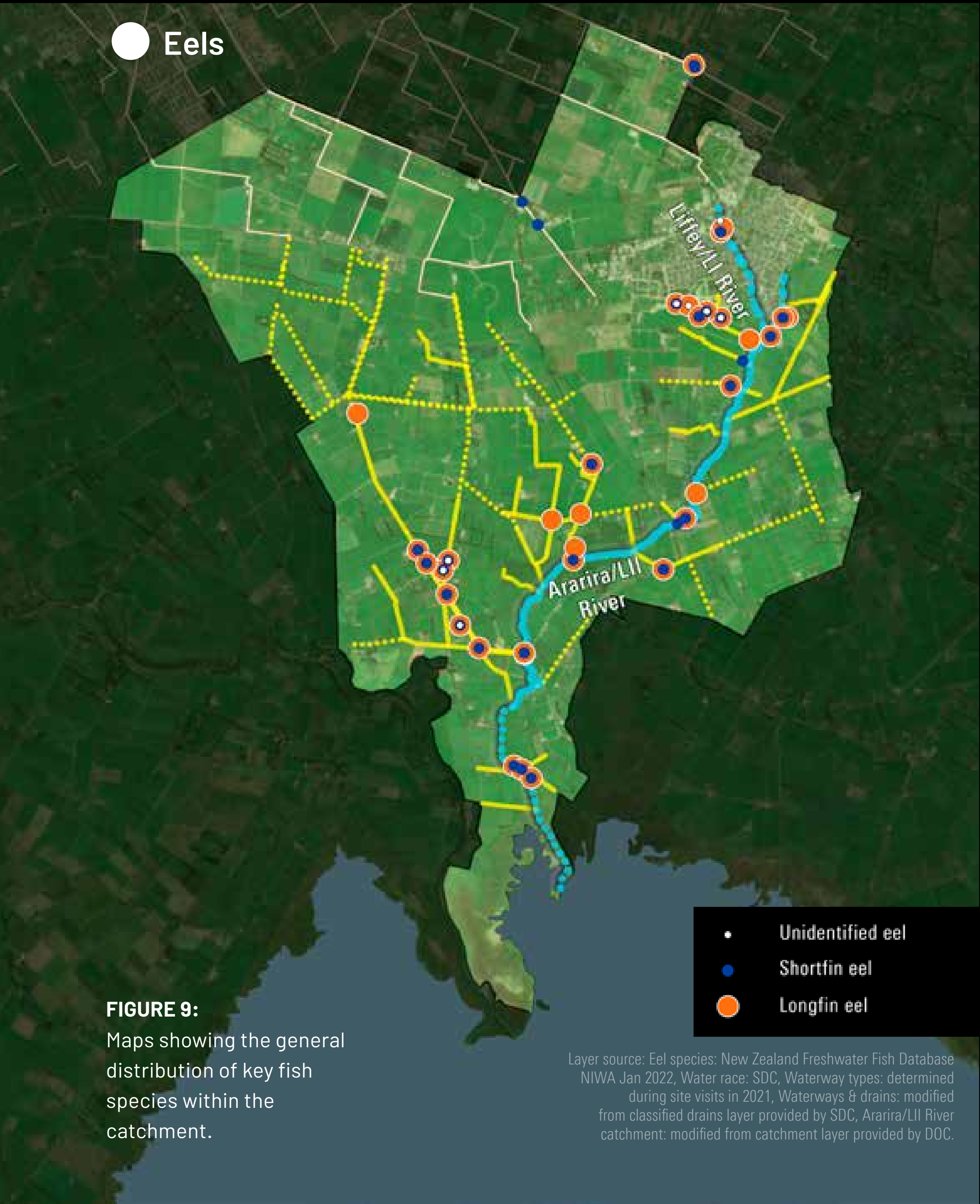
TABLE 2:
Key fish species found today in the Ararira/LII catchment waterways. * These are incidental records for this catchment and unlikely to represent self-sustaining populations.

	Common Name	Status	Conservation Status[1]	Water Races	Drains		Mainstem		
					Ephemeral/ Intermittent	Perennial	Headwaters	Mid Reaches	Lower Reaches
Fish species diversity				5	6	8	9	8	8
	Longfin eel	Endemic	At risk-declining	✔	✔	✔	✔	✔	✔
	Shortfin eel	Indigenous	Not threatened	✔	✔	✔	✔	✔	✔
	Common bully	Endemic	Not threatened	✔	✔	✔	✔	✔	✔
	Upland bully	Endemic	Not threatened	✔	✔	✔	✔	✔	✔
	Bluegill bully*	Endemic	At risk-declining				✔		
	Giant bully	Endemic	At risk-naturally uncommon			✔			
	Īnanga	Indigenous	At risk-declining		✔	✔	✔	✔	✔
	Torrentfish*	Endemic	At risk-declining					✔	
	Lamprey	Indigenous	Threatened-nationally vulnerable				✔		
	Common smelt	Endemic	Not threatened			✔			✔
	Brown trout	Exotic	Introduced & naturalised	✔		✔	✔	✔	
	Rudd	Exotic/pest	Introduced & naturalised			✔	✔	✔	✔
	Goldfish	Exotic/pest	Introduced & naturalised						✔

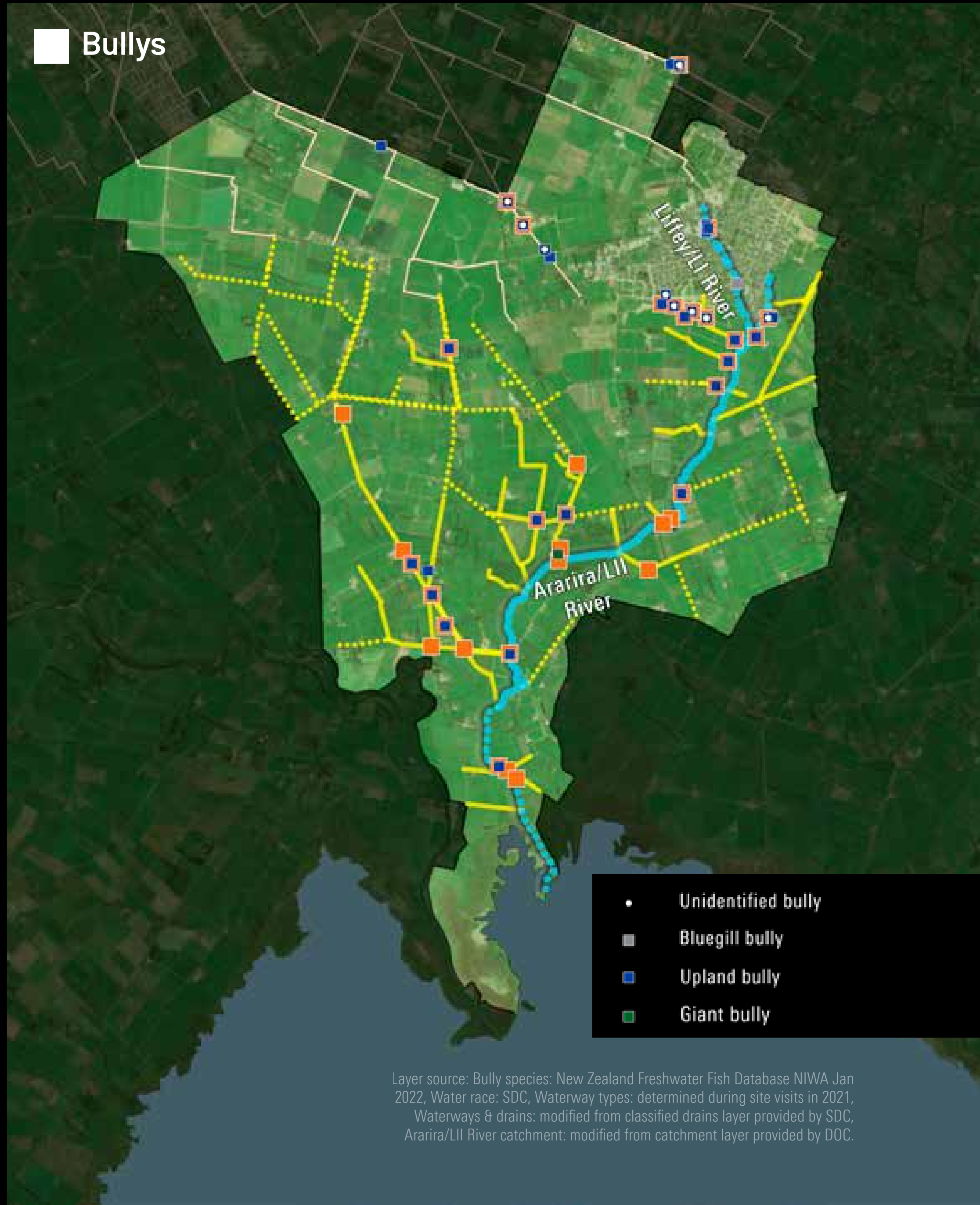
[1] Conservation status (Dunn *et al.*, 2017)

Image source: EOS Ecology

Ararira/LII Catchment
Distribution of Key Fish Species

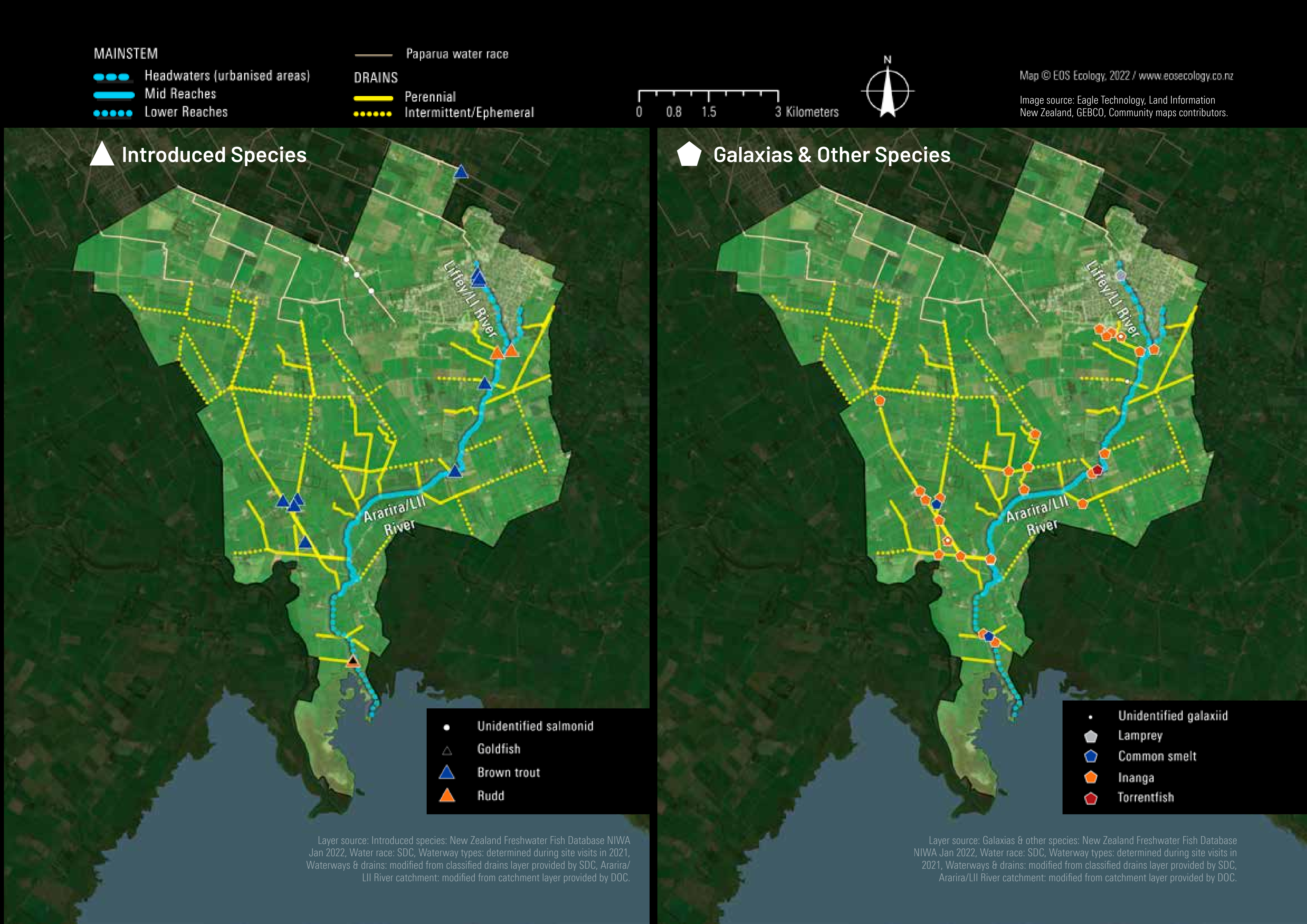


Layer source: Eel species: New Zealand Freshwater Fish Database NIWA Jan 2022, Water race: SDC, Waterway types: determined during site visits in 2021, Waterways & drains: modified from classified drains layer provided by SDC, Ararira/LII River catchment: modified from catchment layer provided by DOC.



Layer source: Bully species: New Zealand Freshwater Fish Database NIWA Jan 2022, Water race: SDC, Waterway types: determined during site visits in 2021, Waterways & drains: modified from classified drains layer provided by SDC, Ararira/LII River catchment: modified from catchment layer provided by DOC.

FIGURE 9:
Maps showing the general distribution of key fish species within the catchment.


MAINSTEM
Headwaters (urbanised areas)
Mid Reaches
Lower Reaches
Paparua water race
DRAINS
Perennial
Intermittent/Ephemeral
0
0.8
1.5
3 Kilometers
N
Map © EOS Ecology, 2022 / www.eosecology.co.nz
Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors.
Introduced Species
Liffey/LII River
Ararira/LII River
Unidentified salmonid
Goldfish
Brown trout
Rudd
Layer source: Introduced species: New Zealand Freshwater Fish Database NIWA Jan 2022, Water race: SDC, Waterway types: determined during site visits in 2021, Waterways & drains: modified from classified drains layer provided by SDC, Ararira/LII River catchment: modified from catchment layer provided by DOC.
Galaxias & Other Species
Liffey/LII River
Ararira/LII River
Unidentified galaxiid
Lamprey
Common smelt
Inanga
Torrentfish
Layer source: Galaxias & other species: New Zealand Freshwater Fish Database NIWA Jan 2022, Water race: SDC, Waterway types: determined during site visits in 2021, Waterways & drains: modified from classified drains layer provided by SDC, Ararira/LII River catchment: modified from catchment layer provided by DOC.

3.2.4 Water Quality

The water quality of waterways within the Ararira catchment has been recorded as part of the Environment Canterbury surface water quality monitoring programme and during recent survey work by the University of Canterbury (Harding & Meijer, 2021). Long term water quality records for the Ararira mainstem upstream of Pannetts Road (since 1995) show that the median nitrate concentration for the river is 3.3 mg/L, which is higher than the national bottom line of 2.4 mg/L for nitrate toxicity (NPSFM, 2020). Overall, nitrate concentrations tend to decrease with distance down the catchment, with springs and surface water sites in the upper catchment generally reporting higher nitrate concentrations. These results suggest that nitrate is at least partly sourced from groundwater that originates up-gradient of the surface water catchment boundary, and that some dilution occurs with distance downstream. Common sources of nitrates in drainage networks include animal waste and inorganic fertiliser which drain into the surface water network through on-farm drains, shallow groundwater, and overland flow paths during rain events (Figure 10).

Similar sources are responsible for phosphorus entering the catchment waterways, although phosphorus also tends to attach to sediment and so enters waterways with sediment-laden water. The long-term median of dissolved reactive phosphorus (DRP) at Pannetts Road monitoring site, located in the Ararira mainstem (middle reaches) is 0.019 mg/L, which is a level that would be expected to enable excessive algae and macrophyte growth and a loss of sensitive macroinvertebrate or fish taxa (NPSFM, 2020). However, recent monitoring suggests that DRP concentrations have stabilised at a lower median concentration within the last decade (Land and Water Aotearoa, 2021).

Measurements of *Escherichia coli (E. coli)* bacteria provide an indicator of faecal pollution in water. The level of faecal pollution relates to the health risk of animal and human exposure to faecal pathogens such as *Campylobacter*. The presence of faecal pathogens has implications for the suitability of the waterways for mahinga kai, swimming, and other recreational use. Results for the Ararira catchment indicate that *E. coli* concentrations are generally higher in the mainstem, as compared to the drain network. With a median concentration of 180 cfu/100 mL for the mainstem at Pannetts Road, this site falls within attribute band D of the NPSFM (2020), which indicates that there is an average infection risk of >3% associated with human contact activities at this site. Although Land and Water Aotearoa (2021) notes that this site is in the best 50% of all lowland rural sites for this attribute, there is clearly room for improvement in this water quality attribute to improve the suitability of the waterways for human contact activities. *E. coli* measurements in the Lincoln urban area show lower values (at the 95th percentile level) than most measurement sites in the farmed areas of the catchment.

Water Quality

High nutrient levels are evident by the prolific growth of algae and macrophytes throughout the Ararira catchment waterways.

Sediment-laden runoff can introduce contaminants such as *E. coli* and phosphorus to the drainage network.

Runoff from urban areas can contain heavy metals and other contaminants which needs to be treated in stormwater treatment systems.

FIGURE 10:
Water quality issues in the Ararira/LII catchment.

Image source: EOS Ecology

3.3 Cultural Values

A recent cultural health assessment for the Ararira catchment reports that the catchment has high cultural importance to the local hapū of Ngāi Te Ruahikihiki and Te Taumutu Rūnanga (Boffa Miskell, 2021). The catchment, being the central area of the takiwā/region, was once a significant travel and mahinga kai area. Different species were collected from different areas. However, substantial drainage and alteration of the catchment has had major impacts on the cultural health of the catchment. The highly modified nature of the river channels and the ongoing agricultural land use are significant issues affecting the cultural health of the catchment. Restoring riparian areas has been recognised as important for improving the cultural health of the catchment, as has improving access to mahinga kai sites.

Key sites of high cultural significance within the catchment include Te Kohaka-a-wao (spring source of the river), open areas of water including Makonui (Clay Bar Lagoon) and Tārerekautuku (Yarrs Lagoon), and settlements and mahinga kai sites along the mainstem including Ōtauhinu, Ōtaumata, and Pāharakeke (Robilliard & Pauling, 2015; Figure 12).

Tārerekautuku, located in the middle reaches of the Ararira River, is known as a key mahinga kai site. The name has several interpretations, with 'tārere' meaning to flow copiously, while 'kautuku' is a name for the native brown bittern swamp bird. In 1880, Ngāi Tahu elder Wiremu Te Uki described the site as being 'a village, a place of food production and a proper fortification'. He listed the mahinga kai species in Figure 11 as those known to be gathered there at that time (Boffa Miskell, 2017). In addition to being an important mahinga kai area, Tārerekautuku was also the site of a former kāinga (settlement), which linked to other settlements and mahinga kai sites across the Kā Pākihi Whakatekateka o Waitaha/the Canterbury Plains and Te Pātaka o Rākaihautū/Banks Peninsula. The reserve is known to support a range of surviving bird, fish and indigenous plant species that are taonga to Ngāi Tahu, as well as having the potential to provide an enhanced habitat for these taonga species and facilitating ongoing mahinga kai use. Despite having been drained, the values of Tārerekautuku, and the current reserve which encapsulates the former lagoon bed, remains significant to Ngāi Tahu manawhenua.

Mahinga Kai

Fish

Tuna/Longfin eel

Tuna/Shortfin eel

Koukoupara /Bullies

Mawehe/Kōaro

Birds

Pārera/Grey duck
Image source: DOC

Pūtakitaki/Paradise duck

Pākura/Pukeko

Kaaha/Shag

Whio/Blue duck
Image source: DOC

Plants

Koareare
– edible rhizome of raupō/bullrush

Aruhe
– edible root of bracken fern

FIGURE 11:
Mahinga kai species known to be gathered at Tārerekautuku Yarrs Lagoon around 1880.

Image source: EOS Ecology unless otherwise stated

Ararira/LII River Catchment Sites Of Cultural Significance

Key sites of cultural significance

Waterways

0 0.5 1 2 Kilometers

Layer source: Waterways: modified from classified drains layer provided by SDC, Sites of cultural significance: Te Rūnanga o Taumutu, Ararira/LII River catchment: modified by from catchment layer provided by DOC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors.

FIGURE 12:
Ararira/LII catchment – map showing culturally important locations within the catchment.

4 Pressures & Current Challenges/Issues

4.1 Land Use Change & Intensification

Acknowledging that catchments typically contain a mixture of activities and land cover types, MfE & Stats NZ (2020) provides categories based on the dominant land cover in a catchment. Based on this system, the Ararira catchment is classified as pastoral, with less than 15% of the catchment with urban land cover, and with pastoral land covering the largest proportion of the catchment. In New Zealand, most of the rivers in the pastoral category are polluted with excess nutrients, suspended sediments, and pathogens (MfE & Stats NZ, 2020). Although water quality trends are improving for some pastoral areas, there is still declining or unchanged water quality evident for most pastoral catchments.

Rural land use dominates the Ararira catchment and there has been substantial intensification over the last three decades. In New Zealand, the number of dairy cattle has increased by 70% between 1994 and 2017 (MfE & Stats NZ, 2020), with dairy farm conversions and intensification accommodating this increase in animal numbers. With these changes to more intensive land use have come changes to land management, including the increased use of irrigation and synthetic fertilisers.

To enable productive farming within the Ararira catchment, there is a need to protect farms from flooding, ponding, and waterlogged ground. Historically, as farmland has been developed in the catchment, the springs, wetlands, and small streams have been converted to a network of artificial drainage channels. However, with farm intensification, there has also been a need to maintain soil moisture levels to maintain agricultural production. In the Canterbury Region, there has been an over 200% increase in total irrigated area for dairy farms between 2002 and 2019 (Stats NZ, 2022). Historical aerial images of the Ararira catchment show that this catchment is part of this trend towards increased irrigated areas and more intensive farming.

Although rural land uses still dominate this catchment, there has been a marked increase in the urban area over recent years. The population of Lincoln has tripled from less than 1,500, to almost 5,000 people in the two decades to 2017 (Montgomery *et al.*, 2017). Further land has been identified for future greenfield development in the catchment, as part of Selwyn District Council's Lincoln Structure Plan (SDC, 2008). The transition from rural to urban land use can degrade the freshwater environment, however, mitigation actions that come with this land use change have the potential to ease catchment pressures. The current urban area covers approximately 6% of the land area within the Ararira catchment. While this is anticipated to increase to nearly 10% of the catchment with planned future urban growth (Figure 13), a recent plan change application (Plan Change 69) that has been approved to convert rural land outside (and to the south) of the future urban growth area into urban land use would increase this even further.

Ararira/LII River Catchment
Current Land Use & Urban Growth

0 0.8 1.5 3 Kilometers

N

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Image source: EagleTechnology, LINZ, StatsNZ, NIWA, Natural Earth © OpenStreetMap contributors.

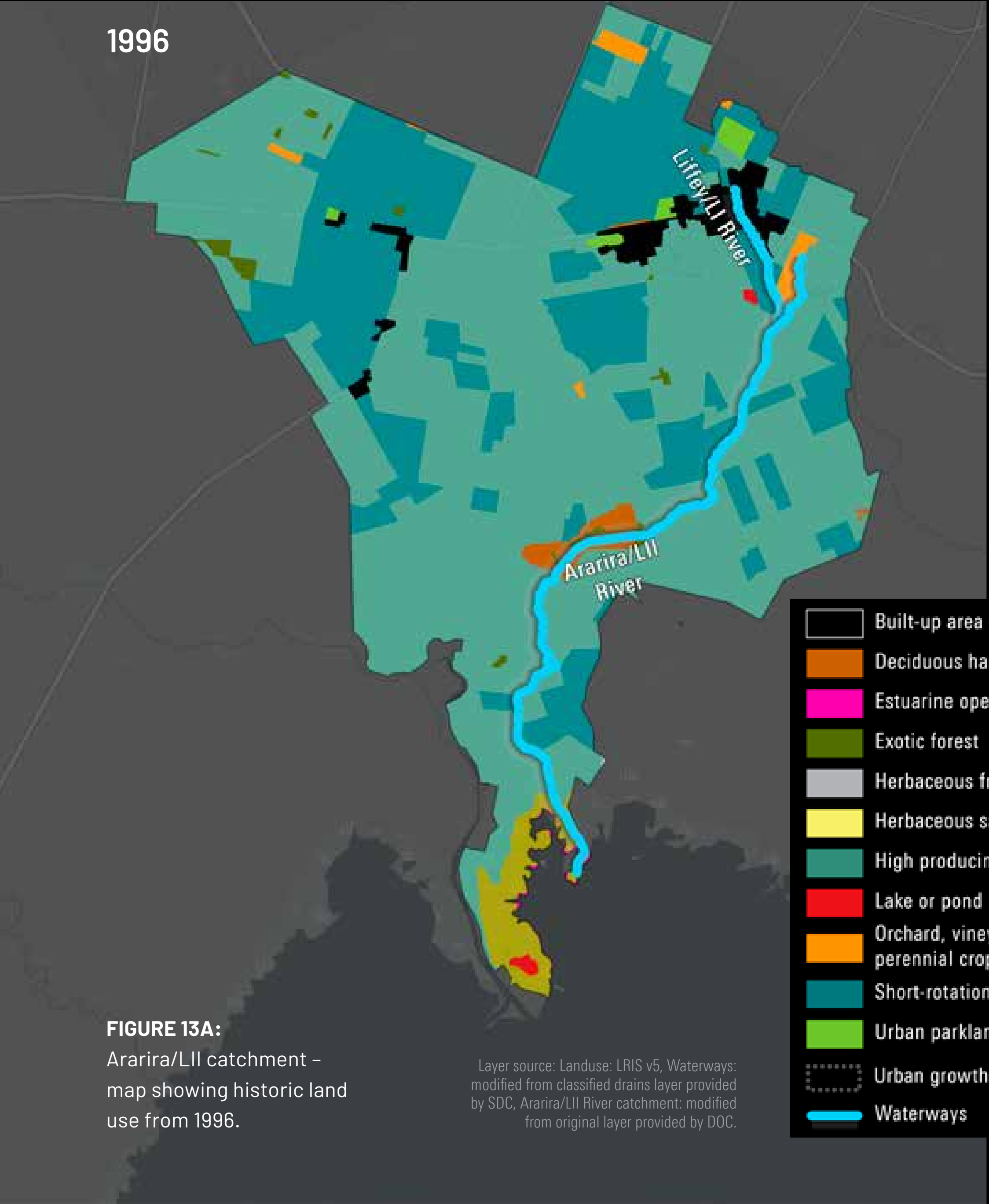


FIGURE 13A:
Ararira/LII catchment – map showing historic land use from 1996.

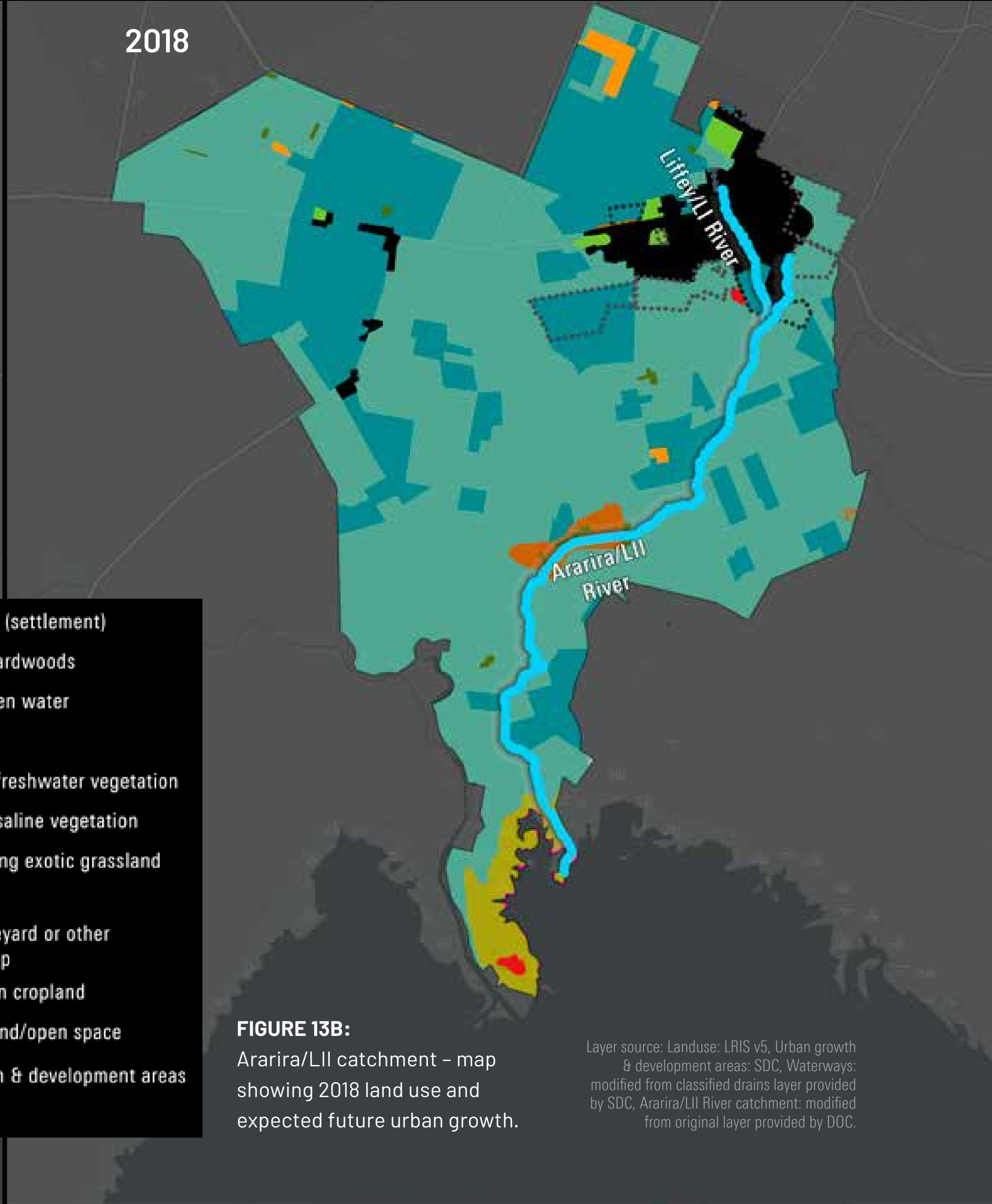


FIGURE 13B:
Ararira/LII catchment – map showing 2018 land use and expected future urban growth.

This plan change is in an area that has a high proportion of springs; meaning the subsequent land use change from rural to urban has the potential to affect future spring flow inputs to the catchment. Some of the urban expansion within the planned future urban growth area is outside of the existing catchment boundary and likely to discharge stormwater to the Huritini/Halswell catchment, but these areas may still have an influence on this catchment via groundwater. With the increase in urban area in a catchment comes an increase in impervious surfaces and stormwater runoff. Stormwater runoff from urban areas typically contains a different suite of contaminants compared to rural runoff, including an increase in the proportion of heavy metals, and this changes the pressures on local waterways. While good urban design can mitigate the pressures of urbanisation to some extent, urbanisation generally results in a flashier hydrograph, higher concentrations of nutrients and contaminants, simplified channel morphology and an increased dominance of tolerant aquatic species (Walsh *et al*. 2005).

4.2 Complexity of Catchment Flows & Climate Change

The hydrology of the Ararira catchment is complex and somewhat counter-intuitive. As a predominantly spring-fed lowland catchment, flows in both the Ararira mainstem and tributary drains are influenced by the state of the groundwater system (i.e., the central Canterbury alluvial aquifer system). Other drivers of water levels in the mainstem and drainage network are short-term responses to rainfall, the level of Te Waihora, and the state of macrophyte growth (cutting macrophytes can result in a step-change reduction in stage of up to 1 m in the mainstem, with no change in flow). The impact of rainfall events in terms of flooding within the catchment depend on both the state of the groundwater and the 'other drivers' of the system. Extreme rain events (defined as the maximum 5-day annual rainfall) in the Selwyn District are expected to increase by 4–12% by 2050 (Cranney *et al*., 2020), which is likely to affect the frequency of flood flows in the catchment. However, the extent of flooding for a given rainfall event will depend on other factors such as the state of macrophyte growth in channels (also see Section 4.3.4).

The Paparua water race system contributes flow from the Waimakariri River to the northwestern part of the Ararira catchment (Figure 14). This system of water races connects into the network of artificial drains that traverse the Ararira catchment. The northwestern part of the catchment is generally the location of the ephemeral and intermittent waterways, with more free draining geology and soils present in this part of the catchment (Figure 4). While some of the water races are contributing surface flow to the Ararira catchment (i.e., they connect directly to the drainage network), others discharge to ground, recharging shallow groundwater. The importance of the flow contributed to this catchment by the water race system is not well understood, but they are likely to influence the flow permanence of ephemeral and intermittent drains in this catchment. While the locations of transitions between permanent, intermittent, and ephemeral waterways have been identified for the present day (Figure 7), it is likely that the location of these transitions will alter as the effects of climate change become more evident. Any future closure of the water race system might also be expected to influence hydrology further down the catchment, with a possible decrease in surface water flows, which may have flow-on effects for instream ecological values and drainage requirements. Likewise, while increased urbanisation in the upper catchment is unlikely to have a significant impact on the overall catchment water balance, any substantial increase in the impermeable surface area will result in a 'flashier' surface flow regime, and flow-on effects for ecological and drainage values.

Future changes to both climate and water management have the potential to further alter the flows of lowland waterways although there is considerable uncertainty around the extent and direction of these changes. Climate change is predicted to result in increased irrigation abstraction from the Canterbury Plains aquifers (Collins *et al.*, 2019), although this is likely to be balanced by increased land-surface recharge (from some of the increased irrigation demand being met from surface water sources) and increased river recharge because of higher alpine river flows. The net effect, in the absence of changes to irrigated areas or water allocation rules, is likely to be negligible changes in the baseflows of lowland streams. However, future changes to water allocation rules are likely to be required to give effect to Te Mana o te Wai. Changes to groundwater allocation rules (for abstractions further up the Plains, outside of the Ararira catchment) may result in higher groundwater levels, and in turn higher lowland stream flows. Previous predictions have indicated that the Central Plains Water irrigation scheme would result in higher groundwater levels and therefore higher lowland stream flows. However, because of differences between the original modelling assumptions and how the scheme infrastructure, irrigated areas, and the balance between existing and new irrigation has developed, these changes to groundwater and streamflow have not eventuated.

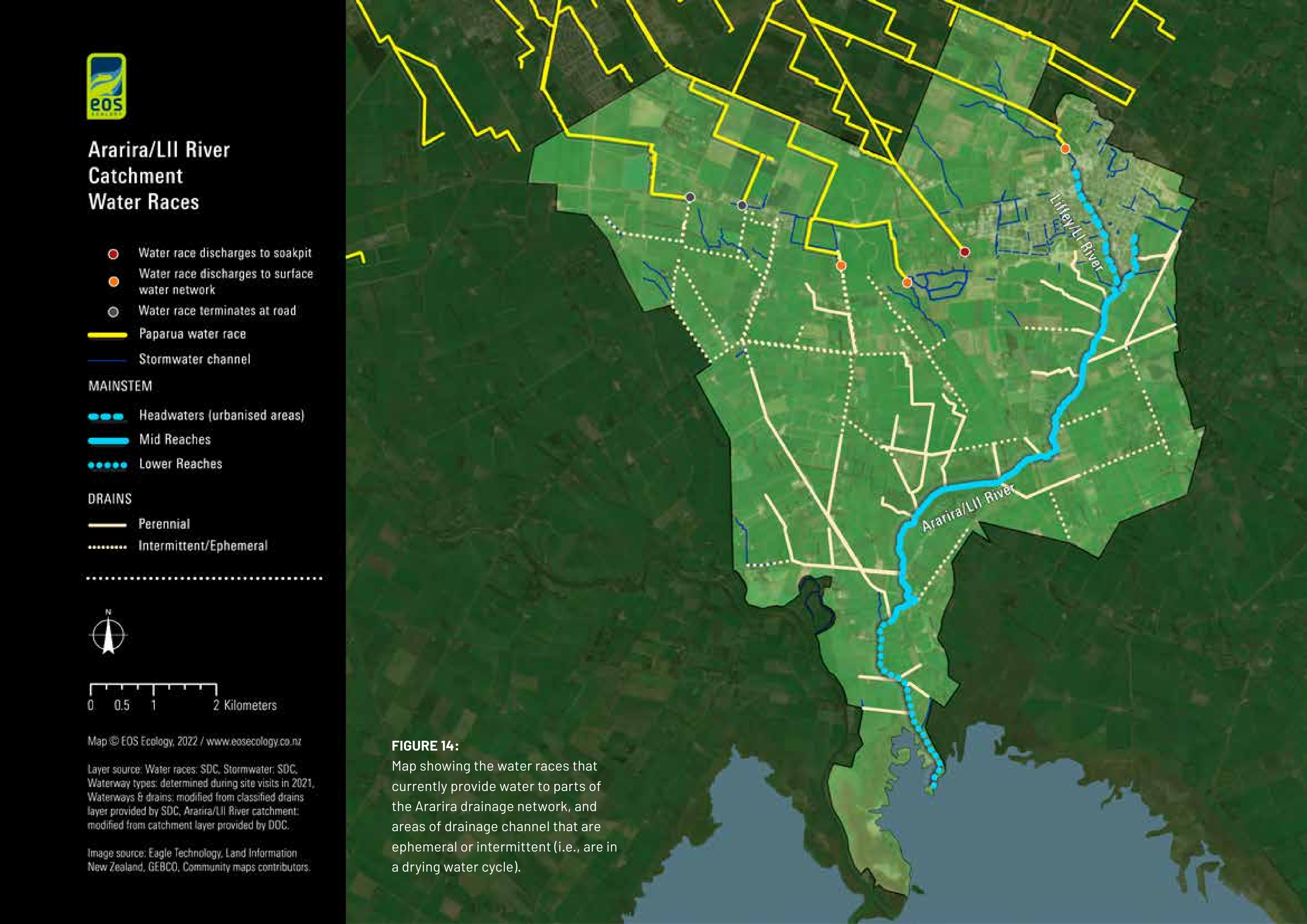


FIGURE 14:
Map showing the water races that currently provide water to parts of the Ararira drainage network, and areas of drainage channel that are ephemeral or intermittent (i.e., are in a drying water cycle).

4.3 Current Challenges

4.3.1 Macrophytes

The excessive growth of macrophytes is a major challenge for drain management in the Ararira catchment. In many places, the drainage channels are seasonally obscured by emergent macrophytes (Figure 15) – typically introduced species such as monkey musk and water cress – and these are routinely removed by a contractor on behalf of the LII Drainage Committee to ensure that the drainage function of the waterways is maintained. Partial shading is not sufficient to prevent the growth of macrophytes in this catchment, where ample nutrient concentrations and slow flows provide ideal conditions for their growth. Although the existing macrophyte maintenance regime is crucial to ensure the drainage function of the waterways is maintained, these practices are known to have several environmental impacts, and are an ongoing cost to the Drainage Committee, since they do not provide a permanent solution to the macrophyte problem. In addition, where macrophytes and sediments are stockpiled along drain margins, this can exacerbate existing bank instability issues by smothering bank vegetation and increasing bank height. A review by James (2011) highlighted the potential environmental effects of mechanical macrophyte clearance, including the mobilisation of fine sediment, changes to water chemistry, physical removal of fauna from the waterbody, and the alteration or loss of instream habitat. The management of macrophytes with chemicals also has environmental implications, with the decaying plant material resulting in decreased dissolved oxygen levels in the water, the release of nutrients, potential toxicity of the herbicide, and the loss or alteration of instream habitat (James, 2011).

Macrophyte Issues

The channel of a perennial drain is completely obscured with emergent macrophytes, dominated by monkey musk.

These drain channels are also obscured with emergent macrophytes.

Emergent macrophytes like monkey musk and watercress grow out from the banks of channels, rather than from the permanantly wetted mid channel.

Emergent macrophytes are likely to require ongoing maintenance (hand weeding) until streamside planting is well established enough to heavily shade the stream margins.

Even areas with tall trees and steep banks that provide some shading can still support seasonal monkey musk; almost complete shading is required to prevent their growth.

After being cut by the weed cutter boat, macrophytes drift downstream in large clumps to a site where they are caught by screens and removed from the river with a digger.

Image source: Robin Smith, DOC

The weed cutter boat operating in the deeper Ararira River mainstem removes submerged macrophytes such as *Elodea* and *Potamogeton crispus* (both introduced species) along with emergent marginal species including monkey musk and watercress. After being cut with the weed cutter boat, macrophytes drift downstream to a site around 1.5 km upstream of the river mouth where they are captured by screens, removed from the river with a digger, and left to decompose. Image source: Robin Smith, DOC

FIGURE 15:
Images illustrating macrophyte issues in waterways in the Ararira/LII catchment.

Image source: EOS Ecology unless otherwise stated

4.3.2 Sediment

Another major challenge for drain management in the Ararira catchment is excessive quantities of deposited fine sediment. Fine sediments accumulate on the bed of slow-flowing channels, with ongoing sediment supply provided by the erosion of steep/slumping banks, runoff from farms via informal flow paths (also known as critical source areas), runoff from gravel roads, and stock access to drain channels (Figure 16). As a result of the large supply of fine sediment to these waterways, the substrate of waterways in this catchment is typically composed of fine sediments and sediment frequently needs to be mechanically removed by a contractor on behalf of the LII Drainage Committee to ensure that the drainage function of the waterways is maintained (Figure 17, Figure 18).

Sediment Inputs


Steep banks that are slumping and inputting sediment to the waterway/drainage channel.

Banks that are regularly sprayed are an ongoing source of sediment to the drainage channel.


Even steep banks that are planted can still be unstable and generate sediment that is not always evident unless you look under the vegetation. This highlights the need for bank rebattering/two-stage channel before planting steep banks.

Areas of urban development can be a significant source of sediment during the construction phase if there is not adequate erosion and seidment control, both during infrastructure development, and during the construction of individual dwellings.

Springs that are unfenced can become pugged and become a source of sediment.

Informal flow paths (also known as critical source areas) that are dry most of the time become sources of sediment during rain as they channel overland runoff to downstream waterways.

Stock access into drainage channels, even those that are dry most of the time, creates sediment that will enter downstream waterbodies during rain events.

FIGURE 16: Images illustrating sediment inputs to waterways in the Ararira catchment.

Image source: EOS Ecology

Fine Sediment

A sandy-bottomed drainage channel – the ripples in the sand indicate the sand is migrating downstream.

Fine sediment from the bed of a drainage channel.

Suspended sediment in a drainage channel, stirred up from sediment within the channel itself.

Sandy substrate and organic matter accumulations are evident in the slow-flowing spring-fed reaches of the upper mainstem.

FIGURE 17:
Images illustrating fine sediment within the drainage network.

Image source: EOS Ecology

Ararira/LII River Catchment Substrate Types

MAINSTEM

- Fine sediment
- Gravel

DRAINS

- Fine sediment
- Gravel

Paparua water race

0 0.5 1 2 Kilometers

Layer source: Substrate type: determined during site visits in 2021 & Harding, J. & Meijer, C (2021), Waterways & drains: modified from classified drains layer provided by SDC, Water races: SDC, Ararira/LII River catchment: modified from original layer provided by DOC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors.

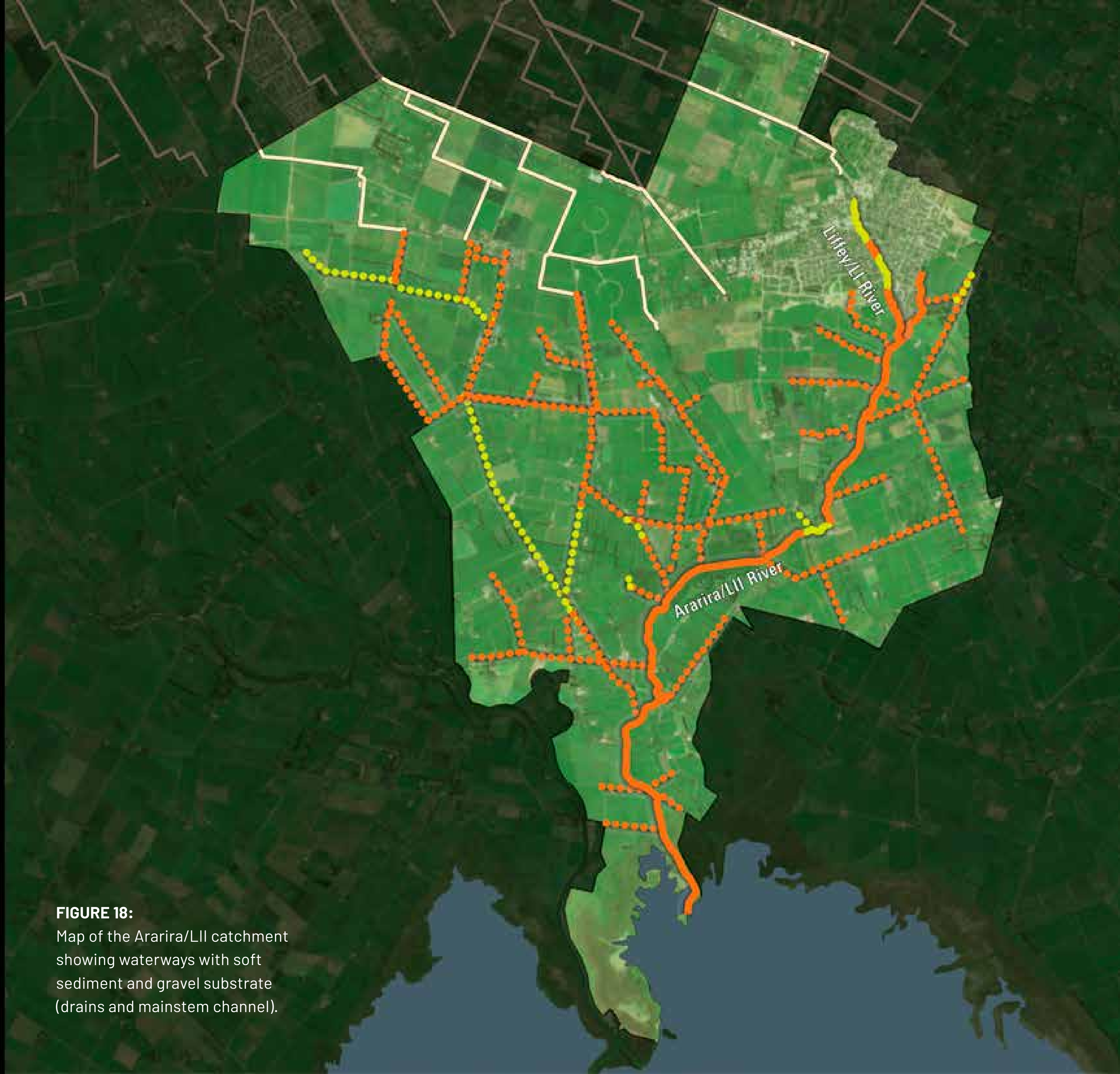


FIGURE 18:
Map of the Ararira/LII catchment showing waterways with soft sediment and gravel substrate (drains and mainstem channel).

4.3.3 Lack of Space Around Drains

Within the Ararira catchment, the network of drainage channels has been developed alongside (and through) farms, roads, access ways and urban areas (Figure 19). In many cases, the drains are very deep, and the banks are steep, with little space available for altering the existing layout. For example, roading, power poles, and pathways may be near the edge of drains (Figure 20). Where drains are located on-farm, there may also be a minimal setback between the drain and fence because of the high value of this productive land. Where there is limited space or setback distance between the banks of the drains and the surrounding land uses, there is less potential for improving the channel characteristics by bank reshaping. Where the existing banks are steep, which increases the likelihood of them acting as a sediment source via instability/slumping, the corridor width required for bank reshaping can be substantial.

Ararira/LII River Catchment Drains Adjacent To Roads

Waterways

Roads

DRAINS

Not adjacent to roads

Adjacent to roads

0 0.5 1 2 Kilometers

Layer source: Waterways & drains: modified from classified drains layer provided by SDC, Roads: LINZ, Ararira/LII River catchment: modified from catchment layer provided by DOC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

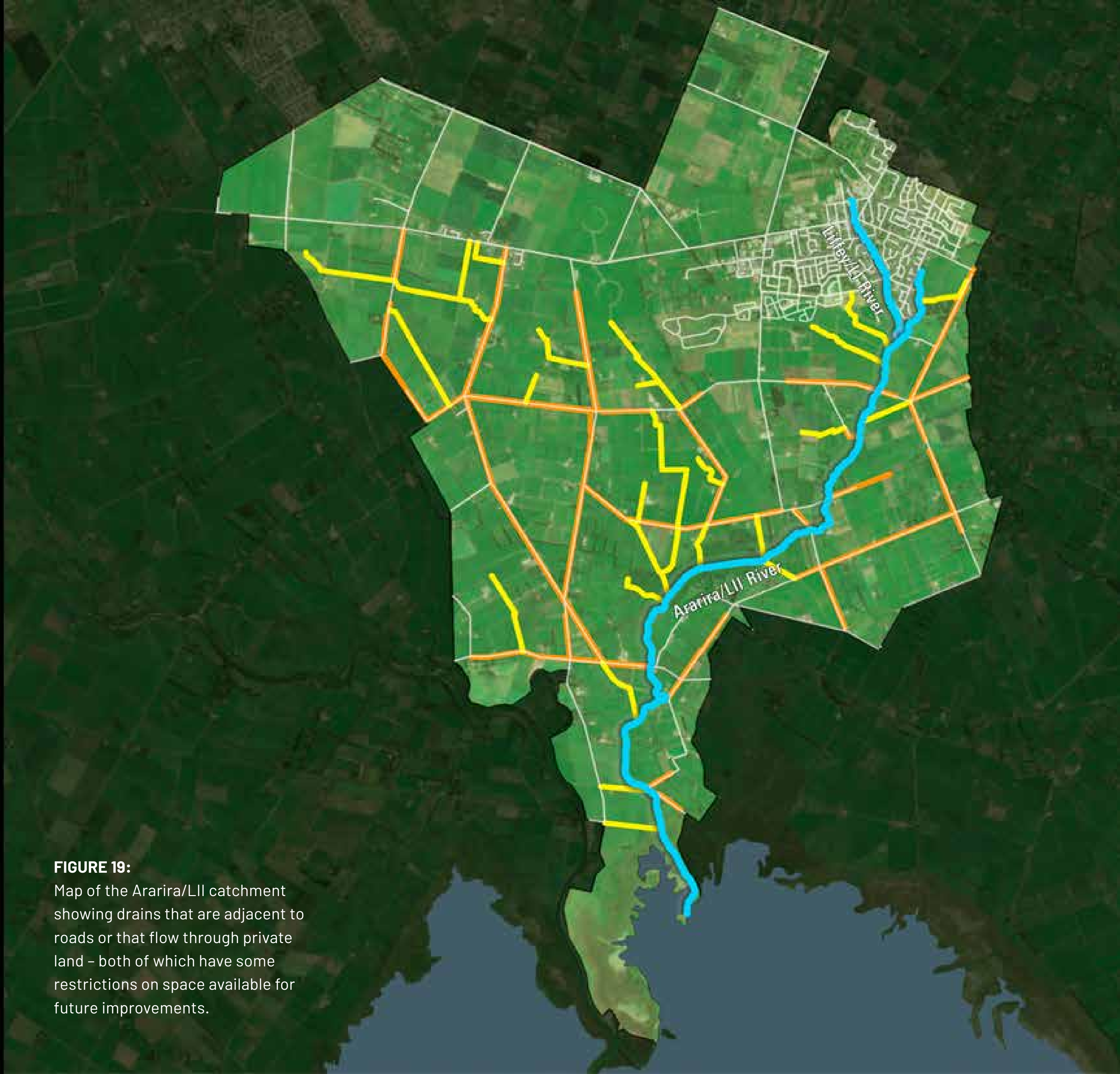


FIGURE 19:
Map of the Ararira/LII catchment showing drains that are adjacent to roads or that flow through private land – both of which have some restrictions on space available for future improvements.

Lack of Space

Where roads are elevated above the adjacent land, there may be very steep banks and little space within the road reserve for bank reshaping.

Powerlines are often located within 1 to 2 m of the top of existing banks, making bank reshaping a challenge.

Roads and fences sited close to the drainage channel leave limited space for reshaping and planting.

Fenced setbacks within farmland are sometimes limited which can make bank reshaping difficult unless fences are moved.

The close placement of cycleways/walkways within urban areas means that bank reshaping for bank stability is not always possible.

FIGURE 20:
Images illustrating lack of space within the drainage network.

Image sources: EOS Ecology

4.3.4 Flooding & Wet Ground

Flooding and wet ground are ongoing challenges for the Ararira catchment (Figure 21, Figure 22). Most of the Ararira catchment soils have been classified as ‘imperfectly drained’ to ‘very poorly drained’ (SMap, Landcare Research). This, combined with shallow groundwater levels, is what makes the drainage network necessary for maintaining the productive capacity of farmland in the catchment.

The LII Drainage Committee commissions regular maintenance of the rated drains within the Ararira catchment. This work includes macrophyte removal with an excavator in the permanent drains, macrophyte cutting with a boat in the mainstem, mechanical removal of sediment from the drain network, and spraying of drain banks in some places. The purpose of this work is to maintain the drainage function of the waterways, in the face of challenges such as excessive macrophyte growth and fine sediment accumulation. Even so, during periods of heavy rainfall, farmland in parts of the catchment may become inundated with water, as the drains do not always convey the increased volumes of water quickly enough to prevent this (Figure 21). In this catchment, drainage is highly influenced by groundwater levels, the level of Te Waihora, the amount of aquatic macrophyte growth in the channels, and the amount of time since weed cutting has occurred in the river. For example, the cutting of macrophytes in the main river channel can result in a river stage decrease of 1 m or more. The result of this is that an equivalent rain event can have a vastly different flooding effect depending on its timing in relation to a macrophyte cut.

Within the Ararira catchment, some areas may be susceptible to flooding in large events from the Huritini/Halswell or Waikirikiri/Selwyn rivers, as these border the Ararira catchment to the east and west (Figure 22). During wet weather, bare ground adjacent to the drains tends to become a major source of fine sediment, contributing to the high suspended sediment load in the drains at this time (Figure 21). There is potential for climate change to place increased pressure on the drainage function of the Ararira catchment in the future. The level of Te Waihora is managed relative to mean sea level. Sea level rise because of climate change will make it more difficult to achieve a successful opening at lower lake levels and may result in higher mean lake levels that would potentially reduce the effectiveness and flood capacity of the land drainage network (in the absence of any other changes to the network). If the recommendations in this Plan are not implemented, the existing maintenance regime may need to be adapted anyway, in response to climate change. Allowing water levels to increase would potentially result in more waterlogged soils, pugging, and sediment entering waterways.

Flooding Issues

Bare ground adjacent to drains may be a source of fine sediment, especially during rainfall.

Image source: (left) Robin Smith, DOC, (middle & right) Aqualinc Research

Drain margins may act like a bund, making it difficult for runoff to flow into the drains during heavy rainfall. In most cases, sediment that is removed from channels is placed on the drain margins, contributing to the size of bunds.

Image source: Robin Smith, DOC

When drains are full, excess water accumulates on adjacent farmland.

Image source: Robin Smith, DOC

Roads in the catchment are often higher than adjacent farmland and are therefore not as susceptible to flooding.

Image source: Robin Smith, DOC

FIGURE 21: Images illustrating flooding and wet ground issues in the Ararira/LII catchment.

Ararira/LII River Catchment Areas Of Maintenance & Flooding

- Lake Ellesmere flood area
- Lower Plains flood area
- Waterways
- Drains
- Macrophyte removal
- Sediment removal
- Spraying

N

0 0.5 1 2 Kilometers

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: Flood areas: Canterbury Maps, Waterways & drains: modified from classified drains layer provided by SDC, Maintenance type: SDC, Ararira/LII River catchment: modified from catchment layer provided by DOC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors.

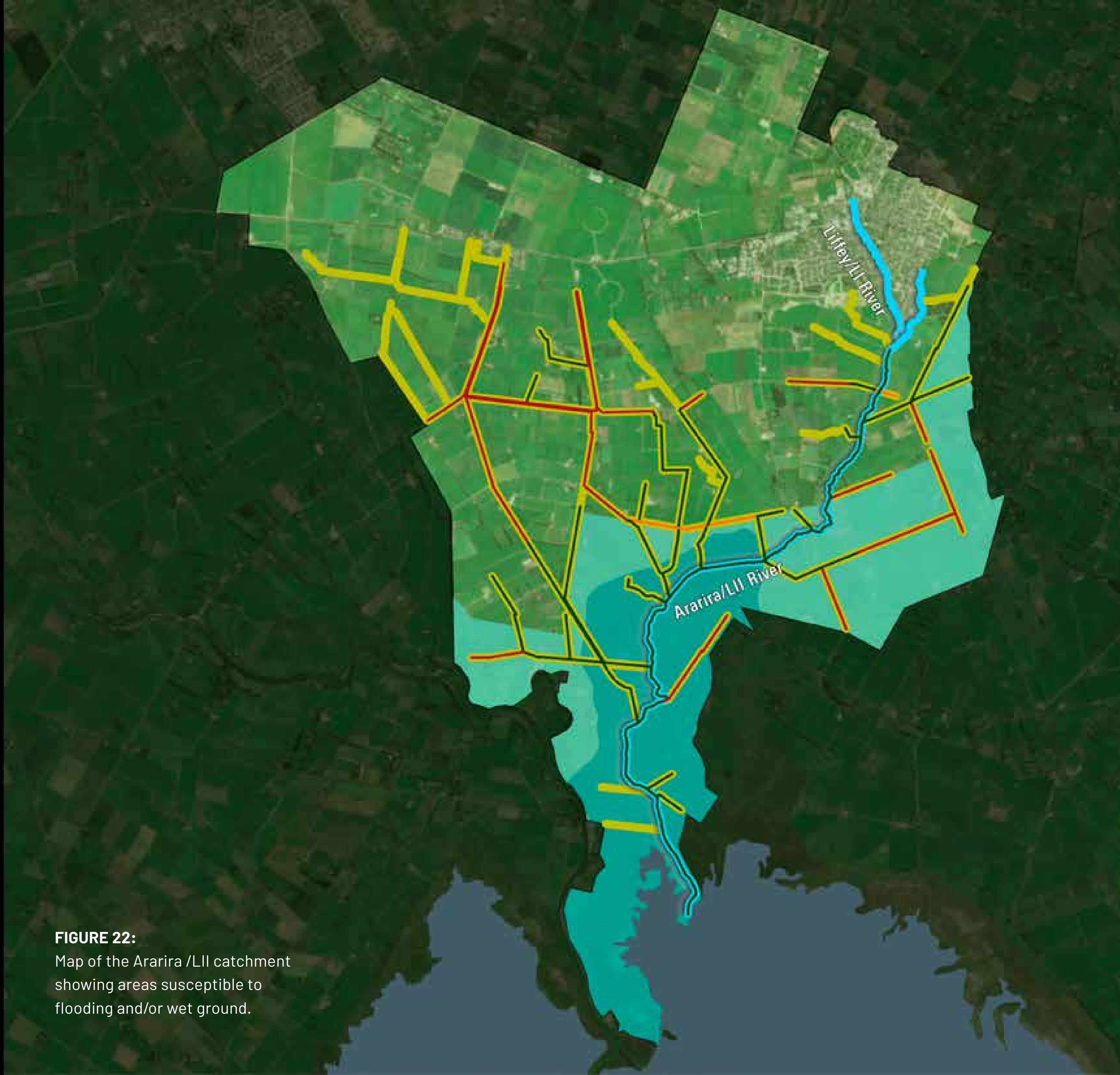


FIGURE 22:
Map of the Ararira /LII catchment showing areas susceptible to flooding and/or wet ground.

The Ararira/LII River near where it enters Te Waihora.
Image source: Robin Smith, DOC

5 Solutions – A Catchment-Scale Approach

With the goal of reimagining how the Ararira catchment could be managed – to continue to maintain adequate drainage function for productive land uses, while also improving biodiversity, water quality, cultural, and ecological values – it is anticipated that a combination of catchment-scale changes in land and drain management, along with the implementation of reach-scale interventions to improve the existing condition of waterways will be needed. This section outlines the overarching catchment-scale approaches that will be crucial to achieving the vision for this catchment. The following section (Section 6), details the specific 'toolbox' of interventions that are designed to mitigate some of the site-specific challenges facing the Ararira catchment at present.

5.1 Transformative Practice

Striving for a transformative, or 'better than good practice' approach to land management will help to ensure that the health of the Ararira waterway and drainage network will be improved not only through the implementation of the tools provided in Section 6, but also by improving land management practices throughout the catchment.
Key practices that are effective at reducing the amount of phosphorus and fine sediment-laden runoff include: fencing off waterways and leaving ungrazed grass filter strips; avoiding pugging of soils (especially in paddocks close to waterways); avoiding overgrazing and bare soil; controlling runoff from tracks, races, and feed pads; applying effluent to land; and following good practice fertiliser application guidelines.

Farm Environment Plans (FEPs) and Freshwater Farm Plans (FW-FPs) are tools to identify and manage the environmental risks of farming activities. In Canterbury, all farms that require a land use consent to farm must also prepare a FEP. In addition, under the Resource Management (National Environmental Standards for Freshwater) Regulations 2020, all farms over 20 ha, or horticultural units greater than 5 ha will need a FW-FP; these are likely to be required from mid-2022 (Ministry for the Environment, 2022b). Of crucial importance to good FEPs is identifying and managing critical source areas, where runoff accumulates in low lying areas of farmland and may flow to nearby waterways via informal flow paths and ephemeral channels. Typical critical source areas include paddock depressions and informal flow paths, gateways, water troughs, bridges, and stock lane ways near streams.

The best practice management of these areas helps to reduce sediment and nutrient loss from farmland to waterways. Runoff can be mitigated by installing bunds and/or grass filter strips between critical source areas and waterbodies. Supporting landowners through the process of creating FEPs and incorporating relevant tools from this CMP into FEPs will allow for better integration of their land management practices with this CMP and reduce the potential for conflict.

Incentivising and recognising those landowners who do more than the minimum in relation to their FEPs is also central to achieving a 'better than good practice' approach across the catchment. An example of 'better than good practice' would be the establishment of riparian setback distances exceeding 3 m for each type of waterway in the Ararira catchment. These riparian setbacks would likely be larger than those required by local government and industry standards where feasible (i.e., where land is not constrained by a road or similar infrastructure). For example, a riparian setback should be at least 5 m in medium sized spring-fed streams to prevent instream fine sediment entering the stream (Holmes *et al.*, 2016). In larger parts of the Ararira stream network, riparian areas should be as wide as 10–15 m to encourage a host of ecosystem benefits (Parkin, 2004), although smaller riparian margins will be appropriate for ephemeral or intermittent streams. Relatively wide riparian margins will also provide space for additional interventions as outlined in Section 6 (Table 4).

5.2 Land Acquisition/Strategic Land Use Change

In some cases, the strategic purchase, retirement, or lease of land will be a viable way of achieving improved values for some parts of the catchment. Changing land use or strategically retiring areas of land adjacent to waterways or drainage channels may help to achieve ecological improvements as well as improved drainage efficiency. If suitable areas of land can be identified and purchased, then reduced flooding risk downstream may be achieved by allowing controlled flooding in areas where there are no dwellings or valuable crops or livestock. In some cases, this land may be suboptimal for current land use practices. In other cases, the opportunity may arise at the time of a land use change. For example, wider riparian margins, that would enable in-channel works for bank stabilisation could be set aside during urban development. At the same time, areas of significant upwelling or spring activity could be identified and protected within wetland or springhead reserves.

TABLE 4:
Summary of Good Management Practice (GMP) in farming guidance, with examples of 'better than good' practice in the context of the Ararira catchment.

Good Management Practice (GMP) guidance (Matrix of Good Management Governance Group, 2015)		Examples of 'better than good' practice in the Ararira catchment context (see Section 6 for further details of recommended interventions)
Action	Implementation guidance examples	
Identify the physical and biophysical characteristics of the farm system, assess the risk factors to water quality associated with the farm system, and manage appropriately.	Consider the following: • Biophysical characteristics such as soil types, topography, and climate. • Physical characteristics such as waterways, artificial drainage networks, irrigation. • Risk factors such as soil loss, nutrient loss, and damage to soil structure.	• Identify the farm characteristics and risk factors in the context of the catchment-specific state and pressures information provided in the Catchment Plan. • Working with your rural professional to develop your farm plan – utilising the information provided in this Catchment Plan.
Identify risk of overland flow of sediment and faecal bacteria on the property and implement measures to minimise transport of these to waterbodies.	Vegetated buffer strips/riparian planting adjusted in width for slope, hydrology, bank stability, land use and proximity to critical source areas.	• A minimum riparian strip width of 5 m, with 10–15 m where space allows on larger permanent waterways and smaller margins on ephemeral or intermittent waterways. • Bank reshaping/two-stage channels where appropriate.
	Identify, record, and manage risk to and from critical source areas such as wallows, bank erosion, pugging, etc.	• Reshape ephemeral waterways to form grassed two-stage channels.
	Sediment traps	• Event-based sediment traps on ephemeral/intermittent waterways. • Small-scale inline sediment traps in the lower reaches of permanently flowing drains/streams.
	Paddock contouring, earth bunds, raised headlands	• Create small scale wetlands to trap/detain sediment and nutrients.
To the extent that is compatible with landform, stock class and intensity, exclude stock from waterways.	Plan and prioritise waterway areas (including wetlands) to fence, based on the vulnerability of the land, significance of the waterway and potential to impact on water quality off-farm.	• Identify potential ephemeral flow paths on farm and consider temporary fencing of these during wetter months. • Fence and plant springheads. • Bundle stock exclusion with other interventions where appropriate (e.g., riparian planting, two-stage channels).
Manage farming operations to minimise direct and indirect losses of sediment and nutrients to water, and maintain or enhance soil structure, where agronomically appropriate.	Consider distance from surface waterways, effectiveness of buffers.	• Establish riparian setback distances exceeding 3 m on all waterway types in the catchment.
Manage grazing to minimise losses from critical source areas.	Graze lower lying areas and areas closest to waterways last.	• Fence and plant springheads. • Vegetated buffer strips where appropriate. • Bank reshaping/two-stage channels where appropriate. • Temporary fencing of intermittent/ephemeral waterways during wetter months. • Not using soft ground for winter grazing in this catchment.

5.3 'Smart Systems' for Drainage Monitoring

The use of 'smart' technology has huge potential for improving the way that drains are maintained and managed. The use of an electronic and Geographic Information System (GIS) approach to gathering drainage maintenance records would provide a readily accessible and up-to-date record of maintenance across the catchment, ensuring timely access to information for those undertaking maintenance operations as well as those managing and implementing catchment solutions. This would help to streamline the maintenance programme and improve efficiencies across the catchment. Ultimately, accurate autonomous record keeping of what drain maintenance activities have been performed where (and when) will enable a more accurate assessment of drainage performance in different areas of the catchment. This initiative would ideally be paired with the monitoring of shallow groundwater levels in multiple areas within the catchment.

The data provided by such a system could be used to optimise drain maintenance and may result in less maintenance-related disturbance to some areas that could otherwise be over-maintained. This would lead to improved instream conditions for a variety of species. There would also be potential to target drain maintenance in areas that need more effective or intensive drainage management. Including information on when key taonga species such as waikōura/kēkēwai/freshwater crayfish are more likely to be present in macrophyte beds of the Ararira mainstem (such as when juveniles are released from the parent) would also help with being able to avoid macrophyte cutting at those times, leading to improved ecological outcomes. Another benefit of such 'smart systems' would be the ability to provide rate payers with accurate information on the maintenance work completed within the drainage network.

Smart drainage monitoring could include, but not be limited to the following aspects:

- GPS capabilities for drainage maintenance equipment to track implementation of maintenance.
- Digitisation of maintenance records.
- Georeferencing areas where and when catchment tools (as per Section 6) are implemented, and dates for when monitoring and/or maintenance needs to be undertaken.
- A portable interactive interface that allows for the entry of notes regarding monitoring and maintenance needed and undertaken at a site.
- Groundwater, surface water, and soil moisture monitoring to better manage for flood events and better target drainage maintenance to the sites that are most in need of it. Soil moisture monitoring could also help manage irrigation requirements.

- An updated GIS waterway and drainage network layer that reflects the actual location of waterways in the catchment, as well as an accurate catchment boundary line. The maps provided in this CMP are a good starting point, but further ground-truthing of the waterway layers is warranted to improve the accuracy of the GIS layers.
- Georeferenced sites with key ecological or cultural values, where a site-specific adaptive management approach is needed. For example, if kōwaro/Canterbury mudfish were found at a location, or the presence of waikōura/kēkēwai/freshwater crayfish or kākahi/freshwater mussels were known from a particular location; whilst Tārerekautuku Yarrs Lagoon operates under its own Reserves Management Plan (Selwyn District Council, 2020).
- Inclusion of drainage maintenance activities undertaken on private land drains that are not currently part of the rated drainage network.

5.4 Changing Maintenance Practices

A Phased Approach to Changing Maintenance

As described in Section 4.3.1, the current approach to macrophyte management in the Ararira catchment has the potential to be environmentally damaging. Therefore, an integral part of reimagining how the Ararira catchment might be managed, is to work towards improved maintenance practices for the catchment. As tools and solutions are implemented to deal with some of the key challenges facing the catchment, it is anticipated that the approach to maintenance will also need to change. This change will not be immediate. It is likely that there will period of transition between the full implementation of the proposed toolbox solutions for this catchment (outlined in Section 6) and the eventual phasing out of some of the current maintenance practices. However, the overarching goal of this CMP is to eventually phase out the more ecologically disruptive interventions such as mechanical and chemical removal of emergent macrophytes in much of the drainage network where possible. It is acknowledged that some of the toolbox solutions also have maintenance requirements, particularly during their establishment, and that current maintenance tools may continue to be required in the future in areas where toolbox solutions provided below are not able to be implemented. During the transition, maintenance methods may need to be altered. For example, macrophyte removal may still be required in channels where riparian planting does not yet provide adequate shade. This work may need to be completed by hand weeding rather than mechanical clearance in these areas, as access for large equipment will no longer be possible. Even when fully implemented, it is likely that there will still be some areas of drains that need to be cleared in the traditional manner, although we anticipate that sediment and macrophyte clearing will be required less frequently and to a much lesser extent than it is currently.

New & Ongoing Maintenance Requirements

Once any of the toolbox interventions are established in the catchment, there will be a need to implement new proactive maintenance regimes to support these interventions. Weed management will be a crucial component of the new maintenance requirements. For example, it is important that weed species are controlled within newly planted two-stage channels, to allow the new plants the best chance of becoming successfully established. Over time, some plants will require replacement to ensure that they perform their intended functions. For example, mature *Carex* may need occasional replacement if they are no longer providing the heavy shade required at waterway margins to limit macrophyte growth.

It will also be important to undertake regular weed surveillance of the drainage network, including the planted margins and areas where interventions have been implemented. If new weed plant species become established and spread within the catchment, then ongoing maintenance costs are likely to increase. The best approach is to identify, and control weed species before they become widespread, and this requires a targeted and ongoing monitoring programme. Examples of terrestrial and aquatic weed species that should be monitored and removed from the catchment are shown in Figure 23.

As is currently needed, the surveillance and clearing of blockages will be an ongoing requirement for the drainage network. Vegetation such as tree trimmings that make their way into the drainage network can create blockages of the drainage channels and culverts, which has implications for drainage during wet weather. The proposed toolbox of solutions is not expected to exacerbate this issue, particularly where bank reshaping is used to provide greater channel capacity. However, blockages will still occur and will need to be an ongoing aspect of the maintenance regime.

Weed Species

Trees


Grey willow
Salix cinerea


Sycamore
Image source: DOC

Terrestrial


Everlasting pea
Lathyrus latifolius
Image source: DOC

Marginal & Aquatic


Yellow flag iris
Iris pseudacoru
Image source: DOC


Male fern
Dryopteris filix-ma

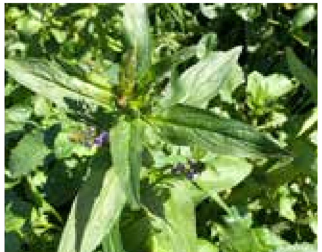

Montbretia
Crocosmia xcrocosmiiflora
Image source: DOC


Cape pond weed
Aponogeton distachyo


Beggars tick
Bidens frondosa
Image source: Paulo Ventura Araújo


Purple loosestrife
Lythrum salicari
Image source: Gail Hampshire


Gunnera tinctoria
Image source: DOC


Blue water speedwell
Veronica anagallis-aquatic


Reed canary grass
Phalaris arundinace
Image source: DOC

FIGURE 23:
Common terrestrial and aquatic weed species that would need to be monitored and removed before they can become widely established at a site and/or throughout the catchment.

Image source: EOS Ecology unless otherwise stated

Kayaking the Ararira/LII.
Image source: Robin Smith, DOC

6 Solutions – 13 Toolbox Interventions

Alongside the catchment-scale approaches outlined above (Section 5), it is expected that tangible improvement of the Ararira catchment will require the implementation of reach-scale interventions to improve the existing condition of the waterways. This section details a ‘toolbox’ of interventions that are designed to mitigate some of the main challenges facing the Ararira catchment at present (Table 5).

6.1 Implementation of the Interventions Across the Ararira Catchment

Our approach for this CMP was to first understand the broad catchment characteristics, cultural/ecological issues, and existing drainage maintenance procedures. We then used this understanding of the catchment to develop a package of intervention options to improve cultural/ecological values in a way that enables vital drainage functions to continue. We believe that this approach could provide a framework for improving cultural and ecological values in many other lowland agricultural catchments that are subject to regular drainage maintenance across Aotearoa, particularly spring-fed systems that are similar in nature to the Ararira catchment. The key to successfully transferring this approach to other catchments will be in the gaining of a clear understanding of the characteristics of catchment waterways, their current state, and the pressures and issues facing the catchment.

As this CMP has not yet been worked through with landowners and other stakeholders, we are not in a position to provide specific locations for the recommended interventions (Table 5). However, it is possible to provide guidance on the types of waterways that would be suitable for each intervention, and where these interventions should have the greatest impact (Table 5, Figure 24). With this guidance in mind, this CMP can then be worked through with stakeholders to finalise specific locations for implementation.

TABLE 5:
Guidance on the waterway types suitable for each of the interventions recommended for use in the Ararira catchment.

			WATERWAY TYPES							
Interventions			Informal Flow Paths	Springs	Water Races	Drains		Mainstem		
						Ephemeral/ Intermittent	Perennial	Headwaters	Mid Reaches	Lower Reaches
1	CHANNEL/BANKS	RESHAPING WITH RIPARIAN PLANTING for low cover/heavy shade – Two-stage – Small-scale			1		1			
2	CHANNEL/BANKS	RESHAPING WITH GRASS only – Two-stage – Small-scale			2 for dry sections of water race	2				
3	CHANNEL/BANKS	RESHAPING WITH RIPARIAN PLANTING - Two-stage - Large-scale							3	3
4	WETLANDS	Large-scale						4 already implemented with urban development	4 e.g., Yarr's Lagoon area	4
5	WETLANDS	Small-scale	5	5		5	5			
6	SEDIMENT TRAPS	Large-scale					6 at the downstream limit, in combination with large-scale wetlands		6	6
7	SEDIMENT TRAPS	INLINE – Small-scale			7 where still flowing as they enter drainage network		7			
8	SEDIMENT TRAPS	EVENT-BASED – Small-scale				8				
9		RIPARIAN PLANTING – Mainstem Habitat						9	9	9
10		PROTECTING SPRINGHEADS		10						
11		FENCING WATERWAYS where there is stock access	11	11	11	11	11	11	11	11
12	INSTREAM HABITAT	LOG VANES – Large-scale & Small-scale					12 small-scale	12 small-scale	12 large-scale	12 large-scale
13	INSTREAM HABITAT	Cobble clusters					13 where coarse substrate	13 where coarse substrate		

Key Interventions

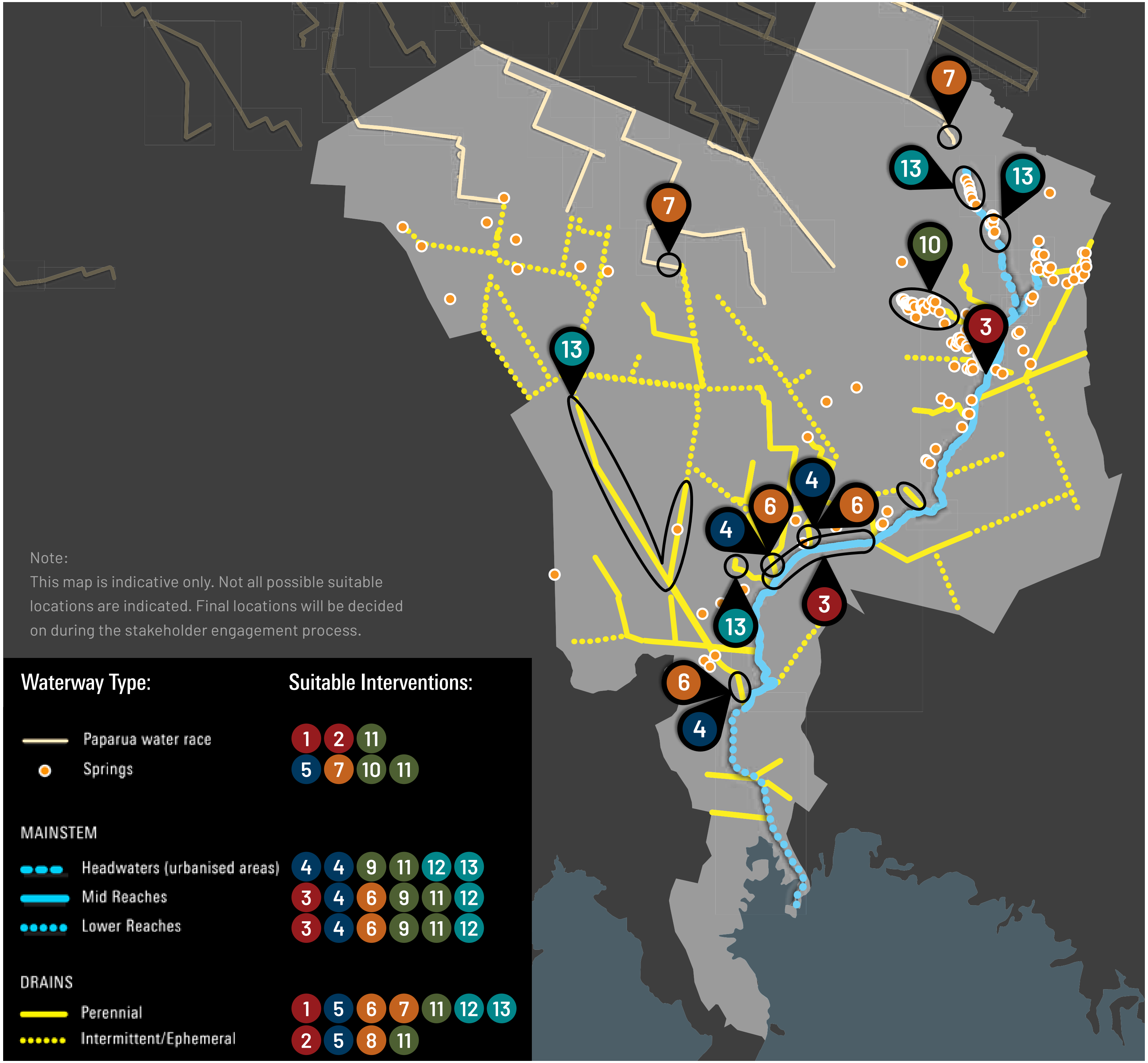


FIGURE 24:
Diagram of the Ararira/LII catchment illustrating some key interventions which may be proposed for use in different parts of the catchment or waterway type.

Image source: EOS Ecology

6.2 Information on Interventions

6.2.1 INTERVENTION 1: CHANNEL/BANKS – RESHAPING WITH RIPARIAN PLANTING for low cover/heavy shade – Two-stage – Small-scale

Two-stage channels are artificially created floodplains/benches that are established by reshaping the banks of existing drains to create a lower bench before battering back the bank to the existing ground level. Two-stage channels can increase water velocity during low flows if there is a narrowed low flow channel, which can decrease sedimentation. Conversely, velocity is decreased during high flows as the flood flows can flow over the wider flood channel with increased flow capacity and this reduces bank erosion. Two-stage channels provide a much more stable lower bank that is less prone to erosion and bank slumping/collapse. They also increase flood capacity, absorb nutrients, and may trap fine sediment on their mini floodplain (i.e., the first channel stage), as sediment is typically deposited on floodplains/benches during high flows. If implemented across multiple locations there may be cumulative water quality improvements in terms of reduced turbidity, phosphorus, and nitrogen. Two-stage channels typically have greater benefits than simple bank reshaping and we recommend that they are used where space is available.

Riparian planting to achieve low cover/heavy shade of the low flow channel is an integral part of this intervention. Specifically, planting of *Carex secta* at the waterway margins will shade out emergent macrophytes that typically become established there (e.g., monkey musk). Placement of *C. secta* is critical to ensure a balance between creating optimum shade and allowing adequate drainage, especially during floods. At maturity, *C. secta* are large plants and in narrow waterways can easily touch each other across the channel. This creates the potential for blockages during floods, especially if branches or macrophytes are washed downstream. Along the banks, plants should be spaced no closer than 1.5 m apart, since with this spacing, canopy closure on the banks will be achieved. The spacing between plants across the channel will be dependent on the channel width. Plants spaced greater than 2 m apart on opposite banks will not touch in the middle of the channel, but they will still ensure a good overhang of the channel margin once mature. If a view of the water is desired, then plants must be located further up the bank from the water's edge. *C. secta* plants are flexible and will not substantially exacerbate flooding effects if used in combination with bank reshaping/two-stage channel construction and planted to maintain a smooth flow path (i.e., no sharp constrictions). Hydraulic modelling of representative channel reaches typical of the permanently flowing drains in the Ararira catchment has shown that the additional cross section area of the two-stage channel will be sufficient to counteract the resistance caused by the planting.

Small-scale two-stage channels with riparian planting for low cover/heavy shade are suitable for perennial drains.

Key Features

- Instream channel width maintained for baseflow.
- Floodplain created to improve bank stability and increase channel capacity.
- Floodplain provides space for riparian planting.
- Upper banks are steeper.
- Upper bank gradient dependent on space available and the existing ground levels.
- Simple bank reshaping may be adequate if banks are low (<1.5 m high), but two-stage channel likely to be required for higher banks.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• reducing sediment inputs to channel • providing space for overhanging vegetation • increasing habitat diversity at waterway margins • reducing nuisance growth of emergent macrophytes • providing a source of organic matter inputs.	• reducing sediment inputs to channel • providing opportunities for improving fish habitat at stream margins • making space for overhanging vegetation • increasing habitat diversity at waterway margins.	• upholding the mana and mauri of the water body • practising kaitiakitanga • providing space for planting indigenous vegetation • improving habitat for mahinga kai species.	• capturing sediment on benches/ floodplains • reducing bank instability and slumping • maybe providing some filtration of overland flow.	• having potential for floodplain to capture *E. coli* or nutrients, but not tested.	• providing the opportunity for low cover/heavy shade riparian planting • providing heavy shade to stream margins, the growth of emergent macrophytes is reduced.	• providing space for riparian planting • being aware the level of benefit will depend on the scale of riparian planting.	• reducing the need for ongoing maintenance of emergent macrophytes.	• increasing the capacity of the channel.

Cross section showing the profile of a typical two-stage channel with riparian planting.

Image source: EOS Ecology

Carex secta provides low cover/heavy shade at the margins of the waterway, limiting the ability of emergent macrophytes to become established in the channel. Image source: EOS Ecology

A recently planted two-stage channel showing the characteristic lower flood plain and steeper slopes of the upper banks (top), with the same channel shown below with the *Carex secta* becoming established and providing greater cover at the margins of the waterway. Image source: Robin Smith, DOC

6.2.2 INTERVENTION 2: CHANNEL/BANKS – RESHAPING WITH GRASS only – Two-stage – Small-scale

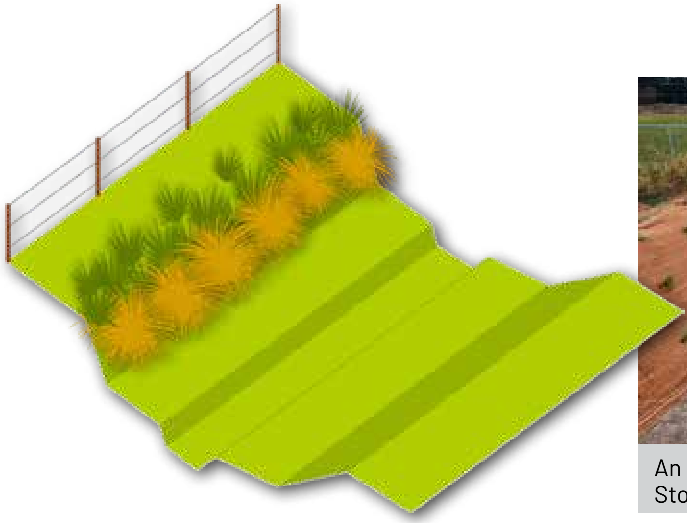
Small-scale two-stage channels/bank reshaping (as described in Section 6.2.1 above) may also be a suitable option to improve the bank stability of ephemeral or intermittent drains, reducing the amount of sediment that these waterways release into the drainage system. However, with fluctuating water levels, riparian planting would not be expected to effectively control the growth of macrophytes in the channel. Therefore, for ephemeral and intermittent channels, grassing the channel is recommended, so that it acts like a swale. Ongoing maintenance would be required, with grass cutting or weed spraying as required. Stock should be excluded from swales when these contain flowing water. However, periodic grazing with sheep could be a useful tool to manage weeds in these areas, with temporary fencing used to exclude stock as needed.

Small-scale two-stage channels with grass only are suitable for ephemeral/intermittent drains.

Key Features

- Floodplain created to improve bank stability and increase channel capacity.
- Steeper upper banks are set back from baseflow channel.
- Upper bank gradient dependent on space available and the existing ground levels.
- Simple bank reshaping may be adequate if banks are low (<1.5 m high), but two-stage channel likely to be required for higher banks.
- Channel is grassed and accessible to allow for required maintenance.
- Design of channel reshaping should consider the need to provide access for mowing.
- Stock are excluded from channel.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• reducing sediment inputs to channel.	• reducing sediment inputs to channel.	• upholding the mana and mauri of the water body • practising kaitiakitanga.	• capturing sediment on benches/ floodplains • reducing bank instability and slumping • maybe providing some filtration of overland flow.	• having potential for floodplain to capture *E. coli* or nutrients, but not tested.				• increasing the capacity of the channel.



An example of a two stage channel – the Leeston Stormwater Bypass. Image source: SDC

Cross section showing the profile of a typical two-stage channel with grass. Image source: EOS Ecology

Image source: EOS Ecology

6.2.3 INTERVENTION 3: CHANNEL – RESHAPING WITH RIPARIAN PLANTING - Two-stage - Large-scale

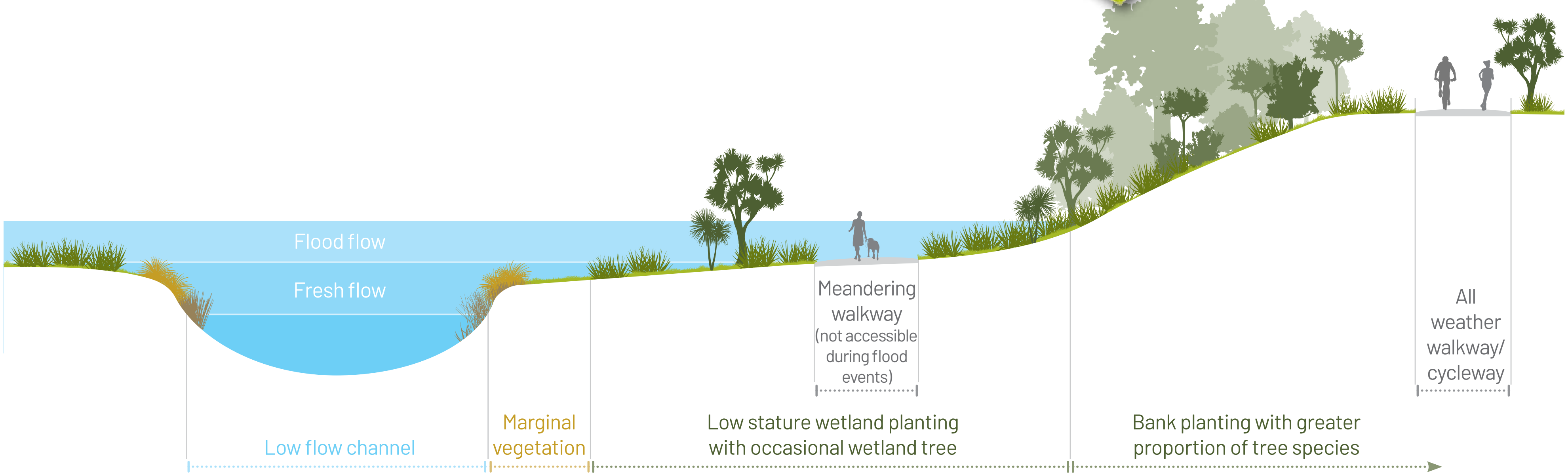
Two-stage channels (as described in Section 6.2.1 above) may be used at a larger scale on the mainstem of the Ararira River, where space allows. In this setting, the two-stage channel would increase channel capacity and improve bank stability by reshaping the river margins to include a large floodplain. The floodplain would create space for riparian planting, which will be dominated by wetland plants but may include larger tree/shrub species, along with low overhanging or emergent vegetation (i.e., rushes and sedges) at the margins of the river. The purpose of the low riparian planting on the floodplain is to slow water and trap sediment when the flood plain is inundated, rather than to provide shade to the channel. It is envisaged that this intervention would be suitable for the mid to lower reaches of the Ararira River, for example the mainstem of the river at Yarr's Lagoon.

Key Features

- Large-scale floodplain for parts of the mainstem, where substantial space available.
- Floodplain created to improve bank stability and increase channel capacity.
- Steeper upper banks are set back from baseflow channel.
- Upper bank gradient dependent on space available and the existing ground levels.
- Provides additional space for flood flows.
- Stock are excluded from channel.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• reducing sediment inputs to channel • providing space for overhanging vegetation • increasing habitat diversity at waterway margins • providing a source of organic matter inputs.	• reducing sediment inputs to channel • providing opportunities for improving fish habitat at stream margins • making space for overhanging vegetation • increasing habitat diversity at waterway margins.	• upholding the mana and mauri of the water body • practising kaitiakitanga • providing space for planting indigenous vegetation • improving habitat for mahinga kai species.	• capturing sediment on benches/ floodplains • reducing bank instability and slumping • maybe providing some filtration of overland flow.	• having potential for floodplain to capture *E. coli* or nutrients, but not tested.	• providing the opportunity for low cover/heavy shade riparian planting • providing heavy shade to stream margins, the growth of emergent macrophytes is reduced.	• providing space for riparian planting • being aware the level of benefit will depend on the scale of riparian planting.		• increasing the capacity of the channel.

The Ararira mainstem would be suitable for a large-scale two-stage channel with riparian planting in the area of Tārerekautuku/Yarr's Lagoon. Image source: Robin Smith, DOC



Cross section showing the profile of a two-stage channel floodplain on the mainstem, with riparian planting. Image source: EOS Ecology

Image source: EOS Ecology

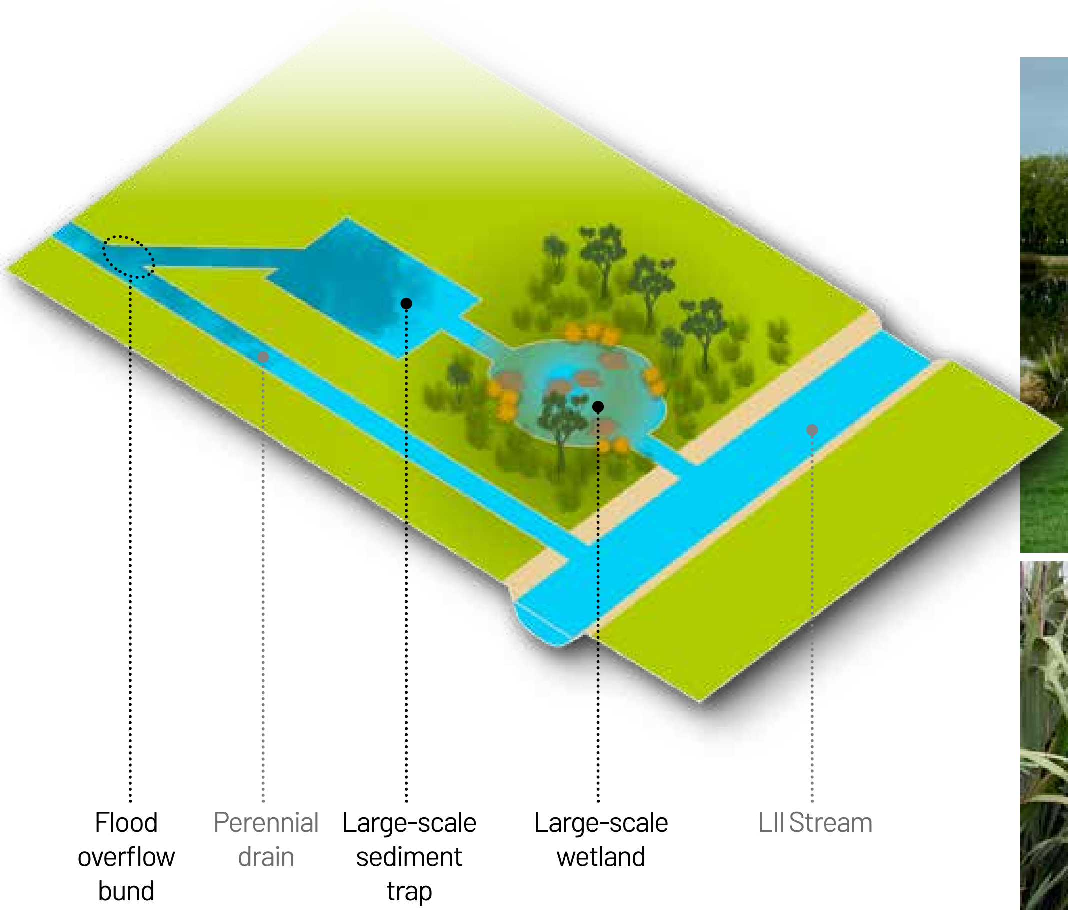
6.2.4 INTERVENTION 4: WETLANDS – Large-scale

Where space is available, large-scale wetlands offer benefits for flood management and water quality improvement, while providing increased habitat for biodiversity. By their nature, wetlands will accumulate sediment over time. Therefore, to reduce the need to disturb the wetland habitat for sediment removal, large-scale wetlands should be bundled with large-scale sediment traps upstream. This will reduce the volume of sediment reaching the wetland and extend its life. Large-scale wetlands may be implemented anywhere where sufficient land is available. An example of a suitable location for a large-scale wetland (in combination with a large-scale sediment trap) would be the Tārerekautuku Yarrs Lagoon area.

Key Features

- Limited to large areas of land.
- Suitable for locations such as Yarrs lagoon, with existing publicly owned land.
- Detailed design required for large-scale wetland projects.
- Work would include excavation and planting.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• contributing to water quality improvements • increasing the area of wetland habitat in the catchment.	• contributing to water quality improvements • increasing the area of wetland habitat in the catchment.	• upholding the mana and mauri of the water body • practising kaitiakitanga • contributing to water quality improvements • providing space for planting indigenous vegetation • improving habitat for mahinga kai species.	• encouraging the deposition and accumulation of sediments – reducing downstream transport of sediment.	• potentially contributing to water quality improvements – level of benefit will depend on the scale of the wetland.		• being aware the level of benefit will depend on the scale of wetland planting.		• designating large areas where flooding is acceptable • reducing peak runoff.



Large-scale wetlands should be bundled with large-scale sediment traps, to reduce the volume of sediment reaching the wetland.

Image source: EOS Ecology

Large-scale wetlands are used in the new urban areas of Lincoln for stormwater management; such systems would also be of use in the rural portion of the catchment.

6.2.5 INTERVENTION 5: WETLANDS – Small-scale

Small-scale wetlands are envisaged as an on-farm wetland opportunity, that individual landowners may want to implement as part of their farm development. Small-scale wetlands offer potential benefits for flood management, as well as sediment control, biodiversity, and water quality improvement. Opportunities for small-scale wetlands may be identified through farm environmental plans, such as the identification and retirement of wet areas, springheads, or critical source areas where traditional farming practices are no longer appropriate.

Key Features

- Likely to be located on farmland.
- Provides an option for farmers to have a duck pond or retire a wet paddock and turn into a planted wetland.
- Small-scale earthworks may or may not be required.
- Work would include planting and fencing to exclude stock.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• contributing to water quality improvements • increasing the area of wetland habitat in the catchment.	• contributing to water quality improvements • increasing the area of wetland habitat in the catchment.	• upholding the mana and mauri of the water body • practising kaitiakitanga • contributing to water quality improvements • providing space for planting indigenous vegetation • improving habitat for mahinga kai species.	• encouraging the deposition and accumulation of sediments – reducing downstream transport of sediment.	• potentially contributing to water quality improvements – level of benefit will depend on the scale of the wetland.		• being aware the level of benefit will depend on the scale of wetland planting.		• designating large areas where flooding is acceptable • reducing peak runoff.

Small-scale wetlands can be designed as ephemeral habitats, providing benefits for flood management as well as sediment control, biodiversity, and water quality improvement.
Image source: EOS Ecology

Small-scale on-farm wetlands can help with water quality improvement, but in Canterbury can also provide habitat for the critically endangered kōwaro/Canterbury mudfish.
Image source: EOS Ecology

Opportunities for creating small-scale wetlands may include retiring wet areas or spring heads, where other farming practices are not as practicable.
Image source: Robin Smith, DOC

6.2.6 INTERVENTION 6: SEDIMENT TRAPS – Large-scale

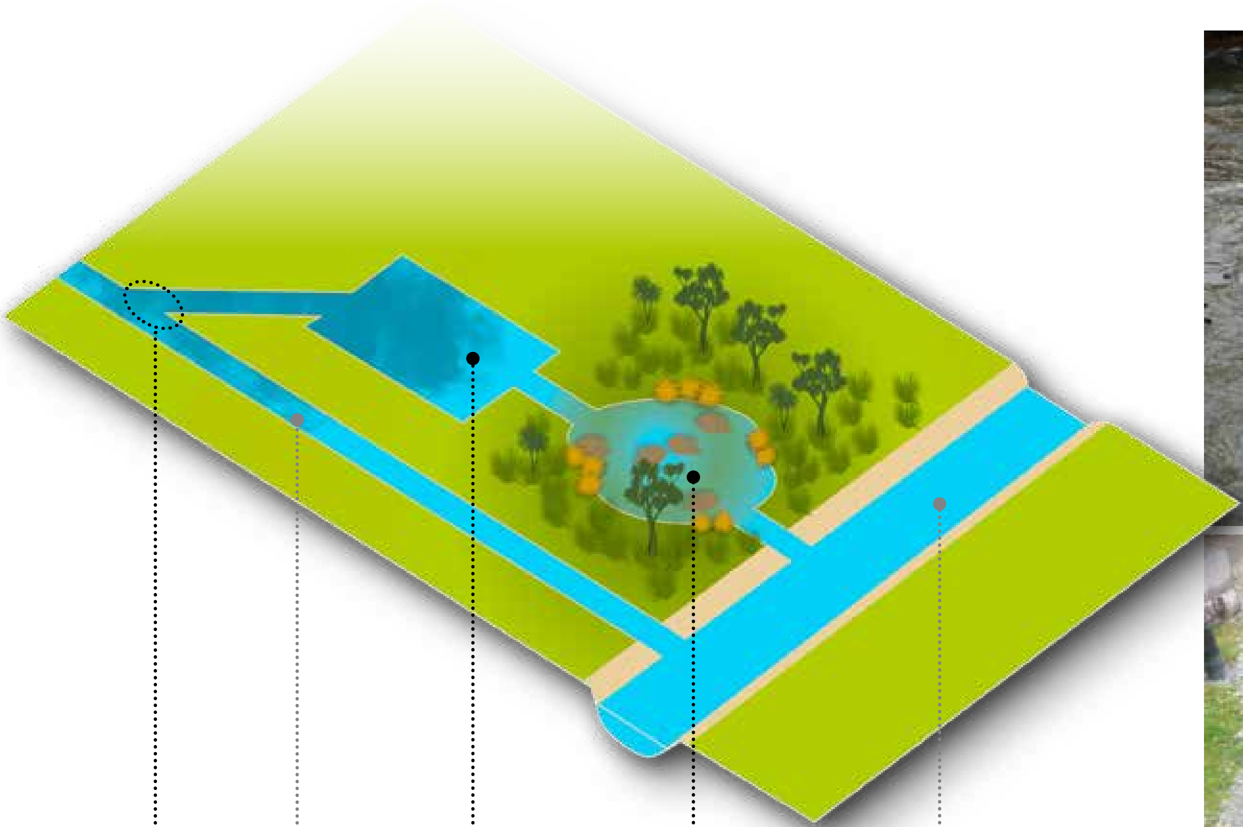
Large-scale sediment traps would be well suited to the downstream end of branches of the drainage network, to reduce sediment inputs into the mainstem of the Ararira River. The purpose of large-scale sediment traps is to provide a location for targeted accumulation and removal of sediment from waterways that have been identified as key sediment sources. This is intended to reduce the environmental impacts and financial costs of widespread sediment removal across the drainage scheme and reduce the amount of fine sediment entering the mainstem of the river. Large-scale sediment traps may be implemented anywhere where sufficient land is available but would be most useful in the lower reaches of the drain network and best placed upstream of large-scale wetlands, to decrease the volume of sediment reaching the wetland itself. An example of a suitable location for a large-scale sediment trap (in combination with a large-scale wetland) would be Tārerekautuku Yarrs Lagoon.

Key Features

- Where large areas of land available or may be purchased.
- Suitable upstream of large-scale wetlands, to reduce sediment input to wetlands.

Core Benefits

Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• reducing the quantity of legacy fine sediment in the waterways • protecting downstream habitats from being smothered fine sediment movement.	• reducing the quantity of legacy fine sediment in the waterways • protecting downstream habitats from being smothered fine sediment movement.	• upholding the mana and mauri of the water body • practising kaitiakitanga • improving habitat for mahinga kai species.	• encouraging the deposition of fine sediment, to facilitate mechanical removal.	• reducing *E. coli* concentrations have been demonstrated in a sediment trap pilot project • potentially reducing nutrients associated with sediment, as this is deposited and mechanically removed.			• creating targeted areas for sediment removal, rather than widespread maintenance.	• creating target areas for sediment deposition and removal.



Large-scale sediment traps would be especially useful if located upstream of large-scale wetlands, to decrease sediment volumes entering the wetland.

Image source: EOS Ecology

Large-scale sediment traps can prevent large volumes of sediment from entering downstream environments, provided they are well maintained with sediment removed as it builds up.

6.2.7 INTERVENTION 7: SEDIMENT TRAPS – INLINE – Small-scale

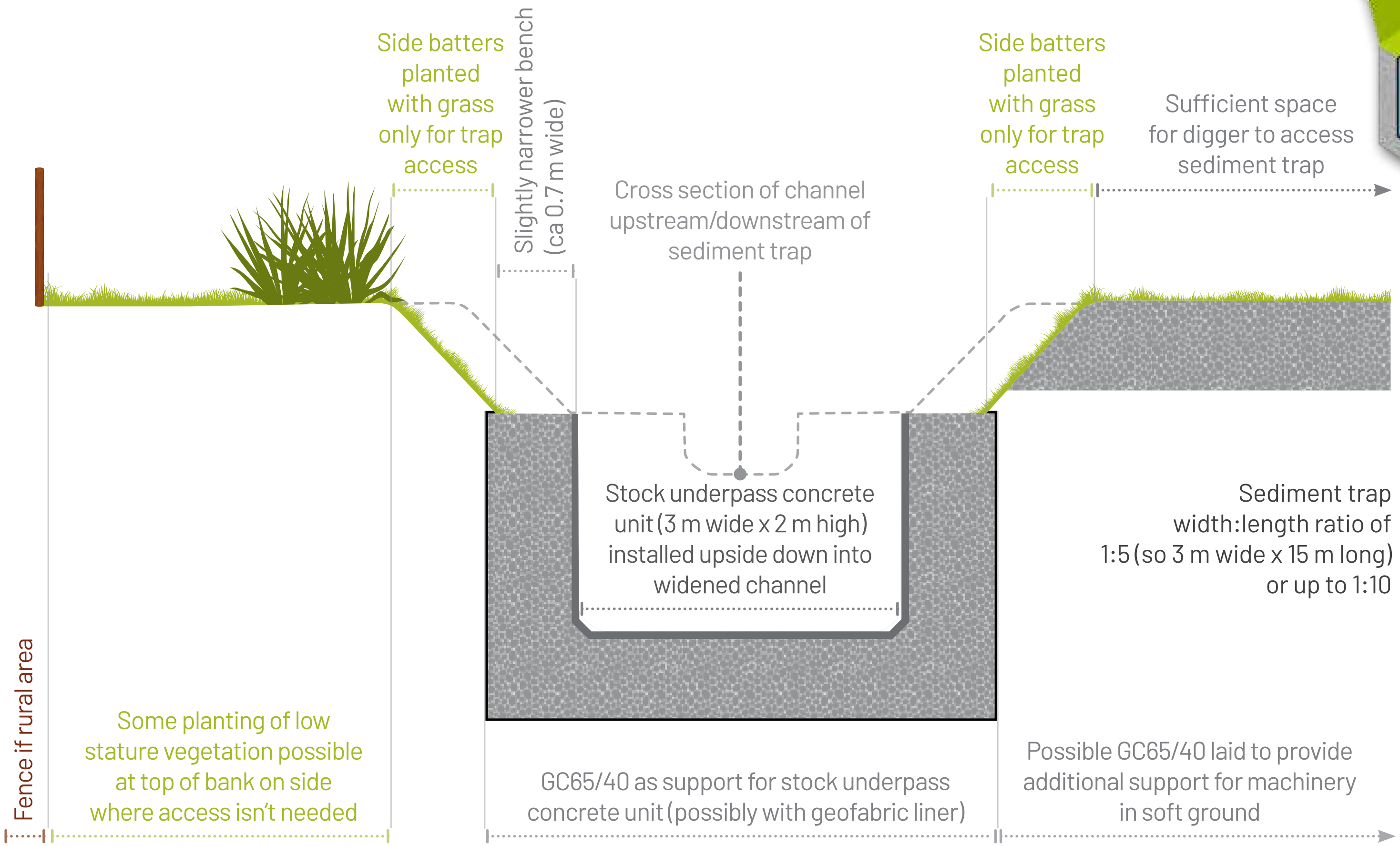
Small-scale inline sediment traps are intended to provide a location for targeted accumulation and removal of fine sediments. The use of a network of small-scale inline sediment traps across the drainage scheme is expected to reduce the environmental impacts and financial costs of widespread sediment removal. Small-scale inline sediment traps would involve enlarging and formalising existing sediment accumulation areas within the drainage scheme, to improve access for maintenance and to minimise the impacts of this maintenance activity. To ensure that the sediment traps don't become a source of bank erosion, we suggest that these widened and deepened sections of channel are also lined to ensure that over time they are not over-deepened and widened. We suggest using precast concrete stock underpass units, installed upside down for this purpose. It will also be necessary to employ expert operators to undertake maintenance, as care will be needed to avoid damage to these structures. The recommended width-length ratio for inline sediment traps is 1:5 as a minimum and up to 1:10.

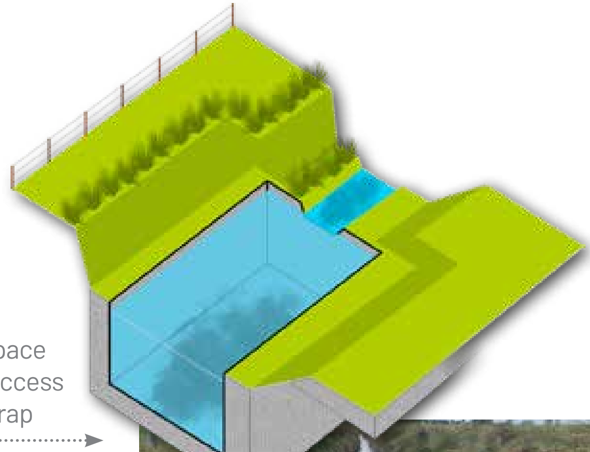
Small-scale inline sediment traps would need to be numerous to achieve substantial benefits for sediment reduction. As a starting point, sediment traps could be prioritised for all permanently flowing drains with at least one permanently flowing tributary. The effectiveness of these would need to be monitored over time to establish how often they needed emptying and whether additional traps would be needed to support the desired sediment reductions and a workable maintenance schedule for the traps. Mechanisms to support this type of intervention could include the procurement of a global consent for the initial construction of small-scale sediment traps and for the ongoing removal of sediment from these traps..

Key Features

- Not limited to rated drain network, suitable for all drain types with perennial flow.
- Potentially useful in water race network, to prevent water race sediment from moving down into the rest of the system.
- An intervention for reducing sediment impact downstream, not for biodiversity purposes
- Hard edge lining with focus on utility/maintenance requirements rather than biodiversity values.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• reducing the quantity of legacy fine sediment in the waterways • protecting downstream habitats from being smothered fine sediment movement.	• reducing the quantity of legacy fine sediment in the waterways • protecting downstream habitats from being smothered fine sediment movement.	• upholding the mana and mauri of the water body • practising kaitiakitanga • improving habitat for mahinga kai species.	• encouraging the deposition of fine sediment, to facilitate mechanical removal.	• reducing *E. coli* concentrations have been demonstrated in a sediment trap pilot project • potentially reducing nutrients associated with sediment, as this is deposited and mechanically removed.			• creating targeted areas for sediment removal, rather than widespread maintenance.	• creating target areas for sediment deposition and removal.





The flat area of water in this channel is a sediment trap location. When the trap is nearly full, a digger can reach over the fence and planting to remove sediment.

An inline sediment trap may simply be a widened and deepened area of channel, where the flow is slower and encourages the deposition of fine sediment. However, we are recommending a more hard-edged solution, to enable easier access for maintenance. Image source: Robin Smith, DOC

Small-scale inline sediment traps provide a location for targeted accumulation and removal of fine sediments. An inline sediment trap may simply be a widened and deepened area of channel.

Image source: EOS Ecology unless otherwise stated

6.2.8 INTERVENTION 8: SEDIMENT TRAPS – EVENT-BASED – Small-scale

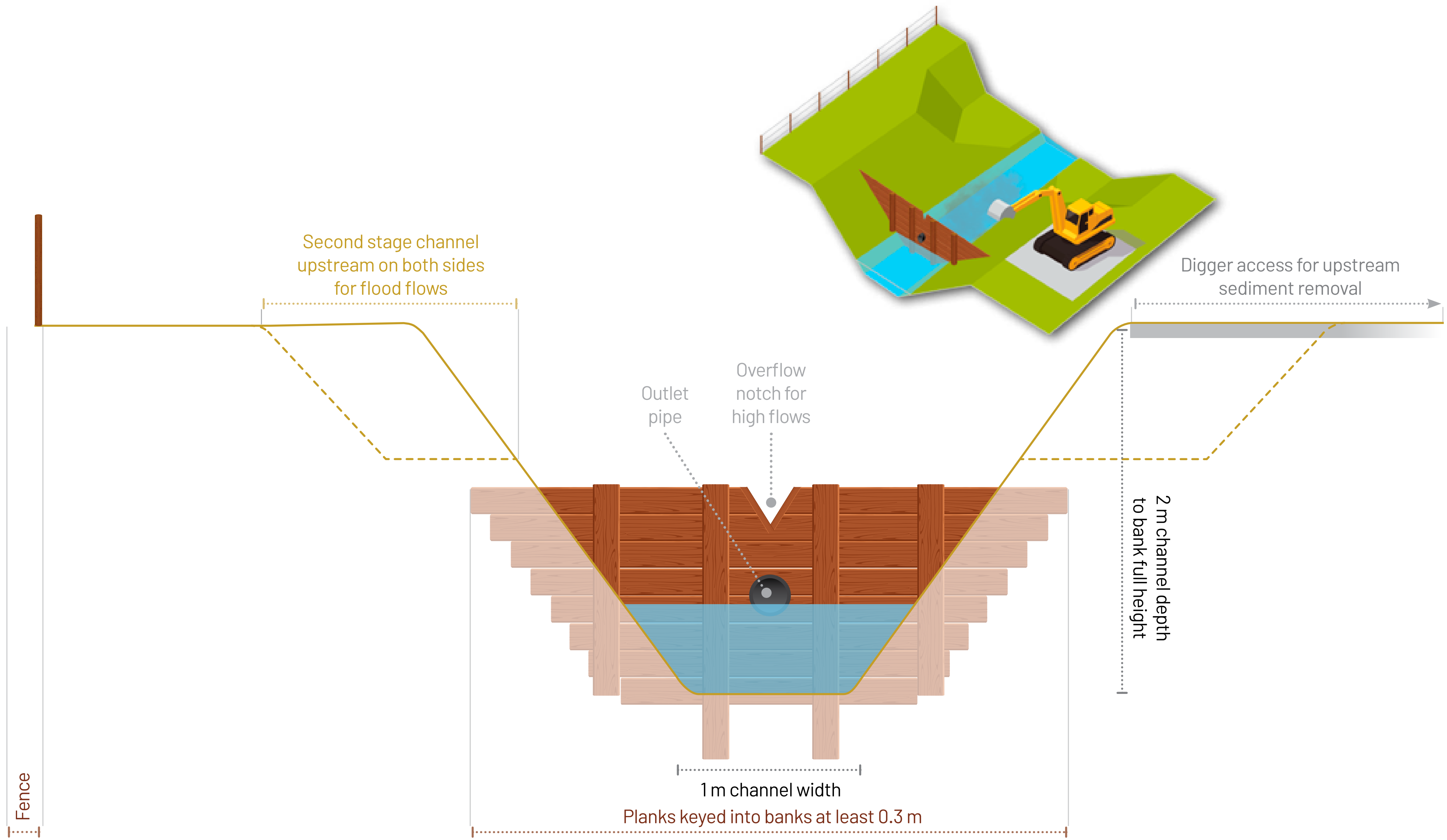
Small-scale event-based sediment traps are targeted areas for sediment removal in ephemeral or intermittent sections of channel, where small-scale inline sediment traps would be expected to be less effective. Based on the design principles of peak runoff control structures, these event-based sediment traps include a level of in-channel backup of water, which encourages the deposition of fine sediment. Similar in concept to peak runoff control structures, this type of sediment trap would require the installation of a control structure at the downstream end of the trap; for example, a culvert outlet, bund, spillway, or choked outlet could be used. The structures would be designed in such a way that the normal intermittent flow would pass easily through the control structure, but that water would be held back during higher flows, allowing sediment to settle out at those times. As this intervention would introduce a fish passage barrier to the system, it would only be suitable for ephemeral or intermittent reaches within the catchment with low habitat values for fish upstream. In some cases, these structures may also be suitable where water races discharge into the drainage network, as water races are likely to be a source of fine sediment to the drainage network.

Mechanisms to support this type of intervention could include the procurement of a global consent for their initial construction and for the ongoing removal of sediment from these traps.

Key Features

- Not limited to rated drain network, suitable for ephemeral or intermittent drains on farms.
- Potentially useful in water race network, to prevent water race sediment from moving down into the rest of the system.
- An intervention for reducing sediment impact downstream, not for biodiversity purposes
- Peak flow control structure used to accumulate sediment and facilitate mechanical removal.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• protecting downstream perennial habitats from being smothered by fine sediment movement.	• by protecting downstream perennial habitats from being smothered by fine sediment movement.	• upholding the mana and mauri of the water body • practising kaitiakitanga • protecting downstream perennial habitats from being smothered by fine sediment movement.	• encouraging the deposition of fine sediment, to facilitate mechanical removal.				• creating targeted areas for sediment removal, rather than widespread maintenance.	• creating target areas for sediment deposition and removal.



Small-scale event-based sediment traps are targeted areas for sediment removal in ephemeral or intermittent sections of channel.

Image source: EOS Ecology

6.2.9 INTERVENTION 9: RIPARIAN PLANTING – Mainstem Habitat

The focus of the riparian planting for mainstem habitat would be to plant areas of the mainstem (headwaters, middle, or lower reaches) where there is no need for bank reshaping or where infill planting is required to improve the existing riparian vegetation. This intervention may also include the replacement of introduced trees, such as willows, with native trees, for example, at Tārerekautuku Yarrs Lagoon and further downstream where willows have been poisoned. The purpose of this type of planting would be to increase terrestrial biodiversity and include larger tree species where appropriate. While riparian restoration needs to be undertaken at the catchment scale to maximise benefits and effectiveness, it is anticipated that riparian planting for mainstem habitat would also provide benefits for cultural and recreational values along the river corridor. Riparian planting of the mainstem is not expected to provide sufficient shading to reduce macrophyte growth or change the need for maintenance of macrophytes in the mainstem. This intervention may be suitable where sufficient hydraulic capacity exists (or can be created through bank reshaping), for example, the lower reaches of the mainstem or the area around Tārerekautuku Yarrs Lagoon and in the upper headwaters.

Key Features

- Larger scale riparian planting should be possible on the mainstem.
- Focus on planting for terrestrial biodiversity.
- Need to consider the impact of shade on understory plants, as there is potential for greater erosion if groundcover is shaded out.
- Plants selected should be eco-sourced and suitable for local conditions.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• providing for increased terrestrial biodiversity • providing a source of organic matter inputs.	• providing a source of organic matter inputs.	• upholding the mana and mauri of the water body • practising kaitiakitanga • providing space for planting indigenous vegetation • improving habitat for mahinga kai species.	• contributing to filtering of sediment from overland flow • reducing bank instability and slumping.	• potentially contributing to filtering of contaminants.		• being aware the level of benefit will depend on the scale of wetland planting.		being completed together with appropriate bank reshaping.

There is generally a lack of understory planting in the mainstem headwaters. This area may be suitable for infill planting.

Recent riparian planting along the mainstem headwaters; this could be replicated along other reaches of the mainstem.

An existing example of riparian planting for mainstem habitat, just upstream of Pannetts Road bridge on the true right bank of the Ararira River. Image source: Robin Smith, DOC

Image source: EOS Ecology unless otherwise stated

6.2.10 INTERVENTION 10: PROTECTING SPRINGHEADS

Springheads may appear as wet or muddy areas on land, where individual or multiple springs occur. In rural areas where stock can access these wet areas, they can be a substantial source of sediment to the drainage system. In urban areas, the discharge of stormwater to the spring can greatly alter the stability of the spring system and impact on the biota that live in spring systems.

Ideally, in rural areas springheads should be fenced off to prevent stock access and the fenced area should be planted with suitable vegetation, including larger shade trees where possible and groundcover species to reduce the need for ongoing maintenance. This could involve fencing and planting individual springheads or setting aside larger areas of land where there are accumulations of springs to provide for a wider spring wetland habitat. This intervention may therefore be bundled with 'small-scale wetlands' and 'large-scale wetlands'. Priority springheads for this type of improvement would be permanently flowing springs where these are located close to and flow into permanently flowing drains in the catchment.

If springs are present in land to be urbanised then it would be appropriate to sequester such systems from stormwater inputs, particularly for larger springheads or for networks of springs in a larger development area. This will ensure that the spring system hydrology will remain unaffected by the flashy nature of urbanised catchments due to stormwater inputs, and will retain better water quality.

Key Features

- Identify and fence off areas of pasture where springheads are present.
- Ongoing maintenance should be minimal once plants are well established.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• increasing biodiversity in protected areas • improving habitat by removing direct stock access to springs.		• upholding the mana and mauri of the water body • practising kaitiakitanga • increasing biodiversity in protected areas • removing stock access to mahinga kai gathering areas.	• removing stock access and pugging of land surrounding springs.	• removing direct stock access to springs.			• reducing sediment inputs to the drainage system.	

A springhead in Silverstream (a waterway to the west of the Ararira catchment) that has been fenced and planted to protect it from adjacent land use.

This springhead would benefit from fencing and planting to reduce sediment inputs to the springhead and associated downstream drainage channel.

For land undergoing urban development it would be important to sequester springs from stormwater inputs, so as to protect the spring's stable hydrology and retain better water quality.

Image source: EOS Ecology

6.2.11 INTERVENTION 11: FENCING WATERWAYS where there is stock access

Where permanently flowing waterways in the catchment are not already fenced, this should be a priority intervention. With the substantial challenges that fine sediment pose in this catchment, this is a basic intervention that can help reduce sediment inputs through the exclusion of stock to the channel. This intervention is best bundled with other interventions (e.g., small-scale two-stage channel/bank reshaping with riparian planting for low cover/heavy shade, riparian planting and protecting springs), but could be a standalone invention in some cases such as where there are gaps in existing fencing. Priority areas for fencing would be the mainstem and permanent drains, but there will also be substantial benefits to be gained from temporary fencing to exclude stock from ephemeral/intermittent drains and informal flow paths during wet periods of the year.

Key Features

- To be used in all locations where stock have access to waterways.
- Suitable for all waterway types.
- Fencing setbacks should aim for a ‘better than good practice’ approach as described in Section 5.1.1.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• improving habitat by removing direct stock access to springs.	• habitat improved by removing direct stock access to waterways.	• upholding the mana and mauri of the water body • practising kaitiakitanga • removing stock access to mahinga kai gathering areas.	• removing direct stock access to waterways.	• removing direct stock access to waterways.			• reducing sediment inputs to the drainage system.	

Riparian planting is fenced off to prevent stock access to the waterway.

A fenced and planted waterway along private farmland near Sergeants Road in the Ararira catchment.

Weed control along the edge of the planted area and the fence is important; where space allows, a 1 m unplanted buffer zone on the riparian side is recommended, to reduce the encroachment of planted vegetation into the adjacent paddock. Spot spraying of weed species may also be required.

Image source: EOS Ecology

6.2.12 INTERVENTION 12: INSTREAM HABITAT – LOG VANES – Large-scale & Small-scale

Log vanes are a type of constructed instream habitat, used to improve habitat and flow diversity for fish and invertebrates. Adding logs to streams can provide a variety of ecosystem benefits but are most often used to create habitat and flow diversity in areas of run habitat. Constructed instream habitat structures are commonplace overseas, but only a few trial examples exist in New Zealand. Recent log vane trials in Waituna Creek (Southland) found that the areas of stream bed around (installed) large logs had substantially higher diversity and biomass of native fish compared to similar areas upstream without logs. In the Ararira catchment, we recommend that log vanes be used primarily to improve instream habitat, although they have also been used to stabilise banks in overseas examples.

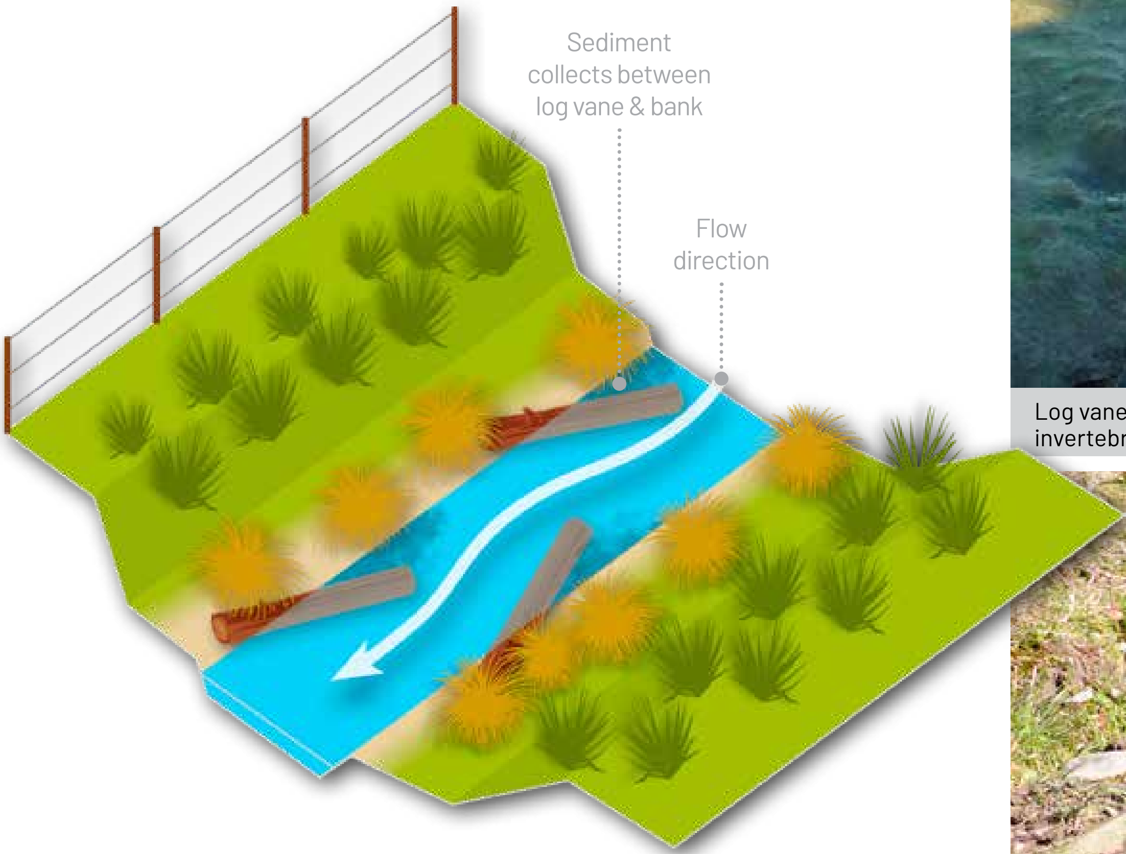
Small-scale log vanes would be suitable for perennial drains with fine substrate, where they may also help to stabilise banks and reduce sediment input from bank erosion. Large-scale log vanes would be most suitable for the mainstem of the Ararira, although access for maintenance needs to be considered when planning the use of this intervention. Large-scale log vanes require more engineering input than small-scale, to ensure secure attachment to channel banks. Large- or small-scale log vanes are only suitable where sufficient hydraulic capacity exists or can be created through bank reshaping, to ensure that drainage function is not compromised by these instream features.

In terms of maximising the potential benefits of instream habitat features, the lower reaches of permanently flowing drains are a priority for small-scale log vanes, close to where these join the mainstem. The lower reaches of the mainstem would be the focus for large-scale log vanes.

Key Features

- Large logs positioned in the stream such that they are partially submerged during low flows.
- Should be installed in combination with two-stage bank reshaping to ensure channel capacity is maintained and logs do not cause erosion
- Provides improved habitat for native fish, including taonga species such as longfin eels
- Also provides aesthetic benefits, potential to improve access to the stream, and roosting sites for waterfowl.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• increasing instream habitat diversity.	• increasing instream habitat diversity.	• upholding the mana and mauri of the water body • practising kaitiakitanga • improving fish and aquatic invertebrate values.	• reducing bank instability and slumping.					



When installed correctly, log vanes can provide upstream bank protection through sediment deposition, and stable areas of mid channel pools downstream.

Image source: EOS Ecology

Log vanes create flow variability within the waterway channel, with benefits for fish and invertebrates.

Log vanes are typically installed pointing upstream. Used in combination with bank reshaping to ensure that channel capacity is not reduced.

6.2.13 INTERVENTION 13: INSTREAM HABITAT – COBBLE CLUSTERS

Cobble clusters are type of small-scale constructed instream habitat, used to improve habitat and flow diversity for fish and invertebrates. Adding cobble clusters to streams can increase the habitat and flow diversity in areas of otherwise uniform habitat. They also provide egg laying sites for both native fish and invertebrates. Cobble clusters are suitable for waterways with an existing hard substrate, such as the gravel bed reaches of the Ararira headwaters, and gravel bed reaches of the drain network. Local successful examples include the Ōpāwaho Heathcote River (where cobbles and boulders have been installed at seven sites between Barrington Street and Waltham Road) and Dudley Creek (where cobbles have been installed along a 700 m reach along Stapletons Road, Christchurch).

Key Features

- Groups of cobbles or boulders are positioned in the stream so that they are submerged during low flows.
- The cobbles provide cover for small native fish within the channel, rather than focusing only on the edge cover.
- The cobbles increase the diversity of flow characteristics in the waterway and this provides increased habitat opportunities for invertebrates and fish.
- Cobble clusters are a small-scale instream habitat feature and should not adversely impact the hydraulic capacity of the waterway.
- Cobble clusters are a low cost intervention.

Core Benefits								
Improves habitat values & invertebrate species biodiversity by:	Improves fish habitat & diversity by:	Improves cultural values by:	Reduces sediment by:	Reduces *E. coli* or nutrients by:	Reduces emergent macrophytes by:	Provides carbon sequestering benefits by:	Reduces costs & environmental impacts of maintenance by:	Maintains or improves drainage function by:
• increasing instream habitat diversity and providing egg-laying sites.	• increasing instream habitat diversity and providing egg-laying sites.	• upholding the mana and mauri of the water body • practising kaitiakitanga • improving fish and aquatic invertebrate values.						

An array of cobble clusters increases instream habitat diversity for invertebrates and fish in gravel bed waterways.

The presence of large cobbles or boulders in the stream bed increases instream habitat diversity.

Bully eggs found on the underside of this cobble – an example of the benefit of introducing large substrate to waterways.

Image source: EOS Ecology

Waikōura/freshwater crayfish is an iconic native 'mega' invertebrate of the Ararira/LII mainstem.

Image source: EOS Ecology

7 Aspirations & Hope for the Catchment

Intensively modified lowland waterbodies are the among the most degraded aquatic systems in Aotearoa. Substantial changes are required to the way we manage these systems if we aspire not just to halt degradation, but to realise their latent potential to support thriving ecosystems. The Ararira is a highly modified catchment with many values left to protect and plenty of opportunity for restoration. This Catchment Management Plan (CMP) provides the roadmap for a transformative approach to waterway management in the Ararira. The tools proposed in this CMP will not only deal with the existing challenges of ongoing drainage, but will also enhance the biodiversity, cultural, and recreational opportunities of the catchment (Figure 38).

The CMP presents a range of tools that have proven to be successful on a trial basis but are yet to be implemented at the scale of an entire catchment, at least within Aotearoa. In the companion Implementation Guide (IG) document, we show how these tools can be embedded within the existing management regime in a staged and coordinated manner to deliver the catchment vision. Some of the solutions presented in this CMP could cost more than existing practices, but their multiple benefits will move the catchment towards a more sustainable future.

The key to the effective implementation of the CMP will be an adaptive management approach. This requires that appropriate measures and targets for a range of values are established and monitored to assess progress and identify when approaches need amending. Appropriate measures ought to include cultural indicators alongside ecological assessments. For example, how has the project improved community connection with the Ararira—are the actions taken supporting/improving mahinga kai opportunities? Have recreational opportunities and biodiversity improved? Key biophysical indicators of success will include a reduction in fine sediment loads, reduced need to physically disturb the channel (e.g., through macrophyte clearing) and increased habitat diversity. The CMP is grounded by the need to continue to provide adequate drainage of productive land, and this also requires monitoring. For example, stream bed and water level measures need to be collected to contribute to responsive drainage management.

As this transformative approach to managing the Ararira is put into practice, and demonstrated to be effective, the catchment will provide an exemplar of modern lowland waterbody management in Aotearoa. Implementing the CMP will move beyond managing the Ararira as a network of drains, towards creating a biodiverse cultural and recreational asset for the community, embodying both the local catchment vision and the national direction of Te Mana o Te Wai.

Future Values

The Ararira mainstem offers opportunities to improve terrestrial biodiversity with riparian planting.

Image source: Robin Smith, DOC

Image source: Robin Smith, DOC

Image source: Robin Smith, DOC

Image source: Robin Smith, DOC

Image source: Robin Smith, DOC

Tārerekautuku Yarrs Lagoon offers an opportunitiy to enhance biodiversity and water quality values within the catchment.

Image source: Robin Smith, DOC

Biodiversity values – Ararira is a major tributary of Te Waihora.

Image source: Robin Smith, DOC

Image source: Robin Smith, DOC

FIGURE 38:
Images illustrating potential future values of the Ararira catchment.


Image source: Fish & Game NZ


Image source: Robin Smith, DOC


Image source: SDC


Image source: EOS Ecology


Image source: SDC

The tools and solutions proposed in this CMP should also enhance the existing recreational values of the catchment and continue to work as nature's classroom.


Image source: EOS Ecology

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Figure 3:

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Image source: Fish & Game NZ