ECOLOGICAL SURVEY AND ASSESSMENT OF WAIMANU FOREST, GISBORNE

ARATU FORESTS LIMITED

For Aratu Forests Limited

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REPORT INFORMATION AND QUALITY CONTROL

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1 INTRODUCTION

Aratu Forests Limited (Aratu) manages Waimanu Forest (2,075.5 ha), which is located in hill country approximately 8 km northeast of Gisborne (Figure 1). Aratu is wanting to establish Waimanu Forest as an example of enhanced biodiversity within plantation forestry and have goals for the forest to be an iconic project which will encapsulate biodiversity, community, iwi narratives, settler families and sustainable forest harvest by 2028. To set project goals and visions, an ecological survey is required to assess the quality and values of the indigenous habitats present in Waimanu Forest.

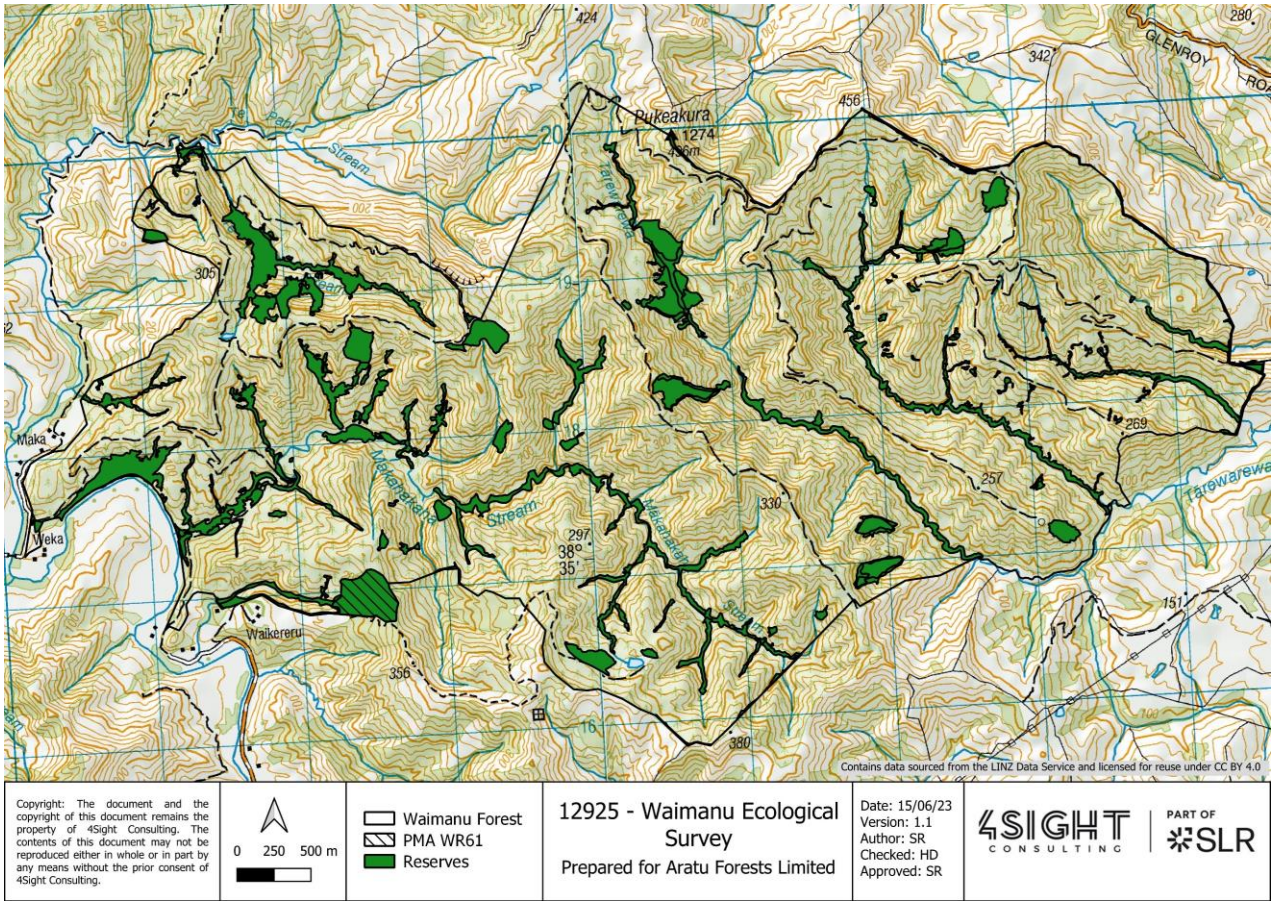

Figure 1. Waimanu Forest reserves, including the part of Gisborne District Council Protection Management Area (PMA) WR61 that lies within the forest.

2 METHODS

2.1 Desktop assessment

A desktop assessment of the site and surrounding areas was undertaken prior to the onsite assessments, including searches of relevant council State of the Environment data, online databases such as the New Zealand Freshwater Fish database (NZFFD), and previous ecological reports.

2.2 Ecological surveys

The ecological survey for Waimanu forest was intended to be undertaken over the summer of 2022/2023 with multiple ecological surveys intended including, avifauna surveys, lizard surveys, freshwater surveys and vegetation surveys. The summer period was incredibly wet, with multiple storm events, including Cyclone Hale (January 2023), and Cyclone Gabrielle (February 2023). The summer of 2022/23 had double the rainfall compared to the previous four

summers, with 1011mm of rain fall during the December to March period (Table 1). This wet summer had implications on the ability to undertake the intended field work, and the weather events caused severe damage in both the surrounding river catchments of, and within Waimanu Forest. The surveys that could be undertaken included the vegetation surveys and some freshwater surveys, however lizard surveys, freshwater surveys in the north-eastern side of the forest and avifauna surveys have been deferred to when the weather is more suitable which is likely spring/summer 2023.

Table 1. Rainfall data for the summer period (December-March) for the previous five years, from the GDC Waimatā at Goodwins road rain gauge[1]

Summer Period (December – March)	Rainfall (mm)
2018-2019	324.6
2019-2020	299.6
2020-2021	263.0
2021-2022	698.6
2022-2023	1011.2

2.3 Vegetation and habitat survey and assessment

Potential sites for surveys were identified based on information provided by Aratu and by checking aerial imagery. A site visit was undertaken during the week of 16-20 January 2023. Where possible, each area of indigenous vegetation was walked through, otherwise it was viewed from as close as possible using binoculars. Vegetation and habitat types, including wetlands, were identified, described, and mapped for each site. All vascular plant species observed were recorded. Threatened plant species likely to occur at or near the site were actively searched for in appropriate habitats and, if found, their locations recorded and mapped. The distributions and densities of pest plants were recorded. Vegetation condition was assessed, and management options were identified.

Following cyclone Hale the week before the site visit, many of the access roads within the forest had slips and fallen trees which blocked access by vehicles. In addition, several fords were impassable due to wash outs and logs. Rain later in the week also made these fords too dangerous to cross on foot. Consequently, several sites were not visited. These sites were therefore assessed using existing information including ecological reports and aerial imagery.

2.4 Freshwater survey

Freshwater surveys were conducted at three locations in the forest, access and weather prevented additional sites being accessed in the northeastern extent of the forest. Due to Cyclone Gabriele, monitoring was conducted at sites where safe access was available, as the damage to roads and reduced access to the forest was still an issue during the time of the surveys.

The three sampling sites selected were in areas where there was indigenous vegetation present (Site 1), where a large stream exited the forest area (Site 2) and in a tributary within the forest area that has a mixture of exotic and indigenous vegetation, with the stream having an indigenous riparian area of approximately ten meters on either side (Site 3) (Figure 3 Figure 5). GDC monitor a State of the Environment (SOE) site in Waimanu forest that is sampled annually as part of their biomonitoring programme, that includes macroinvertebrates sampling. The data from this site was also used in this report, and data was provided by GDC for the period of 2016-2020. Data has not been collected at the site since 2020 for unknown reasons.

Surveys were undertaken on 3 April 2023 in fine weather with fine weather in the preceding ten days prior to sampling. Site locations are displayed in **Error! Reference source not found.** and Table 2.

[1] Rainfall data | Gisborne District Council (gdc.govt.nz)

Table 2. Freshwater survey locations within Waimanu Forest in the Waimatā catchment, 2023.

Site number	Site name	Coordinates (NZTM)	Description
1	Te Pahi Stream	E2041512 N5720077	A stream that has a combination of exotic and indigenous land use with some farmland in the bottom reaches
2	Makahakaha Stream	E2041387 N5717461	The Makahakaha Stream as it exits Waimanu Forest. The upstream area includes exotic forest located within Waimanu Forest
3	Makahakaha Stream tributary	E2042334 N5718108	A tributary of the Makahakaha Stream, with both exotic and indigenous vegetation in the catchment. This stream has indigenous riparian margins.
4	GDC Makahakaha Stream monitoring site	E2041908 N5717728	Annual biomonitoring site of GDC located on the Makahakaha Stream.

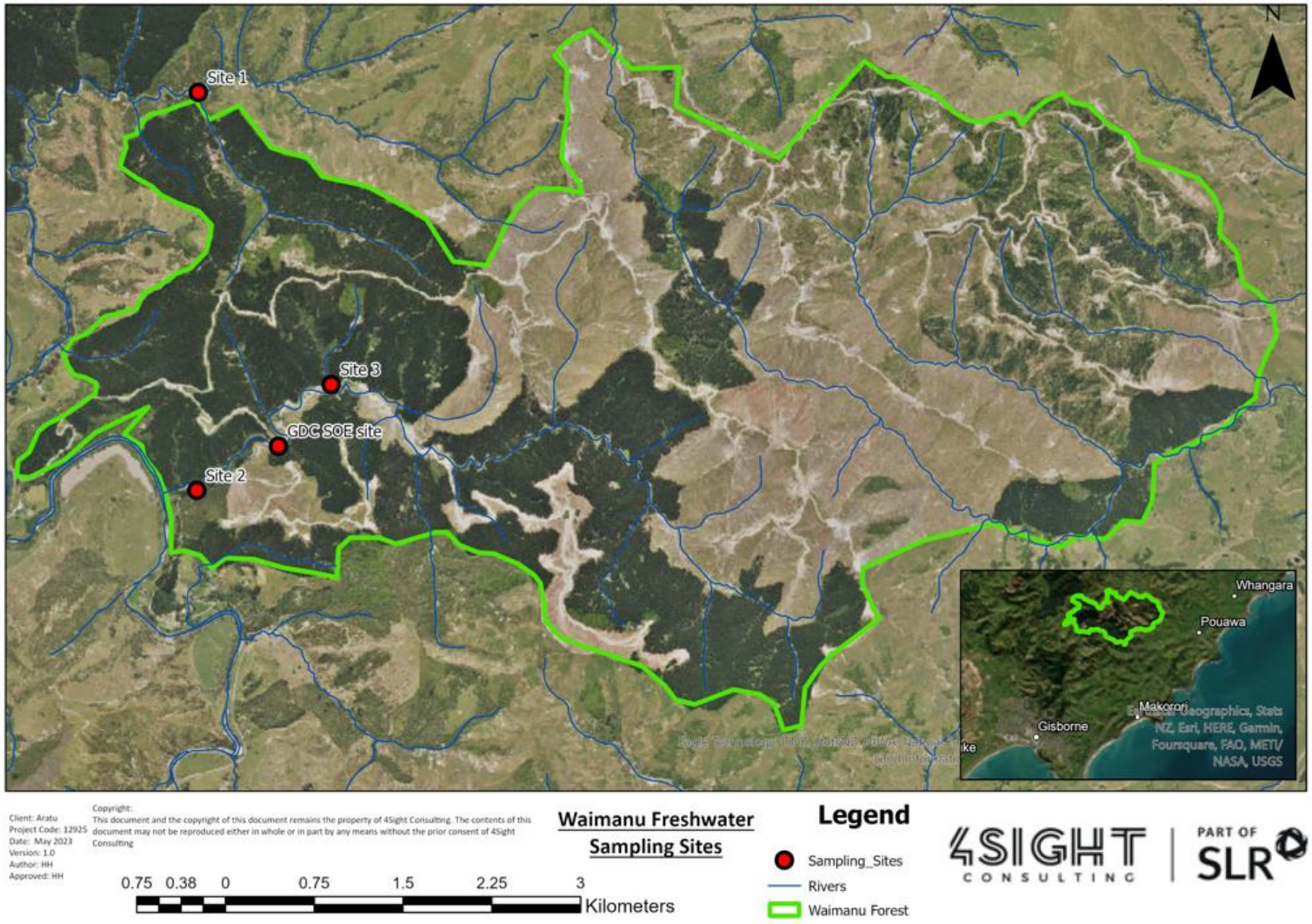

Figure 2. Locations of freshwater sampling sites within Waimanu Forest, Gisborne.

Figure 3. Site 1 looking downstream at the sampled reach in Te Pahi Stream. 3 April 2023.

Figure 4. Site 2 - the Makahakaha Stream near the south-western boundary of Waimanu Forest, 3 April 2023

Figure 5. Site 3 - the Makahakaha Stream tributary within Waimanu Forest, 3 April 2023.

2.4.1 Macroinvertebrate survey

Macroinvertebrate communities can be indicators of instream habitat and water quality as different taxa show varying degrees of sensitivity to water pollution and other impacts (Stark *et al*. 2001). Monitoring of macroinvertebrate communities was undertaken at each sampling site.

Macroinvertebrates were collected following the State of Environment (SOE) protocol in the National Monitoring Standard for Macroinvertebrates (Milne *et al.* 2022). A single composite kicknet sample was collected at each site on 3 April 2023, comprising between four and eight unit efforts from the different mesohabitats (including woody debris, cobbles, boulders, macrophytes) in proportion to their abundance across the monitoring reach. Each unit effort was approximately 0.1–0.15 m^2 in area and the total sampling was 0.6–0.9 m^2. Sampling was undertaken across a 100 m reach.

The macroinvertebrate samples were preserved in 70% - 80% isopropyl alcohol (IPA), returned to the laboratory and sorted (using protocol 'P3: Full Count with Subsampling Option'). Macroinvertebrates were identified to the lowest practicable level and counted to enable biotic indices to be calculated.

A range of biotic indices were calculated, namely the number of taxa (taxa richness); the percentage of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) recorded in a sample (%EPT); and the Macroinvertebrate Community Index (MCI). EPT are three orders of insects that are generally sensitive to organic or nutrient enrichment but excludes *Oxyethira* and *Paroxyethira* as these taxa are not sensitive and can proliferate in degraded habitats. The MCI is based on the average sensitivity score for individual taxa recorded within a sample (Table 3).

The GDC samples were collected using the Macroinvertebrate C1 protocol (Stark *et al*. 2001) slightly modified in hard bottomed streams. Invertebrates were sampled from all habitats within the stream over a 100 m reach using a kick net and dislodging the streambed material upstream of the net and collecting all dislodged material in the net. This differs from the C1 protocol as all habitats were sampled not just riffles. Samples are collected in 0.5 mm mesh net (305 mm 204 mm net opening), sieved and preserved with 70% IPA in the field. Only one pooled sample at each site is collected, which is about 1m^2 of habitat sampled. Proportions of each habitat type sampled for macroinvertebrates were recorded e.g wood, stones, edges etc. Samples were processed using protocol P2 (Stark *et al*. 2001) by Stark

Environmental Ltd, using the fixed 200 count and scan for rare taxa method (Duggan *et al*. 2002). The number of different types of mayflies, Stoneflies and Caddisflies (EPT) are given as a percentage of abundance (%EPT). A macroinvertebrate community index (MCI or sbMCI) was calculated for each site. EPT refers to the sensitive groups Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). A quality assurance protocol involved 10% of samples being randomly selected and sent for processing by another taxonomist every three years.

Table 3. Summary of macroinvertebrate metric descriptions.

Quality	Descriptors	MCI	QMCI
Excellent	Clean water	> 120	> 6
Good	Doubtful quality/possible mild pollution	100 – 120	5 – 6
Fair	Probable moderate pollution	81- 99	4 – 5
Poor	Probable severe pollution	< 80	< 4

2.4.2 Rapid Habitat Assessment

The RHA is a standardised method used by regional councils throughout New Zealand, including the GDC for State of the Environment (SOE) monitoring. The RHA method involves the visual evaluation of 10 habitat parameters at a site and assigns each a score between 1 and 10. The individual scores are then summed to produce an overall RHA score (Clapcott 2015). The 10 habitat parameters are:

1. Deposited sediment: The area of stream bed covered by sediment.
2. Invertebrate habitat diversity: The number of different habitat types (e.g. boulders, wood, leaves) suitable for different aquatic macroinvertebrates.
3. Invertebrate habitat abundance: The area of habitat that is suitable for sensitive aquatic macroinvertebrates.
4. Fish cover diversity: The number of different habitat types suitable for fish (e.g. woody debris, undercut banks, and root mats).
5. Fish cover abundance: The area of suitable habitat available for fish.
6. Hydraulic heterogeneity: The range of different hydraulic features present, such as pools, riffles and backwaters.
7. Bank erosion: The extent of stream bank erosion.
8. Bank vegetation: The maturity, diversity and naturalness of riparian vegetation.
9. Riparian width: The width of the riparian buffer zone.
10. Riparian Shade: How much of the stream is shaded from the sun.

Each parameter was assessed with a score from 1 to 10 (with 10 being the best possible score). Scores were summed yielding a score out of 100 for each site. The RHA will determine the habitat types and values of the stream reaches (Clapcott *et al*. 2019).

Habitat assessment scores and condition categories are shown in Table 4.

Table 4. Rapid Habitat Assessment scores and the condition categories for habitat condition.

Habitat condition	RHA score
Poor	0-25
Fair	26-50
Good	51-75
Excellent	76-100

2.4.3 Deposited sediment

Deposited sediment was assessed at three sites using the SAM-2 sampling methods (Clapcott *et al*. 2011) on 3 April 2023. A visual estimate of the proportion of habitat covered by fine deposited sediment (<2mm) was conducted at 20 locations within the sampling reach over five transects. The average deposited sediment cover was then calculated from the 20 observations giving a total percentage of deposited sediment cover.

2.4.4 Freshwater Fish

Environmental DNA (eDNA) sampling was conducted at two sites (Site 1 and Site 2). Six replicate samples were taken at each site. For each sample one litre of water was filtered through a syringe, the filter was then preserved and analysed by Wilderlab. eDNA comprises genetic material that is shed by organisms through the loss of skin, hair, scales, fluids and faeces. It can be isolated by filtering water, processed using PCR, and used to monitor the distribution of species through time and space using sensitive molecular tests.

3 ECOLOGICAL CONTEXT

3.1 Waiapu Ecological District

The following description is adapted from McEwen (1987):

Waiapu Ecological District is characterised by coastal lowlands and hills east of Raukaumara Range, which are mostly below 600m a.s.l., with some higher hills towards the range. The coastline consists of alternating bays where small rivers and streams reach the coast, and rugged promontories, often ringed with cliffs.

The geology of the ecological district is mostly late Cenozoic (Miocene-Pliocene) mudstone-sandstone hill country with unstable Eocene, Paleaocene, and late Cretaceous indurated siltstone and bentonitic mudstone in the upper Waipaoa catchment. There is a small area of alluvial plains, marine and fluvial deposits in the Tolaga Bay area, and Cretaceous sedimentary rocks in the Waitahaia catchment, north-westward to the crest of the Raukumara Range.

The climate is characterised by very warm summers, with day temperatures occasionally exceeding 32°C with dry foehn northwest winds. Winter temperatures are moderate. It is very sunny. Annual rainfall varies from 1,200mm in the drier south to about 2,400mm in the west on the flanks of the Raukumara Range. Droughts may occur in spring and summer.

Hill and steepland soils are formed from Tertiary and Cretaceous sandstones, siltstones, bentonitic mudstones and argillites, with moderate to severe soil erosion including extensive gullying and slipping, and deep-seating slumping. Volcanic ash soils occur on easier slopes; alluvial soils are present on river flats; small areas of sand soils on coastal dunes.

Prior to human occupation, the vegetation on hill country would have been covered in forest, probably mainly podocarp-hardwood, with some red beech (*Fuscospora fusca*) and silver beech (*Lophozonia menziesii*) on the highest land in the west, and local black beech (*Fuscospora solandri*) on lower, mostly broken terrain. There is evidence of formerly extensive kahikatea (*Dacrycarpus dacrydioides*)-dominated podocarp forest on alluvial flats. Semi-coastal and coastal forest would have been present on lower country.

Today, much of Waiapu Ecological District is farmed (semi-extensive sheep and cattle), with increasing areas of exotic forest on severely eroded, formerly farmed slopes. Areas of mānuka (*Leptospermum scoparium*) shrubland are present on coastal hills, with only smaller areas of indigenous forest remaining.

The estimated landcover within Waiapu Ecological District is 36.1% 'High Producing Exotic Grassland', 30% 'Exotic Forest', 12.8% 'Manuka and/or Kanuka', 5% 'Broadleaved Indigenous Hardwoods', 4.4% 'Low Producing Grassland', and 2.3% 'Indigenous Forest' (Land Cover Database v5.0, Landcare Research 2020).

3.2 Nearby protected areas

There are no protected areas within Waimanu Forest or on its boundaries. The closest protected areas, including Donners Bush Recreation Reserve and a cluster of QEII covenants, are located more than 1.3 km to the southwest of the forest. Two of these covenants, 5-04-185 (Waikereru hills) and 5-04-098 (Long Bush Reserve), form Waikereru Ecosanctuary (https://www.waikereru.org/, Ecoworks 2009).

3.3 Recommended Areas for Protection (RAP)

Waikereru Bush (19 ha) was identified as a Priority 1 Recommended Area for Protection (RAP 61) in the Protected Natural Areas Programme (PNAP) report for Waiapu Ecological District (Leathwick *et al*. 1995). About half of the RAP lies within the south-western boundary of the forest (Figure 1).

The RAP comprises two areas of primary tawa (*Beilschmiedia tawa*)-kohekohe (*Didymocheton spectabilis*) forest separated by tall secondary kānuka (*Kunzea robusta*) forest on upper mudstone hillslopes. Associated tall canopy species are kahikatea, matai (*Prumnopitys taxifolia*), pukatea (*Laurelia novae-zelandiae*), and rewarewa (*Knightia excelsa*), with shorter canopy and subcanopy species including māhoe (*Melicytus ramiflorus*), ngaio (*Myoporum laetum*), and kōwhai (*Sophora tetraptera*) (Leathwick *et al*. 1995, Smale *et al*. 2013). In 1995, the site was grazed and the boundary fence was in poor condition. In 2012, feral goats (*Capra hircus*) were adversely affecting lower vegetation tiers and there was light canopy browse by possums (*Trichosurus vulpecula*) (Smale *et al*. 2013, Gisborne District Council 2018).

3.4 Protection Management Areas (PMA)

One Gisborne District Council Protection Management Area (PMA), Waikereru Bush (12.8 hectares), overlaps the southern boundary of Waimanu Forest (Figure 1, Table 5). This site was assessed by Don McLean of the Department of Conservation, Gisborne, as part of the Protected Management Areas Survey Programme in 2017/2018 (Gisborne District Council 2018). PMAs are areas which provide a representative example of the district's original natural ecosystems. This PMA corresponds to the RAP identified in Section 3.3 above.

Table 5: G7A Schedule: Protection Management Area Overlay entry for Waikereru Bush in the Tairāwhiti Resource Management Plan (Gisborne District Council 2006).

PMA Number	Name	Description	NZMS reference	Planning Map Sheet
WR61	Waikereru Bush	This 12.8 ha area contains two pieces of primary hillslope tawa-kohekohe forest separated by a piece of tall secondary kanuka forest.	Y18	523784 R92

3.5 Threatened Environments Classification

The Threatened Environment Classification is a combination of three national databases: Land Environments New Zealand (LENZ), Land Cover Database (LCDB), and the protected areas network (reflecting areas legally protected for the purpose of natural heritage protection). The classification combines this information into a simple and practical GIS tool. 'Threatened environments' (categories 1 to 5) are those in which >70% of indigenous vegetation cover has been cleared and/or <20% of what remains is legally protected (Walker *et al*. 2015).

Small areas of Category 1 land environments (<10% indigenous cover left) are present in the lower reaches of the Makahakaha Stream (Figure 6). Most of Waimanu Forest is covered by Category 2 land environments (10-20%

indigenous cover left). Category 3 land environments are also present, predominantly in the northern parts of the forest (Figure 6).

National Priority 1 in the National Priorities for Protecting Rare and Threatened Native Biodiversity on Private Land (MfE 2007) is to "To protect indigenous vegetation associated with land environments, (defined by Land Environments of New Zealand at Level IV), that have 20 percent or less remaining in indigenous cover", that is Category 1 and 2 threatened environments.

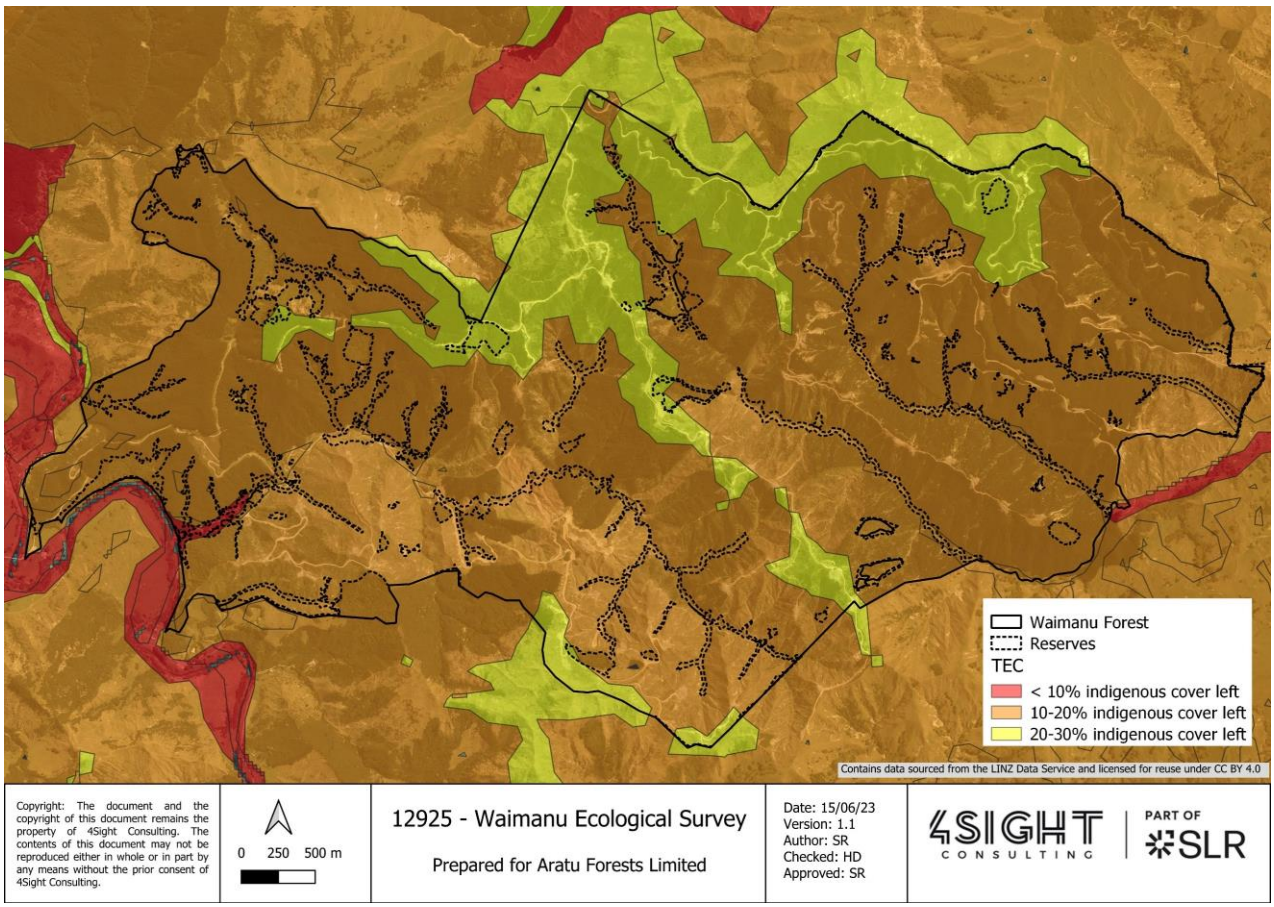

Figure 6: Threatened Environment Classification for Waimanu Forest.

3.6 Nearby ecological restoration projects

The Waimatā River Restoration Project has relevance to the project area, as the river forms the western boundary of Waimanu Forest. Key areas of discussion are riverbank erosion, sedimentation, the type and extent of riparian vegetation, and the impacts of production forestry and pest plants and animals (Waikereru (undated)). The Waimatā catchment group was established in 2020 and the group has undertaken restoration efforts including wetland restoration, planting thousands of indigenous plants, and fencing riparian areas.

Waikereru Ecosanctuary is located *c.*1.4 km to the south of Waimanu Forest on either side if the Waimatā River. Identified management opportunities to improve ecological values include pest plant and animal control, planting, and monitoring (Ecoworks 2009).

3.7 Local context

The vegetation to the west, south and northeast of Waimanu Forest is dominated by pasture, with scattered areas of indigenous forest. There are large areas of plantation forest to the north and south. The Waimatā River forms the forest's western boundary. Other waterways present in the forest include Makahakaha Stream, Tārewarewa Stream, and Te Patu Stream.

Waimanu Forest is located about 6 km from the coast and elevation ranges from *c*.40 m a.s.l next to the Waimatā River to 496 m a.s.l at Pukeakura on the forest's northern boundary. The forest falls within the semi-coastal/lowland bioclimatic zones (Leathwick *et al*. 1995).

The bedrock mostly comprises Middle Miocene sandstone and mudstone (Tolaga Group) with Early Pliocene sandstone and siltstone (Mangaheia Group) in the west and southwest (Heron 2014).

Soils are predominantly Orthic Recent (RO), with smaller areas of Orthic Brown (BO) soils (FSL New Zealand Soil Classification GIS layer, Landcare Research 2018). Orthic recent soils occur mainly in sites that have been eroded. Orthic brown soils are commonly on slopes or young land surfaces.

3.8 Potential vegetation

In an assessment of the potential vegetation pattern of New Zealand (Leathwick *et al*. 2001), the pre-human vegetation of Waimanu Forest is predominantly mapped as Rimu/tawa-kamahi forest, with smaller areas of Kahikatea-pukatea-tawa forest mostly near the Waimatā River.

A classification of New Zealand's terrestrial ecosystems (Singers and Rogers 2014) maps the pre-human vegetation of Waimanu Forest as predominantly WF13-2 Tawa, kohekohe, titoki, podocarp forest on moderate to steep hill slopes, with smaller areas of WF8 Kahikatea, pukatea forest on poorly drained soils near the Waimatā River (Table 6, Figure 7).

Table 6: Potential ecosystem types for Waimanu Forest (Singers and Rogers 2014).

Ecosystem Unit	Description	Distribution
WF8: Kahikatea, pukatea forest	Podocarp, broadleaved forest of abundant kahikatea, with occasional to abundant pukatea, kiekie and supplejack, and locally rimu, tawa and swamp maire, particularly on organic and gley soils with a high water table.	Predominantly west of the Main Divide on poor-draining alluvial, organic and gley soils in warm to mild, humid to sub-humid areas of the North Island, from Northland to Wellington (e.g. western Egmont National Park). Also occurs in localised areas in Nelson and Blenheim. East of the Main Divide it occurs in semi-arid regions, restricted small areas in permanent wet depressions and lake margins.
WF13-2: Tawa, kohekohe, titoki, podocarp forest	The canopy is dominated by tawa, kohekohe, and titoki, with occasional podocarp species such as kahikatea and matai.	

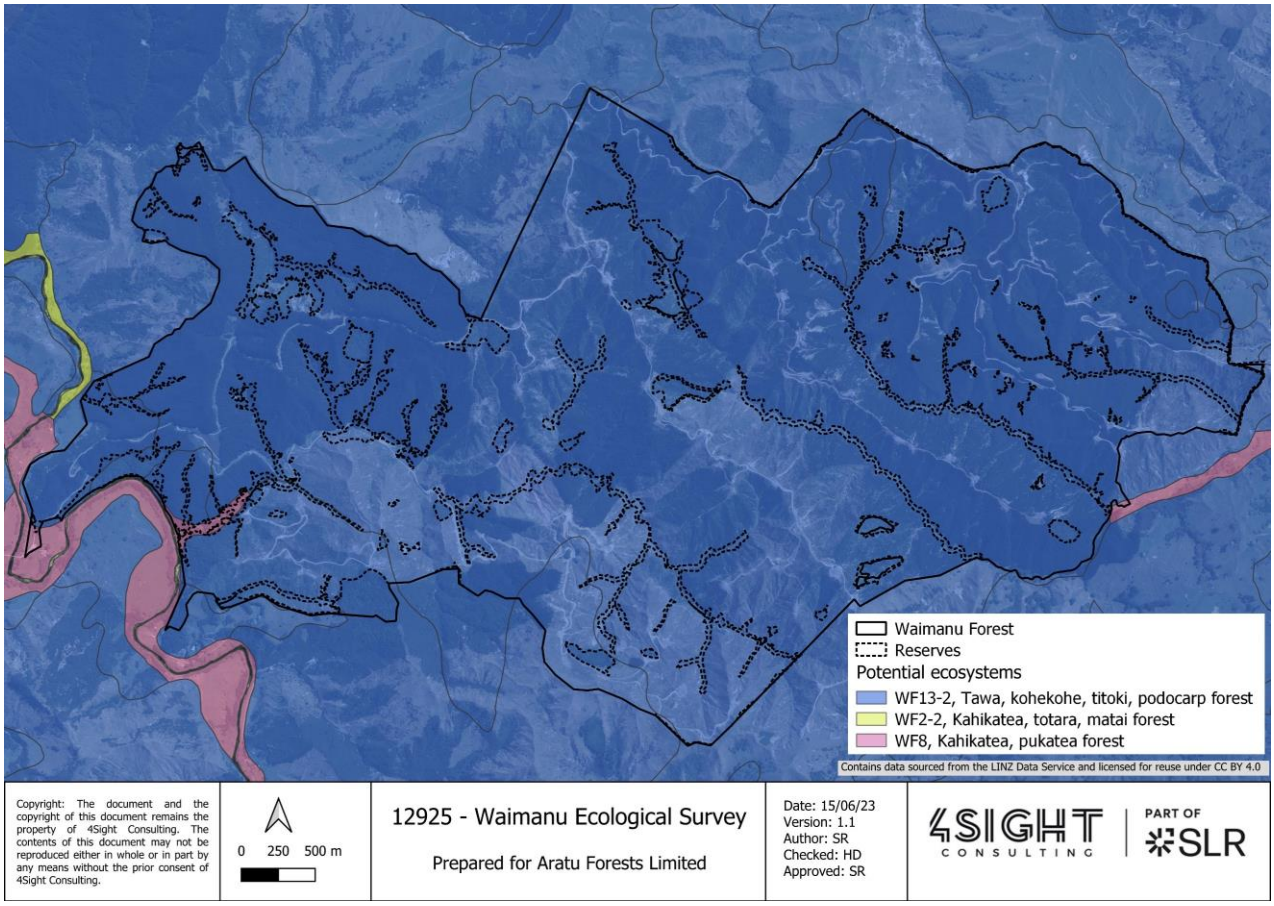

Figure 7: Potential ecosystem types for Waimanu Forest (Singers and Rogers 2014).

4 VEGETATION AND HABITATS

4.1 Overview

Four broad indigenous vegetation types were identified and mapped during the site visit:

- Rewarewa/kohekohe-tawa forest (43.7 hectares)
- Podocarp/tawa forest (9.2 ha)
- Broadleaved species forest and scrub (16.8 ha)
- Kānuka forest and scrub (39.5 ha)

Exotic scrub and grassland were also identified in several reserves alongside waterways.

4.2 Podocarp/tawa forest

This vegetation type is present alongside the Waimatā River in the westernmost part of Waimanu Forest. A few tōtara (*Podocarpus totara*), rewarewa, mataī, and kahikatea trees are emergent above a tawa canopy (Figure 8). The understorey is open but contains kawakawa (*Piper excelsum*) and *Coprosma rhamnoides*, and less common māhoe, supplejack (*Ripogonum scandens*), whekī (*Dicksonia squarrosa*), and rōhutu (*Lophomyrtus obcordata*). Litter, hooked sedge (*Carex uncinata*), climbing hard fern/pānako (*Icarus filiformis*), and lance fern (*Austroblechnum lanceolatum*) are common at ground level.

Nearest the river, there are open areas with hedge woundwort (*Stachys sylvatica*), Mexican daisy (*Erigeron karvinskianus*), creeping buttercup (*Ranunculus repens*), hooked sedge, white clover (*Trifolium repens*), gully fern (*Pakau pennigera*), and *Hydrocotyle moschata*, extensive areas covered in tradescantia (*Tradescantia fluminensis*) and selaginella (*Selaginella kraussiana*), and at least one patch of periwinkle (*Vinca major*).

Figure 8. Tōtara and mataī in tawa forest (left) and open areas near the river dominated by weedy species (right).

4.3 Rewarewa/kohekohe-tawa forest

Rewarewa/kohekohe-tawa forest was the most widespread vegetation type observed in natural areas within Waimanu Forest, including in reserves and a land bank. Scattered rewarewa is emergent over a canopy of kohekohe and tawa. The understorey was open but contained kawakawa, māhoe, *Coprosma rhamnoides*, nikau (*Rhopalostylis sapida*), and scattered seedlings of titoki (*Alectryon excelsus*), rewarewa, pigeonwood/porokaiwhiri, and tōtara. The groundcover comprised litter, hooked sedge, and ferns (e.g. climbing hard fern/pānako, *Pellaea rotundifolia*, *Adiantum cunninghamii*, and *Polystichum wawranum*). Pukatea (*Laurelia novae-zelandiae*) seedlings were common at one site suggesting mature trees of this species were also present. Rata (*Metrosideros perforata*) was a common epiphyte (Figure 9).

Figure 9. Rewarewa/kohekohe-tawa forest (left) and forest interiors (right) in several different remnants.

4.4 Broadleaved species forest and scrub

This vegetation type was observed alongside Yaw Road in the centre of Waimanu Forest. Rewarewa are emergent over a mixed canopy of māhoe, pate (*Schefflera digitata*), kōhūhū, rangiora (*Brachyglottis repanda*), *Olearia rani*, porokaiwhiri (*Hedycarya arborea*), putaputawētā (*Carpodetus serratus*), mamaku, tī kōuka, houhere (*Hoheria*

sexstylosa), and kānuka (Figure 10). On the edge of the site is an area of tutu (*Coriaria arborea*) with an understorey dominated by Mexican daisy and exotic grasses.

Very small areas of scrub dominated by broadleaved tree species were found alongside the lower reaches of the Makahakaha Stream. Common species include māhoe, karamū, houhere, tī kōuka, kānuka, and pate, with rare titoki (Figure 10).

Broadleaved forest and scrub was also found adjacent to areas of kohekohe forest. At one site, kānuka, houhere, lancewood, mamaku, tutu, māhoe, and makomako were present (Figure 9, top left).

Figure 10. Rewarewa/broadleaved species forest and scrub (left) and māhoe, karamū, and houhere alongside Makahakaha Stream (right).

4.5 Kānuka forest and scrub

Kānuka forest and scrub is present in areas identified as land banks alongside Yaw Road and Waimanu Road, and also alongside the Te Patu Stream, and the lower reaches of the Makahakaha Stream. Kānuka forms a canopy over scattered *Coprosma rhamnoides* and blackberry (*Rubus fruticosus* agg.), common exotic grasses and herbs, including cocksfoot (*Dactylis glomerata*), sweet vernal (*Anthoxanthum odoratum*), Yorkshire fog (*Holcus lanatus*), Mexican daisy (*Erigeron karvinskianus*), creeping buttercup, and scattered grey sedge (*Carex divulsa*) (Figure 11). Where kānuka is dense enough to significantly reduce light levels, the ground is covered in litter. A few indigenous species such as ferns, māhoe, kōhūhū, and the native grass *Oplismenus hirtellus* subsp. *imbecillis* are also present. Mingimingi (*Leucopogon fasciculatus*) is relatively common at a site west of Waimanu Road near Noah Road. Alongside Makahakaha Stream, Himalayan honeysuckle (*Leycesteria formosa*), karamū (*Coprosma robusta*), and tutu are also present. Wilding conifers are occasional in kānuka forest alongside Yaw Road.

Figure 11. Kānuka forest and scrub in land banks alongside Yaw Road (left) and Waimanu Road (right).

4.6 Exotic scrub and grassland

Exotic scrub and shrubland is present in reserve areas alongside several waterways. Typical species present include cocksfoot, creeping bent (*Agrostis stolonifera*), other exotic grasses, hedge woundwort, Himalayan honeysuckle, blackberry, wild carrot (*Daucus carota*), and purpletop vervain (*Verbena incompta*). A few radiata pine (*Pinus radiata*) trees are also present (Figure 12).

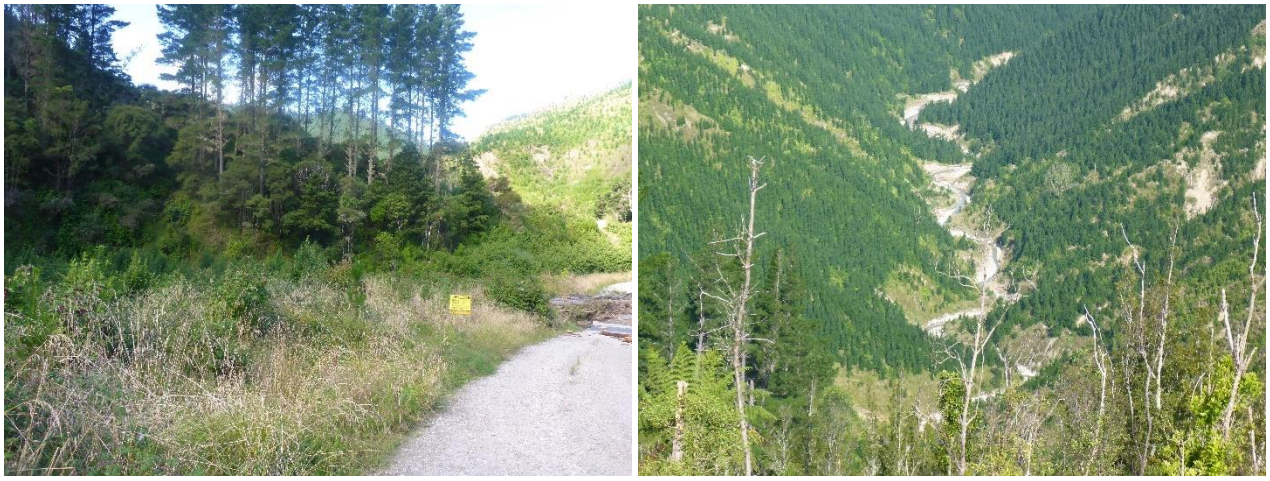

Figure 12. Exotic scrub and grassland alongside the Makahakaha Stream by Tarn Road (left) and alongside Tārewarewa Stream (right).

5 FLORA

A total of 148 vascular plant species (99 indigenous and 49 exotic) have been recorded in Waimanu Forest (Appendix A). Five Threatened or At - Risk plant species (as per de Lange *et al*. 2018) were identified (Table 7). Kānuka, rōhutu, and rātā species (*Metrosideros* spp.) have had their threat classification raised due to the threat posed by myrtle rust, a fungal disease that can kill species in the Myrtle family (Myrtaceae).

Table 7: Threatened and At Risk plant species recorded in Waimanu Forest, January 2023.

Species	Common name	Threat classification	Plant type	Notes
Jovellana sinclairii	New Zealand calceolaria	At Risk-Declining	Dicot herb	Rare
Kunzea robusta	Kānuka	Threatened-Nationally Vulnerable	Tree	Common
Lophomyrtus obcordata	Rōhutu	Threatened-Nationally Critical	Shrub	Site 3 only
Metrosideros diffusa	White rātā	Threatened-Nationally Vulnerable	Vine	A few sites
Metrosideros perforata	Akatea	Threatened-Nationally Vulnerable	Vine	Common

A range of environmental pest plant species were recorded within Waimanu Forest, with 11 of the observed species listed in the Gisborne Regional Pest Management Plan (RPMP) (Gisborne Regional Council 2017) (Table 8). However, weed densities are generally low within Waimanu Forest, and very low within tall indigenous forest remnants.

Table 8: Pest plant species recorded in Waimanu Forest, January 2023.

Species	Common Name	Gisborne RPMP	Notes
Buddleja davidii	Buddleia	Site Led	Roadside, one plant seen
Clematis vitalba	Old man's beard	Progressive containment	Roadside, one plant seen
Cortaderia sp.	Pampas	Sustained control	Roadsides
Cotoneaster sp.	Cotoneaster	-	Kānuka scrub, one plant seen
Erigeron karvinskianus	Mexican daisy	Site Led	Widespread
Genista monspessulana	Montpellier broom	Site Led	Podocarp/tawa forest
Jacobaea vulgaris	Ragwort	Sustained control	Roadside
Leycesteria formosa	Himalayan honeysuckle	-	Podocarp/tawa forest
Rubus fruticosus agg.	Blackberry	Sustained control	Roadside, kānuka scrub
Pinus sp.	Wilding conifer	Site Led	Various sites
Populus alba	White poplar	-	Makahakaha Stream margins
Rubus fruticosus agg.	Blackberry	Sustained control	Road margins, scrub
Salix ×fragilis	Crack willow	-	Makahakaha Stream
Selaginella kraussiana	Selaginella	-	Podocarp/tawa forest
Solanum pseudocapsicum	Jerusalem cherry	-	Podocarp/tawa forest
Tradescantia fluminensis	Tradescantia	-	Podocarp/tawa forest
Ulex europaeus	Gorse	Sustained Control	Roadside
Unidentified tree species		-	Kānuka scrub
Vinca major	Periwinkle	Site Led	Podocarp/tawa forest

6 FAUNA

6.1 Birds

Eighteen bird species (12 native, 6 introduced) were recorded in Waimanu Forest during previous and current site visits (Table 9). One Threatened and one At Risk bird species (as per Robertson *et al*. 2021) were identified.

Table 9: Bird species recorded in Waimanu Forest.

Native species	Common name	Threat classification	Notes
Anthornis melanura	Bellbird, korimako	Not Threatened	
Anthus novaeseelandiae	New Zealand pipit, pīhoihoi	At Risk-Declining	Seen on road
Chrysococcyx lucidus	Shining cuckoo, pīpīwharauroa	Not Threatened	
Circus approximans	Australasian harrier, kahu	Not Threatened	
Falco novaeseelandiae ferox	Bush falcon, karearea	Threatened-Nationally Increasing	Seen next to the Makahakaha Stream
Gerygone igata	Grey warbler, riroriro	Not Threatened	
Hemiphaga novaeseelandiae	New Zealand pigeon, kererū	Not Threatened	
Hirundo neoxena	Welcome swallow	Not Threatened	
Petroica macrocephala subsp. *toitoi*	North Island tomtit, miromiro	Not Threatened	One bird seen
Prosthemadera novaeseelandiae	Tui, kōkō	Not Threatened	
Rhipidura fuliginosa subsp. *placabilis*	North Island fantail, pīwakawaka	Not Threatened	
Tadorna variegata	Paradise shelduck, pūtangitangi	Not Threatened	Waimatā River
Introduced species			
Anas platyrhynchos	Mallard		
Anser anser	Greylag goose		Waimatā River
Emberiza citrinella	Yellowhammer		
Gymnorhina tibicen	Australian magpie		
Phasianus colchicus	Common pheasant		
Turdus merula	Blackbird		

6.2 Pest mammals

Feral goats (*Capra hircus*), feral pigs (*Sus scrofa*), red deer (*Cervus elaphus scoticus*), fallow deer (*Dama dama*), brushtail possums (*Trichosurus vulpecula*), and feral cats (*Felis catus*), have been recorded in Waimanu Forest. A range of other pest animal species are also likely to be present, including rats (*Rattus* spp.), mice (*Mus musculus*), mustelids (*Mustela* spp.), and hedgehogs (*Erinaceus europaeus*) (Leathwick *et al*. 2001, Forbes *et al*. 2018).

Numerous goats, a cat, and pig and deer sign were seen during the site survey, as well as extensive animal tracks. Palatable plant species were largely absent from the browse tier within the forest.

Predatory mammals such as rats, mustelids, possums, pigs, and cats can kill indigenous species, reducing their numbers or causing local extinctions. Browsers such as possums, goats, and deer can change vegetation structure and composition through preferential browsing of palatable plant species, while rats and mice eat seed.

6.3 Freshwater fish

A total of ten fish species were found in the freshwater eDNA surveys at Site 1 and Site 2 (Table 10). Five species have the threat classification of 'At Risk – Declining' (Dunn *et al.* 2018) including longfin eel (*Anguilla dieffenbachii*), torrentfish (*Cheimarrichthys fosteri*), Bluegill bully (*Gobiomorphus hubbsi*), redfin bully (*Gobiomorphus huttoni*) and kōaro (*Galaxias brevipinnis*). The Australasian anchovy (*Engraulis australis*) was also detected in results, which is not a freshwater fish species, rather a marine fish species, and likely causes of this are a transportation of DNA through bird, humans or potential inputs such as bio fertiliser.

Table 10. Freshwater fish species found in the Waimanu forest area.

Scientific Name	Common Name	Conservation Status	Site 1	Site 2
Anguilla australis	Shortfin eel	Native - Not Threatened	Yes	Yes
Anguilla dieffenbachii	Longfin eel	At Risk – Declining	Yes	Yes
Gobiomorphus basalis	Cran's bully	Native - Not Threatened	No	Yes

Gobiomorphus cotidianus	Common bully	Native - Not Threatened	Yes	Yes
Cheimarrichthys fosteri	Torrentfish	At Risk – Declining	Yes	Yes
Gobiomorphus hubbsi	Bluegill bully	At Risk – Declining	Yes	Yes
Gobiomorphus huttoni	Redfin bully	At Risk – Declining	Yes	No
Retropinna retropinna	Common smelt	Native - Not Threatened	No	Yes
Galaxias brevipinnis	Kōaro	At Risk – Declining	Yes	Yes
Engraulis australis	Australasian anchovy	N/A	No	Yes

7 AQUATIC VALUES

7.1 Freshwater macroinvertebrates

The macroinvertebrate results at all three sites have a low diversity of macroinvertebrate species, with 7-8 species per sample. The species that dominated all three samples were single-gilled mayfly *Deleatidium* (which has a tolerance score of 8) with a range of 190-400 individuals per sample. The samples at the three sites were comprised of 50-57% sensitive EPT taxa and were represented by 82-97% EPT abundance.

Due to the low numbers of taxa in the samples, the MCI and %EPT values should be used with caution, as the low numbers of species can skew the overall score. It is likely that due to the wet summer, and the weather events in the months preceding the sampling, that macroinvertebrate larvae were washed and scoured from the streams within Waimanu Forest, which would explain the low abundance and diversity of species. The weather events could have negatively affected invertebrate recruitment which has therefore resulted in the low diversity of species. Further sampling would provide more information to the state of the streams, and potentially their recovery following the events of the cyclones.

All sites scored in the 'Fair' water quality band for MCI with values being between 87 and 97.

Full macroinvertebrate results are displayed in Table 11.

Table 11. Macroinvertebrate results from three sites sampled within Waimanu Forest, Gisborne, 3 April 2023.

Taxa	MCI score	Site 1 Te Rata Stream	Site 2 Makahakaha Stream	Site 3 Makahakaha Stream Trib
Mayfly *Coloburiscus*	9	3		3
Mayfly *Deleatidium*	8	340	400	190
Stonefly *Spaniocerca*	8		1	
Caddisfly *Aoteapsyche*	4	1	1	5
Caddisfly *Hydrobiosis*	5	2	1	4
Dobsonfly *Archichauliodes*	7	1		
True Fly Chironomus	1	1		1
True Fly *Maoridiamesa*	3			1
True Fly *Muscidae*	3	8	2	8
True Fly *Orthocladiinae*	2	64	7	22
True Fly *Polypedilum*	3		2	
Number of Taxa		**8**	**7**	**8**
EPT taxa		**4**	**4**	**4**
Number of Individuals		**420**	**414**	**234**
% EPT		**82**	**97**	**86**
% EPT Taxa		**50**	**57**	**50**
MCI Value		**97**	**94**	**87**

7.2 GDC macroinvertebrate data

The five years of macroinvertebrate data from 2016-2020 show a high species diversity with a range of 11-27 taxa per sample across the five years (Figure 13). The samples all had high numbers of individuals with >200 individuals per sample and EPT taxa represented between 6-41% of the taxa in the samples. The %EPT abundance at the site was 46% in the first year of the sampling but has decreased in the subsequent sampling years with 2020 having the lowest abundance with 0.48% EPT abundance.

The MCI scores at the site range from 75-107 with the first year of sampling resulting in 'Good' water quality and the following three years with 'Fair' water quality and the final sampling year of 2020 resulting in 'Poor' indication of water quality.

Raw macroinvertebrate data is presented in Appendix B.

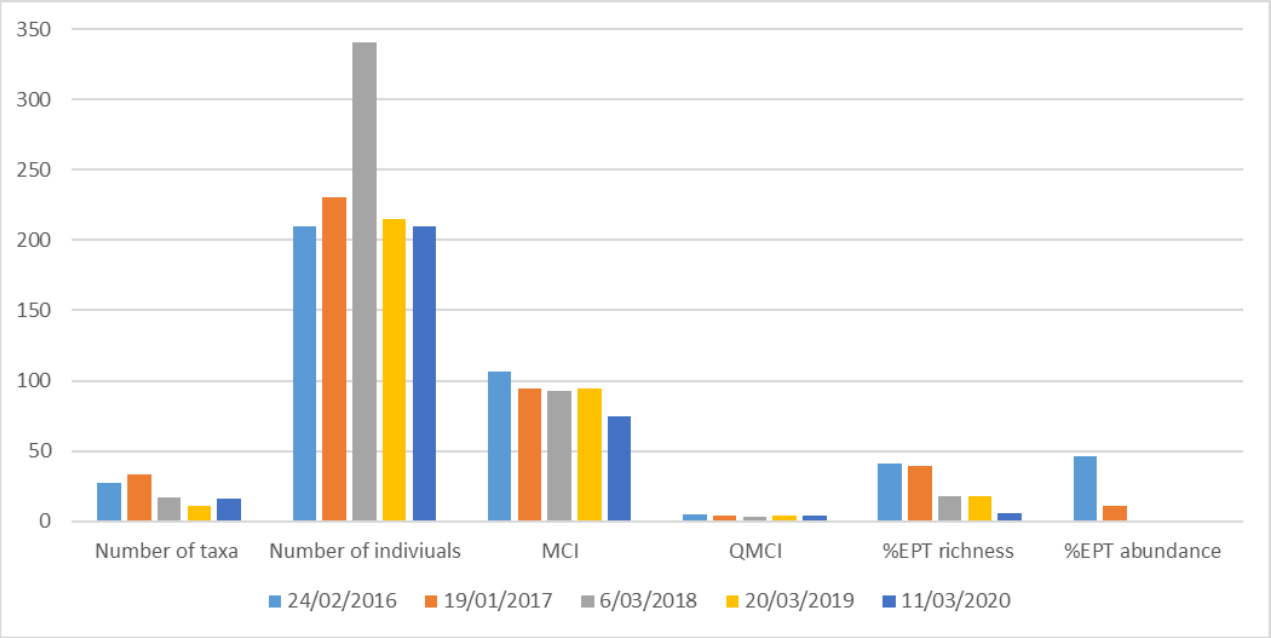

Figure 13. Macroinvertebrate data from the GDC SOE sampling site on the Makahakaha Stream in Waimanu forest from 2016-2020.

7.3 Deposited sediment

The deposited sediment levels at all three sites were generally low with all sites having less than 20% deposited sediment cover (Table 12). Site 3 had the highest deposited sediment levels with 18% cover and site 2 had the lowest deposited sediment cover with only 2% cover. It is likely that the low deposited sediment cover is attributed to the cyclone events with sediment flushed out of the freshwater system in the extremely high flows that they experienced.

Table 12. Deposited sediment at three sites within Waimanu Forest, Gisborne, 3 April 2023.

Site name	Deposited sediment % cover
Site 1 - Te Pahi Stream	6%
Site 2 - Makahakaha Stream	3%
Site 3 - Makahakaha Stream Tributary	18%

7.4 Rapid habitat assessment

7.4.1 Site 1

The Te Pahi Stream was 2.5 meters wide and approximately 20cm deep. There was a mixture of substrates including boulders, cobbles and gravel. Periphyton cover was approximately 90% of the streambed and included a combination of brown filamentous algae, brown mats and sludge in the slower flowing edge areas of the stream (Figure 14). The Rapid Habitat Assessment score for the site was 61 indicating 'Good' habitat (Table 13).

Figure 14. Te Pahi stream with a mixture of boulders, cobbles and gravel and 90% periphyton cover. 3 April 2023.

7.4.2 Site 2

The Makahakaha Stream at the sampling location was two meters wide, and approximately 10cm deep (Figure 15). The substrate was a mixture of large and small cobbles, with deposited sediment cover higher in the slower flowing areas. Periphyton cover was a mixture of sludge and brown filamentous with some orange thin films. The hydraulic heterogeneity was a mixture of pools, riffles and fast runs. There was bank erosion present on both sides of the stream, and large quantities of woody debris and deposited sediment on the stream banks and flood plains surrounding the sample reach. The RHA score for the site was 54 indicating 'Good' instream habitat (Table 13).

Figure 15. The Makahakaha Stream, looking downstream at the sampled reach. Erosion on the stream banks and woody debris were present on both sides of the stream. 3 April 2023.

7.4.3 Site 3

The Makahakaha Stream tributary was two meters wide and approximately 10cm deep, it had a steep gradient with a mixture of substrate types including boulders, cobbles and gravel (Figure 16). The habitat included pools, riffles and slow runs and had periphyton cover of thin films and some brown mats. At the top end of the sampled reach a perched culvert was present which will be preventing fish passage (Figure 17). The Rapid Habitat Assessment score for the site was 47 indicating 'Fair' habitat (Table 13).

Figure 16. The Makahakaha Stream sample reach, with a steep gradient and large boulders, Waimanu forest, Gisborne, 3 April 2023.

Figure 17. A perched culvert present in the Makahakaha Stream tributary in Waimanu Forest, 3 April 2023

Table 13. Rapid Habitat Assessment results for three sites in Waimanu Forest, Gisborne.

Habitat Parameter	Te Pahi Stream	Makahakaha Stream	Makahakaha Stream Trib
	Site 1	Site 2	Site 3
1. Deposited sediment	4	4	4
2. Invertebrate habitat diversity	8	7	9
3. Invertebrate habitat abundance	7	7	5
4. Fish cover diversity	3	2	3
5. Fish cover abundance	5	4	4
6. Hydraulic heterogeneity	9	6	5
7. Bank erosion	3	2	1
8. Bank vegetation	8	8	3
9. Riparian width	10	10	10
10. Riparian shade	4	4	3
Total (out of 100)	61	54	**47**
Condition score	**Good**	**Good**	**Fair**

7.5 Freshwater summary

The freshwater sampling results from Waimanu forest indicate that there is excellent fish diversity within the forest area with a total of 10 fish species and five of those are in the 'At – Risk Declining' threat classification. One of the fish species identified in the sampling was anchovies, which is likely a contamination of the sampling area by humans or birds. The diversity of fish species shows that fish habitat within the forest is good and provides habitat for an array of species including species that prefer fasting flowing rocky streams such as kōaro, which are good at accessing inland

streams due to their ability to climb. Other species including smelt and bullies are not climbing species but they are both good swimmers so will penetrate inland in streams that aren't too steep.

The freshwater macroinvertebrate results from 2023 highlight that the summer season has been very wet with lots of disturbance to the freshwater systems within Waimanu forest. The results at all the sites have low numbers of taxa and individuals in the samples compared to the samples taken from Makahakaha Stream SOE site 2016-2020 which have at least double the numbers of taxa and individuals. The abundance of EPT taxa at the sample sites was >50% indicating there are sensitive taxa present. MCI scores at the three sites sampled in 2023 indicate 'Fair' water quality. MCI scores at the GDC SOE site have decreased over the five years of sampling, but there is not enough data to understand if there is a downward trend or not, further sampling would provide more information on this. If regular monitoring was established, more information would provide a better understanding of the water quality and habitat within the forest and provide information in different seasons which will give understanding to seasonal change.

Deposited sediment at all sites sampled was low, however it would be recommended to continue with this sampling as it is likely that deposited sediment levels were influenced by the high flows in the streams during summer and sediment was likely flushed from the freshwater system. Deposited sediment levels cannot be assigned to the National Policy Statement for Freshwater Management (NPS-FM) NOF band because there is not enough data (monthly samples over five years are required), however Site 1 and 2 are in the range of 'A' band and Site 3 is in the 'C' band range to provide context to the deposited sediment levels at the sample sites.

Sediment monitoring will provide information as to whether sediment is accumulating in the streams or not, and what effect the forest activities are having on the watercourses. Freshwater habitat at the sampled sites indicate that there is good to fair habitat and highlight the key areas which would improve habitat are stream shade, fish cover and bank erosion which could all be improved with indigenous riparian margins along the stream banks.

8 ECOLOGICAL SIGNIFICANCE ASSESSMENT

An ecological significance assessment was undertaken for each area of indigenous vegetation against the criteria listed in the Tairawhiti Resource Management Plan as described under C9.1.6.2.A.e.iv.

Following guidance from Te Kaunihera O Te Tairāwhiti / Gisborne District Council, for a site or area to be significant it must receive a medium rating for one criterion or more. Therefore, all areas of podocarp/tawa forest (4.2), rewarewa/kohekohe-tawa forest (4.3), broadleaved species forest and scrub (4.4), and kānuka forest and scrub (4.5) within Waimanu Forest are ecologically significant.

Table 14. Ecological significance assessment for indigenous vegetation types in Waimanu Forest.

Criterion	Description	Vegetation type (report section)				Comments
		4.2	4.3	4.4	4.5	
1. Representativeness	The site is a good example of an indigenous vegetation or habitat type within the Gisborne district	Mod	Mod	Low	Mod-low	4.2.and 4.3 moderate quality examples of expected potential vegetation within the district
2. Diversity	The site has a natural diversity of landforms, ecosystems, flora, or fauna	Mod	Mod	Mod	Low	Lack of palatable plant species in the understory
3. Rarity	Presence of nationally or regionally rare flora, fauna, ecosystems or landforms or regular use by nationally or regionally rare fauna	Mod	Low	Low	Low	4.2 *Jovellana sinclairii* 4.5 Some small sites <10% indigenous cover left
4. Ecological viability	The site's ability to maintain itself without active management	Mod	Mod	Mod	Mod	Require active management to maintain good quality habitats
5. Size and shape		Mod	Mod	Low	Low-Mod	Small to moderate size Most sites have irregular boundaries and/or are narrow

6. Context	The site's relationship with other areas of indigenous vegetation including any ecological linkages or corridors to other areas of significant indigenous vegetation or habitats of indigenous fauna	Mod	Low	Low	Low	4.2 Buffers Waimatā River Other areas relatively isolated, but may be used by mobile bird species to travel between indigenous remnants
7. Naturalness		Mod	Mod	Mod	Mod	Weeds on edges, goats, and deer
8. Important fauna habitat	The importance of the site for breeding, feeding, roosting, or loafing areas used by threatened indigenous fauna on a regular or annual basis	Low	Low	Low	Low	The forest area provides habitat for Falcon. Watercourses provides key habitat for a variety of native fish species including torrentfish, kōaro, longfin eel, redfin bully and bluegill bully.
Significant?		Yes	Yes	Yes	Yes	

9 NATIONAL PRIORITIES FOR PROTECTING RARE AND THREATENED NATIVE BIODIVERSITY ON PRIVATE LAND

There are four national priorities for protecting rare and threatened native biodiversity on private land (MfE 2007). Each of these is assessed below for Waimanu Forest.

✓ **National Priority 1: To protect indigenous vegetation associated with land environments, (defined by Land Environments of New Zealand at Level IV), that have 20 percent or less remaining in indigenous cover.**

The only sites within Waimanu Forest with ≤20% indigenous cover left were located alongside the lower reaches of the Makahakaha Stream (see Section 3.5), where small areas of kānuka forest and scrub and broadleaved species scrub were present.

✗ **National Priority 2: To protect indigenous vegetation associated with sand dunes and wetlands; ecosystem types that have become uncommon due to human activity.**

No dunelands or natural wetlands were identified during the site visit.

✗ **National Priority 3: To protect indigenous vegetation associated with 'originally rare' terrestrial ecosystem types not already covered by priorities 1 and 2.**

No originally rare ecosystem types (as identified by Williams *et al*. 2007 and Holdaway *et al*. 2012) were identified.

✓ **National Priority 4: To protect habitats of acutely and chronically threatened indigenous species.**

Indigenous vegetation within Waimanu Forest provides habitat for bush falcon (Threatened-Nationally Increasing), New Zealand pipit (At Risk-Declining), *Jovellana sinclairii* (At Risk-Declining) and four plant species threatened by myrtle rust (kānuka, rōhutu, white rātā, and akatea). Waterways provide habitat for 'At Risk – Declining' fish species (kōaro, longfin eel, redfin bully, bluegill bully and torrentfish).

10 PROTECTION AND RESTORATION OPPORTUNITIES

The following protection and restoration opportunities are suggested which will provide the Waimanu Forest area with better habitat connectivity, reduced weed infestations and increased indigenous habitat area and quality. Potential restoration sites are mapped in Figure 18.

10.1 Pest plant and animal control

Pest plant and animal control could be undertaken throughout Waimanu Forest to reduce the adverse effects of browsing and predation on indigenous biodiversity.

Pest animal control should focus on goats and deer, but also target pigs and possums.

Pest plant control priorities include the eradication of species that are currently at low abundance, such as buddleia and old man's beard, so that they do not spread. Other weeds such as pampas along road edges, and wilding conifers (e.g. in land bank kānuka alongside Yaw Road) should also be controlled to protect existing ecological values.

10.2 Indigenous planting and restoration

10.2.1 Planting riparian areas and increasing setbacks

Waterways could be protected by increasing planting setbacks on riparian margins throughout the forest during the current and next rotation. Further protection would be provided by allowing indigenous vegetation to regenerate and/or planting indigenous species. This would be particularly beneficial within the Makahakaha Stream catchment, as it is almost entirely located within Waimanu Forest. Protecting this waterway along its entire length would provide ecological benefits such as erosion protection, reductions in sedimentation, improved fish habitat, increasing stream shade and enhancing freshwater habitat. Riparian margins, as well as providing ecological benefits to the stream habitat will also assist with decreasing bank erosion and assist to reduce any environmental effects from the forestry activities by providing a buffer between the harvesting areas and the watercourses.

The lower reaches of the Makahakaha Stream have a high priority for restoration as they are located on Category 1 land environments with <10% indigenous cover left, reflecting the historic clearance of lowland kahikatea-pukatea forest. Restoration works here could include increasing planting setbacks, protecting areas of regenerating indigenous vegetation, and strategic planting of indigenous species.

10.2.2 Indigenous planting

An opportunity exists to connect the existing area of podocarp/tawa forest and a large area of kānuka forest to the south to the potential Makahakaha Stream restoration site (see above) by restoring a band of indigenous vegetation alongside the Waimatā River. This would help protect the margins of the Waimatā River and improve connectivity between natural areas. It would also complement the Waimatā River Restoration Project. A suggested width (*c*.50 m) is mapped (Figure 18), but a wider restoration area would be more sustainable and protect ecological values to a greater degree.

Encouragement of natural regeneration and/or planting of indigenous species on old slips would increase the extent of indigenous forest and protect against further erosion. Potential sites include slips alongside Te Patu Stream and its tributary which are surrounded by indigenous vegetation, where restoration of these areas would help buffer and connect existing indigenous forests. Some weed control may also be required if woody weeds/pest plants colonise these sites.

Kānuka forest and scrub in land banks could be allowed to naturally regenerate, or these areas could be actively restored to kohekohe-tawa forest by controlling pest plants and animals, and planting indigenous species.

Any planting that is undertaken for restoration purposes should predominantly comprise hardy, fast-growing species such as kānuka, which will more quickly form a vegetation cover on steep sites. Podocarps should also be included in initial plantings. Other species such as kohekohe could be planted once the kānuka is established to help speed up natural regeneration.

10.2.3 Additions to the reserve network

The following areas could be added to the reserve network:

1) Slips with regenerating indigenous vegetation adjacent to existing areas of indigenous vegetation.

2) Indigenous vegetation in land banks, including kānuka forest and kohekohe-tawa forest.

10.2.4 Forestry activities

It appears that some areas of kānuka forest and scrub alongside the Makahakaha Stream were cleared when adjacent plantation forest areas were last harvested. It would be ecologically beneficial to retain this type of vegetation in riparian margins throughout the forest as it would help protect water quality. These areas could also be used as a basis for restoration activities on riparian margins.

Best practice forestry guidelines should be followed. It was noted that plantation trees had been felled into indigenous areas at a few sites. All efforts should be made to fell trees away from reserve areas.

Clear-felling on high-risk erosion susceptibility (red zone) land could be reduced in extent to reduce slipping, improve water quality by reducing sedimentation, and prevent mobilisation of forestry slash.

10.2.5 Management plans

Indigenous plantings should be guided by planting plans prepared for each site, and should include goals, site preparation, plant species and numbers, plant spacing, planting maintenance, and monitoring requirements.

Management plans will also be required for other restoration activities such as pest animal control.

Plans can also be developed for riparian margins including calculating buffer widths which will provide the most protection to the watercourses.

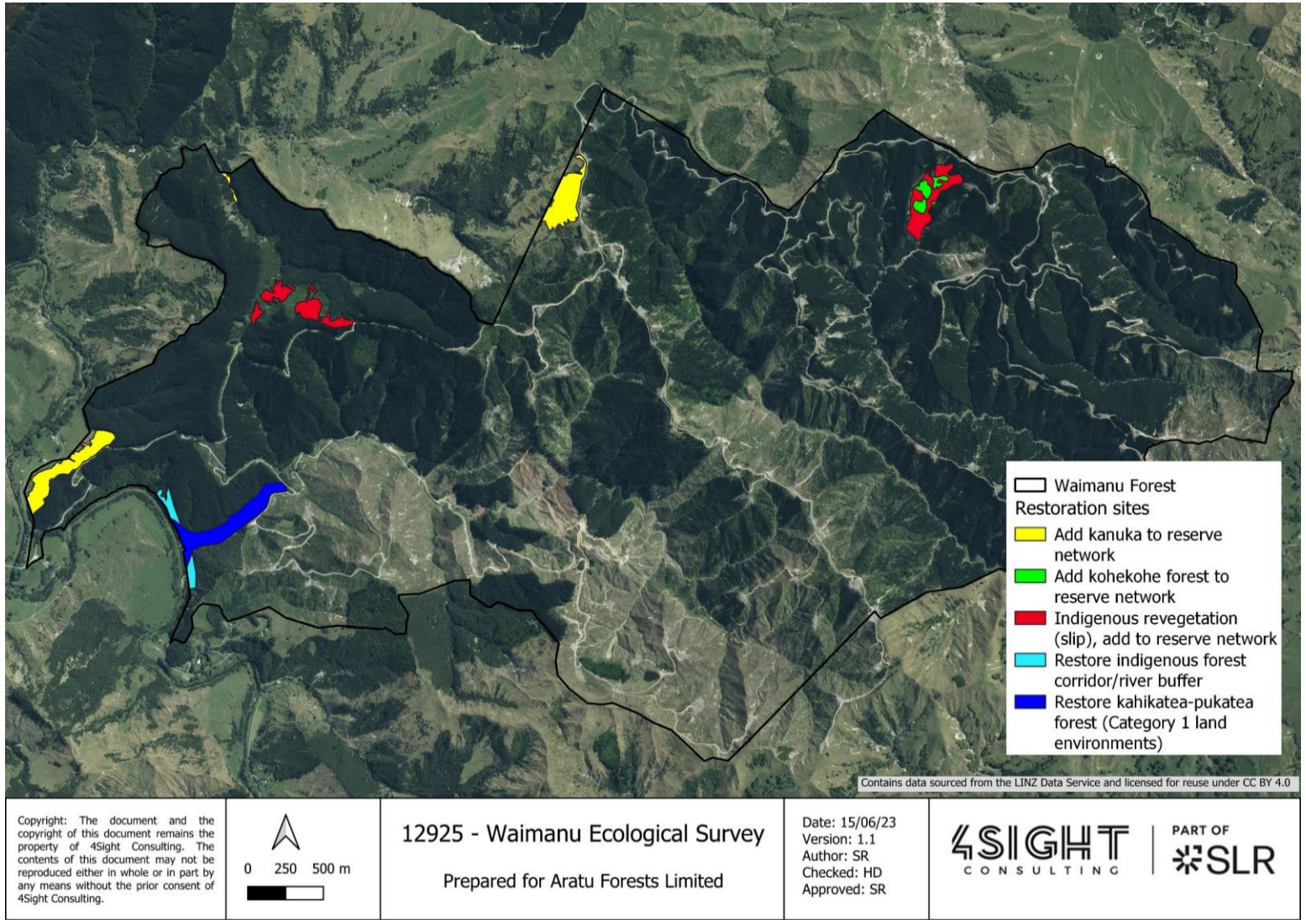

Figure 18. Potential restoration sites. Increasing planting setbacks along waterways and pest plant and animal control are not shown.

11 MONITORING

The following monitoring could be established in indigenous vegetation and freshwater habitats within Waimanu Forest to provide information on the success of any protection and restoration works undertaken. The results of all monitoring activities should be recorded. Monitoring should be guided by restoration plans prepared for each site.

11.1 Forest condition

Permanently marked vegetation plots could be established within selected areas of indigenous vegetation. Monitoring should include recording the cover of all plant species present within each vegetation tier, and levels of animal browse. The goal of monitoring would be to determine changes in vegetation composition following restoration activities. The standardised Recce method (Hurst and Allen 2007) is widely used but requires good botanical skills.

11.2 Five-minute bird counts

Five-minute bird counts (5MBC) can be used to provide estimates of the relative abundance of bird species (Hartley and Greene 2012). This could be used to determine change over time or as a result of restoration activities.

11.3 Pest control and planting

Any pest animal operations should be documented, including date, target species, and control method. Outcomes should be assessed for weeds by assessing kill rates in post-works visits. Pest animal numbers should be monitored using standardised methods such as residual trap catch, kill counts, tracking tunnels, and pellet counts, both before (to determine the need for control) and after control operations (to determine the effectiveness of control).

11.4 Freshwater

Annual or biannual freshwater sampling sites should be established within the forest to understand the state of the freshwater habitats in the forest, and to measure the effectiveness of the protection and restoration measures implemented. Monitoring should include macroinvertebrate, deposited sediment and habitat surveys. Further specific fish surveys could also be undertaken such as electric fishing or spotlighting to identify more specific areas where fish populations are, such as kōaro. Riparian buffers established in the forest will provide critical ecological mitigations to the effects of forestry activities particularly forestry harvest.

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Appendix A:

Vascular plant species recorded in Waimanu Forest

Species in **bold text** were recorded by Gisborne District Council (2018) in Protected Management Area WR61 Waikereru Bush, and may be present in the part of the PMA within Waimanu Forest. These species were not seen in Waimanu Forest during the January 2023 survey.

Indigenous species	Common Name	Growth Form
Acaena novae-zelandiae	Red bidibid	Herb
Adiantum cunninghamii	Common maidenhair	Fern
Alectryon excelsus	Tītoki	Tree
Aristotelia serrata	Makomako; Wineberry	Tree
Arthropteris tenella	Jointed fern	Fern
Asplenium appendiculatum	Ground spleenwort	Fern
Asplenium bulbiferum	Hen and chicken fern	Fern
Asplenium flaccidum	Hanging spleenwort	Fern
Asplenium hookerianum	Hooker's spleenwort	Fern
Astelia fragrans	Bush flax; Kakaha	Monocot herb
Astelia hastata		Monocot herb
Austroblechnum lanceolatum	Lance fern; Nini; Rereti	Fern
Beilschmiedia tawa	Tawa	Tree
Brachyglottis repanda	Rangiora	Tree
Carex dipsacea		Sedge
Carex lessoniana	Rautahi; Toetoe rautahi	Sedge
Carex species		Sedge
Carex uncinata	Hook sedge	Sedge
Carex virgata	Swamp sedge	Sedge
Carmichaelia australis	North Island broom	Tree
Carpodetus serratus	Marble leaf; putaputawētā	Tree
Clematis species		Liane
Coprosma rhamnoides		Shrub
Coprosma robusta	Karamū	Tree
Cordyline australis	Cabbage tree; Tī kōuka	Monocot tree
Coriaria arborea	Tutu	Tree
Corynocarpus laevigatus	Karaka	Tree
Cyathea cunninghamii	Gully tree fern; pūnui	Fern
Cyathea dealbata	Ponga; silver fern	Fern
Cyathea medullaris	Mamaku	Fern
Cyathea smithii	Kātote; soft tree fern	Fern
Dacrycarpus dacrydioides	Kahikatea	Tree
Dendroconche scandens	Fragrant fern; mokimoki	Fern
Dichelachne crinita	Long-hair plume grass; Pātītī	Grass
Dicksonia squarrosa	Whekī	Fern
Didymocheton spectabilis	Kohekohe	Tree
Doodia australis	Rasp fern, pukupuku	Fern
Earina species	Bamboo orchid	Orchid
Entelea arborescens	Whau	Tree
Euchiton sp.		Herb
Freycinetia banksii	Kiekie	Monocot liane
Geniostoma ligustrifolium	Hangehange	Shrub
Griselinia littoralis	Broadleaf; Kāpuka	Tree
Haloragis erecta	Toatoa	Sub Shrub
Hedycarya arborea	Pigeonwood; Porokaiwhiri	Tree
Histiopteris incisa	Mātātā; water fern	Fern
Hoheria sexstylosa	Houhere; Lacebark	Tree
Hydrocotyle moschata	Hairy pennywort; hydrocotyle	Herb
***Hymenophyllum* species**	Filmy fern	Fern
Icarus filiformis	Climbing hard fern; pānako	Fern
Jovellana sinclairii	New Zealand calceolaria	Herb

Juncus edgariae	Edgar's rush; Wīwī	Rush
Knightia excelsa	Rewarewa	Tree
Kunzea robusta	Kānuka	Tree
Laurelia novae-zelandiae	Pukatea	Tree
Leucopogon fasciculatus	Mingimingi	Shrub
Lophomyrtus obcordata	Rōhutu	Tree
Melicope simplex	Poataniwha	Tree
Melicytus ramiflorus	Māhoe	Tree
Metrosideros diffusa	White rātā	Liane
Metrosideros perforata	White rātā	Liane
Muehlenbeckia australis	Large-leaved pōhuehue	Liane
Myoporum laetum	Ngaio	Tree
Myrsine australis	Māpou	Tree
Nertera depressa	Nertera	Herbb
Olearia rani	Heketara	Tree
Oplismenus hirtellus subsp. *imbecillis*		Grass
Ozothamnus leptophyllus	Tauhinu	Shrub
Paesia scaberula	Pig fern; ring fern	Fern
Pakau pennigera	Gully fern	Fern
Parablechnum novae-zelandiae	Kiokio	Fern
Parapolystichum glabellum	Smooth shield fern	Fern
Parsonsia heterophylla	New Zealand jasmine	Liane
Passiflora tetrandra	Kohia; New Zealand passion flower	Liane
Pellaea rotundifolia	Round-leaved fern	Fern
Pennantia corymbosa	Kaikōmako	Tree
Persicaria decipiens	Swamp willow weed	Herb
Phormium cookianum	Mountain flax; whaririki	Monocot herb
Piper excelsum subsp. *excelsum*	Kawakawa	Tree
Pittosporum tenuifolium	Kōhūhū	Tree
Podocarpus totara	Tōtara	Tree
Polystichum wawranum		Fern
Prumnopitys taxifolia	Mataī	Tree
Pseudopanax arboreus	Five-finger; whauwhaupaku	Tree
Pseudopanax crassifolius	Horoeka; Lancewood	Tree
Pteris macilenta	Sweet fern	Fern
Pteris tremula	Shaking brake	Fern
Pyrrosia elaeagnifolia	Leather-leaf fern	Fern
Rhopalostylis sapida	Nīkau	Tree
Ripogonum scandens	Supplejack	Liane
Rubus cissoides	Bush lawyer; Tātarāmoa	Liane
Schefflera digitata	Pate	Tree
Senecio bipinnatisectus	Australian fireweed	Herb
Sophora tetraptera	Kōwhai; Large-leaved kōwhai	Tree
Streblus heterophyllus	Small-leaved milk tree; Tūrepo	Tree
Typha orientalis	Raupō	Reed
Urtica ferox	Ongaonga; tree nettle	Shrub
Vitex lucens	Pūriri	Tree
Zealandia pustulata	Hound's tongue fern	Fern
Introduced species	**Common Name**	**Growth Form**
Agrostis stolonifera	Creeping bent	Grass
Anthemis cotula	Stinking mayweed	Herb
Bellardia viscosa	Tarweed	Herb
Buddleja davidii	Buddleia	Shrub
Carex divulsa	Grey sedge	Sedge
Cirsium vulgare	Scotch thistle	Herb

Clematis vitalba	Old man's beard	Liane
Cotoneaster species	Cotoneaster	Shrub
Crepis capillaris	Hawksbeard	Herb
Cynodon dactylon	Indian doab	Grass
Cynosurus cristatus	Crested dogstail	Grass
Cyperus eragrostis	Puketangata; Umbrella sedge	Sedge
Daucus carota	Wild carrot	Herb
Dianthus armeria	Deptford pink	Herb
Digitalis purpurea	Foxglove	Herb
Dipsacus fullonum	Wild teasel	Herb
Erigeron karvinskianus	Mexican daisy	Herb
Erigeron sumatrensis	Broad-leaved fleabane	Herb
Genista monspessulana	Montpellier broom	Shrub
Geranium robertianum	Herb Robert	Herb
Geranium species		Herb
Holcus lanatus	Yorkshire fog	Grass
Jacobaea vulgaris	Ragwort	Herb
Leycesteria formosa	Himalayan honeysuckle	Sub Shrub
Linum catharticum	Purging flax	Herb
Lolium arundinaceum	Tall fescue	Grass
Lolium perenne	Perennial ryegrass	Grass
Lysimachia arvensis	Pimpernel	Herb
Paspalum dilatatum	Paspalum	Grass
Phytolacca octandra	Inkweed	Sub Shrub
Pinus radiata	Radiata pine	Tree
Plantago lanceolata	Narrow-leaved plantain	Herb
Plantago major	Broad-leaved plantain	Herb
Populus alba	White poplar	Tree
Potentilla indica	Indian strawberry	Herb
Prunella vulgaris	Self-heal	Herb
Ranunculus repens	Creeping buttercup	Herb
Rytidosperma racemosum	Danthonia	Grass
Salix ×fragilis	Crack willow	Tree
Selaginella kraussiana	African clubmoss; selaginella	Fern
Solanum pseudocapsicum	Jerusalem cherry	Shrub
Stachys sylvatica	Hedge woundwort	Herb
Tradescantia fluminensis	Tradescantia	Herb
Trifolium repens	White clover	Herb
Ulex europaeus	Gorse	Shrub
Unidentified tree species		Tree
Verbascum thapsus	Woolly mullein	Herb
Verbena incompta	Purpletop vervain	Herb
Vinca major	Periwinkle	Herb

Appendix B:

Macroinverterbrate results from GDC SOE data

Taxa	MCI score	Makahakaha Stream	Makahakaha Stream	Makahakaha Stream	Makahakaha Stream	Makahakaha Stream
		24/02/2016	19/1/2017	6/3/2018	20/3/2019	11/3/2020
PLATYHELMINTHES	3		1	11	1	1
NEMATOMORPHA	3					1
NEMERTEA	3		4	7	21	2
OLIGOCHAETA	1		3			
CRUSTACEA						
Amphipoda	5		2			
Ostracoda	3		1			
Talitridae	5			1		
INSECTA						
Ephemeroptera						
Austroclima	9	33	5	1		
Austronella	7	1	1			
Coloburiscus	9	1				
Deleatidium	8	39	1	1	1	
Zephlebia	7		2	1		
Megaloptera						
Archichauliodes	7	1	2	1		
Odonata						
Hemicordulia	5					1
Microvelia	5	2	1			1
Coleoptera						
Berosus	5	3	3	1	5	1
Dytiscidae	6					
Elmidae	6	1	4	1	1	1
Diptera						
Austrosimulium	3	7	5	1		
Culicidae	3		1			
Empididae	3		1	1		1
Ephydridae	4	1		1		
Muscidae	3	2	1			
Orthocladiinae	2	3	1	1		1
Paradixa	4	1				
Sarcophagidae		1	1			
Stratiomyidae	5				2	1
Tanypodinae	5	29	11			
Tanytarsus	3		25			1
Trichoptera						
Hudsonema	6	3	6			
Hydrobiosis	5	1	1			
Hydropsyche Aoteapsyche	4	13	1			1
Hydroptilidae early instars	2		2			
Oecetis	6		1			
Olinga	9	1				
Oxyethira	2	35	4	61	26	3

Paroxyethira	2					3
Polyplectropus	8		1		1	
Psilochorema	8	1	1			
Pycnocentrodes	5	4	1			
Triplectides	5	1	2			
ACARINA	5	2	3	1	1	1
MOLLUSCA						
Lymnaeidae	3			1	1	
Potamopyrgus	4	9	131	249	155	190
Sphaeriidae	3					
Number of taxa (including rare taxa)		27	33	17	11	16
Number of individuals (including rare taxa)		210	230	341	215	210
MCI		107	95	93	95	75
QMCI		5.26	4.16	3.63	3.73	3.94
%EPT richness (excl. Hydroptilidae)		40.74	39.39	17.65	18.18	6.25
%EPT abundance (excl. Hydroptilidae)		46.67	10.87	0.88	0.93	0.48
MCI grade		Good	Fair	Fair	Fair	Poor