Overview of the Kukutaaruhe Gully Restoration Initiative

A client report prepared for the Kukutaaruhe Education Trust

Part 1 of 3

ERI Report 136

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Written by

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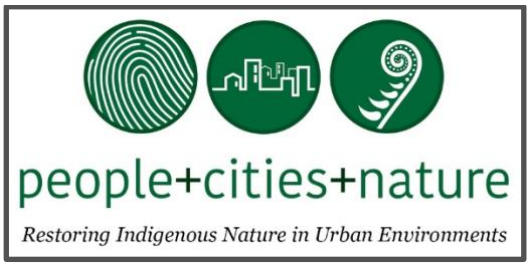

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Executive summary

Kukutaaruhe Gully is a minor branch of Hamilton's extensive gully system, and runs from the corner of Bankwood and Clarkin Road, behind Fairfield College, connecting with Donny Park in the north and out into the Waikato River. The Kukutaaruhe Education Trust was established to support the implementation of the Fairfield Project, which is a partnership between Ngati Wairere, local community and Fairfield College. The project's goals include the establishment of an ecological and environmental education centre on the approximately 12 ha of land behind Fairfield College and restoration of the adjacent Kukutaaruhe Gully.

In 2019, the University of Waikato's Environmental Research Institute was contracted by the Kukutaaruhe Education Trust to create an Overview of the Kukutaaruhe Gully restoration initiative. This is one in a three-part series created together under one contract:

- **Part 1 of 3 is the first document presented here, an Overview of the Kukutaaruhe Gully Restoration Initiative**
- Part 2 of 3, the Operational Forest Restoration plan for Kukutaaruhe Gully
- Part 3 of 3 is an Ecological Restoration Plan Template.

This document provides the following:

- A site description that identifies existing known indigenous species and current ecological threats
- A link with the Donny Park Reserves Act Management Plan (2004) and the Local Indigenous Biodiversity Programme (LIBS)
- A list of recommended operational plans with broad guidelines for what these should include
- An overview of the opportunities for social engagement in the Fairfield Project

Part 2 of 3 is an Operational Forest Restoration Plan for Kukutaaruhe Gully and Part 3 of 3 is an Ecological Restoration Plan Template.

While Kukutaaruhe Gully currently presents a substantial restoration challenge, with steep slopes dominated by invasive vines and shrubs, restoring the area is of great ecological and cultural significance. Restoration of the gully will not only increase Hamilton's native vegetation cover and the habitat this provides to native fauna but will also extend the green corridor which runs from Donny Park to the Waikato River, facilitating the movement of native plants and animals throughout the city. The Kukutaaruhe restoration initiative therefore has great potential to contribute to Hamilton-wide restoration efforts as a component of the Waikato Regional Council's Local Indigenous Biodiversity Strategy (LIBS). With time and restoration action the Kukutaaruhe Gully may well be declared a Significant Natural Area, due to close proximity with the existing Donny Park and Ranfurly park

Significant Natural Areas and the previously recorded presence of giant kookopu (*Galaxias argenteus*) in the gully stream, which is a species 'At Risk – Declining'.

The holistic approach embraced by the Kukutaaruhe Education Trust will benefit city residents and indigenous biodiversity, as the Trust seeks to connect the local community to the natural environment, provide a venue for environmental education and contribute to the restoration of Hamilton's unique gully network.

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1. Introduction

1.1 Background

In 2019, the University of Waikato's Environmental Research Institute was contracted by the Kukutaaruhe Education Trust to create an overview of the Kukutaaruhe Gully restoration initiative. The Kukutaaruhe Education Trust was established in 2016 as an operational entity to support the implementation of the Fairfield Project – a partnership between Ngati Wairere, local community and Fairfield College. The project's goals include the establishment of an ecological and environmental education centre on the grounds behind Fairfield College and restoration of the adjacent Kukutaaruhe Gully in Hamilton City (Figure 1).

This document provides the following:

- A site description that identifies existing known indigenous species and current ecological threats
- A link with the Donny Park Reserves Act Management Plan (2004) and the Local Indigenous Biodiversity Programme (LIBS)
- A list of recommended operational plans with broad guidelines for what these should include
- An overview of the opportunities for social engagement in the Fairfield Project

A crucial part of any urban ecological restoration initiative is careful overview planning, which may be summarized in the steps present in Table 1. We urge leaders to consult this table regularly to ensure their projects stay on track.

TABLE 1. IMPORTANT STEPS TO FOLLOW WHEN FORMING AN URBAN ECOLOGICAL RESTORATION PROJECT. BORROWED WITH PERMISSION FROM WALLACE & CLARKSON (2019).

Restoration Plan Steps	Examples
1. Engage with all relevant partners	local government, iwi, community groups, businesses
2. Define restoration goals	target ecosystem, non-native species removal, increased ecological function
3. Build landscape-scale vision	understand connectivity with neighbouring ecosystems
3. Form long-term timeline	for a forest, this should be decade to century length
4. Create accurately scaled project budget	plant costs, labour costs, administration costs
5. Acquire funding	through granting agencies, local government, donations
6. Form restoration methods with scientific underpinning	correct density of plantings, large enough plants, timely enrichment plantings
7. Perform restoration actions with partners	conduct restoration plantings with partners present, follow up care
8. Monitor outcomes to gauge success	annual monitoring of plant survival (quantitative if possible), photo points
9. Adapt methods moving forward	change species mix being planted based on survival monitoring results

FIGURE 1. A CONCEPT MAP FOR THE 12 HECTARES OF LAND BEHIND FAIRFIELD COLLEGE. PHOTO FROM THE FAIRFIELD PROJECT FACEBOOK PAGE.

The significance of Hamilton gullies

The Hamilton Ecological District in New Zealand's North Island has been severely modified by agriculture, silviculture and urbanisation, with less than 2% of the 159,376 ha area currently covered in native vegetation (Clarkson & McQueen, 2004; Hamilton City Council, 2007). Hamilton City lies at the centre of the district and only 2.1% of its approximately 11,000 ha is covered in indigenous vegetation (Clarkson, Wehi, & Brabyn, 2006). Thus, natural habitat is severely limited in Hamilton City, falling far short of the 10% native vegetation target recommended to prevent large-scale biodiversity loss (Cornes, Thomson, & Clarkson, 2012).

Hamilton's extensive network of branching gullies cover approximately 770 ha, or 7% of the city area (Cornes et al., 2012), and present a unique opportunity to conserve and restore native vegetation within the city. The gullies are grouped into four major systems (Kirikiriroa, Mangakotukutuku, Mangaonua and Waitawhiriwhiri), and multiple minor systems, each with an outlet to the Waikato River (Figure 2). Given that they represent the major remaining undeveloped greenspace in an otherwise highly built up environment, Hamilton gullies are a central focus for the restoration of the city's native vegetation (Clarkson & McQueen, 2004).

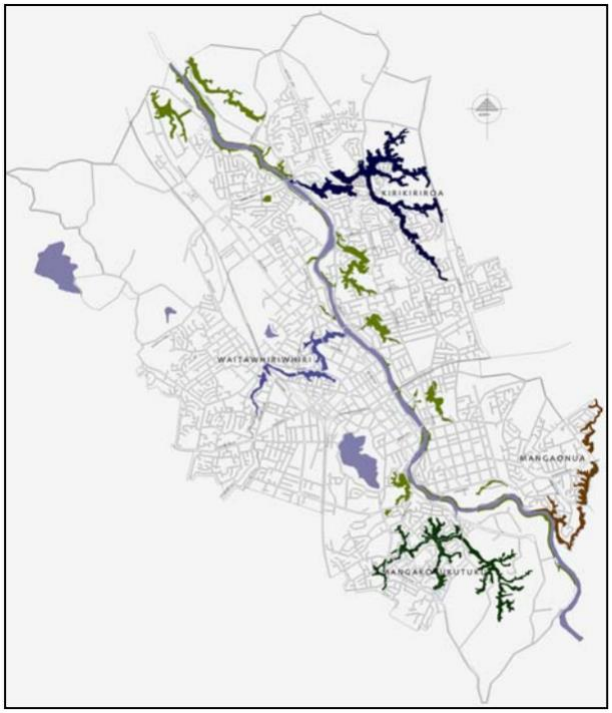

FIGURE 2. GULLY SYSTEMS OF HAMILTON CITY. IMAGE BORROWED WITH PERMISSION FROM CLARKSON AND MCQUEEN 2004.

Gully vegetation plays a vital role in increasing bank stability by protecting against erosion, thereby improving water quality (Hamilton City Council, 2007). The Waikato River corridor and associated gullies are further valued for the recreational, scenic and restorative benefits they provide to city residents (Elliot Noe, 2019; Hamilton City Council, 2004). Finally, restoring Hamilton's gully system will not only provide habitat for native New Zealand wildlife, but the branching nature of the gullies can provide continuous green corridors for the movements of both flora and fauna.

The ecological significance of Kukutaaruhe Gully

Kukutaaruhe Stream and Gully, also referred to as Bankwood Stream/Gully, runs from the corner of Bankwood and Clarkin Road, behind Fairfield College, past Waikato Diocesan School for Girls and residential housing, connecting with Donny Park in the north and out into the Waikato River. Kukutaaruhe Educational Trust leases approximately 12 ha of the gully and adjacent fields from the Ministry of Education.

Restoration of the gully will not only increase Hamilton City's native vegetation cover and the habitat this provides to native fauna but will extend the currently existing green corridor, which runs from Donny Park to the Waikato River. Extending and connecting these stream and river corridors, flanked

and buffered by native vegetation, will allow fauna to move through the city, expanding the habitat available for their use. Ideally, these green corridors should be further linked with peat lakes and lowland forest remnants to maximise the benefits of restoration to native fauna and flora.

Collaboration on a regional scale will be required to establish this interconnected network of gullies, forest remnants and peat lakes. The Kukutaaruhe restoration initiative therefore has great potential to contribute to Hamilton-wide, and even Waikato-wide, restoration efforts as a component of the Waikato Regional Council's Local Indigenous Biodiversity Strategy (LIBS). The LIBS programme seeks to promote cooperation and integration among those working to maintain native biodiversity, such as government agencies, landowners and tangata whenua, in order to manage ecological networks at district and regional levels. The LIBS programme recognizes that healthy environments are inextricably linked with human wellbeing, and therefore focuses not only on enhancing native biodiversity, but on mental and physical health benefits to people, employment, education, and providing for kaitiakitanga. This holistic approach is shared by the Kukutaaruhe Education Trust, as they seek to connect the local community to the natural environment, provide a venue for environmental education and contribute to the restoration of Hamilton's unique gully network.

The historical and cultural significance of Kukutaaruhe Gully

In the past, Hamilton's gullies provided important traditional resources to Maaori, including kai (food), such as fruiting berries of indigenous plants, fern roots, tubers, seeds, ngaa manu (birds) and ngaa ika (fish) (Landcare Research, n.d.), rongoaa (medicinal herbs), raranga (weaving) and whakairo (carving). These areas were also used for growing crops.

Kukutaaruhe Gully is Waahi Tapu, as taonga have been recovered from Donny Park and the surrounding area. In te reo Maaori, Kukutaaruhe translates as kuku (native pigeon or kereru) and taaruhe (flight path), as Ngati Wairere valued the area for snaring and hunting kereru which fed on kahikatea, miro and tawa berries. Waituhi (water-filled wooden troughs with snares) were used to snare thirsty kereru (Hamilton City Council, 2004).

The area's largest pa, Te Tuupari, was located near the land now occupied by the Waikato Diocesan School for Girls. The warlord Hanui, one of Ngati Wairere's greatest hand-to-hand combat warriors, lived at Te Tuupari in the 1700s (Hamilton City Council, 2004). The name of the pa refers to the steep riverside cliff immediately below it (Hamilton City Council, 2003). In the battle of Kukutaaruhe, the Ngati Mahuta Chiefs Te Whare and Tapaue led a failed attack on Te Tuupari Pa (Hamilton City Council, 2003). Tradition recalls a number of Paataka, or food store houses, within the enclosures of Te Tuupari Pa. A carved threshold, believed to originate from one of these carved Paataka, was found by

archaeologists in 1977 in a nearby swamp. It is now held in the Waikato Museum (Hamilton City Council, 2003).

The south-eastern section of the land that makes up the Kukutaaruhe Gully restoration initiative belongs to the Fairfield College marae, Te Aratiatia, of which Te Iho Rangi is the wharenui. The marae's original façade was carved by Professor Kereti Rautangata and rejuvenated in 2016 by Ngaruawahia-based master carver Warren McGrath.

Pepeha: Te Iho Rangi is the wharenui, Aratiatia is the marae, Ngati Wairere is the iwi which gifted the land, Kukutaaruhe is the name of the whenua.

1. Site description

2.1 Gully landforms, soils and flora

2.1.1 Historic forest composition

Steep gully sides ('hillslope', 'crest' and 'footslope' in Figure 3, wetland in Figure 4) are characterised by well-drained soils composed of loose rhyolitic sand and gravel from the Hinuera Formation. Clarkson, Clarkson, and Downs (2007, p.9) describe the vegetation that would have characterised gully sides:

> "The scarps and steep gully side slopes were covered with forest dominated by totara, matai, and kowhai. Kanuka and kamahi were also present, and mahoe occurred in more poorly drained sites. The understorey included shrubs of mapou, mingimingi, and *Rhabdothamnus solandri*, and the ground was covered in a variety of ferns such as *Blechnum chambersii*, *Doodia media*, and *Polystichum richardii*. Slopes too steep for forest had herbaceous or shrubby vegetation, including *Machaerina sinclairii*, whararikí, rangiora, koromiko, and heketara. No intact remnants of this vegetation type remain in the Hamilton Ecological District."

Soils of the gully floors ('backswamp', 'levee' and 'terrace peatland'; Figure 4 and wetland in Figure 3) are poorly drained and composed of alluvium, rhyolitic sand, silt and gravel from the Hinuera Formation with occasional organic material. Clarkson et al. (2007) describe the vegetation that would have dominated gully floors as follows:

> "The poorly drained gully floors and their associated backswamps were dominated by kahikatea, pukatea, swamp maire, cabbage tree and pokaka. Understorey and ground cover species included mapou, fuchsia, lancewood, pate, *Coprosma rotundifolia*, *Cyathea cunninghamii*, *Astelia grandis*, kiekie, and supplejack. This type is represented in a small (1 ha) remnant, Hammond Bush, located alongside the Waikato River in southern Hamilton City, and is described in detail in de Lange (1996). Kahikatea trees are absent from Hammond Bush, probably a result of the nutrient status at the site, although seedlings of this species have been found there. A larger (2.2 ha) remnant of this vegetation type is present on a private reserve near Temple View. This remnant, Koromatua Bush, is situated within two shallow gullies (de Lange 1996)."

It is important to consider topography and soil type (Figure 3) when undertaking restoration work because different landforms determine what ecosystems can form in what locations (i.e. what plants will grow where). There are four main topographic landforms in the Kukutaaruhe gully (Figure 3).

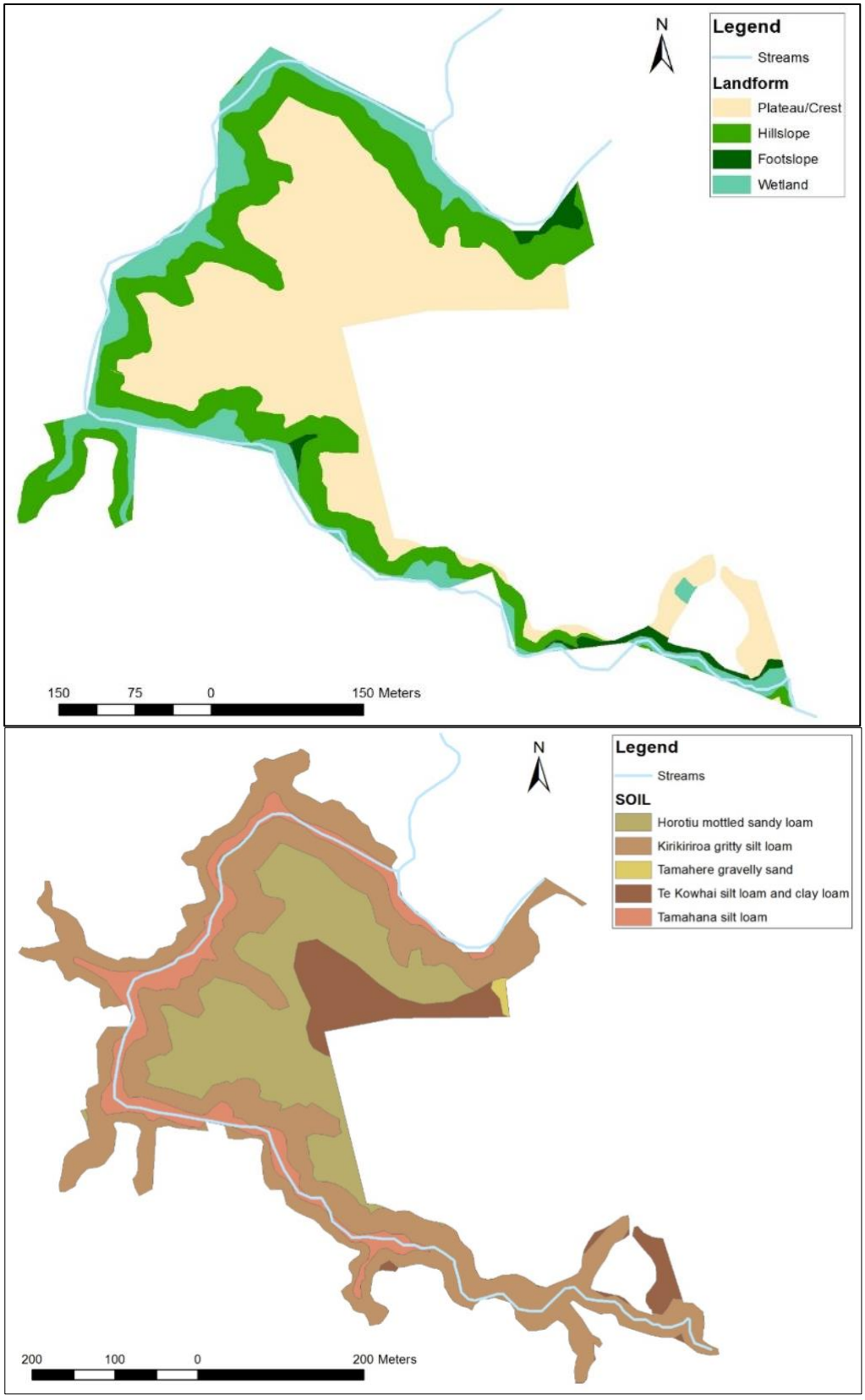

FIGURE 3. TOPOGRAPHICAL LANDFORMS (TOP) AND SOIL TYPES (BOTTOM) OF THE KUKUTAARUHE GULLY. THESE CHARACTERISTICS LARGELY DETERMINE ECOSYTEM TYPES AND THEREFORE RESTORATION ACTIONS. SOIL MAP COURTESY OF REECE HILL.

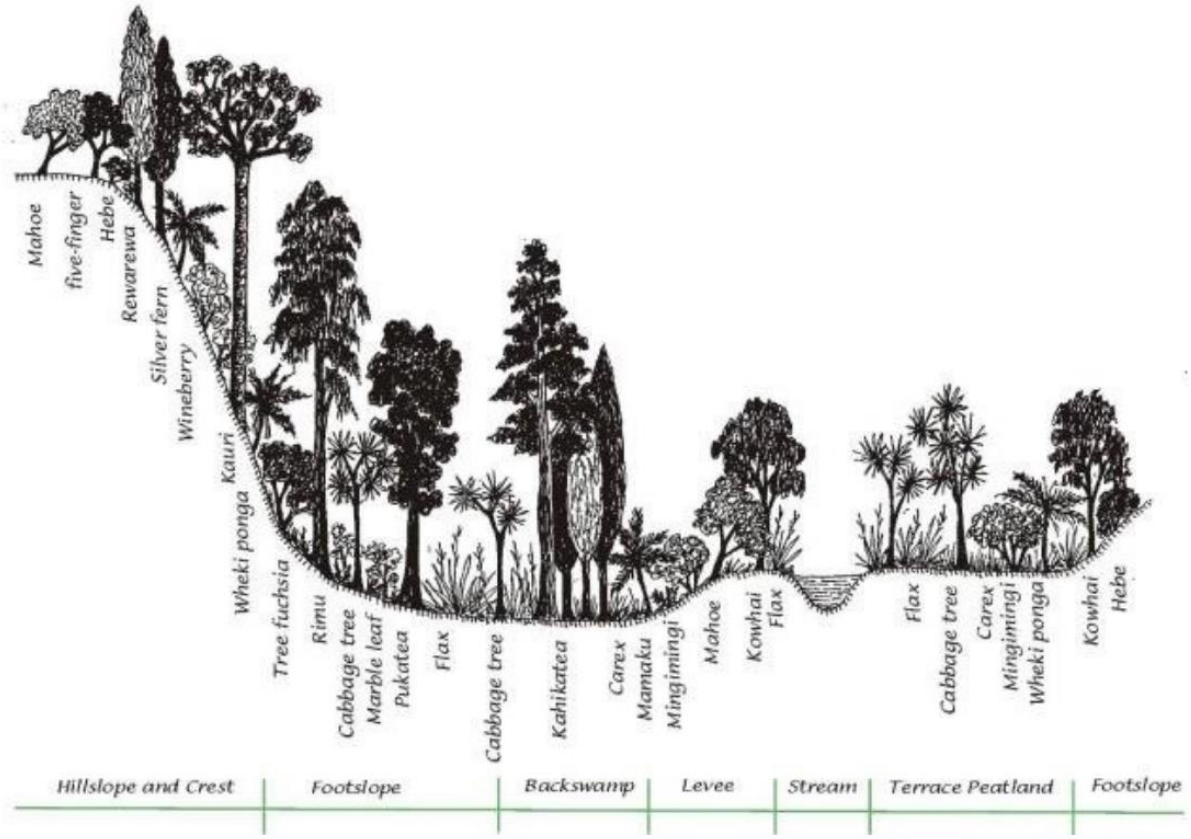

FIGURE 4. EXAMPLE OF A HAMILTON GULLY PROFILE SHOWING THE MAIN TOPOGRAPHIC UNITS AND KEY ASSOCIATED NATIVE PLANT SPECIES. FROM WALL AND CLARKSON, 2001.

2.1.2 Current vegetation survey and cover

An on-the-ground survey of the Kukutaaruhe Gully was conducted by staff of the Environmental Research Institute (University of Waikato) over several weeks in August 2019. The survey began at the southern-most end near the marae and Clarkin Road and advanced northwards to the Donny park end (Figure 3). Surveyors walked slowly each day, weaving back and forth through the gully itself where it was passable, taking notes on vegetation and any sign of fauna (e.g. bird calls or scat). The survey did not include observations from the far bank of the gully on the other side of the stream from Fairfield College. Where the gully was so thickly overgrown it was not passable on foot, surveyors observed from the top of the hillslope on the Fairfield College side and used binoculars to identify distant plants.

Kukutaaruhe Gully currently presents a substantial restoration challenge, as the steep gully slopes are dominated by invasive vines and shrubs, notably blackberry, Japanese honeysuckle, privet and gorse. Principal canopy species are primarily exotic and include willow, privet, bamboo, Taiwan cherry, oak and eucalyptus. However, pockets of native trees and shrubs persist, including kaanuka, tarata, maahoe, cabbage trees and tree ferns. The gully floor is covered in continuous carpets of *Tradescantia*, with arum lilies, onion weed and elephant ears abundant throughout (Figures 5 & 6). The gully is further

characterized by a depauperate native epiphyte and liane community, with only two species sighted during the survey. For a full list of exotic species detected during the survey see Appendix 3, and for a full list of native species found that have not been planted by the Fairfield Project see Appendix 1.

Kukutaaruhe Education Trust organized community working bees to begin revegetation of the gully in 2017, with subsequent plantings in 2018 and 2019. For a list of species planted to date, see Appendix 2.

FIGURE 5. EXAMPLES OF WEEDS COVERING LARGE AREAS OF KUKUTAARUHE GULLY. THE TOP LEFT PICTURE SHOWS A BLACKBERRY SLOPE, THE BOTTOM LEFT A JAPANESE HONEYSUCKLE GULLY AND THE RIGHT A *TRADESCANTIA* COVERED STREAM SIDE.

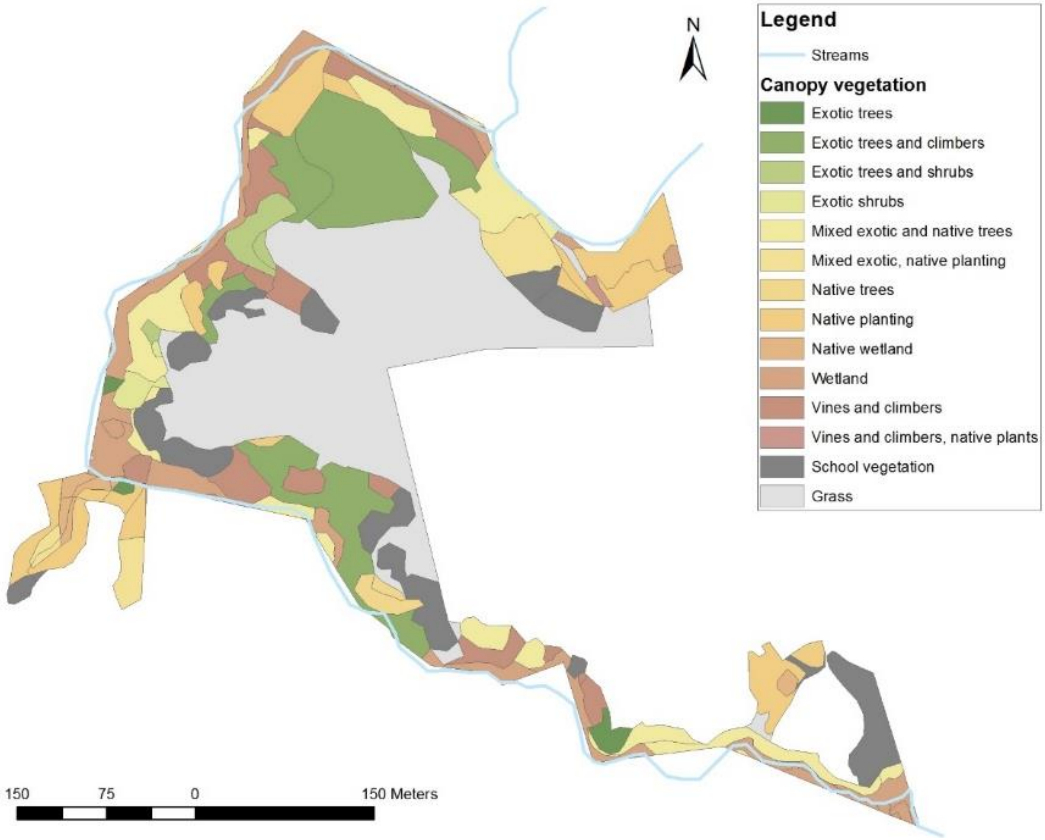

Figure 6. Characterization of 2019 Kukutaaruhe vegetation cover types.

2.2 Gully fauna

2.2.1 Birds

Over the course of the gully survey, the following native birds were seen or heard: tuuii, grey warbler, fantail, kingfisher, silvereye, welcome swallow, puukeko and spur-winged plover. These natives are relatively widespread and common on the New Zealand mainland, as they are able either to move large distances and therefore use a number of forest patches to meet their needs (e.g., tuuii), or are small omnivorous or insectivorous birds that are capable of using non-forest habitat, such as gardens and hedgerows (e.g. silvereyes, grey warblers and fantails) (Innes & Fitzgerald, 2018). These native bird species can withstand a certain level of predation pressure (Burge, Innes, Fitzgerald, & Richardson, 2017; Innes, Nugent, Prime, & Spurr, 2004).

Tuuii were seen feeding on Taiwan cherry flowers, with up to five individual birds seen in one tree. A local resident has recorded up to 12 individual tuuii in a flowering kowhai (K. Barry, personal

communication, August 29, 2019). Tuuii will travel large distances (> 20 km) over the non-breeding season in search of food and groups will congregate at sources of abundant fruit or nectar (Burge et al., 2017; Fitzgerald & Innes, 2015; Stevens, 2006). In the spring (September – January), tuuii form mating pairs which defend smaller territories around nests and their foraging range decreases to approximately 0.5 km (Bergquist, 1985; Fitzgerald & Innes, 2015; Stevens, 2006). Local residents have detected tuuii in the gully year round, indicating that the birds are breeding in or near the gully (K. Barry, personal communication, August 29, 2019). Tuuii play a very important role in native forest regeneration through pollination and fruit dispersal.

Local residents have further reported regularly hearing morepork (ruuruu) in the gully as well as sightings of kaakaa visiting the gully over a period of four to five weeks (K. Barry, personal communication, August 29, 2019) (Figure 7).

FIGURE 7. A KAAKAA PHOTOGRAPHED IN KUKUTAARUHE GULLY IN NOVEMBER 2017 WITH A TUUII IN THE BACKGROUND. PHOTO PROVIDED BY K. BARRY.

Kukutaaruhe Gully currently provides ideal habitat for puukeko, which prefer sheltered fresh water adjacent to open grassy areas (Dey & Jamieson, 2013). Puukeko will pull up and eat planted vegetables and crops and have caused significant problems in previous restoration programs (Dey & Jamieson,

2013) – we therefore recommend that the impact of puukeko on native plantings be monitored. If puukeko are significantly affecting restoration efforts, planting seedlings inside plastic tube cloches, as was done on Tiritiri Matangi and Mana Islands, is recommended.

Introduced birds detected over the course of the gully survey included blackbird, song thrush, Eastern rosella, chaffinch, goldfinch, greenfinch, house sparrow, common starling, Australian magpie, common myna and spotted dove. Thus, currently, the gully avifauna is dominated by introduced species. Urban forest restoration can increase native bird species richness and diversity, and shift bird communities from those dominated by introduced granivores and generalists to those dominated by native forest birds (Elliot Noe, 2019). Given that the primary factor limiting native birds in New Zealand cities is lack of habitat (Elliot Noe, 2019), restoration of Kukutaaruhe Gully has great potential to increase the amount of suitable habitat available to our native birds in Hamilton. However, habitat restoration should be paired with effective pest control to provide safe breeding areas for native birds (see *2.3. Current ecological threats*).

2.2.2 Fish

Kukutaaruhe Stream is a spawning site for the endemic giant kookopu (*Galaxias argenteus*) (Franklin, Smith, Baker, Bartels, & Reeve, 2015) (Figure 8). Giant kookopu are classified as 'At Risk – Declining' in the New Zealand Threat Classification System listings (Goodman et al., 2014). Therefore, their presence classifies Kukutaaruhe Gully as an area of significant indigenous biodiversity necessitating protection under Policy 11A, criterion 3 of Waikato's Regional Policy Statement (Waikato Regional Council, 2018). The majority of spawning sites in Kukutaaruhe Stream were found in *Tradescantia fluminensis* (Franklin et al., 2015). We therefore recommend consulting with experts, such as Dr Paul Franklin from NIWA, before any clearing of the non-native, invasive weed *Tradescantia* commences. There are likely ways a gradual interplanting of native plants can be done within the *Tradescantia* to transition the site once again to native habitat the fish spawning behaviour originally evolved within.

FIGURE 8. GIANT KOOKOPU SPAWNING SITES ALONG KUKUTAARUHE/BANKWOOD STREAM. MAP COURTESY OF NIWA.

While there are no other published records of which specific fish species are present in Kukutaaruhe Stream, research by Collier et al. (2009) found the following native fish in Hamilton's streams: shortfin eel (*Anguilla australis*), longfin eel (*A. dieffenbachia*), banded kookopu (*Galaxias fasciatus*), giant kookopu, inanga (*G. maculatus*), common smelt (*Retropinna retropinna*), common bully (*Gobiomorphus cotidianus*), and torrentfish (*Cheimarrichthys fosteri*). Apart from giant kookopu, three of these species are classified as 'At Risk – Declining' (Table 2). The presence of these species in Hamilton gullies emphasizes once again the high value of these areas for native species conservation.

Introduced species detected by Collier et al. (2009) included koi carp (*Cyprinus carpio*), gambusia (*Gambusia affinis*), catfish (*Amieurus nebulosus*) and indeterminate trout (see *2.3. Current ecological threats*).

TABLE 2. THE CONSERVATION STATUS OF FISH DETECTED BY COLLIER ET AL. (2009) IN AND AROUND HAMILTON CITY STREAMS.

Species name	Common name	Conservation status
Anguilla dieffenbachii	Longfin eel	At Risk – Declining
Anguilla australis	Shortfin eel	Not Threatened
Galaxias argenteus	Giant kookopu	At Risk – Declining
Galaxias fasciatus	Banded kookopu	Not Threatened
Galaxias maculatus	Inanga	At Risk – Declining
Retropinna retropinna	Common smelt	Not Threatened
Gobiomorphus cotidianus	Common bully	Not Threatened
Cheimarrichthys fosteri	Torrentfish	At Risk – Declining

Collier et al. (2009) suggest that riparian plantings may enhance the distribution and abundance of some moderately sensitive native fish species by providing shade, potential food resources, habitat, and spawning sites (as evidenced by the giant kookopu) in urban gully streams. They suggest the following actions could improve gully habitat for native fish:

1) Planting of riparian areas with tree species that provide overhanging vegetation and improved bank stability
2) Active reintroduction of wood to streams to enhance cover and habitat heterogeneity

As this is not our team's area of expertise, and given the case of the giant kookopu using *Tradescantia* for spawning sites, we recommend consulting experts before developing a weeding/planting plan that may affect native fish in Kukutaaruhe Gully.

2.2.3 Invertebrates

An Auckland tree weetaa (*Hemideina thoracica*) was detected in a mamaku tree fern during the site survey (Figure 9). Auckland tree weetaa belong to an iconic group of endemic Orthoptera and are abundant throughout most of the North Island (Wehi, Jorgensen, & Morgan, 2015). Although restoration planting can successfully provide habitat for weetaa, their populations can be limited by a lack of suitable cavities. Large trees with natural cavities should therefore be retained where possible (Wehi et al., 2015). Wehi et al. (2015) suggest that where large trees need to be removed, installing artificial cavities (i.e., 'weetaa motels') could provide suitable habitat for weetaa. The negative effect of path placement, artificial lighting and rodent abundance on weetaa populations need to be considered when designing restoration initiatives.

FIGURE 9. AUCKLAND TREE WEETAA (*HEMIDEINA THORACICA*) FOUND IN MAMAKU FERN DURING SURVEY OF KUKUTAARUHE GULLY IN AUGUST, 2019.

There is no further published data available on Kukutaaruhe Gully invertebrates. However, research on aquatic invertebrate biodiversity in three of Hamilton's large gully systems (Kirikiriroa, Waitawhiriwhiri and Mangakotukutuku) documented the presence of mayflies and caddisflies representing 8 families, 16 genera and 26 species (Smith, 2007). Smith (2007) found a caddisfly species new to science, which has been named *Oxyethira kirikiriroa* in honour of the stream where it was found (Smith, 2008). Smith (2007) concluded that riparian vegetation cover-over seepages should be maintained to provide suitable habitat for specialist species normally associated with small native forest streams and seepages.

2.2.4 Bats

Hamilton and Auckland are the only cities in New Zealand known to have resident populations of long-tailed bats (*Chalinolobus tuberculatus*) (Tonkin & Taylor Ltd, 2018). Long-tailed bats are listed as Nationally Critical, the highest conservation threat category in the New Zealand Threat Classification System. Hamilton's gullies and the Waikato River represent vital habitat for the city's long-tailed bat population, through provision of mature trees for roosting, aquatic insect prey and natural corridors for movement (Tonkin & Taylor Ltd, 2018).

While no data is available on bat presence in Kukutaaruhe Gully, bats were detected further north in Mangaiti Gully in Tonkin and Taylor's 2018 bat survey. Mangaiti Gully was identified as commuting habitat for bats with low nightly activity. Even if bats are currently not present in Kukutaaruhe Gully, we recommend following management procedures that create and protect habitat for bats to promote bat use of this area in the future.

Long-tailed bats require cavities or hollows provided by large, old and dead trees for roosting – in the past, these would have been native canopy trees such as riimu, kaahikatea, tootara or pukatea. More recently, bats have been detected roosting in pine, eucalyptus and oak trees in and around Hamilton (Waikato Regional Council, 2015). Given that it will take decades for restoration plantings to provide large, old or dead trees suitable for bats in Kukutaaruhe Gully, we recommend leaving large, old and/or dead standing exotic trees that are not classified as invasive weeds, as far as safety permits. Furthermore, Waikato Regional Council should be contacted before any large or dead trees are removed from the site.

Rats, possums, stoats and cats are known to prey on bats, and rats and possums compete with them for roosting sites. Intensive introduced mammal control is therefore vital for bat protection (see *2.3. Current ecological threats*). This should not only take the form of traps and poisons, but of awareness-raising and advocacy with neighbouring cat owners. Sheet metal strips could be installed to stop rats and possums from climbing known or potential roost trees.

2.2.5 Reptiles and amphibians

No published work is available on lizards and amphibians in Hamilton City, although research on lizards in cities is underway through the People, Cities & Nature research programme (People Cities & Nature), and certain other greenspaces in Hamilton are included as study sites. A native lizard, the copper skink (*Oligosoma aeneum*), has been sighted during restoration plantings in Kukutaaruhe Gully (Figure 10). All native lizards are fully protected. Their populations are threatened by mice, rats, mustelids, hedgehogs and cats (see *2.3. Current ecological threats*).

FIGURE 10. COPPER SKINK (*OLIGOSOMA AENEUM*) FOUND IN KUKUTAARUHE GULLY DURING RESTORATION PLANTING IN MAY, 2019. PHOTO RETRIEVED FROM THE FAIRFIELD PROJECT FACEBOOK PAGE.

Plague skinks (*Lampropholis delicata*), also known as rainbow skinks, are also present in Hamilton (*personal observation*). They are native to Australia and can reach high population densities and compete with native lizards and other native animals for food and habitat (Department of Conservation, 2015).

The only frog known to be present in Hamilton is the green and golden bell frog (*Litoria aurea*). This species was introduced from Australia, where it is critically endangered. Its impact on the New Zealand environment is unknown, though it may pose a threat to native frogs through disease transmission. It may further prey on and compete with native species, as it is known to eat invertebrates, freshwater crayfish, slugs, and other frogs and lizards.

2.3 Current ecological threats

The threats to native biodiversity in Kukutaaruhe Gully are the same as those found in all New Zealand cities. The small size and linear shape of the gully make it particularly susceptible to 'edge effects' – restoration plantings will be under constant threat from encroaching plant and animal pests and exposed climatic conditions (e.g. urban heat island and desiccation).

2.3.1 Weeds

Kukutaaruhe Gully is dominated by invasive plants that severely modify natural habitats and disrupt historic ecological processes. Key invasive plants in the gully which are listed in the National Pest Plant Accord (NPPA) include Japanese honeysuckle, grey and crack willow, woolly nightshade, tree privet, green goddess and *Tradescantia* (for a full list of all exotic vegetation seen during the site survey, see Appendix 3). Exotic weed control should focus on controlling:

- smothering weeds, such as Japanese honeysuckle, jasmine
- introduced fruiting species whose seeds are widely spread by birds, such as tree and Chinese privet, Taiwan cherry and evergreen buckthorn
- weeds that occupy forest margins and gaps more quickly than native plants, such as blackberry, gorse and woolly nightshade
- weeds tolerant of low light levels which quickly cover the forest floor, smothering native seedlings, such as *Tradescantia*, wild ginger and ivy

2.3.2 Introduced mammals

Introduced mammals negatively affect forest health through predation, herbivory and competition with native species.

Waikato Diocesan School for Girls and the Fairfield Gully Project have detected rats, mice and a single stoat using tracking tunnels, rats using kill traps, possums using wax tags and chew cards and cats, using trail cameras. A landowner whose property borders the gully reported a stoat sighting. It is highly likely that hedgehogs and rabbits will also be present in the gully and in the adjacent fields behind Fairfield College (Elliot Noe, 2019; Morgan, Waas, & Innes, 2009). In addition, during the site survey, a woman was seen walking her dog off-leash along the edge of the gully.

Selective browsing on preferred plant species by possums leads to a gradual change in forest composition. Tree fuchsia and mistletoes are highly palatable to possums. Other preferred native plant species present in Kukutaaruhe Gully include tootara, kaikawaka, tiitoki and fivefinger. Possums eat the fruit of at least 65 native plant species, as well as buds, flowers, ferns, bark and fungi. While the impact of rabbits on forest regeneration in New Zealand is unknown, they can destroy vegetation in dry

areas. Rats and mice also eat seeds and fruit of native plants. Recent research in Hamilton and New Plymouth indicates rats have a significant detrimental effect on native vegetation regeneration in urban forests (Elliot Noe, 2019). Introduced herbivores further decrease the amount of leaf litter inputs to the soil, thereby affecting decomposition and nutrient cycling.

Of the introduced mammals known to be present in Kukutaaruhe Gully, rats, possums, mustelids and cats are most likely to pose the greatest threat to native fauna. Collectively, these species eat eggs, nestlings, juveniles and adult birds, as well as invertebrates, reptiles and bats. Hedgehogs and mice eat invertebrates and lizards and may compete with native insectivorous species.

The introduced mammal community in the Hamilton gullies is complex, with all species interacting with each other through predation and competition. Introduced mammal control is recommended as highest priority because without it, other restoration actions will be negated by the impact of these pest mammals on native plants and animals. We further recommend working with local residents to raise awareness of the effect pet cats have on native animals in the gully. A decision will need to be made whether dogs will be allowed in the gully. While dog-walking is a great way to get local residents out enjoying the area, potential consequences for native wildlife need to be considered. Keeping dogs on leash and cleaning up after them should be sufficient to decrease most risk, while still providing residents the opportunity to benefit from regular use of the gully.

2.3.3 Wasps

Four wasp species found in the Waikato are considered pests – the Australian paper wasp, Asian paper wasp, the common wasp and the German wasp. Wasps prey on native insects, compete with native birds and insects for food and may sting people, which can lead to allergic reactions. Wasps can be controlled using Vespex®, a protein bait containing the insecticide fipronil. Wasps feed on the bait and transfer it back to their nest, distributing the poison throughout the colony and thereby destroying the nest. Vespex® can be used on public or private land. For more information see https://www.doc.govt.nz/nature/pests-and-threats/methods-of-control/wasp-control/ and https://merchento.com/.

2.3.4 Pest fish

Brown bullhead catfish, gambusia, koi carp and wild goldfish are four pest fish species found in the Waikato Region. Three of these (catfish, gambusia and koi carp) were detected by Collier et al. (2009) in Hamilton streams. The catfish preys on small native fish and eggs, competes for food with kooura (freshwater crayfish), and reduces water quality by disturbing stream-bottom sediments. Koi carp uproot water plants, prey on native fish and invertebrates and lower water quality. Gambusia prey on native fish and their eggs. Wild goldfish compete with native fish, water snails and aquatic plants, and may further contribute to algal blooms (Waikato Regional Council, 2014).

2.3.5 Myrtle rust

Myrtle rust is a fungal disease that affects myrtle plants such as maanuka, kaanuka and swamp maire. Myrtle rust can cause leaf deformities, heavy leaf loss, damaged fruits, canopy dieback, stunted plant growth, and eventually may lead to plant death, causing large-scale population impacts. Early symptoms of the disease include bright yellow or orange powdery patches on leaves. There have been two confirmed cases of myrtle rust in Hamilton – one at Claudelands and one on private property in Riverlea, where ramarama (*Lophomyrtus bullata*) were infected. The Department of Conservation advises taking the following steps if myrtle rust is suspected:

- Don't touch
- Don't collect samples as this might spread the disease
- If you can, take a photo of the rust and the plant it is on
- Report symptoms to the inaturalist website
- If you accidently come in contact with the affected plant or the rust, bag your clothing and wash your clothes, bags and shoes/boots when you get home

3. Conclusion and list of recommended operational plans

The Kukutaaruhe Gully requires extensive ecological restoration, which could be accomplished through creation and enactment of a series of operational plans (see below). This would likely help fully realise the gully's substantial potential to become listed as a Significant Natural Area (SNA), as defined by the draft National Policy Statement on Indigenous Biodiversity (See Appendix 1 in document at this link: www.mfe.govt.nz/publications/biodiversity/draft-national-policy-statement-indigenous-biodiversity). Currently information in section 2.2.2 of this document discusses a previously recorded presence of giant kookopu (*Galaxias argenteus*) in the gully stream, which is a species 'At Risk – Declining' (Franklin, Smith, Baker, Bartels, & Reeve, 2015). Presence of this species would sway strongly in favour of designating the gully as an SNA, however the state of vegetation is not favourable. There is high weed infestation of the areas that do have sparse mature native vegetation present, and the recently planted restoration areas are very young and patchy, so lend little to the case to make it an SNA at present. However, given time and restoration action, the presence of this fish species, and the valuable connections with the Donny Park's Raupo wetland SNA and the nearby Ranfurly Park SNA, the Kukutaaruhe Gully might also become categorised as an

SNA. For information about the Donny Park's Raupo Wetland SNA and Ranfurly Park SNA, see the document *Key Ecological Sites of Hamilton City, Volume II* (Cornes et al., 2012).

We recommend that the Kukutaaruhe Education Trust develop or contract others to create the following operational plans for comprehensive restoration:

- Restoration of avifauna
- Restoration of fish
- Restoration of invertebrates
- Restoration of bats
- Restoration of reptiles and amphibians
- Control of introduced mammals
- Restoration of native forest (this operational plan has been completed by the ERI as a companion document to the Overview of Kukutaaruhe Gully Restoration Initiative report)

Operational plans should be revised every 5-10 years. Each operational plan should include the following:

1) Baseline surveys to determine what species are currently present (i.e., before restoration commences) and their relative abundance. This will allow analysis of change in community structure and composition over time and enable restoration progress to be monitored. We recommend setting up permanent monitoring plots, transects and stations for flora and fauna. This is essentially the first step in monitoring (see point 3 below)

2) Management recommendations detail the actions needed to achieve specified objectives. Management recommendations need to consider available resources, including time, money and labour. Recommendations can be given a priority classification score from 'low' to 'very high' to help with allocation of resources.
   Management recommendations are time dependent (usually covering a period of 1-5 years) and need to be consistently monitored to see if they are producing the desired results. If not, they will need to be revised ('adaptive management').

3) Monitoring plans are essential to quantify ecosystem changes over time and assess the success of restoration actions. According to Atkinson (1994), without effective monitoring, 'mistakes will be repeated and the opportunities for repeating successes will be lost'. Monitoring methods should be chosen based on the restoration project's goals and objectives, as well as available resources. Monitoring plans will need to clarify what activity/outcome is being monitored, what questions monitoring aims to answer, timing of monitoring, location of monitoring

plots/points/transects, and how data will be stored, analysed and reported. The Auckland Community Ecological Monitoring Guide (see *5. Useful resources*) provides a valuable resource. The monitoring procedure should be recorded in detail so that monitoring can continue over the years in a repeatable manner, and results can be compared through time. Monitoring results should be used to inform management actions ('adaptive management') and may also provide evidence to funders that restoration goals are being achieved.

4) Opportunities for social engagement – given that restoration ecology in cities should always be done for and with people, it is vital to define how the local community can be involved in restoration and benefit from it.

4. Opportunities for social engagement

The Kukutaaruhe Gully restoration initiative represents an outstanding opportunity to engage the Hamilton community about gully restoration, thereby encouraging local residents to reconnect with the natural environment and New Zealand's unique biological heritage. Apart from Fairfield College and Waikato Diocesan School for Girls, which are already involved in planting and gardening through the Fairfield Project, Kukutaaruhe Gully is close to St. Paul's Collegiate School, Fairfield Intermediate School, St. Joseph's Catholic School, Woodstock School, Insoll Avenue School, Bankwood School and Fairfield Primary School. We recommend connecting with all of these schools and encouraging them to get involved in tree planting, weeding, gardening and any other initiatives run by the Kukutaaruhe Education Trust.

To grow their volunteer base, the Trust could reach out to local residents, as people who live near an area and have the opportunity to use it on a regular basis are more likely to care strongly enough about it to contribute their time and money to its enhancement. Since dog-walkers are likely to enjoy using the gully regularly and frequently, dog-walking on lead could be allowed in the area as long as it does not negatively affect native fauna. The Trust should further encourage and support neighbouring landowners to restore native vegetation and undertake introduced mammal control on their private land. The Trust could supply neighbouring landowners with suitable native plants and pest control devices, provide best practice advice on restoration and begin a conversation about cat ownership and the impact of cats on native wildlife.

Volunteers can be involved in many aspects of gully restoration – tree planting, weeding, bird counts, pest monitoring and control, lizard, bat, invertebrate or fish monitoring and educational outreach programs. The Trust could run training sessions for volunteers to improve their plant, bird, bat, insect,

lizard and fish identification and monitoring skills. Such opportunities to improve one's skills and gain experience are highly valued by students hoping for a career in conservation biology or restoration ecology. These opportunities could be advertised at the University of Waikato, Wintec and neighbourhood intermediate schools.

In addition, the Trust could offer workshops in collaboration with the marae on raranga and rongoaa.

We recommend the Trust continue use of its attractive website so the public can engage with the project and volunteers can connect, upload monitoring results or submit photos. We also recommend the Trust keep a frequently updated social media presence (we acknowledge that these steps may already be underway, e.g. excellent Facebook presence is noted). Moreover, the Trust could contribute stories on gully restoration progress to the local newspaper.

We recommend the Trust connect with other community groups working on ecological restoration within the Hamilton area. This may be facilitated through the Waikato Biodiversity Forum, which hosts regular meetings although note always catering to urban restoration groups, which face unique challenges. Meetings could be scheduled to share knowledge, expertise, advice and stories on the challenges faced. Social events could be organised that allow people to mingle and meet in a relaxed setting. This could include fieldtrips and tours of restored areas or other areas of natural significance in Hamilton and the wider Waikato region. The Trust could connect with other interested parties, such as the local chapters of Forest & Bird, the Ornithological Society of New Zealand, Predator Free Hamilton, Project Echo or the Waikato Botanical Society.

Furthermore, the Trust could liaise with University of Waikato staff and students to design research projects that would benefit both the Trust and the students. The University provides a Summer Research Scholarship that could be used to fund a summer research collaboration. Future PhD and Masters students could use the gully as a research site.

The Trust could also seek corporate sponsorship to support restoration work and has already had success with grant funding, which can greatly help this type of joint public endeavour. Future development of the site could include interpretive panels, clear accessibility through path establishment and guided walks.

5. Useful Resources

Kukutaaruhe Gully:

- The Fairfield Project Facebook page: https://www.facebook.com/thefairfieldproject/
- The Fairfield Project website: http://www.thefairfieldproject.co.nz/

Waikato based:

- A selection of Hamilton Gully Restoration Groups:
  - Riverlea Environment Society: https://www.resi.org.nz
  - Mangakotukutuku Streamcare Group: http://www.streamcare.org.nz/gully.htm
  - Mangaiti Gully Restoration Group: http://gullyrestoration.blogspot.com
- Controlling weeds in riparian margins: a guide to restoration projects and other plantings: https://www.waikatoregion.govt.nz/assets/WRC/Services/plant-and-animal-pests/weeds-and-riparian-margins.pdf
- Ecological restoration in the Waikato: https://www.doc.govt.nz/get-involved/run-a-project/restoration-advice/native-plant-restoration/local-planting-guides/ecological-restoration-in-the-waikato/
- Go Eco: Environment centre in Hamilton: https://www.goeco.org.nz
- Gully Restoration Guide: http://www.gullyguide.co.nz/files/Gully_Guide_Mar07.pdf
- Hamilton's native bats: http://www.waikatoregion.govt.nz/environment/natural-resources/biodiversity/project-echo
- Pest animal resources and advice, Waikato Regional Council: https://www.waikatoregion.govt.nz/services/regional-services/plant-and-animal-pests/animal-pests/
- Waikato Biodiversity Forum: http://www.waikatobiodiversity.org.nz

New Zealand wide:

- Auckland community ecological monitoring guide. A framework for selecting monitoring methods: http://www.knowledgeauckland.org.nz/publication/?mid=2697
- Community Urban Restoration & Education Guide: https://www.landcare.org.nz/files/file/1560/CURE%20Guide.pdf
- Ecological Restoration Plan for Maungatautari 2003-2004 working document: https://www.naturespace.org.nz/sites/default/files/u4/Maungatautiri%20restoration_plan_Nov_04_0.pdf
- Hartley, S. & Forsyth, F. 2013. "Restoration Planning - closing the loop". Presentation adapted from presentations by Colin Meurk & Murray Williams: https://www.victoria.ac.nz/sbs/research-centres-institutes/centre-biodiversity-restoration-ecology/pdfs/Restoration-Planning-Silverstream-2013-wb.pptx
- Mana Island Ecological Restoration Plan: https://www.doc.govt.nz/globalassets/documents/parks-and-recreation/places-to-visit/wellington/mana-island-restoration-plan.pdf
- NZ Landcare Trust website: https://www.landcare.org.nz/
- People, Cities & Nature - Urban Restoration Research Programme: https://www.peoplecitiesnature.co.nz/
- Peters, M., & Clarkson B., 2010. Wetland Restoration, a Handbook for New Zealand Freshwater Systems. Manaaki Whenua Press: https://www.landcareresearch.co.nz/publications/books/wetlands-handbook
- Society for Ecological Restoration, Restoration Resource Center: https://www.ser-rrc.org
- Taranaki restoration planting guides: https://www.restoretaranaki.nz/resources/

- The New Zealand Environment Guide: http://www.environmentguide.org.nz/
- The Ōkahu Catchment Ecological Restoration Plan: http://ngatiwhatuaorakei.com/uploads/attachment/30/THE-O%CC%84KAHU-CATCHMENT-ECOLOGICAL-RESTORATION-PLAN5.pdf
- Vertebrate pest control decision support system: https://pestdss.landcareresearch.co.nz/
- Weedbusters: https://www.weedbusters.org.nz

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Appendix 1. Native plants detected at Kukutaaruhe Gully in 2019 (not including those planted by the Fairfield Project)

Species	Common name
Agathis australis	kauri
Alectryon excelsus	titoki
Carex sp.	sedge sp.
Coprosma propinqua	small leaved coprosma
Coprosma robusta	karamu
Cordyline australis	cabbage tree, tī kouka
Corynocarpus laevigatus	karaka
Cyathea dealbata	silver fern
Cyathea medularis	mamaku
Dacrycarpus cupressinum	rimu
Dacrycarpus dacrydioides	kahikatea
Dianella nigra	NZ blueberry
Dicksonia squarosa	wheki
Doodia australis	rasp fern
Griselinia littoralis	broadleaf, kapuka
Hoheria sextylosa	houhere, lacebark
Knightia excelsa	rewarewa
Kunzea robusta	kanuka
Melicytus ramiflorus	maahoe
Metrosideros excelsa	pohutukawa
Microsorum pustulatum	hounds tongue
Muehlenbeckia complexa	small-leaved pohuehue
Myrsine australis	mapau
Olearia albida	tanguru
Olearia angulata	none known
Phormium tenax	flax, harakeke
Pittosporum crassifolium	karo
Pittosporum eugenioides	tarata, lemonwood
Podocarpus totara	totara
Prumnopitys ferruginea	miro
Pteridium esculentum	bracken fern
Pteris tremula	Australian bracken
Pyrrosia eleagnifolia	epiphyte (leather-leaf fern)
Rhopalostylis sapida	nikau palm
Sophora microphylla	kowhai
Veronica stricta	koromiko, hebe

Appendix 2. Native plants planted by the Fairfield Project from 2017-2019.

Species	Common name
Alectryon excelsus	titoki
Aristotelia serrata	makomako, wineberry
Beilschmiedia tawa	tawa
Carex dissita	forest sedge
Carex secta	sedge, purei, pukio
Carpodetus serratus	putaputaweta, marbleleaf
Coprosma propinqua	small leaved coprosma
Coprosma rhamnoides	small leaved coprosma
Coprosma rigida	small leaved coprosma
Coprosma robusta	karamu
Cordyline australis	ti kouka, cabbage tree
Corynocarpus laevigatus	karaka
Dacrycarpus dacrydioides	kahikatea
Dacrydium cupressinum	rimu
Dianella nigra	turutu, New Zealand blueberry, inkberry
Eleaocarpus hookerianus	pokaka
Hedycarya arborea	pigeonwood
Hoheria sexstylosa	houhere, lacebark
Knightia excelsa	rewarewa
Kunzea robusta	kanuka
Laurelia novae-zelandiae	pukatea
Leptospermum scoparium	manuka
Melicytus ramiflorus	maahoe
Myrsine australis	mapou
Pennantia corymbosa	kaikamako
Phormium cookianum	whararikі
Piper excelsum	kawakawa
Pittosporum tenuifolium	kohuhu
Plagianthus regius	manatu, ribbonwood
Podocarpus totara	totara
Prumnopitys taxifoilia	matai
Pseudopanax arboreus	five finger, whauwhaupaku
Rhopalostylis sapida	nikau palm
Schefflera digitata	pate
Sophora microphylla	kowhai
Streblus heterophylla	milkwood
Veronica stricta	koromiko, hebe

Appendix 3. Introduced plants detected in Kukutaaruhe Gully in 2019 and whether they are listed in the National Pest Plant Accord (NPPA).

Species	Common name	Listed in the NPPA
Betula sp.	birch	
Abutilon hybridum	Chinese lantern	
Acacia melanoxylon	Tasmanian blackwood	
Acanthus mollis	bear's breeches	
Acca sellowiana	feijoa	
Acer pseudoplatanus	sycamore	
Agapanthus praecox	agapanthus	
Allium triquetum	onion weed	
Alocasia brisbanensis	elephants ears	
Alstroemeria sp.	Peruvian lily	
Arctium minus	burdock	
Arum italicum	Italian arum	
Asparagus asparagoides	bridal creeper, smilax	
Buddleja davidii	butterfly bush	
Cassia leptophylla	gold medallion tree	
Cestrum fasciculatum	red cestrum	
Citrus japonica	kumquat	
Crocosmia x crocosmiiflora	Montbretia	
Cryptomeria japonica	Japanese cedar	
Eucalyptus laevopinea	silvertop stringybark	
Euonymus japonicus	Japanese spindle tree	yes
Euphorbia lathyrus	caper spurge	
Fatsia japonica	fatsia	
Fumaria muralis	scrambling fumitory	
Ginko biloba	ginko	
Gunnera tinctoria	giant rhubarb	yes
Hedera helix	ivy	
Hedychium gardnerianum	wild ginger/Kahili ginger	yes
Hydrangea macrophylla	hydrangea	
Ilex aquifolium	holly	
Iris foetidissima	stinking iris	
Jasminum polyanthum	jasmine	
Lamium galeobdolon	aluminium plant	yes
Ligustrum lucidum	tree privet	yes
Ligustrum sinense	Chinese privet	
Liquidambar styraciflua	American sweetgum	
Liriodendron tulipifera	tulip tree	
Lonicera japonica	Japanese honeysuckle	yes
Magnolia grandiflora	laurel magnolia	
Nephrolepis cordifolia	tuber ladder fern	yes
Phoenix canariensis	phoenix palm	
Phytolacca octandra	inkweed	
Populus nigra	lombardy poplar	
Prunus campanulata	Taiwan cherry	

Prunus avium	wild cherry	
Pseudosasa japonica	bamboo/arrow bamboo	
Quercus sp.	oak	
Rhamnus alaternus	evergreen buckthorn	yes
Rosa sp.	rose	
Rubus fruticosus	blackberry	
Rumex sagittatus	climbing dock	
Salix cinerea	grey willow	yes
Salix fragilis	crack willow	yes
Setaria palmifolia	palm grass	
Solanum mauritianum	woolly nightshade	yes
Solanum nigrum	black nightshade	
Tradescantia fluminensis	Tradescantia/wandering Jew	yes
Ulex europaeus	gorse	
Vinca major	periwinkle	
Yucca sp.	yucca	
Zantedeschia aethiopica	green goddess/arum lily	yes