Huia Water Treatment Plant Replacement

Assessment of Ecological Effects
Prepared for Watercare Services Limited

26 July 2019

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Cover photograph: Proposed replacement WTP site, Sarah Flynn 2017

EXECUTIVE SUMMARY

The Huia Water Treatment Plant, located at the corner of Woodlands Park Road and Manuka Road, is Auckland's third-largest water treatment plant. It treats approximately 20 percent of Auckland's water supply, sourced from the Upper and Lower Huia Dams and Upper and Lower Nihotupu Dams. The plant is nearing the end of its operational life and needs to be replaced.

The preferred site for the replacement treatment plant ("the Project Site") is adjacent to the existing plant in Waima, within the Little Muddy Creek catchment on the Manukau Harbour and in the peri-urban foothills of the Waitakere Ranges. The works footprint is 4.3 ha in total, 3.5 ha of which comprises indigenous forest and scrub – dominated vegetation. The Project Site forms part of a 24,000 ha Significant Ecological Area (SEA_T_5539 in the Auckland Unitary Plan (AUP) - Operative in part) that encompasses much of the Waitakere Ranges.

Notwithstanding that forest cover throughout the Ranges is modified by historical resource exploitation and human settlement, the Waitākere Ranges ecosystem as a whole is nationally significant as one of the largest areas of coastal and lowland forest with intact sequences remaining in the Auckland Region.

Residual ecological effects associated with the loss of 3.5 ha of significant native vegetation will be compensated through establishment of an endowment fund and charitable trust ("Waima Biodiversity Trust") that will coordinate and implement biodiversity management throughout a 990 ha "Waima Management Area", ~720 ha of which is bush-covered and classified as SEA in the AUP. Approximately 60% of the land in the proposed Waima Management Area is in private residential property, while the remainder is regional parkland[1], local reserves and Watercare-owned land. The Trust's proposed initiatives will set up and implement biosecurity management and biodiversity monitoring on private land, integrated with Council programmes, to create a legacy of substantively improved forest ecosystem health and an effective administrative body for long-term management within the Little Muddy Creek catchment.

In our assessment, the benefits of the proposed compensation meet or exceed the "High" overall level of effect. We consider that the 'magnitude' of benefit is "High", as we anticipate the return and/ or range expansion of suppressed biota as a result of the proposed management, along with improved forest condition, regeneration processes and habitat values within the managed forest areas. The ecological value of the receiver catchment is comparable to the impact site and therefore 'very high'.

A package is proposed for the residual freshwater ecological effects that encompasses both the creation of a stream diversion channel to mitigate on-site effects of the loss of a length of intermittent stream, and daylighting of culverted components of a small tributary of the Armstromg Stream.

In our estimation, these positive effects on the environment will more than compensate for the loss of forest extent, and associated impacts on connectivity which are the key residual adverse effects arising from the Replacement WTP development.

[1] The Waitakere Ranges Regional Park covers some 17,000ha, or around 60 per cent of the heritage area (Auckland Council 2018).

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1.0 Introduction

1.1 Background

Watercare Services Limited (Watercare) is responsible for the treatment and supply of potable water and for the collection, treatment and disposal of wastewater to around 1.5 million people in Auckland. Watercare is a Council Controlled Organisation (CCO), wholly owned by the Auckland Council.

Watercare operates five dams within the Waitākere Ranges, including the Upper and Lower Huia Dams and the Upper and Lower Nihotupu Dams. Water from these western water supply dams is treated at the Huia and Waitākere Water Treatment Plants before being distributed via the water transmission network, primarily to west and north Auckland. The Huia Water Treatment Plant (Huia WTP) is the third largest water treatment plant in Auckland and is a crucial component of Auckland's water supply network, treating approximately 20% of Auckland's water.

The Huia WTP was constructed in 1929 and is now nearing the end of its operational life (90 years old). Watercare therefore proposes to construct a new WTP to replace the aging Huia WTP. As part of this project Watercare is also proposing to construct two treated water reservoirs (50ML total capacity) to increase treated water storage within the western supply zone.

This report has been prepared to assess the effects of the proposed works and to accompany the regional resource consent application and/or outline plan of works in relation to the proposed construction and operation of the WTP and reservoirs.

1.2 Project Description

The replacement WTP will be constructed on the corner of Manuka Road and Woodlands Park Road directly across from the existing Huia WTP site. The replacement WTP will have a treatment capacity of 140 mega-litres per day (MLD). A new 25ML treated water reservoir will be located on the northern side of Woodlands Park Road (Reservoir 1), with another 25ML reservoir (Reservoir 2) subsequently constructed on the existing Huia WTP site once the existing plant has been decommissioned. The proposed works also includes construction of the North Harbour 2 watermain (NH2) valve chamber and tunnelling reception shaft within the Reservoir 1 site. Further details are provided in "Huia Replacement WTP Assessment of Environmental Effects Report prepared by Tonkin + Taylor Ltd (May 2019).

1.3 Site Description

The project is located on land owned by Watercare and is designated in the Auckland Unitary Plan (AUP) for 'Water supply purposes – water treatment plants and associated structures' (designation reference 9324 – Huia and Nihotupu Water Treatment Plants). The project spans three sites owned by Watercare which have a total site area of 15 ha. The land parcel on which the proposed replacement Huia WTP is located has an area of approximately 4.2 ha, the proposed Reservoir 1 land parcel is approximately 6.4 ha, and the existing WTP site (within which Reservoir 2 is proposed) is approximately 4.0 ha.

The replacement Huia WTP is proposed to be located adjacent to the existing Huia WTP site on the corner of Woodlands Park Road and Manuka Road. The first 25ML reservoir (Reservoir 1) will be located on the northern side of Woodlands Park Road below Exhibition Drive directly across from the existing Huia WTP. The second 25ML reservoir (Reservoir 2) will be located on the existing Huia WTP sites. The sites are all accessed from Woodlands Park Road. These three sites are collectively referred to as “the project site”.

The project site is located approximately 1 km from Titirangi Village and approximately 1.5 km north of the closest reach of the Manukau Harbour. The project site is predominately surrounded by residential (large lot) zones in all directions other than to the south-east of the proposed WTP site which adjoins land zoned Open Space – Conservation and designated by Auckland Council for Regional Park purposes.

The replacement WTP site slopes gently from the Woodlands Park Road to the south with gullies located at the southern boundary running north to south. The eastern extent of this site features steep slopes which rise up towards Scenic Drive. A section of the Yorke Gully Stream traverses the south eastern part of the replacement WTP site and a small tributary of the Armstrong Gully Stream is located in the north-western corner of the site.

The Reservoir 1 site is relatively hummocky with a knoll located in the middle of the site near the southern boundary, and a small gully feature (Armstrong Gully) runs through the site. Extremely steep slopes are present along the northern boundary beneath and above Exhibition Drive. A permanent section of Armstrong Gully stream is located to the west of Reservoir 1.

The existing WTP site where Reservoir 2 will be located has been developed as a WTP for the last 90 years. The site has a generally moderate to steep slope towards the south, with very steep slopes along the eastern and southern site boundaries. The Armstrong Gully watercourses are piped beneath the centre of the site, discharging into an open channel near the southern boundary. A small tributary of the Armstrong Gully Stream extends from the replacement WTP site into the north-eastern corner of the existing Huia WTP site.

Both the WTP and Reservoir 1 sites are almost completely vegetated in native bush, while the existing WTP site is approximately half vegetated in native bush with the remainder developed as part of the existing Huia WTP. The sites are identified as part of an extensive Significant Ecological Area (SEA_T_5539) in the AUP that essentially extends across the entire Waitakere Ranges.

1.4 Scope and Layout of the Report

The purpose of this report is to:

- describe the ecological values present within the 15 ha Project Site selected as the preferred site for the replacement treatment plant (Figure 1);
- assess the ecological effects associated with the proposed WTP development that encompasses a portion of the Project Site, and
- set out proposed measures to avoid, remedy, mitigate or compensate for significant adverse ecological effects.

This report is set our as follows:

Section 1 presents an overview of the project, site and ecological context.

Section 2 identifies the component ecological features within the 15 ha Project Site assessed for this report and sets out the survey and data analysis methodology.

Section 3 presents results of ecological surveys, along with analysis of relative ecological integrity across the Project Site.

Sections 4 and 5 assess overall the values and significance ecological features within the Project Site.

Section 6 describes the extent and type of impact within the Project Site due to the proposed WTP upgrade and assesses the magnitude and level of associated ecological effects.

Section 7 presents the proposed impact management strategy, including measures undertaken to avoid higher value ecological features within the Project Site; remediation and mitigation measures proposed to maintain and enhance ecological features that are retained; and compensation proposed to address significant residual ecological effects.

1.5 Site Context

The Project Site (Figure 1) is located in Waitakere Ecological District, in the peri-urban foothills of the Waitakere Ranges, and within the Waitakere Ranges Heritage Area[2].

The Waitakere Ranges Heritage Area Act 2008 describes the ecological importance of the ranges as follows:

"*The Waitakere Ranges and its foothills and coasts comprise an area of some 27,720 ha of public and private land located between metropolitan Auckland and the west coast of Waitakere City and Rodney District. The area is of local, regional, and national significance. The area is outstanding in northern New Zealand for its terrestrial and aquatic ecosystems, which include large continuous areas of primary and regenerating lowland and coastal rainforest, wetland, and dune systems with intact ecological sequences. The area contains distinctive and outstanding flora, fauna, and landscapes…The Waitakere Ranges also contribute to metropolitan Auckland's water supply*…"

The Waitakere Ranges are a botanically rich area containing 20% of New Zealand's vascular plant species and 60% of New Zealand fern species. Kauri forest, and kauri, podocarp, broadleaved forest (generally derived from logged kauri forest[3]) largely comprise the mature forest remnants, within a matrix of regenerating kanuka-dominated forest containing emerging kauri rickers and podocarps. Historically kauri forest seems to have been best developed on river terraces, coastal plains and the generally flat flood basalts[4]. Due to historic logging, extensive tracts of mature kauri forest are now largely restricted to hill country in Coromandel, Northland, Great Barrier and Little Barrier Islands, and the Waitākere and Hunua Ranges. The Waitakere Ranges contains approximately 2,500 ha of dense kauri forest as well as many small stands and extensive areas containing individual trees (Hill et al. 2017).

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[2] Waitakere Ranges Heritage Area encompasses 27,700 ha of public and private land between metropolitan Auckland and the coast of the Tasman Sea to the west, from the northern headland of Manukau Harbour to Te Henga.

The Waitākere Ranges Heritage Area Act 2008 (the Act) was put in place to recognise the area's national, regional and local significance and to promote the protection and enhancement of its heritage features for present and future generations. The Act requires any council decisions, documents, policies and regulations or resource consent applications affecting the heritage area to be considered against the Act's objectives. Act intersects with a wide range of other legislation, including designations for Waitākere's water supply network.

[3] Singers et al. 2017

[4] Agathis australis http://nzpcn.org.nz/flora_details.aspx?ID=2047

The Waitākere Ranges ecosystem as a whole is nationally significant as one of the largest areas of coastal and lowland forest with intact sequences remaining in the Auckland Region. Approximately 85% of the 15 ha Project Site is bush-clad, encompassing 12.6 ha of native forest and scrub that forms a small part of Significant Ecological Area (SEA) T_5539 in the Auckland Unitary Plan Operative in part (AUP). This SEA encompasses approximately 24,000 ha of predominantly indigenous forest across the Waitakere Ranges (excluding cleared and developed parts such as roads, residential houses, gardens and recreation areas, rural farmland etc.) that extends from the remote western coastline to the rural and suburban foothills in the north and east. Approximately 17,000 ha of indigenous vegetation and habitat within SEA_T_5539 is managed as regional parkland. Forest ecosystems characteristic of the Waitakere Ranges including kauri podocarp forest and regenerating secondary forest are dominant in the site, and representative freshwater habitats are also present.

Forest cover throughout the Waitakere Ranges is mainly secondary regeneration, interspersed with remnant patches of old-growth kauri, podocarp and broadleaf forest mosaics. This vegetation pattern is the product of extensive, predominantly post-colonial resource exploitation and human settlement. Timber exports from harvest of accessible coastal forest commenced in 1836, while large-scale forestry occurred between 1840 – 1870. Substantial areas were subsequently cleared and farmed, though Auckland City Council acquired and retired much of the farmland in the central part of the ranges in 1900 for water supply purposes, while much marginal land was allowed to revert to bush due to poor economic returns.

Forest in the foothills of the Ranges provides the ecological connections, linkages and stepping stones for wildlife from the Ranges to the Manukau Harbour and across the Auckland isthmus to the Hauraki Gulf. The Waitakere Ranges are part of the Northwest Wildlink, a corridor of interlinking habitat between the Ranges and the Hauraki Gulf Islands.

The vegetation within the Project Site reflects the history of forest clearance and milling throughout the Ranges generally (c.f. Esler 2006), and includes remnant kauri, podocarp-broadleaved forest and large areas of regenerating forest and shrubland. Historical aerial photographs (Figure 2) show that a substantial portion of the Project Site was cleared and occupied by houses prior to 1940. Species assemblages differentiate areas that were once inhabited from parts of the site that were fully or partially cleared but allowed to revert to bush with minimal subsequent disturbance.

The Project Site is within the parcel of land titled Nihotupu Filter Station property (AC GeoMaps). This land parcel is located within the Little Muddy Creek catchment, which discharges to Manukau Harbour. The existing Huia WTP currently sits within the upper reaches of Armstrong Gully, while the proposed new WTP will primarily be located within the headwaters of the Yorke Gully (left branch). The Yorke Gully receiving environment is located within Waitakere Ranges Regional Parkland, commonly referred to as Clarks Bush. Both of these streams discharge into the Waituna Stream, before discharging into Little Muddy Creek.

Within the local context, the site is connected to and forms a linkage with regional parkland to the south (which contains two of the oldest kauri trees in the Auckland region[5]) and west, and to a network of forest patches in the Titirangi-Waima area. Forest is fragmented by roads and urban settlement, but forest canopy cover is dense and characterised by stands of regenerating kauri. The site therefore has an important connecting function within the local context and is part of a wider area of adjoining kauri forest and regional parkland.

[5] Clarks tree and Bishop tree; New Zealand Tree Register 56.

Figure 1:

Figure 2: 1940 (above) and 1959 (below) aerial photographs of the Project Site (source: Auckland Council Geomaps).

2.0 Survey Methods

2.1 Vegetation

2.1.1 Desktop Review

A preliminary assessment of ecological values within the project site had been undertaken as part of the alternative site evaluation process (Tonkin & Taylor 2012, Boffa Miskell 2017), including production of a preliminary vegetation map which was used to stratify sampling for the detailed survey work. Auckland Council's GeoMaps Biodiversity (Current Ecosystems) layer identifies all bush within the Project site and much of the surrounding landscape as WF11 - Kauri podocarp broadleaved forest (as described in Singers 2017[6]). The Project Site is identified as part of SEA_T_5539 which covers much of the forested Waitakere Ranges, however this evaluation is also evidently at a broad scale, as there does not appear to be any specific assessment data for the Project Site. Hence Council's Biodiversity classification and SEA status were primarily of relevance to our overall significance evaluation.

NZ Plant Conservation Network (http://nzpcn.org.nz) data available for the Project Site and its environs were compiled, while members of the Auckland Botanical Society also supplied records of notable species observations for the area.

2.1.2 Recce Plots

Vegetation composition data were collected via recce (reconnaissance plot) surveys of 37 10x10m plots[7] (randomly generated using an algorithm prior to commencing field work), stratified within vegetation types identified on the preliminary vegetation map (Figure 3). Objectives of this assessment were to identify habitats and plant communities present within the project area, including species composition, species abundance and vegetation structure, and to relate vegetation patterns to physical and historic site factors.

Within each plot, the cover-abundance of all species present is assessed in six standard height tiers. Six cover-abundance classes are used (< 1%, 1– 5%, 6–25%, 26–50%, 51–75%, 76–100%). A detailed description of the method is provided in Hurst & Allen (2007).

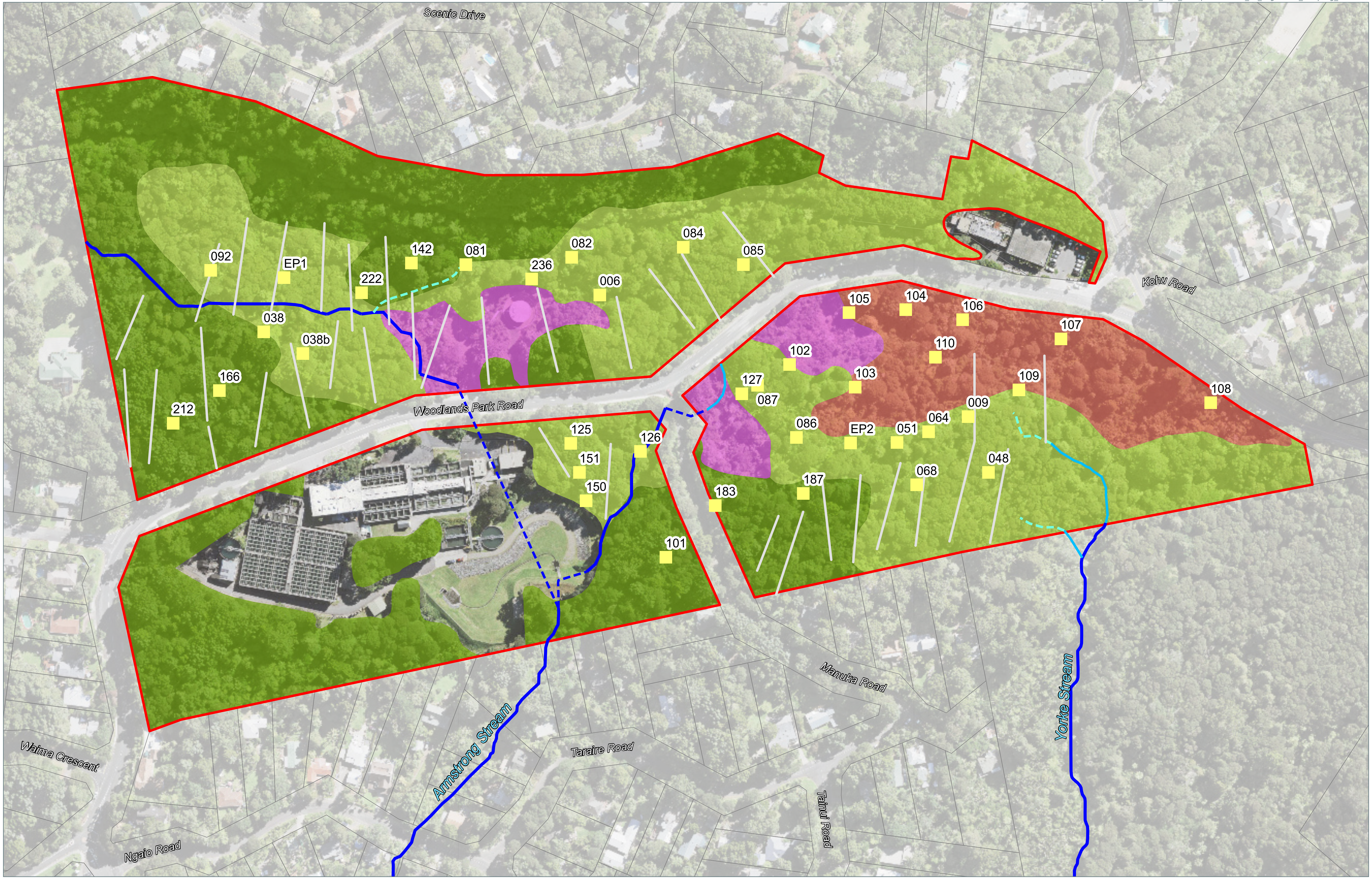
In addition to standard recce data collection, canopy tree species, height, and diameter of all specimens greater than 5 cm DBH[8] were recorded to enable incorporation of plot data into biomass analyses.

[6] Singers et al. 2017 notes (p.11) "*not all sites in the Auckland region support the full species composition described under the 'Characteristic native biota' headings. Regional variability, past disturbance or management may mean that some species are not present at a site. Therefore, some sites in Auckland may be classified as an ecosystem for which the description is not an exact match.*"

[7] The plot size used is the smallest required to sample all species present, so that sufficient numbers of plots will adequately sample the community composition.

[8] Diameter at Breast Height

File Ref: A16055C_Huia_WTP_AEE.aprx/A16055C_03_Vegetation_Sampling_Locations



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0 — 1,000 m
1:2,000 @ A3

Data Sources: Boffa Miskell, GHD, LINZ, Auckland Council

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

- Site Boundary
- Vegetation Plots
- Vegetation Transects

Preliminary Vegetation Types

- Kanuka Forest
- Kauri - Podocarp Forest
- Kanuka Broadleaf Scrub Mosaic
- Modified Scrub

Indicative Streams (Auckland Council Modelled Overland Flow Paths)

- Permanent
- Permanent Piped
- Intermittent
- Ephemeral

A16055 HUIA WTP UPGRADE

Figure 3: Vegetation Sampling Locations

Date: 15 May 2019 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **Rachel.deLambert@boffamiskell.co.nz** | *Drawn:* ATy | *Checked:* SFl

Advantages of the recce survey method are that it is relatively fast and efficient way to collect comprehensive and detailed information on species composition, species abundance and vegetation structure. Cover abundance is better correlated with biomass than plant density per se, and therefore gives a reliable indication of the influence of species in a community. Recce is a useful method when individuals cannot be consistently identified and counted and is better at recording rare species and 'non-structural' life forms compared with other vegetation sampling methods. All species are listed, enabling identification of the distribution of uncommon and rare species.

Assumptions are that the plot size is large enough to capture most or all species present, and that all species present are recorded; and that observer accuracy is similar between sites and over time. Gradient analysis assumes that known / measured site factors (topography, drainage, disturbance history etc.) represent main environmental gradients influencing composition. Limitations of the recce plot method are that cover abundance estimates are somewhat subjective and imprecise, with an unknown level of observer bias, while conspicuous species are likely to be overestimated. Nor does this method provide population density estimates (i.e., numbers of individuals).

2.1.1 Transect Surveys

Canopy trees were surveyed in a series of 33 belt transects across the site to provide additional information on forest structure and composition, including basal area, relative frequency and dominance within mapped vegetation types. Canopy tree species, height, and diameter of all specimens greater than 5 cm DBH were recorded along 50 m x 3 m belt transects, systematically sampled at 20 m intervals across the site (from a random starting point).

We used this information to assist in interpretation of ordination and classification analyses, description of vegetation types and assessment of ecological integrity. Measurements of individual trees also provided information on the age structure of the stand and the relationship between dominance and stem density.

The transect survey method assumes that the precision and accuracy of abundance estimates are not influenced by the selected length, layout or number of transects. Advantages of the transect method are that observer bias is less likely to influence results, as parameters are not subjectively estimated. Limitations are that non-random distribution of sample populations (as is usual for most populations) reduces precision and accuracy of the method. We note that the purpose of transect surveys for this study is primarily descriptive (i.e., no detailed statistical comparisons between experimental sites or treatments are undertaken), nevertheless these limitations are noted in our interpretation of results.

2.1.2 Data Capture and Supplementary Information

Latitudes and longitudes were recorded for plots and transects using an ipad with GPS capability, along with incidental/ ad hoc records of conifers and other large trees, and site features of note. Geographic site data (watercourses and flood-prone areas, historic photographs showing site disturbance history, existing infrastructure) were compiled from information available online at Auckland Council's GeoMaps site. All mapped features were ground-truthed in the field using GPS navigation on an ipad.

A detailed topographic survey of the site was undertaken for the project was used to ascertain physical gradients (slope, elevation, aspect etc.).

The locations of individual trees were recorded using an ipad with GPS capability. We note that these GPS locations were used to inform our assessment of ecological values and ascertain boundaries of the attributes of the site. The GPS capability of an ipad is limited in accuracy to some 5-10 m, especially when used under canopy cover. The project arborist (Greenscene) has used more accurate location methods where precise locations of individual trees were required for design or tree-health assessments.

2.1.3 Data Analysis

Statistical analyses were undertaken using PAST (PAleontological STatistics), a software package developed for executing a range of standard numerical analysis and operations used in quantitative paleontology, earth sciences and ecology.

Classification and ordination were used to analyse recce plot data and describe vegetation patterns. Classification groups plots with similar species composition into distinct associations or communities, while ordination finds hypothetical variables that account for as much of the variance in a data set as possible, derives axes and orders the plots so that compositionally similar plots are close to each other. The distribution of plant communities and the ordination arrangement of plots are compared with the site factors to infer the causes for spatial changes in species composition.

Quantitatively based vegetation classification requires the use of a clustering algorithm. Our classification used UPGMA (Unweighted Pair Group Method with Arithmetic Mean), a simple agglomerative (bottom-up) hierarchical clustering method that is widely used for the classification of sampling units (such as vegetation plots) on the basis of their pairwise similarities in relevant descriptor variables (such as species composition).

Cluster analysis requires a subjective assessment of the ‘logical break point’ where sample groups represent meaningful ecological units. Ordination of the plot data assists in validating potential clusters and provides insight into “diagnostic species” that most strongly influence the groupings. We used Principal Components Analysis (PCA) to generate ordination axes.

Prior to analysis, we weighted cover classes by doubling scores of the top three canopy tiers, recognising the influence of large stature vegetation components on environmental conditions within the stand (microclimate, soil etc.). No other data transformations or exclusions were made.

Stem density and DBH data analyses included calculation of basal area and stem density per transect / plot. The basal area / m^2 of transects was calculated by adding the basal areas ($BA=0.00007854 \times DBH^2$) of all trees in an area and dividing by the area surveyed (150 m^2). Stem density / m^2 was calculated by dividing the number of stems per transect. These figures were standardised to $10m^2$ to enable comparison between plots and transects.

Canopy dominance patterns across the site were derived by identifying the largest tree per 10 m interval along a transect. Results for each transect were summed to give species an overall score between 0 (never dominant) and 5 (always dominant). Patterns of species dominance were plotted on an aerial photograph of the site, using the mid-point of the transect as the location of the summary point.

2.2 Herpetofauna

2.2.1 Desktop Review

Department of Conservation Bioweb Database (Herpetofauna) (30 November 2017) and Auckland Council Lizard records (March 2017) within 20 km of the site were assessed to provide context for lizard fauna recorded within the site and inform an assessment of ecological values for the Project Site.

2.2.2 Survey Site Selection

A preliminary field assessment was carried out on 6 October 2017 to identify prospective areas of suitable lizard habitat. Sample points were generated across the site in GIS using a random number algorithm. Ten survey sites were selected throughout the Project envelope, stratified within areas of suitable habitat, in order to encompass all broadly categorised vegetation and habitat types suitable for lizards.

Potential native frog habitats within the project area were assessed and found to be unsuitable because of sediment deposition or lack of loose refugia.

2.2.3 Sampling Methods

Lizard survey methods included:

- Systematic searching (checking refugia and nocturnal spotlight surveys)
- Live trapping (pitfall traps), and
- Artificial retreats (Onduline boards)

Lizard surveys were used to assess species presence, not to determine relative or absolute density of populations.

Five pitfall traps and five artificial retreats were installed at each survey site (Figure 4). Pitfall traps and artificial retreats were micro-sited next to potential lizard habitats including loose rocks and piles of wood to increase to potential to attract lizards. Geckos were surveyed by roaming spotlight survey, focussing on vegetation edges and incorporating all potential gecko habitat types.

Lizard survey methodology was consistent with techniques described in the DOC Herpetofauna Inventory and Monitoring Toolbox and was carried out under the Wildlife Act Authority number 61087-FAU.

Department of Conservation Bioweb Database (Herpetofauna) and Auckland Council Lizard records within 20 km of the site were assessed to provide context for lizard fauna recorded within the site and inform an assessment of ecological values for the Project Area.

Figure 4: Lizard pitfall trap (left) and artificial refuge (right).

2.2.4 Timing

Lizard surveys were timed to avoid unsuitable weather, including extremely hot and dry weather (December 2017 – February 2018) and scattered rain or cold weather (various). Nocturnal surveys were carried out after sunset between 8 pm and 11 pm on warm, dry nights during spring in consecutive years (October/ November 2017 and November 2018). Pitfall trapping and systematic searching and artificial retreat checks were carried out daily, in the morning from 26 February – 2 March 2018 (Table 1) during a period of fine, warm weather.

***Table 1**: Lizard survey effort, timing and weather conditions.*

Date	Activity	Weather conditions
11/9/17	Pitfall trap and AR setup	n/a
25/10/17	Nocturnal survey (4 person hours)	Calm conditions, light cloud 14°C.
26/10/17	Nocturnal survey (3.5 person hours)	Calm conditions, light cloud 15°C.
7/11/17	Nocturnal survey (4 person hours)	Warm, calm conditions with light cloud.
26/2/18	Check ARs, open pitfall traps	Warm (15-24°C).
27/2/18	Check ARs and pitfall traps	Warm (19-25°C).
28/2/18	Check ARs and pitfall traps	Warm (19-24°C).
1/3/18	Check ARs and pitfall traps	Warm (19-25°C)
2/3/18	Check ARs and pitfall traps. Remove traps.	Warm (19-26°C)
12/11/18	Nocturnal survey (4 person hours)	Warm, calm conditions, ¼ moon
13/11/18	Nocturnal survey (3 person hours)	Warm, calm conditions, ¼ moon

2.3 Bats

2.3.1 Desktop Review

The Waitakere Ranges is key habitat for long-tailed bats in Auckland and multiple bat surveys have been undertaken in the vicinity of the Site. Literature from bat surveys undertaken in the area was reviewed including bat data previously collected by Boffa Miskell. Further data was requested from the Auckland Council fauna database (B Paris 2017, pers. comm., December 22).

2.3.2 Acoustic Survey

The baseline bat survey was undertaken using automatic bat monitors (model ARM v1.2, henceforth referred to as ABM) which passively record both long-tailed bat (40 kHz) and lesser short-tailed bat (28 kHz) echolocation calls on two concurrently operating frequency channels. They operate remotely by recording and storing each echolocation call (bat pass), along with the date and time of occurrence.

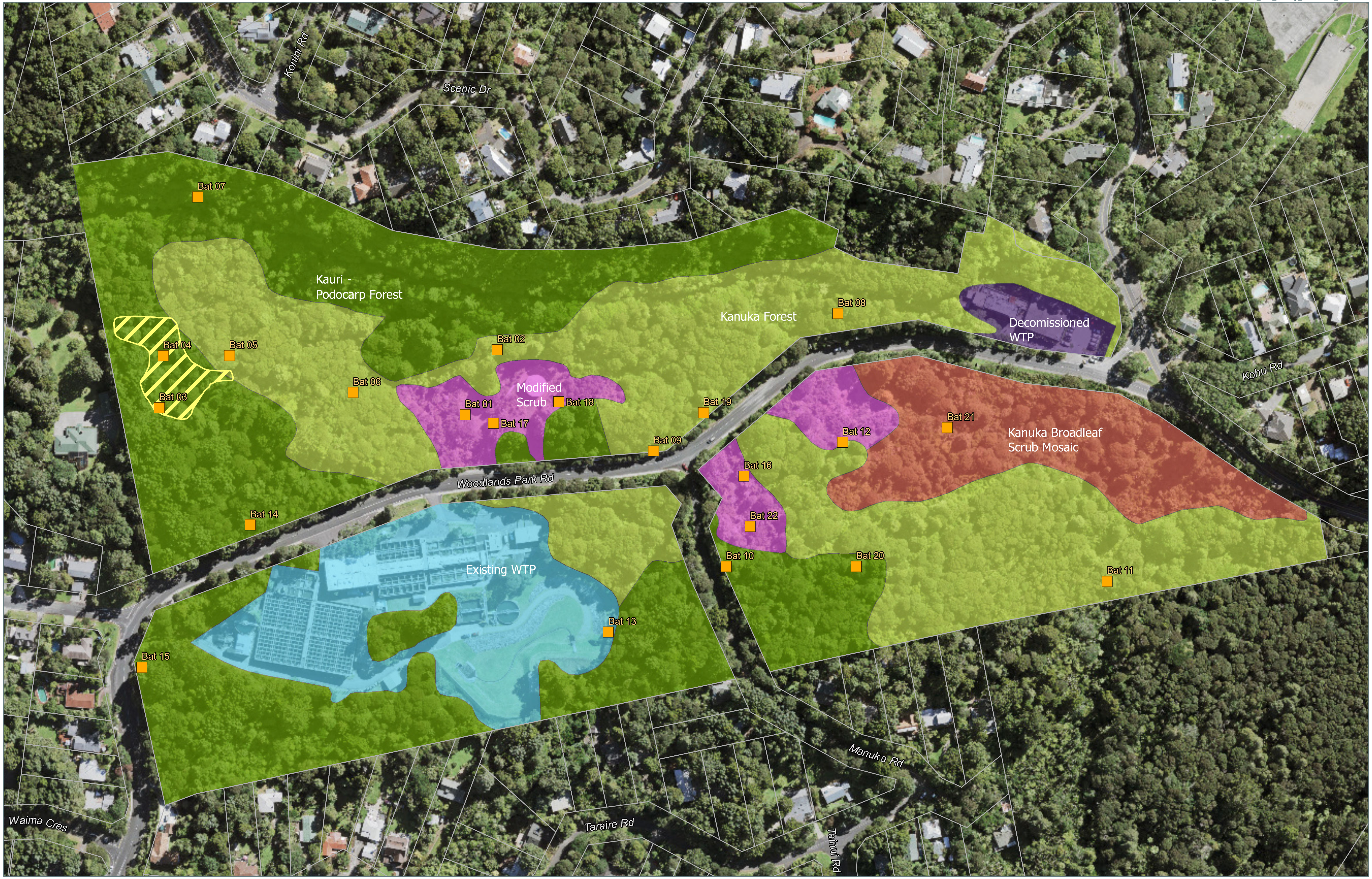
2.3.2.1 Spatial Survey Design

A 100 m by 100 m grid was overlaid on the project area in ArcGIS. From this grid, six transects were created each 100 m apart and acoustic recording devices placed at 100 m intervals along the transects to cover different vegetation types across the site as well as key habitat features used by bats including roads, open areas, watercourses and vegetation edges. This transect layout was used an indicative survey design when deploying the recording devices in the field. However, the final placement of the ABMs was determined by the bat specialist in the field and the survey locations shifted from the proposed grid layout to increase the probability of bat detections by targeting high quality habitat features (Figure 5). The spring 2018 survey targeted large trees likely to be impacted as a result of the proposed works.

Follow-up point and transect surveys with a handheld detector and binoculars were carried out on road edges and the bush interior to resolve the identity of uncertain records. A preliminary walk-over and a subsequent survey paired with an acoustic recorder were undertaken so that the origin of any bat-like sounds registering in real-time on the handheld detector could be identified and compared to the spectrograms produced on the acoustic recorder (deployed over the same interval).

2.3.2.2 Timing

ABMs were deployed during the spring and summer period when pups are young and maternity roosts are occupied. This monitoring period was chosen as during the breeding season, breeding female bats and their dependant young are occupying maternity roosts that generally occur in the most productive habitat within their colony's range (Pryde, O'Donnell, & Barker, 2005). Consequently, if high levels of bat activity are recorded in the project area during this period it is likely the project area is in the vicinity of core habitat for a bat colony. The timing of bat activity can also be analysed to provide an indication of maternity roosts being located in close vicinity to the site. The deployment period of the acoustic recorders was 13 November 2017 – 11 January 2018, with a follow-up survey undertaken from 24 October – 13 November 2018. During the survey intervals, some recorders were redeployed to new locations within the site.



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Data Sources: LINZ Data Service (Aerials, Cadastre), Auckland Council, GHD, Boffa Miskell

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

- Automatic Bat Monitors
- Swamp Area

Vegetation / Existing Use

- Kanuka Forest
- Kauri - Podocarp Forest
- Kanuka Broadleaf Scrub Mosaic
- Modified Scrub
- Existing WTP
- Decomissioned WTP
- Land Parcels

A16055 HUIA WTP ALTERNATIVES ASSESSMENT

Figure 5: Acoustic Bat Survey Locations

Date: 27 February 2019 | Revision: 2

Plan prepared by Boffa Miskell Limited

Project Manager: Rachel.deLambert@boffamiskell.co.nz | *Drawn:* SGa | *Checked:* GCu

Recorders were programmed to record from one hour before sunset to one hour after sunrise each night.

Follow-up transect surveys with hand-held detectors were undertaken on 17 December 2018 (preliminary walkover, from one hour prior to sunset to one hour and 20 minutes after sunset) and on 23 January 2019 (paired with an acoustic recorder) from one hour prior to sunset to 30 minutes post-sunset.

2.3.2.3 Data Analysis

Long-tailed bat activity is influenced by overnight temperatures and rainfall (O'Donnell, 2000). Weather data from the survey period was analysed to ensure conditions were suitable for bats to be active and therefore detectable via acoustic recordings. Suitable conditions are henceforth referred to as 'fine weather nights' and are defined for the purpose of this report as nights where the temperature was above 10°C at sunset and there was less than 5 mm of rainfall during the night.

Acoustic data from fine weather nights was analysed using BatSearch 3.12, a programme designed by the Department of Conservation.

2.4 Birds

2.4.1 Desktop Review

New Zealand Bird Atlas data (OSNZ 2007, derived from surveys undertaken in 1999-2004) was obtained for the 10 km x 10 km "square" within which the project area is located, and 5MBC data collected by Auckland Council from nine locations within the Waitakere Ranges over the December – January 2017/18 survey interval as part of Council's Operation Forestsave monitoring programme (data supplied by Tim Lovegrove, Auckland Council). This data was used to compare species composition and relative abundance data from a range of habitat types across the Waitakere Ranges with the same data from within the Proposed Project Site (collected during the BML survey).

2.4.2 Five-Minute Bird Counts and Incidental Observations

Five-minute bird counts 5MBCs were carried out at eight locations across the site (Figure 6). The locations for individual 5MBCs were chosen to ensure a representative sample of habitats present was surveyed, with the assistance of the preliminary map of vegetation communities and site walkovers prior to commencement of surveys. Six individual 5MBCs were carried out at each site giving a total of 48 5MBCs undertaken during the site survey. The 5MBCs were carried out over three separate days (07/12/2017; 12/12/2017 and 21/12/2017) within a two-week period in December 2017, during which each of the eight sites was sampled twice.

The 5MBCs consisted of recording all bird species seen and/or heard during the count period (Dawson & Bull 1975). Individual birds were recorded once; the first time they were seen or heard. Counts began no earlier than 1.5 hours after sunrise and ended no later than 1.5 hours before dusk and avoided busy 'commuting' times (7:30 am to 8:30 am and 4:30 pm to 5:30 pm) to reduce the level of noise interference from traffic. Each count lasted five minutes and was preceded by a five-minute stand down period to allow activity to settle following observer arrival. To limit observer variability all counts were carried out by the same person and counts were on days with similar weather conditions with wet and windy conditions avoided. Individual locations for 5MBC are generally recommended to be spaced 200 m apart, however, several roads run through the site and so we attempted to balance adequate coverage of the site and vegetation types as well as a small set back from the road edge, and as a result several of the sites were closer than this.

All bird species heard or seen during 5MBCs as well as any bird species of note that were heard or seen incidentally during the course of the site survey were recorded. Binoculars (Bushnell 10 × magnification, 42 mm objective lens) were used to identify bird species during 5MBCs and incidental observations during the site survey.

In the event that any 'At Risk' or 'Threatened' species were recorded at the site, additional, species specific monitoring techniques (e.g. call playbacks) were to be utilised.

2.4.3 Acoustic Monitoring

Acoustic surveys are widely used to sample avian communities for ecological research (Shonefield & Bayne 2017). Acoustic recording devices (ARDs) were used during these surveys to enhance the potential detection of bird species from 5MBCs undertaken during daylight hours as well as monitoring for nocturnal species. ARDs are most useful when utilised in conjunction with 5MBCs (that involve visual and call identification) as ARDs rely on birds to call or make distinctive wing flapping noises.

Nine ARDs (Version B.2) were set up at the site and spaced between 150 m to 200 m apart and each was attached to a tree out of reach of people. ARDs were programmed to record daily from 7:00 pm until 1:00 am and then from 5:30 am to 8:30 am and were left in place for 14 consecutive days and nights (07/12/2017 to 21/12/2017). Night time monitoring enabled nocturnal species to be identified whilst the early morning and evening monitoring captured the dawn chorus and crepuscular activity. Acoustic files were analysed using the software package RavenLite (Version 2.0) and the location and species of all detected birds was recorded.

Vegetation data collected during the BML surveys was used to identify seasonal food sources and maximise the potential to detect wide-ranging and transient species that may be visiting the site for specific resources like fruiting or flowering trees or cavities in mature trees. These points were then targeted using ARDs and two ARDS were deployed for eight consecutive days (05/04/2018 to 13/04/2018). These two ARDs were deployed adjacent to two large fruiting puriri trees within the Proposed Project Site (refer Figure 6) and the setup and recording intervals were identical to those deployed from 07/12/2017 to 21/12/2017.

2.4.4 Data Analysis

Analysis of 5MBCs involved calculating the average number of each bird species recorded (seen and/or heard) per 5MBC station over the six count periods. The average number of birds per species for each 5MBC station was graphed (with error bars) to determine variability within the site. The average number of each species recorded across the entire site over the six count periods was compared with 5MBC data collected by Auckland Council from nine locations within the Waitakere Ranges (Figure 7). Each of the nine Auckland Council monitoring lines consisted of 15 individual 5MBC sites. Each count station had a radius of 100 m and all birds seen and heard were counted, including within the column of air above. Stations were 200 m apart.

File Ref: A16055_50_5_Minute_Bird_Counts_v1.mxd

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0 25 50 m
1:2,000 @ A3

Data Sources: LINZ Data Service (Aerials, Cadastre), Auckland Council, GHD, Boffa Miskell
Projection: NZGD 2000 New Zealand Transverse Mercator

Legend
- 5 Minute Bird Counts
- Acoustic Recording Devices - Deployed Dec 17
- Acoustic Recording Devices - Deployed Apr 18
- Site Boundary

Vegetation / Existing Use
- Kanuka Forest
- Kauri - Podocarp Forest
- Kanuka Broadleaf Scrub Mosaic
- Modified Scrub
- Existing WTP
- Decomissioned WTP

A16055 HUIA WTP ALTERNATIVES ASSESSMENT

Figure 6: Bird survey points - 5MBC and ARD Locations

Date: 16 April 2018 | Revision: 0
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Project Manager: Rachel.deLambert@boffamiskell.co.nz | *Drawn:* SGa | *Checked:* LSh

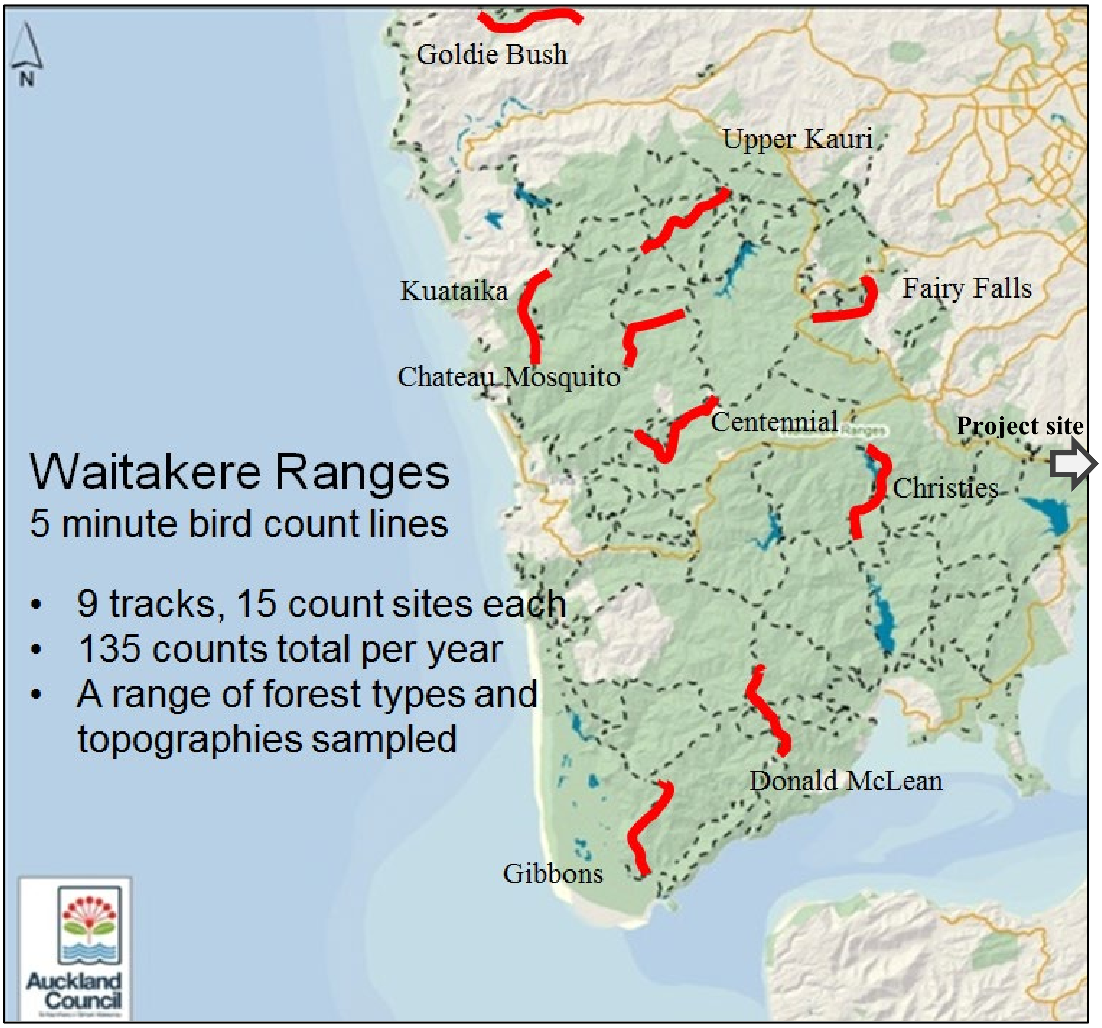

Figure 7: 5MBC data collected by Auckland Council from nine locations within the Waitakere Ranges.

2.5 Invertebrates

Dr Peter Maddison conducted a survey of the invertebrate fauna between July and December 2017 to inform Watercare's consent application, encompassing patches around Scenic Drive, Exhibition Drive, the Huia Aquaduct Track and Manuka road/Clark's Bush Reserve. The complete survey report is included in Appendix 1, while methods and results are summarised in this report.

Invertebrate surveys sampled soil, litter and ground level faunal elements, as these components are directly associated with the subject site, whereas the influence of the surrounding landscape is likely to influence the composition of mobile flying insect fauna present.

Sample locations included mature forest within Clark's Bush, along the Huia Aqueduct and in kahikatea-dominated wet forest opposite the existing water treatment plant. Three main sampling methods were used, including pitfall trapping, malaise trapping and litter extraction.

10 pitfall traps per site were laid along a transect in Clark's Bush and along the Huia Aqueduct at 20 m intervals and installed in drier areas in a rough circle around the kahikatea wetland. Samples were collected at monthly intervals.

Two malaise traps were operated for 3 months, in the Clarks Bush and kahikatea forest sites 6 samples were collected in total.

Two leaf litter samples were collected for litter extraction from near the Clark's Bush track entrance, along with two samples from the kahikatea forest site.

All samples were examined under a dissecting microscope (X20) and sorted and recorded by recognisable taxonomic unit (RTU). Identifications were made by reference to existing specimens (e.g. in the National Arthropod Collection) or examination by expert taxonomists or systematists as required.

2.6 Freshwater Ecology

2.6.1 Desktop Review

Prior to any field surveys being undertaken the location of the proposed footprint of works were assessed relative to freshwater habitats. The desktop review informed the type of freshwater habitats that may be encountered. A preliminary site visit was also undertaken at some locations by a BML freshwater ecologist, prior to the formal freshwater survey fieldwork. The Auckland Council GIS platform, overland flow path layers, relevant New Zealand Freshwater Fish Database records, River Environment Classification stream orders and topographic maps were also utilised to inform the ecological value assessment.

2.6.2 Stream Classification

Prior to any formal ecological assessment all watercourses within the proposed footprint of works were assessed for their permanence. This assessment was undertaken in the field by walking the length of all watercourses and was based on the definitions within the Auckland Unitary Plan – Operative in Part[9]. The permanence classification informed the survey site selection.

- [9] River or stream - A continually or intermittently flowing body of fresh water, excluding ephemeral streams, and includes a stream or modified watercourse; but does not include any artificial watercourse (including an irrigation canal, water supply race, canal for the supply of water for electricity power generation, and farm drainage canal except where it is a modified element of a natural drainage system).
- Intermittent stream - Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three of the following criteria:
  a) it has natural pools;
  b) it has a well-defined channel, such that the bed and banks can be distinguished;
  c) it contains surface water more than 48 hours after a rain event which results in stream flow;
  d) rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel;
  e) organic debris resulting from flood can be seen on the floodplain; or
  f) there is evidence of substrate sorting process, including scour and deposition.
- Ephemeral stream - Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream.
- Overland flow path - Low point in terrain, excluding a permanent watercourse or intermittent river or stream, where surface runoff will flow, with an upstream contributing catchment exceeding 4,000m²

Additional streamwalks were undertaken at specific locations to ascertain accurate locations of the stream channel. In these circumstances, streams were located using an iPad with GPS capability. As outlined above, the GPS capability of an iPad is limited in accuracy to some 5-10 m, especially when used under canopy cover. As a result, the stream channels for these specific waterways were ascertained as a best fit from the streamwalks and the overland flow path data. Where works are proposed in close proximity to streams, such as sections of the Armstrong Stream, land survey data was used to provide a greater degree of stream alignment accuracy.

2.6.3 Habitat Assessment

Ecological values were assessed through a combination of methods. The Auckland Council Stream Ecological Valuation methodology, an Auckland Regional Council Habitat Assessment methodology and visual assessments were utilised across the different reaches.

Basic stream attributes were recorded for all watercourses while the stream permanence assessment was being undertaken. Stream attributes recorded included the following:

- Channel and bank habitat
- In-stream habitat
- Riparian habitat

Full habitat assessments were undertaken at selected permanent and intermittent stream sites. These full habitat assessments were predominantly in the form of Auckland Council Stream Ecological Valuation (SEV) Assessment Methodology as outlined in Auckland Council (2011). However, some sites were unsuitable for the SEV methodology and instead an assessment based upon an Auckland Regional Council habitat assessment methodology were undertaken (see Appendix 2).

Fish and macroinvertebrate communities were assessed at three sites. Fish communities were surveyed through electric fishing and the use of a NIWA backpack mounted EFM300 electric fishing machine and following standard protocols as outlined in the New Zealand Freshwater Fish Sampling Protocols (Joy et al. 2013). These protocols recommend that a length of 150 m is fished in order detect >90% of the fish species present within the reach. Fishing this length of stream was not practical for this assessment, and a reach of 50 m was fished at each site. This reach matched the reach for the habitat assessment.

Macroinvertebrates were collected and processed in accordance with national standard protocols C1 and/or C2 and P3 as described in Stark et al. (2001).

2.6.4 Stream Ecological Valuation

The SEV is recommended by Auckland Council for providing an ecological valuation of stream functionality. The SEV uses a set of fourteen qualitative and quantitative variables to assess the integrity of stream ecological functions (Table 2; Auckland Council 2011). Field work consists of a comprehensive assessment of the in-stream and riparian environment. This includes a fish

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- Artificial watercourse - Constructed watercourses that contain no natural portions from their confluence with a river or stream to their headwaters. Includes; canals that supply water to electricity power generation plants; farm drainage canals; irrigation canals; and water supply races but excludes naturally occurring watercourses.

survey, aquatic macroinvertebrate sampling and cross-sections of the stream to measure width, depth and substrate, as well as using qualitative parameters for reach-scale attributes.

The SEV methodology recommends that a stream reach (or length) of 20 times the average stream width is surveyed, with a minimum length of 50 m recommended. A length of 50 m was surveyed at each of the SEV sites.

***Table 2**: Summary of 14 ecological functions used to calculate the SEV score (Auckland Council 2011).*

Hydraulic functions:	Biogeochemical functions:
Processes associated with water storage, movement and transport. Natural flow regime Floodplain effectiveness Connectivity for species migrations Natural connectivity to groundwater	Relates to the processing of minerals, particulates and water chemistry. Water temperature control Dissolved oxygen levels maintained Organic matter input In-stream particle retention Decontamination of pollutants
Habitat provision:	Biotic functions:
The types, amount and quality of habitats that the stream reach provides for flora and fauna. Fish spawning habitat Habitat for aquatic fauna	The occurrences of diverse populations of native plants and animals that would normally be associated with the stream reach. Fish fauna intact Invertebrate fauna intact Riparian vegetation intact

This data is analysed using a series of formulae in order to produce an SEV score of between 0-1, where a 0 is a stream with no ecological functionality and 1 is a pristine stream with maximum ecological function. Accepted interpretation of SEV scores is provided in Table 3.

***Table 3**: Interpretation of SEV scores (Adopted from Golder Associates, 2009).*

Score	Category
0 - 0.40	Poor
0.41 – 0.60	Moderate
0.61 – 0.80	Good
0.81+	Excellent

The application of the SEV methodology to intermittent streams has recently been tested through field trials, with the suitably of this method confirmed (Auckland Council 2016). The field assessment and variables assessed remains the same for intermittent reaches, with the only change being the reference data within the calculation spreadsheet (Auckland Council 2016). The recommended season for SEV assessments of intermittent streams is between July and October, following a minimum of two months of winter flows.

The field surveys were undertaken on 19 October 2017 (Armstrong_impact), 20 October 2017(Yorke_Project; Yorke_receiving) and 16 November 2017 (Armstrong_receiving). Site Yorke_Project is an intermittent watercourse had almost no surface water present at the time of surveying, with only three very shallow, isolated pools present. A partial SEV assessment was undertaken, with data collected on as many attributes as possible. We note that this date is within the recommended season for sampling intermittent streams, as outlined in the Auckland Council

Technical Report 206/02310. However, owing to the lack of surface water velocity, macroinvertebrate sample and fish surveys were unable to be undertaken.

While it is acknowledged that is not ideal to undertake a partial SEV, it was determined that the two attributes (velocity and depth) could be estimated based on the previous site visit. It was also not practical to wait some six months, or more, until the intermittent channel contained flowing water again. It is self-evident that, as it is an intermittent stream, flows vary seasonally. The assumptive nature of the SEV tool was also acknowledged during the decision making process and it was accepted as suitable to estimate the unmeasurable attributes. We are confident that the estimated attributes are a fair representation of the ecological function of this stream.

The SEV methodology also allows the calculation of mitigation through the use of Environmental Compensation Ratio (ECR), which will inform mitigation options within the AEE.

2.6.5 Biological Indices

Macroinvertebrate Community Index

The Macroinvertebrate Community Index (MCI) score is a biotic index that can be used as an indicator of stream water quality. It relies on the fact that biological communities are a product of their environment – with different organisms having different habitat preferences and pollution tolerances (Stark & Maxed 2007). The MCI involves assigning tolerance values to all taxa based on their tolerance to pollution. Taxa that are characteristic of pristine conditions score higher than taxa that are found in polluted conditions, where 0.1 is the lowest and 10 is the highest. The final MCI scores are calculated using presence-absence data, with the score range from 0 to 200. The streams with no taxa present a score zero and streams in exceptionally pristine conditions score 200 (Table 4; Stark 1993).

The MCI-sb is a variation of the MCI designed for streams with a predominantly soft substrate (soft bottom), with adjusted taxa tolerance values. The MCI-sb is analogous with the MCI and either score may be used depending on the stream habitat.

***Table 4**: MCI score interpretations (Stark & Maxted 2007).*

Quality Class	Descriptions	MCI or MCI-sb Score
Excellent	Clean Water	>119
Good	Doubtful quality or possible mild pollution	100 - 119
Fair	Probably moderate pollution	80-99
Poor	Probably severe pollution	<80

Other Indices

Taxa richness and EPT taxa richness was also calculated for each site at which a macroinvertebrate sample was collected. Taxa richness is a count of the total number of different taxa present at each site. EPT taxa refers to the number of taxa present from within three pollution-sensitive orders of insects; Ephemeroptera (mayflies), Plecoptera (stoneflies) and

[10] Neale, M.W., Storey, R.G., Quinn, J.L. 2016. Stream Ecological Valuation: Application to intermittent streams. Prepared by Golder Associates (NZ) Limited for Auckland Council. Auckland Council technical report, TR2016/023.

Trichoptera (caddisflies). The purse-caddisfly species Oxyethira and Paroxyethira will be excluded from EPT calculations as they are considered to be generally pollution tolerant.

Fish Index of Biotic Integrity, or Fish IBI, is calculated for use within the SEV calculator. The Fish IBI is a measure of how intact the native fish community is within a stream reach or stream. Utilising a number of metrics including altitude and distance inland, and a large background of data from sites across Auckland, a number of between zero and sixty is calculated (Table 5; Storey et al. 2011).

Table 5: *Attributes and suggested integrity classes for the Auckland Fish IBI (Storey et al.. 2011).*

Total IBI Score	Integrity Class	Attributes
50–60	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the stream position are present. Site is above the 97th percentile of Auckland sites
43 –49	Very Good	Site is above the 90th percentile of all Auckland sites species richness is slightly less then best for the region
36–42	Good	Site is above the 70th percentile of Auckland sites but species richness and habitat or migratory access reduced some signs of stress
28–35	Fair	Score is just above average, but species richness is significantly reduced habitat and or access impaired
18–27	Poor	Site is less than average for Auckland region IBI scores, less than the 50th percentile, thus species richness and or habitat are severely impacted
6–17	Very Poor	Site is impacted or migratory access almost non-existent
0	No Fish	Site is grossly impacted or access non-existent

3.0 Results and Interpretation

3.1 Vegetation Communities

3.1.1 Classification and Ordination

A total of 87 native vascular plant species were recorded during the vegetation survey (Appendix 3), comprising 7 gymnosperm tree species, 20 fern species, 40 trees and shrubs, 9 climbers and epiphytes and 11 herbaceous plants.

Hierarchical cluster analysis (UPGMA) of recce plot species assemblage data identified six groups of plots (Table 6, Figure 8[11]), based on species assemblages.

***Table 6**: UPGMA Classification groupings*

Group name[12]	Colour	Assemblage characteristics
i. Kauri forest	indigo	Kauri dominant, with common mamangi and matipo; tanekaha, ponga, kohekohe, pigeonwood, rimu and rewarewa are usually present.
ii. Kanuka-mamangi forest	red	Kanuka dominates the canopy, with common mamangi, matipo, kohekohe and ponga.
iii. Kanuka – (kahikatea) forest	turquoise	Kanuka dominates the canopy, interspersed with mature kahikatea. Ponga, mahoe, nikau and kohekohe are common, while a variety of broadleaved subcanopy species including tree fuchsia, pate, hoheria and mamangi are present at low abundances.
iv. Kanuka/ mahoe forest	magenta	Kanuka dominates the canopy, interspersed with mahoe, treeferns, nikau and secondary broadleaved species (most commonly pigeonwood and pate, with patchy mamangi, young karaka and kohekohe). Kawakawa, hangehange, mahoe and ponga form a fairly continuous understorey, and ground ferns are common. A few remnant kahikatea are locally present, but conifers are otherwise absent from this group of plots.
v. (Kanuka)/ mixed scrub	yellow	Mahoe, ponga and *Bartlettina* form a low canopy beneath a patchy emergent tier of kanuka. Common native shrubs include kawakawa, hangehange, pate and nikau, while kahili ginger and climbing asparagus are ubiquitous. A variety of other 'garden escape' weed species occur in this group of plots.
vi. Mahoe scrub	green	Mahoe dominates this assemblage, while kanuka is sparse or absent. Nikau, hangehange, Kahili ginger and climbing asparagus are common to locally abundant, while kohekohe and Tradescantia are patchily present. A variety of 'garden escape' weed species occur in this group of plots.

[11] Fig. 8 shows cluster analysis groupings overlaid on the final vegetation map to enable comparison of sample point data with the overall findings. Note that differences between the two layers arise as the vegetation map also takes into account transect survey data (refer Sections 3.1.2), while vegetation mapping imposes distinct boundaries where communities are not always well defined (refer Section 3.1.3).

[12] Nomenclature follows Atkinson (1985) terminology for structural classes. See Appendix 4.

Kauri forest is the most distinct vegetation type. Assemblages ii-iv described in Table 6 are somewhat related and represent the less modified / more mature secondary forest types within the site. Groups v and vi are distinct from each other, but both comprise modified scrub associations with a substantial component of exotic weeds.

3.1.2 Canopy Dominance and Basal Area

Canopy dominance and basal area were plotted on aerial photographs and compared against UPGMA classifications and historic aerial photographs to validate and refine vegetation community boundaries. Patterns of canopy dominance and basal area for key species are shown in Appendix 5(a – k).

Kanuka is the most common and widespread canopy dominant throughout the site (Appendix 5a) but is notably sparse in areas where kauri is abundant (Appendix 5b, 5f) and in mahoe scrub (Appendix 5c). Patterns of kanuka distribution and size are a helpful guide in delineating the boundaries of the vegetation types.

Mahoe is a clear canopy dominant in the mahoe scrub community and more modified parts of the site and is co-dominant in kanuka / mahoe forest. We infer from comparison with historic aerial photography (refer Figure 2) that abundant mahoe is likely to be associated with relatively recent historic clearance, and / or areas of human settlement.

Kahikatea is a common canopy dominant surrounding the watercourse and floodplain in the north-western quarter of the site (Appendix 5d) but diminishes in both dominance frequency and basal area (Appendix 5g) towards the north-eastern quarter and is infrequently dominant in the south-eastern quarter of the Project Site. The pattern of kahikatea distribution and biomass has led us to separate the kanuka-kahikatea forest class identified using the UPGMA analysis into kanuka forest and kahikatea forest vegetation types.

UPGMA analysis produced a mixed pattern of vegetation classes in the Project Site east of Manuka Road. Basal area plots of podocarps and kauri (Appendix 5f - k) show an assemblage of large conifers in the area immediately adjacent to Manuka Road classed as kauri-podocarp forest, but few large conifers in the forest approximately 100 m eastward of Manuka Road, though this is ostensibly the same vegetation class. Mamangi (an early successional forest tree) is a consistent canopy dominant throughout this area (Appendix 5e) and may indicate that the vegetation pattern reflects a gradient of disturbance, with early and late successional stages of a single ecosystem unit present.

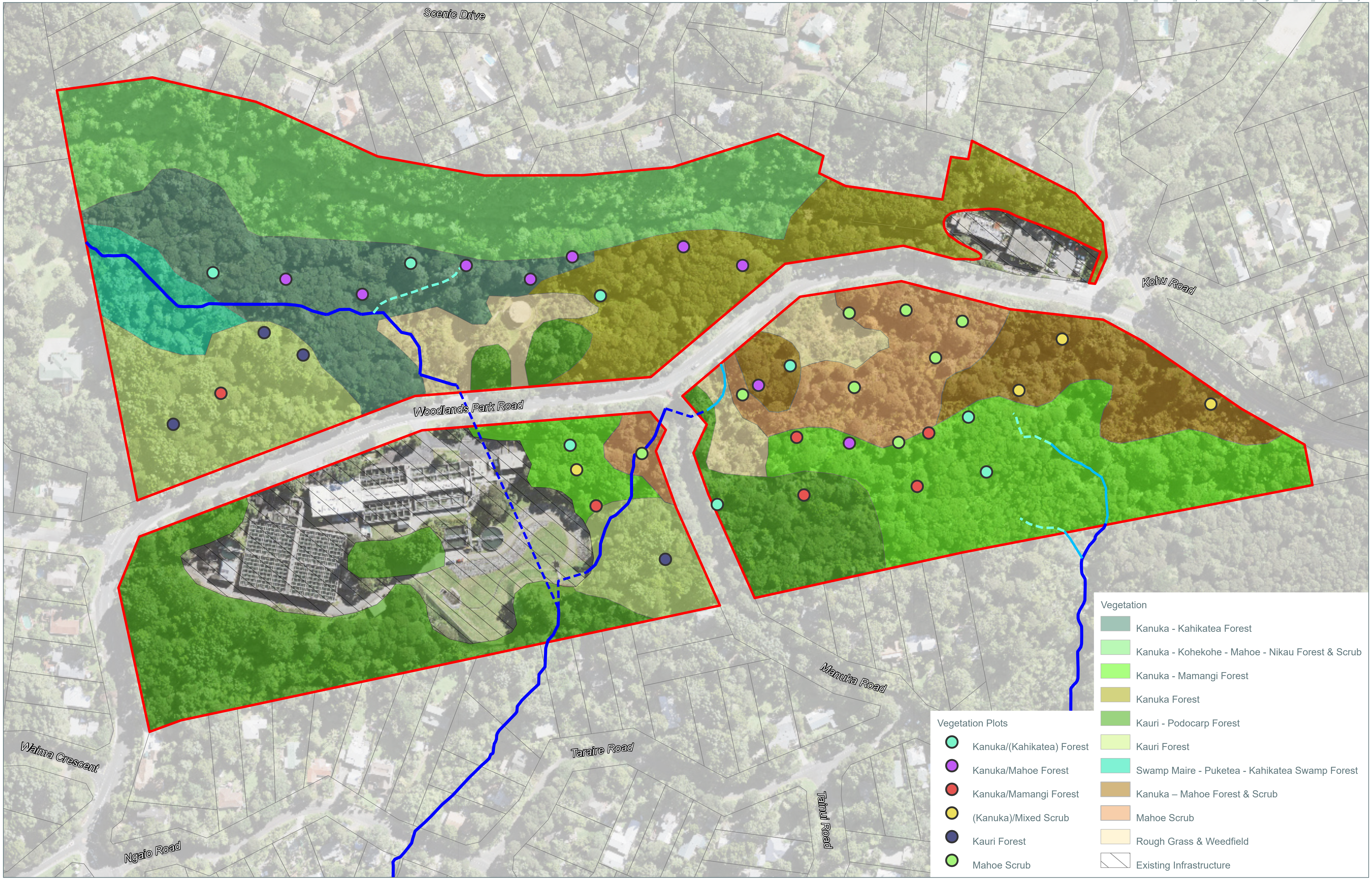
3.1.3 Vegetation Mapping

Vegetation types were delineated using combined results from the UPGMA analysis and transect survey results (Figure 9). As detailed in the previous sections, these datasets generally concur, while transect canopy data helped to clarify some ambiguities in the hierarchical cluster analysis.

The summed extent of each mapped vegetation type (and existing infrastructure) within the Project Site is set out in Table 7.

Due to the disturbance history of the site, vegetation classes do not fully represent the presence and distribution of mature, mid-late successional canopy trees that were retained while the surrounding land was cleared. These trees contribute to habitat complexity and facilitate regeneration of the surrounding bush.

File Ref: A16055C_Huia_WTP_AEE.aprx/A16055C_08_Vegetation_Plot_Cluster_Analysis



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Data Sources: Boffa Miskell, GHD, LINZ, Auckland Council

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

Site Boundary

Streams
- Permanent
- Permanent Piped
- Intermittent
- Ephemeral

A16055 HUIA WTP UPGRADE

Figure 8: Vegetation Plot Cluster Analysis

Date: 15 May 2019 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: Rachel.deLambert@boffamiskell.co.nz | *Drawn:* ATy | *Checked:* SFl

***Table 7**: UPGMA Classification groupings*

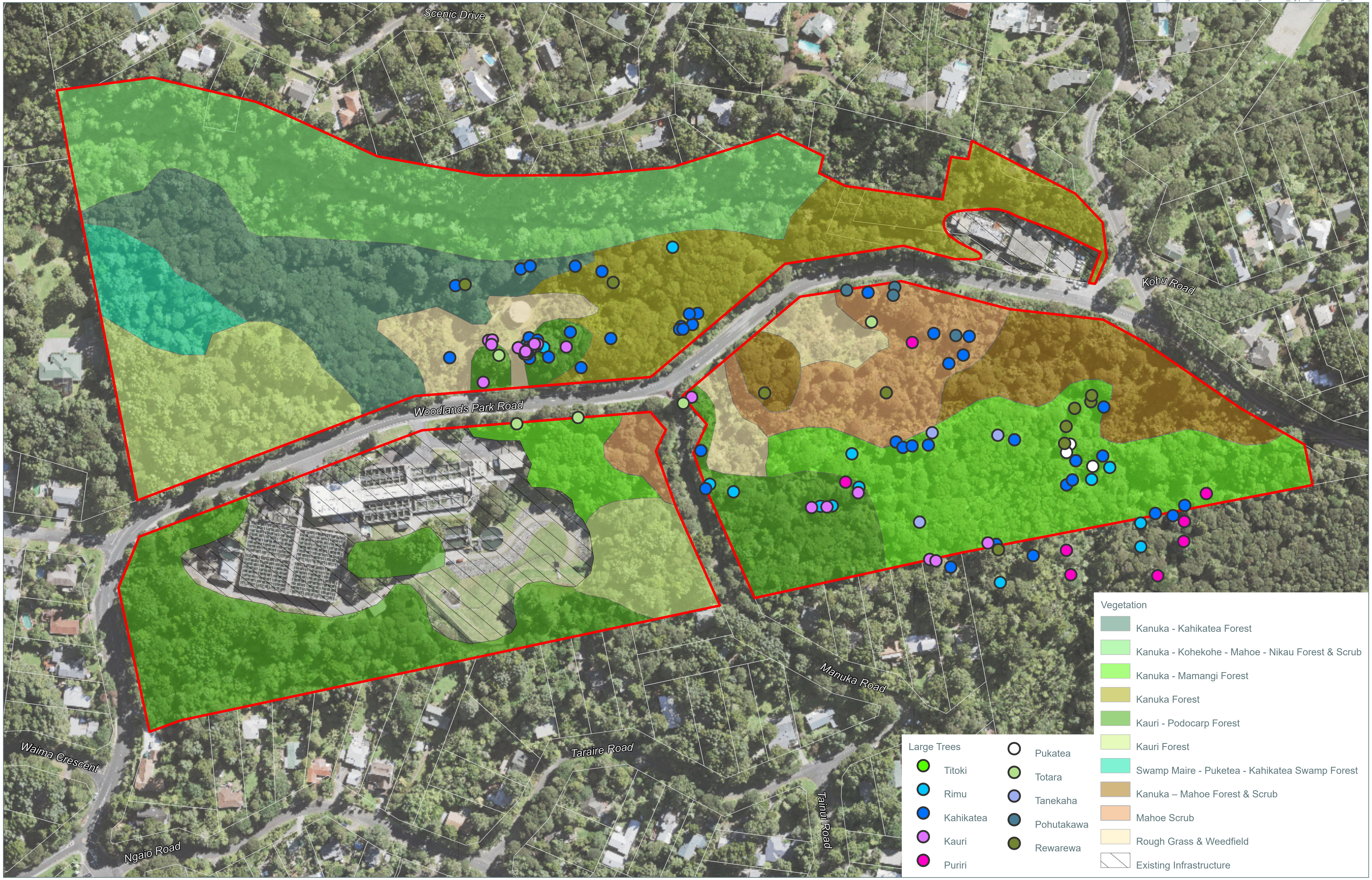
Mapped component	Total extent (ha)
Kauri forest	1.33
Kauri - podocarp forest	2.23
Kanuka - kahikatea forest (on floodplain)	1.12
Kanuka - kohekohe - mahoe - nikau forest & scrub (on escarpment)	2.62
Swamp maire - puketea - kahikatea swamp forest	0.37
Kanuka - mamangi forest	1.95
Kanuka forest	1.23
Kanuka - mahoe forest & scrub	0.86
Mahoe scrub	0.86
Rough grass & weedfield	0.67
Existing infrastructure	1.91
Total	**15.2**

Large canopy trees (>20 cm diameter) encountered within and adjacent to the development footprint during surveys and site walkovers are mapped in Figure 9. Note that this is not a comprehensive survey of all large trees in the Project Site but is confined to potentially affected trees. Early-successional species such as kanuka and mamangi are not mapped as the distribution of these populations are well represented in the vegetation classification, and too numerous to map individually. We included two vegetation types in the vegetation map that were not derived from the vegetation classification or dominance analyses. Maire tawake – pukatea – kahikatea wetland forest was encountered during field surveys (transects intersect this feature) but not sampled using recce plots as this assemblage was delineated using GPS. Areas of grassland and weedfield were not sampled in recce plot surveys but were mapped onto an aerial photograph and ground-truthed during site walkovers.

The vegetation mapping exercise confirms the broad Singers et al. (2017) ecosystem classification of kauri, podocarp, broadleaved forest (WF11 - Endangered), but provides a finer-grained analysis that also identifies the presence of other forest ecosystems including swamp and flood-plain kahikatea forests (WF8 and MF4 – both Critically Endangered), and kauri forest (WF10 - Endangered), along with early and mid-successional stages of forest regeneration. Vegetation types are generally consistent with characteristic forest communities of the Waitakere Ranges.

Anthropogenic modification and disturbance remains a key influence on current vegetation composition, as indicated by species composition, stature, stem density and biomass, along with patterns of weed infestation. Species assemblages also differentiate areas that were once inhabited from parts of the site that were fully or partially cleared but allowed to revert to bush with minimal subsequent disturbance. The more modified parts of the site were inhabited for a period, with dwellings and gardens. The nature of this activity is reflected in the presence of scattered mature kahikatea and other canopy trees amongst areas of modified scrub (refer Figure 9), as well as substantial infestations of ornamental garden escapes (bartlettina, plectranthus, etc.).

Topographic and fertility gradients are evident in the pattern of kauri dominance on ridges & upper slopes, merging into kauri – podocarp forest on more fertile middle and lower slopes. Soil moisture is also a factor in forest composition, with kahikatea emerging as the predominant mature phase species in flood-prone areas, and swamp forest (maire tawake, pukatea and kahikatea) in the permanently wet site on the north-western margin of the project area.



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www.boffamiskell.co.nz

0 1,000 m

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Data Sources: Boffa Miskell, GHD, LINZ, Auckland Council

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

Site Boundary

A16055 HUIA WTP UPGRADE

Figure 9: Vegetation Types & Large Trees

Date: 20 May 2019 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **Rachel.deLambert@boffamiskell.co.nz** | *Drawn:* ATy | *Checked:* SFl

3.1.1 Kauri Dieback

Likely symptoms of kauri dieback were observed on a single large kauri tree within the mature kauri forest stand in the north-western quarter of the Project Site.

Kauri dieback has emerged as a major and significant threat to the future of the Waitakere Ranges Heritage Area's forest ecosystems. Mapping and surveillance (Hill et al. 2017) has established that there are 344 distinct areas of kauri ecosystem within the Waitakere Ranges, and 33.4% of these areas have kauri dieback or possible kauri dieback symptoms present. Kauri dieback zones show a strong association with tracks and watercourses, and human disturbance is generally regarded as a key vector of the disease.

3.1.2 Threatened Ecosystem Types

Mature or well-advanced successional stages of forest ecosystem types described as endangered or critically endangered according to IUCN criteria (Singers et al. 2017) cover approximately 50% of the Project Site as a whole, with secondary forest and scrub communities, cleared areas and existing infrastructure comprising the remainder.

3.1.3 Threatened Plants

The Department of Conservation's most recent revision of the conservation status of New Zealand indigenous vascular plant taxa (de Lange et al. 2018) includes kauri *(Agathis australis)* and all Myrtaceae in the nationally threatened plant list. Kauri, and all *Metrosideros* species recorded within the site including pohutukawa and climbing ratas *(M. diffusa, M. perforata* and *M. carminea),* are now assessed as Threatened – Nationally Vulnerable, while maire tawake *(Syzygium maire)* is now Nationally Critical. Kanuka *Kunzea robusta)* is classified as Nationally Vulnerable, and manuka *(Leptospermum scoparium)* is classified as At Risk.

The inclusion of kauri on the nationally threatened plants list is due to the appearance of Kauri Dieback disease, which is now known to occur in populations of kauri throughout its range (though large portions of kauri forest still appear free of the disease). Large trees and intact examples of kauri forest and kauri, podocarp, broadleaved forest within the Project Site are identified in Figure 9, however individual kauri saplings and seedlings are sparsely scattered throughout the site.

Most new classifications of Myrtaceae as Nationally Vulnerable are a precautionary measure due to the as yet unknown impact of myrtle rust on native species. In particular, de Lange et al. (2018) notes that the classifications for manuka, kanuka and common *Metrosideros* species are Designated, i.e., these abundant and widespread species do not meet standard threat status criteria. Kanuka is abundant throughout the entire site and wider catchment, and climbing ratas are also common, and particularly abundant in more mature vegetation. A few medium-sized pohutukawa (and a pohutukawa – rata hybrid) are present within the Project Site immediately south of Woodlands Park Road (possibly planted as these are in the front yards of dwellings that were formerly present here).

Myrtle rust is a significant threat to maire tawake which has a fragmented distribution due to historic clearance and reclamation of wetland habitat. The maire tawake population within the Project Site is located in maire tawake – pukatea – kahikatea wetland forest (Figure 10).

A mature specimen of *Elaeocarpus hookerianus* (Regionally Critical) was recorded within the Project Site, in the area mapped as kauri-podocarp forest (Figure 10).

File Ref: A16055C_Huia_WTP_AEE.aprx/A16055C_10_Threatened_Plants

Boffa Miskell
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0 1,000 m
1:2,000 @ A3

Data Sources: Boffa Miskell, GHD, LINZ, Auckland Council

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

Site Boundary
Pokaka
Crimson Rata
Swamp Maire

A16055 HUIA WTP UPGRADE

Figure 10: Threatened Plants

Date: 29 March 2019 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **Rachel.deLambert@boffamiskell.co.nz** | *Drawn:* ATy | *Checked:* SFl

3.1.4 Ecological Integrity

Ecological integrity assessment compares the structure, composition, and function of an ecosystem to reference ecosystems operating within natural or historic disturbance regimes. Metrics for assessing ecosystem integrity are increasingly being used in conservation management to enable comparative evaluation of prospective conservation areas, and to assess changes in ecosystem condition (Tierney et al., 2009).

A proper evaluation of ecological integrity requires inventory of reference sites and development of ecosystem-specific metrics, and site assessments would generally be undertaken at a larger scale than that of the Project Site. Nevertheless, the approach of comparing component vegetation communities against a set of metrics that distinguish an impacted, degraded, or depauperate state from a relatively unimpaired, complete, and functioning state is useful to assist decision-making around ecosystem values and priorities for the site.

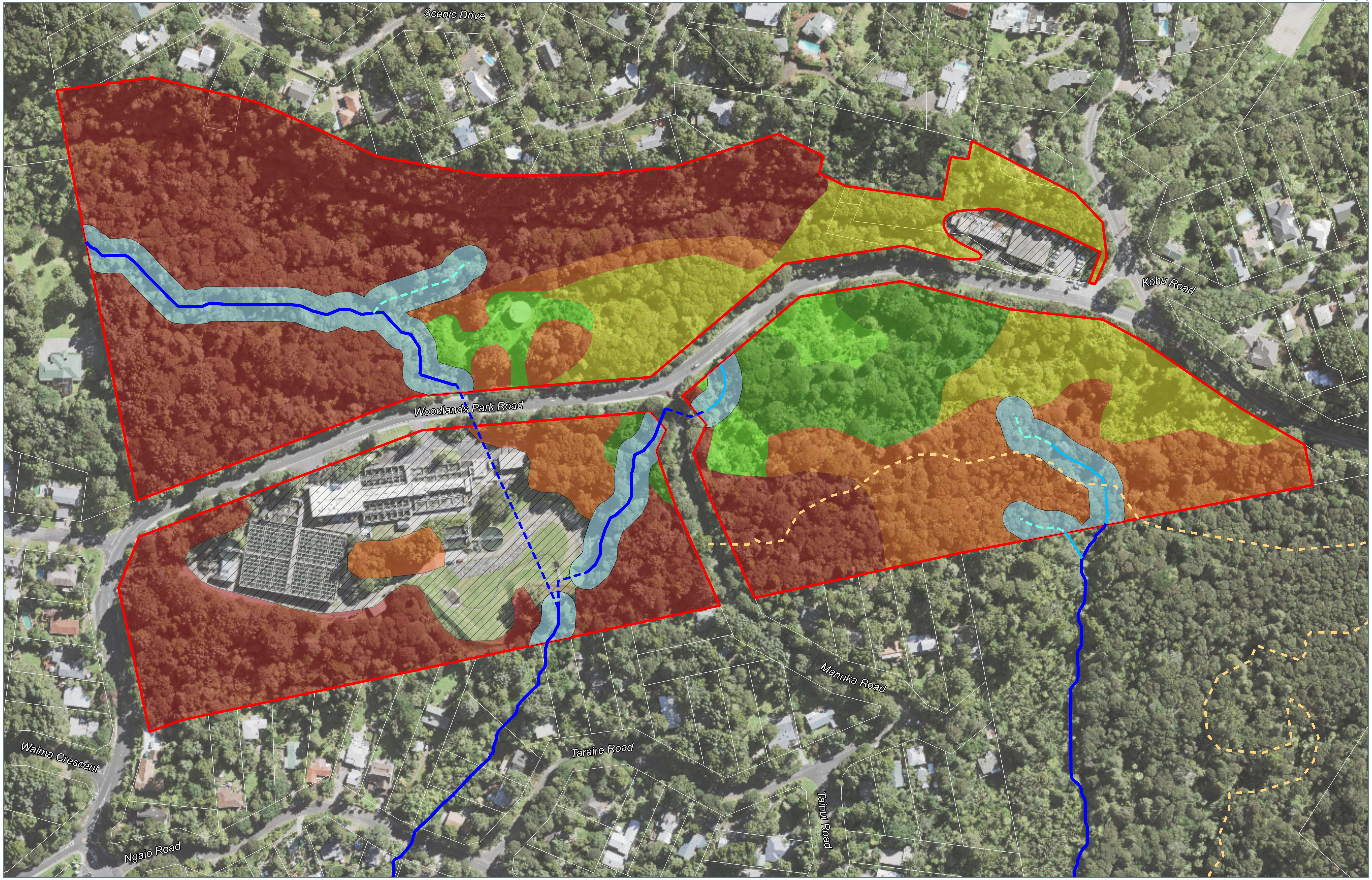
Our evaluation assesses the integrity of vegetation communities present. The purpose of this analysis is to prioritise avoidance of the most intact ecological features. Mature indigenous forest is assumed to be the 'natural state' for the site. Kauri forest plots are used as the model 'reference state' (relatively unmodified old-growth forest) against which other vegetation types are assessed.

Each of the vegetation types identified in Figure 9 are evaluated against a set of factors that describe vegetation structure, condition and composition, and ranked on a 5-point scale from high integrity (red) to low integrity (light green). Factors chosen for evaluation include parameters that can be assessed using plot and transect data. Relative rankings against Ecological Integrity factors for vegetation types within the site are presented in Table 8, and mapped in Figure 11.

Table 8: *Ecological Integrity Analysis*

Ecological Integrity factors	*kauri forest*	*kauri – podocarp forest*	*kahikatea - kanuka forest*	*maire tawake - puketea - kahikatea forest*	*kanuka - mamangi forest*	*kanuka forest*	*kanuka-kohekohe-mahoe - nikau forest & Scrub*	*kanuka - mahoe forest & Scrub*	*mahoe Scrub*	*rough grass & weedfield*
Canopy health/ intactness	Red	Red	Red	Yellow	Red	Red	Orange	Yellow	Yellow	Light green
Vegetation structure (3+ canopy tiers present & distinguishable)	Red	Red	Orange	Red	Orange	Orange	Orange	Yellow	Green	Light green
Regeneration of secondary species	Red	Red	Red	Red	Orange	Orange	Orange	Orange	Orange	Light green
Native species dominance (all tiers)	Red	Orange	Red	Red	Orange	Orange	Orange	Green	Green	Light green
Native species richness and presence of significant flora	Red	Red	Orange	Red	Red	Orange	Orange	Green	Green	Light green
Vegetation biomass	Red	Red	Red	Orange	Orange	Orange	Yellow	Yellow	Yellow	Light green
IUCN threat status	Red	Red	Red	Red	Green	Green	Green	Green	Green	Light green

File Ref: A16055C_Huia_WTP_AEE.aprx/A16055C_11_Ecological_Integrity



Boffa Miskell
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0 — 1,000 m

1:2,000 @ A3

Data Sources: Boffa Miskell, GHD, LINZ, Auckland Council

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

- Site Boundary
- Track

Ecological Integrity
- 1 Highest
- 2
- 3
- 4
- 5 Lowest
- Existing Infrastructure

Stream
- Permanent
- Permanent Piped
- Intermittent
- Ephemeral
- 10 m Stream Buffer

A16055 HUIA WTP UPGRADE

Figure 11: Ecological Integrity

Date: 15 May 2019 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: Rachel.deLambert@boffamiskell.co.nz | *Drawn:* ATy | *Checked:* SFI

3.1.1 Ecological Context

The process of forest fragmentation due to human activities is an important contributing factor to biodiversity decline. Forest fragmentation occurs when a large region of forest is broken down into a collection of smaller patches of forest habitat, resulting in a ‘binary landscape’ composed of spatially dispersed forest fragments with a non-forest matrix between them (Franklin et al.. 2002). Effects of fragmentation on species and communities, locally and at the landscape level, depends on the life history characteristics and behaviour of the species themselves. As a general rule, the outcome of forest fragmentation is modification of forest interior communities, and expansion of disturbance-tolerant species and communities.

In order to provide a landscape scale context for the Project Site, we undertook a simple analysis of the extent and pattern of forest fragmentation within the Little Muddy Creek catchment. Using mapped SEA data, we calculated the edge:interior ratio (m/ ha) within 1 ha grid squares across the catchment, and mapped the results using the ArcGIS Jenks ‘natural breaks’ classification algorithm (Figure 12).

The Little Muddy Creek catchment retains a high proportion of indigenous forest cover, including remnants of old-growth forest, and extensive areas of secondary forest and scrub established following large-scale forest clearance in the mid to late 19^{h} – early 20th century. However, landuse intensification (primarily residential development and associated roading infrastructure), mainly concentrated around ridgelines and coastal headlands, has caused habitat fragmentation throughout the catchment, restricting movements of flightless fauna and increasing the extent of “forest edge” environment (including along Manuka and Woodlands Park Road). Furthermore, development along ridgelines has disproportionately affected older-growth kauri forest remnants, while kanuka forest (interspersed with remnant patches from earlier successional cohorts, containing mature podocarp and broadleaved forest trees) dominates the gully systems and steep escarpments that retain relatively continuous forest cover

The Project Site forms part of a largely intact forested corridor that extends around the head of the catchment (generally defined by Scenic Drive) which connects forest in the Lower Nihotupu Reservoir and Little Muddy Creek catchments. We note that this corridor is not wholly uninterrupted, as Woodlands Park Road and Manuka Road form effective barriers to dispersal for small, flightless fauna such as lizards and many invertebrates. Nevertheless, this expanse of forest is the most complete east-west linkage in the Little Muddy Creek catchment.

The vegetation classification and ecological integrity evaluation identifies a gradient in the quality and condition of the ecosystem within the Project Site and recognises that the more modified parts of the site are primarily of contextual value as buffers and connective linkages to areas of better quality. The Project Site as a whole forms part of a largely intact forested corridor that extends around the head of the catchment which connects forest in the Lower Nihotupu Reservoir and Little Muddy Creek catchments.

3.2 Herpetofauna

Forest and scrub habitats throughout the Little Muddy Creek catchment (and Waitakere Ranges generally) are suitable for native lizards, and a relatively diverse native lizard community has previously been detected in the surrounding catchment. Database records within 10 km of the site included five native terrestrial lizard species (**Table** 9; Figure 13).

File Ref: A16055C_18_Fragmentation_Analysis_Regional_Context_Existing_Scenario.mxd

Boffa Miskell
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0 0.5 1 km
1:25,000 @ A3

Data Sources: LINZ Data Service (Aerials), Auckland Council (SEAs), Boffa Miskell

Projection: NZGD 2000 New Zealand Transverse Mercator

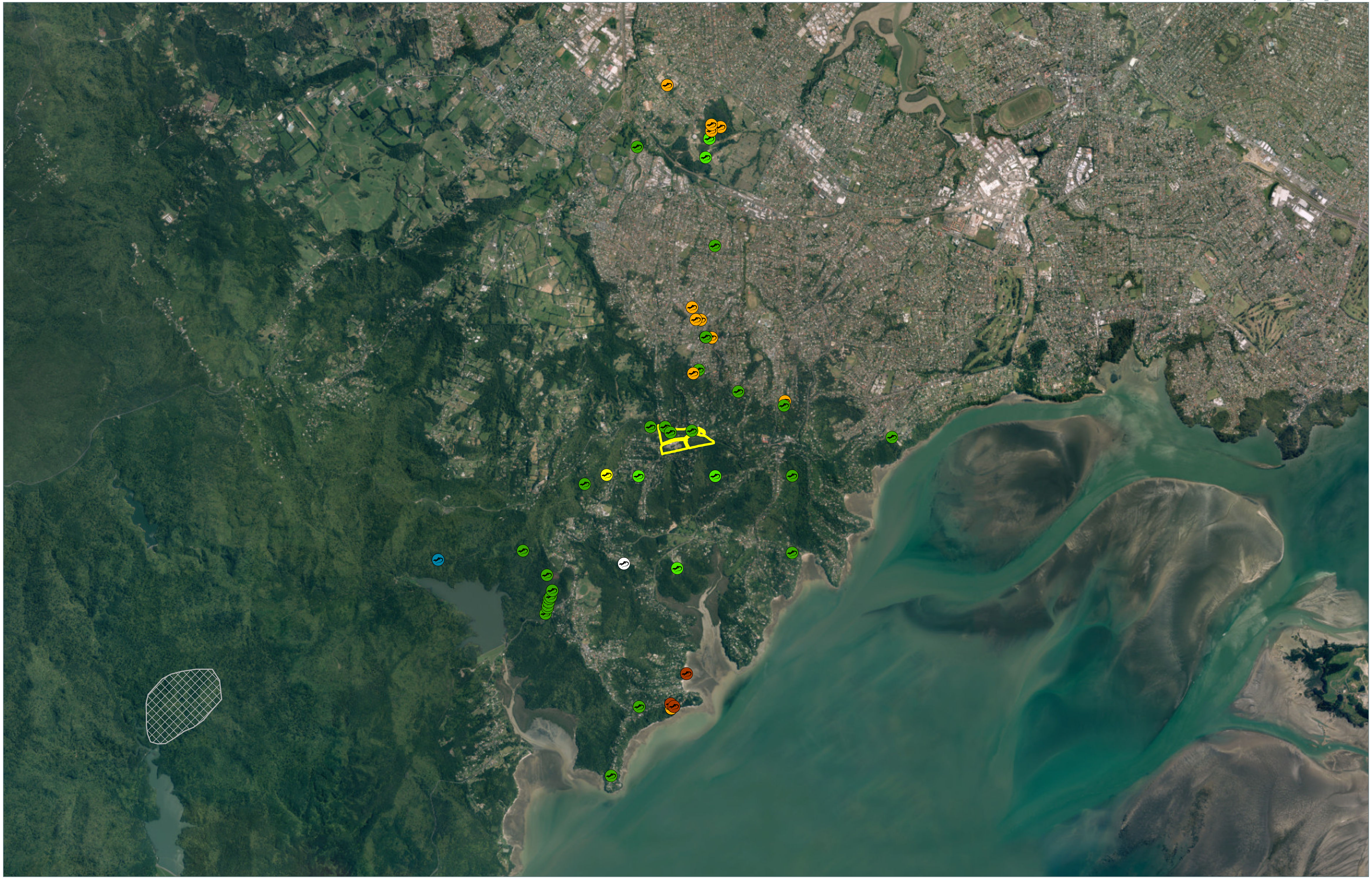
Legend
Site Boundary
AUP SEAs
Fragmentation
Low
High

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Figure 12: Fragmentation Analysis

Date: 2 August 2018 | Revision: 0
Plan prepared by Boffa Miskell Limited
Project Manager: Ian.Boothroyd@boffamiskell.co.nz | *Drawn:* SGa | *Checked:* SFl

File Ref: A16055_56_Fauna_Records.mxd



A16055 HUIA WTP UPGRADE

Figure 13: Fauna Records in Vicinity of Site

Legend

Herpetofauna Records 5 km
- Copper Skink
- Elegant Gecko
- Forest Gecko
- Hochstetter's Frog
- Ornate Skink
- Pacific Gecko
- Striped Skink
- Unidentifed Skink
- WTP Site
- Approximate location of long-tailed bat roosting habitat

0 1 2 Km

1:45,000 @ A3

Data Sources: LINZ Data Service (Aerials, Cadastre), Auckland Council, DOC, Boffa Miskell

Projection: NZGD 2000 New Zealand Transverse Mercator

Boffa Miskell
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Date: 16 April 2018 | Revision: 1
Plan prepared by Boffa Miskell Limited
Project Manager: Rachel.deLambert@boffamiskell.co.nz | *Drawn:* GCu | *Checked:* SFl

The database contains three records of forest gecko along Exhibition Drive in the immediate vicinity of the Project Site.

Habitat within the Project Site is typical of that found elsewhere in the catchment. Hence, there is a reasonable likelihood that lizard species recorded in the wider vicinity are present within the Project Site (and conversely, that observations within the Project site are broadly representative of comparable habitats in the wider catchment).

Table 9: *Lizard records within a 10 km radius of the proposed Huia WTP site.*

Species	No. of records	Threat class
Copper skink (*Oligosoma aeneum*)	11	Not Threatened
Ornate skink (*Oligosoma ornatum*)	3	At Risk - Declining
Striped skink (*Oligosoma striatum*)	1	At Risk - Declining
Elegant gecko (*Naultinus elegans*)	5	At Risk - Declining
Forest gecko (*Mokopirirakau granulatus*)	25	At Risk - Declining

Six copper skinks and one unidentified skink were detected during site surveys (Figure 14). No geckos were detected. Skinks were recorded across the site in a variety of vegetation types, including kauri - podocarp forest, kanuka-mamangi forest, kanuka - kohekohe - mahoe - nikau forest & scrub, kahikatea - kanuka forest and at the edge of mahoe scrub.

Lizards are inherently difficult to detect and monitor in the field, especially where population densities are low due to predation pressure from introduced pests (Anderson et al 2012). Detection rates and diversity of native lizards within the Project Site were both very low, despite the availability of suitable habitat on the site, and the use of an array of survey methods to maximise chances of detection.

3.3 Bats

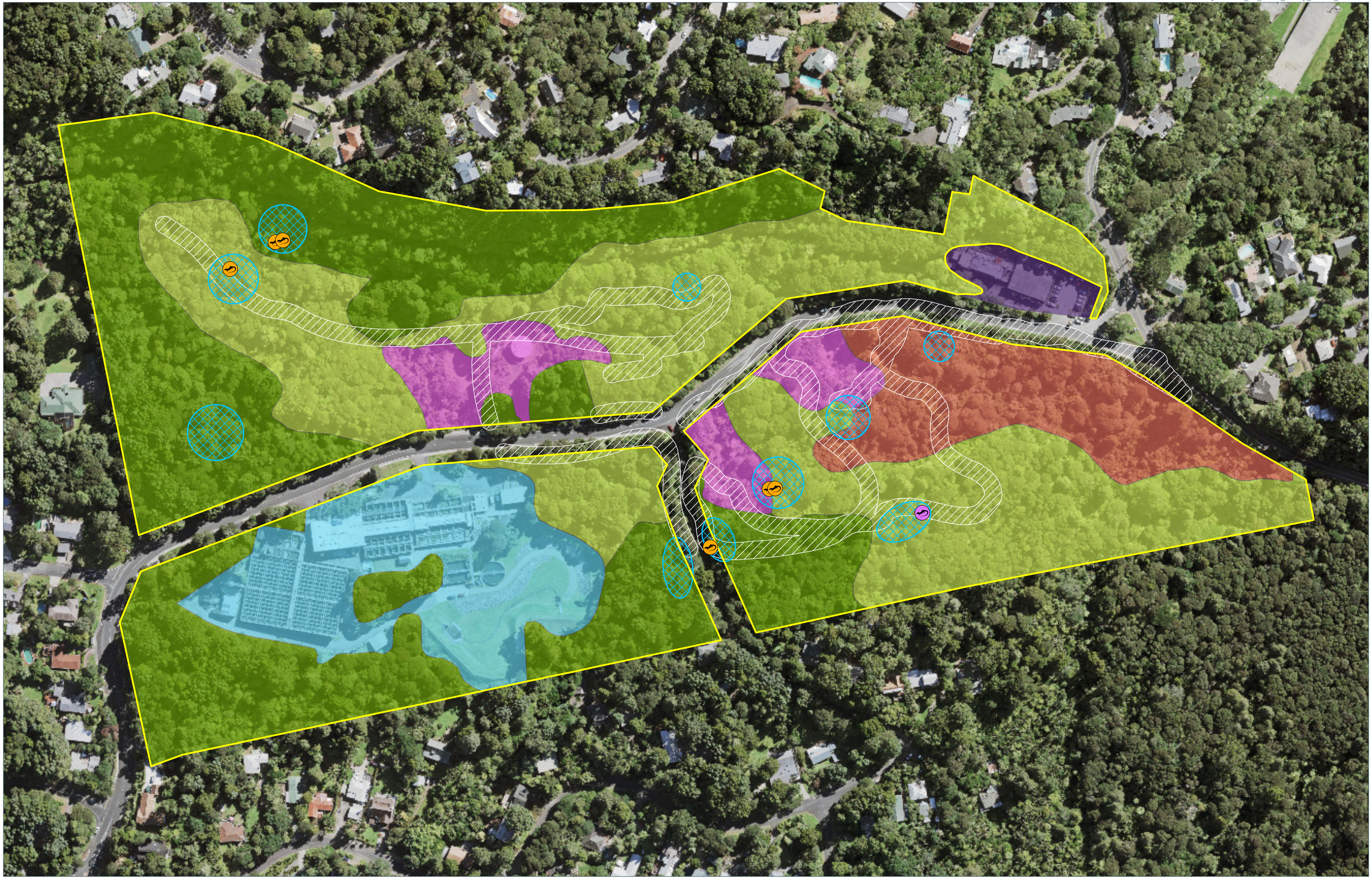
3.3.1 Desktop review

Surveys undertaken on behalf of Auckland Council at eight monitoring locations within 2.6 km of the site did not record bats (B. Paris, pers. comm. 22/12/2017). The closest records from previous bat surveys in and around the wider Waitakere Ranges include the Opanuku Stream corridor approximately 5.5 km to the north (Bioresearches, 2014; Envirologic, 2007), and a likely maternity roost site in old kauri trees adjacent to the Lower Huia Reservoir, 7.5 km to the west of the site (Boffa Miskell Ltd., 2017; refer Fig. 13).

3.3.2 Acoustic Survey

During the summer 2017/ 2018 survey period for acoustic monitoring, the minimum overnight temperature averaged 15.8°C and it dropped below 10°C on two nights. Rainfall was limited during the survey period with an average of 0.5 mm cumulative throughout the night (19:00 – 07:00 hr). Cumulative nightly rainfall measured above 5 mm on one night during the survey period.

File Ref: A16055_57_Lizard_Survey_Results_Rev2.mxd



Boffa Miskell
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0 25 50 m
1:2,000 @ A3

Data Sources: LINZ Data Service (Aerials, Cadastre), Auckland Council, GHD, Boffa Miskell

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

- Lizard Survey Areas
- Gecko Spotlighting Areas

Lizard Observations

- Copper skink (6)
- Unidentified skink (1)
- Site Boundary

Vegetation / Existing Use

- Kanuka Forest
- Kauri - Podocarp Forest
- Kanuka Broadleaf Scrub Mosaic
- Modified Scrub
- Existing WTP
- Decomissioned WTP

A16055 HUIA WTP ALTERNATIVES ASSESSMENT

Figure 14 Lizard Survey Results

Date: 16 April 2018 | Revision: 2
Plan prepared by Boffa Miskell Limited
Project Manager: Rachel.deLambert@boffamiskell.co.nz | *Drawn:* GCu | *Checked:* KMu

During the Spring 2018 survey period, the minimum overnight temperature averaged 12.6°C and it dropped below 10°C on two nights. Nightly rainfall averaged of 2.1 mm cumulative throughout the night (19:00 – 07:00 hr). Cumulative nightly rainfall measured above 5 mm on five nights during the survey period.

Based on the above data, the number of 'fine weather nights' analysed for each acoustic recorder during the different survey periods are listed in Table 10.

A single inconclusive reading (with a spectrogram signature resembling but not typical of a bat echolocation call) was recorded on one night in December 2017 on the margin of Woodlands Park Rd, adjacent to mature kauri-podocarp forest west of the existing treatment plant. A further 29 similar uncertain, readings were recorded in the same location on 18 nights during the spring 2018 survey (12 of these were recorded more than an hour before official sunset, which is atypical of bat behaviour), with a few similar readings in new sample site around the clearing on the northern side of Woodlands Park Road (refer Figure 5).

Follow-up transect surveys with hand-held detectors on 17 December 2018 and 23 January 2019 (the latter paired with an acoustic recorder) were undertaken to validate uncertain readings. No bats were seen or heard during the handheld detector surveys, while ambient anthropogenic noises (cars, bikes, and pedestrians) were observed to have variable acoustic signatures at 40 kHz that could appear bat-like on a spectrogram. Sounds produced by some passing cars produced spectrograms which explained most of the 'uncertain' passes. We concluded from these observations that the 'uncertain' records from previous acoustic surveys were not bat passes.

Long-tailed bats are very selective in their choice of maternity roost trees, and usually utilise a limited number of the oldest trees in the landscape for breeding (O'Donnell 2018). We are confident that the lack of bat activity within the Project Site during the summer survey (and the lack of activity during previous Auckland Council monitoring in the vicinity) signifies an absence of favoured maternity roost trees. However, long-tailed bats have large home ranges, often moving kilometres between day roost sites and various foraging grounds, and individual bats tend to space themselves in different parts of the landscape to reduce competition (O'Donnell 2001; Dekrout 2009). Hence, individuals may occasionally utilise the Project Site for foraging and / or solitary roosts.

The lack of bat activity within the Project Site during the summer survey (and the lack of activity during previous Auckland Council monitoring in the vicinity) indicates an absence of favoured maternity roost trees. However, given the large home ranges of long-tailed bats, the relative proximity of known bat roosts at Lower Huia Reservoir, and the habitat connectivity between the Project Site and this colony means individual long tailed bats may occasionally utilise the Project Site for foraging and/ or solitary roosts.

Table 10: *Summary table of data collected from acoustic bat recorders deployed across the Huia Water Treatment Plant Site during November 2017 – January 2018, and October - November 2018.*

Location ID	Date Deployed	'Fine Weather Nights' Surveyed	Number of bat passes recorded
Bat 01	13/11/17 – 7/12/17	19[1]	0
Bat 02	13/11/17 – 7/12/17	23	0
Bat 03	13/11/17 – 7/12/17	23	0
Bat 04	13/11/17 – 7/12/17	23	0
Bat 05	13/11/17 – 7/12/17	23	0
Bat 06	13/11/17 – 7/12/17	23	0
Bat 07	13/11/17 – 7/12/17	8[1]	0
Bat 08	13/11/17 – 7/12/17	23	0
Bat 09	13/11/17 – 7/12/17	23	0
Bat 10	13/11/17 – 7/12/17	23	0
Bat 11	7/12/17 – 20/12/17	14	0
Bat 12	7/12/17 – 20/12/17	14	0
Bat 13	7/12/17 – 20/12/17	14	0
Bat 14	21/12/17 – 11/01/18	21	0
Bat 15	21/12/17 – 11/01/18 Redeployed: 24/10/18 – 13/11/18	21 15	1 (uncertain) 29 (uncertain)
Bat 16	21/12/17 – 11/01/18 Redeployed: 24/10/18 – 13/11/18	21 15	0 0
Bat 17	24/10/18 – 13/11/18	15	2 (uncertain)
Bat 18	24/10/18 – 13/11/18	15	2 (uncertain)
Bat 19	24/10/18 – 13/11/18	12[1]	1 (uncertain)
Bat 20	24/10/18 – 13/11/18	18	0
Bat 21	24/10/18 – 13/11/18	18	0
Bat 22	24/10/18 – 13/11/18	18	0

[1] Due to equipment issues, some ABMs did not record for the entire deployment period.

3.4 Birds

Fourteen bird species were detected during the 48 × 5MBCs carried out within the Proposed Project Site and consisted of seven native and seven exotic species (Figure 15; Appendix 6).

Within the site there was little variation between 5MBC stations in terms of both the average number of individual species detected and the assemblage of bird species. Tui were the most abundant species detected during 5MBCs across the Proposed Project Site with very high counts recorded at Site 3, associated with tui feeding on a large pohutukawa in full flower recorded during the 12/12/2017 5MBCs. Kereru were only detected at two of the 5MBC sites within the Proposed Project Site, however, they are not very vocal and are often only detected when observed flying or when their wing beat is heard.

ARDS results (Table and 12) essentially corroborate the results of 5MBC surveys, with the addition of morepork, spur-winged plover, barbary dove and mallard. Welcome swallows were not detected during 5MBCs within the Proposed Project Site but were consistently observed feeding and nesting in and around the existing WTP. Swamp harrier (Not Threatened) were incidentally observed in flight over the site.

Comparison with 5MBC data collected by Auckland Council from nine sample sites within the Waitakere Ranges (Figure 16) indicates that the assemblage and conspicuousness of native bird species detected within the project site is representative of similar habitat in the wider Waitakere Ranges. Bird populations present include fruit and nectar-feeders (tui and kereru in particular) that have a role in pollination and dispersal of many native tree and shrub species.

Native bird species absent from the Proposed Project Site (compared to the Auckland Council sites[13]) were tomtit (Not Threatened), fernbird (At Risk Declining) and North Island robin (At Risk - Declining) (Robertson et al. 2017). Tomtits have been sighted in regional parkland around Parau, approximately 3 km westward of the Project Site[14].

As reflected by their threat classification, both fernbird and North Island robin have patchy distributions and are not common within the unmanaged areas of the Waitakere Ranges. The absence of these species from the Proposed Project Site is likely due in part to the lack of suitable habitat, pest mammal densities and close proximity to urban areas.

OSNZ records list 63 terrestrial bird species previously recorded within the 10 km × 10 km grid square encompassing the Project Site, comprising 31 native and 32 introduced species (Appendix 7). 16 species are classified as At Risk or Threatened, though only North Island kaka (At Risk – Recovering), North Island fernbird (At Risk – Declining), New Zealand pipit (At Risk – Declining) and long-tailed cuckoo (At Risk – Naturally Uncommon) would utilise habitats present within the Project Site (Robertson et al. 2017). None of these species were detected during 5MBCs or acoustic monitoring surveys.

[13] Auckland Council survey sites cover the equivalent of 60 ha, while the Proposed Project Site is 15 ha. The majority of Auckland Council sites are within the Waitakere Ranges and are buffered from edge effects by surrounding habitat and contain a wider diversity of habitat types and topography than the Proposed Project Site.

[14] Thomas, O. 2017. eBird Checklist: https://ebird.org/ebird/view/checklist/ S38380988 (Recorded: 30 July 2017). eBird: An online database of bird distribution and abundance [web application]. eBird, Ithaca, New York. Available: http://www.ebird.org.

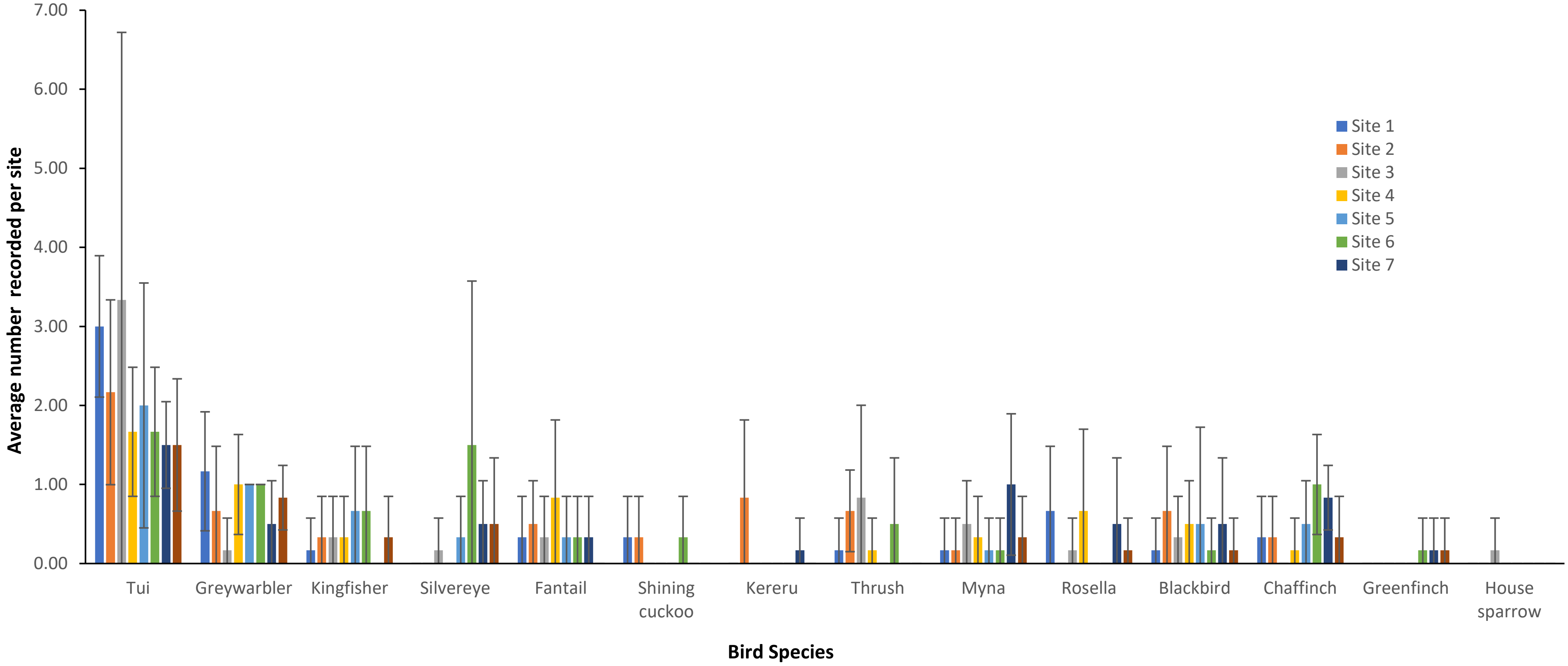

Figure 15: The average number of each bird species detected during six counts periods at each of the eight 5MBC sites within the Proposed Project Site (error bars are standard deviations)

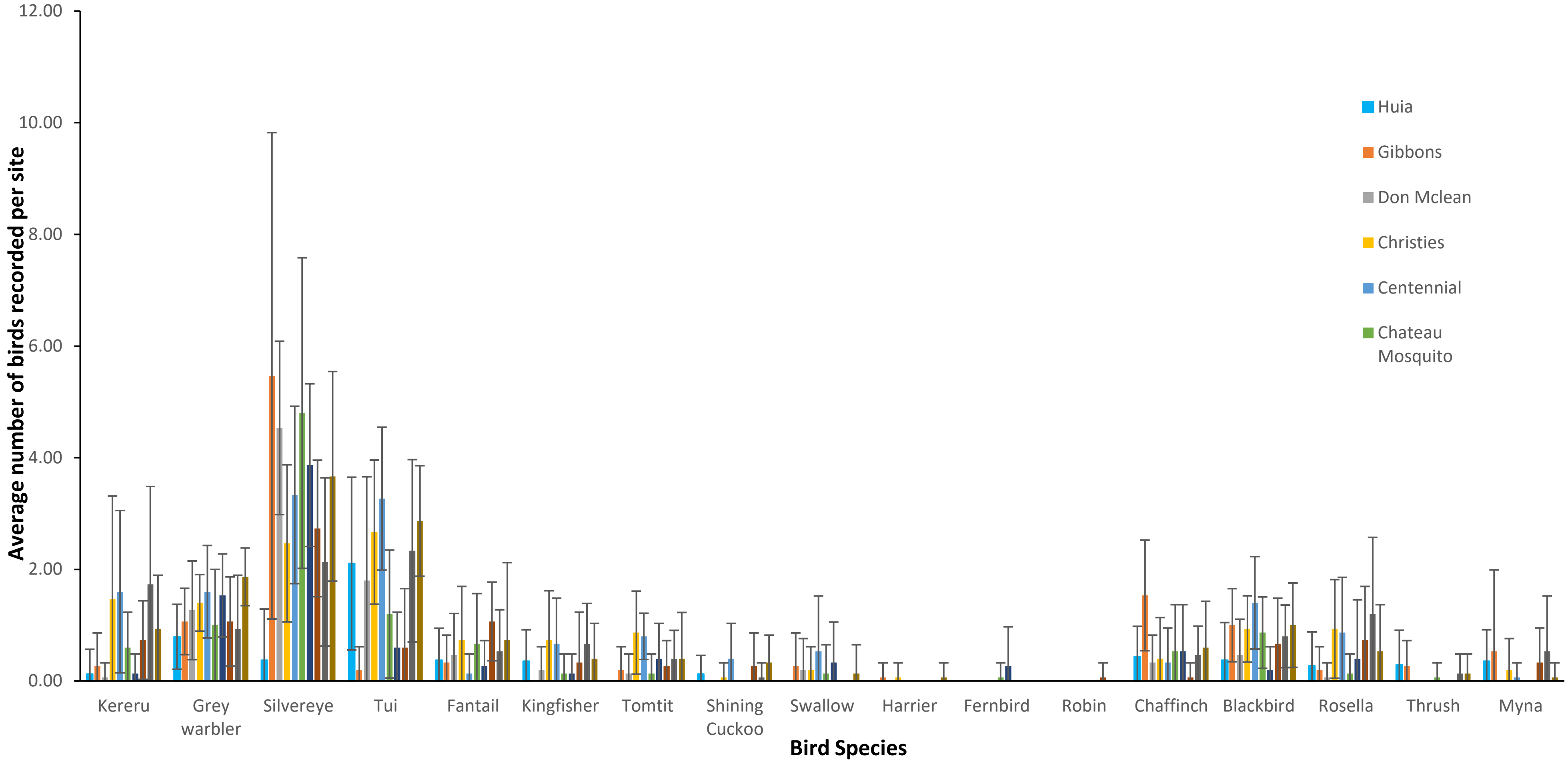

Figure 16: The average number of each bird species detected during six counts periods across the entire Proposed Project Site and during one count period at each of the nine Auckland Council 5MBC sites (error bars are standard deviations).

Table 11*: Bird species recorded on ARDs at nine sites within the Proposed Project Site (between 07/12/2017 and 21/12/2017).*

Species	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7	SITE 8	SITE 9
Fantail	✓	✓	✓	✓	✓	✓	✓	✓	
Grey warbler	✓	✓	✓	✓	✓	✓	✓	✓	
Kingfisher	✓	✓	✓	✓	✓	✓	✓	✓	✓
Morepork	✓	✓	✓		✓		✓	✓	✓
Shining cuckoo	✓	✓	✓	✓	✓	✓	✓	✓	
Silvereye	✓		✓	✓	✓	✓	✓	✓	✓
Tui	✓	✓	✓	✓	✓	✓	✓	✓	✓
Chaffinch	✓	✓	✓	✓				✓	
Rosella		✓		✓				✓	✓
Blackbird	✓	✓	✓	✓				✓	✓
Myna		✓						✓	✓
House sparrow			✓						✓
Thrush	✓	✓	✓	✓		✓			✓
Spur-winged plover	✓	✓	✓					✓	
Mallard								✓	
Barbary dove									✓

Table 12: *Bird species recorded on ARDs at two sites within the Proposed Project Site (between 05/04/2018 and 13/04/2018).*

Species	SITE 10	SITE 11
Fantail	✓	✓
Grey warbler	✓	✓
Kingfisher	✓	✓
Morepork	✓	✓
Kereru	✓	
Silvereye	✓	✓
Tui	✓	✓
Chaffinch	✓	✓
Blackbird		✓
Myna		✓
Thrush	✓	✓
Spur-winged plover	✓	

The avifauna assemblage within the project site is representative of Waitakere Ranges bush habitats. No threatened or uncommon birds were detected within the Proposed Project Site. Wide-ranging species such as kaka are not resident in the Proposed Project Site but may use the area occasionally as they favour emergent trees and are attracted to periodically abundant food sources (e.g., during mast kahikatea fruiting seasons).

3.5 Invertebrates

The combination of sampling methods detected 732 RTUs (separate taxa) across all areas sampled. In general, the invertebrate fauna found is comparable with that of similar bush-clad areas of the southern Waitakere Ranges (notwithstanding the extreme micro-scale variability of invertebrate communities across the landscape, and current limits of scientific knowledge of the invertebrate fauna, both locally and nationally).

The two mature forest areas sampled (kauri and kauri-podocarp forest, respectively) had a large component of native (and mostly endemic) invertebrate species associated typically with kauri, broadleaved, and secondary kanuka forest types. A species of ngaokeoke or velvet worm (*Peripatoides*), was found in both mature forest sites. The taxonomy, distribution and threat status of ngaokeoke is not well understood, and the status of known and any newly described species will need to be reviewed following formal clarification of the taxonomy of this group in New Zealand (Department of Conservation 2014). Ngaokeoke are generally restricted to damp environments within and beneath logs and leaf litter and are therefore vulnerable to habitat disturbance.

Samples from the kahikatea swamp included some specialised fauna (Ostracoda, Copepoda and Turbellaria) which are relatively uncommon in Waitakere Ecological District, reflecting the rarity of the ecosystem type in which they occur.

3.6 Animal Pests

Pest fauna surveys were excluded from the values assessment as mammalian pest numbers fluctuate widely from season to season, and in response to pest management activity in the vicinity[15]. Predator management data collected as part of Ark in the Park research and management (Martineau 2010) indicate that mammalian predators are ubiquitous throughout the Ranges in any areas not subject to intensive control. Traps maintained as part of community-led possum control efforts in the Waima- Lainghom area since early 2017 have yielded a steady catch rate, with the total number of reported kills in the hundreds (*M. Harvey pers. comm, in correspondence 20/07/18 and 3/10/18*).

Few adventive invertebrate species, and no aggressive invaders such as Argentine ant (*Linepithema humile*) were recorded within the Project Site, though sampling primarily focused on less modified parts of the site. Argentine ants were detected in low numbers nearby in Woodlands Park during MAF rapid field surveys in 2002 (Harris et al 2002), and have become locally abundant in recent years, and a community-led eradication attempt is underway here *(M. Harvey pers. comm. 20/07/18).* Argentine ants successfully exploit areas of human habitation, while in native ecosystems, Argentine ants tend to inhabit forest edge and low-stature vegetation types, hence modified and fragmented areas are more vulnerable to invasion (Harris et al 2002). Argentine ant impacts include predation of native birds, lizards and invertebrates, and competition with them for food, potentially leading to ecosystem-scale impacts associated with disruption of pollination and seed dispersal systems.

We consider the available data supports our presumption that native bird, lizard and invertebrate fauna populations within the Project Site and wider catchment face significant pressure from predatory pest animals, to the extent that the long term viability of some native species may be compromised.

[15] We understand that there are coordinated pest management initiatives in the immediate and wider catchment areas, however no specific information on how these are coordinated or resourced has been supplied.

3.7 Freshwater Ecology

3.7.1 Overview

The ecological values of the aquatic habitats within the Project Site are presented by catchment: Armstrong Gully and Yorke Stream. Survey reaches are named by their location: Project (i.e. within the Project Site) or receiving (i.e. are downstream of development areas and will potentially receive stormwater from the development site).

3.7.2 Armstrong Gully

The portion of the Project Site to the north of Woodlands Park Road encompasses the headwaters of the Armstrong Gully. South of Woodlands Park Road, the main Armstrong Gully watercourse is currently piped under the existing Huia WTP, discharging into open channel near the southern boundary of the Huia WTP property. An intermittent-to-permanent tributary of the Armstrong Gully watercourse (Armstrong_Manuka) has an open channel in its upper reaches (in the northeastern corner of the existing WTP site), and runs alongside the dry pond for ashort distance before being piped and discharged to the Armstrong Stream gully (at the same location as the discharge from the dry pond).

The watercourses termed "Project" are those north of Woodlands Park Road (Armstrong_Project; Armstong_Project_ephemeral) and near the corner of Manuka Road and Woodlands Park Road (Armstrong_manuka_Project). The receiving watercourse is located to the south of the existing Huia WTP (Armstrong_receiving; Figure 17). An SEV survey was undertaken on each of the permanent watercourses (Armstrong_Project and Armstrong_ receiving). An ARC habitat assessment was undertaken on a smaller intermittent channel (Armstrong_manuka), while a visual assessment was undertaken at ephemeral channel (Armstrong_ephemeral), both of which are also present within the Project Site.

Habitat Descriptions

- *Armstrong_Project*

Watercourse Armstrong_Project has an average channel width of 0.47 m, and a silt/sand streambed with occasional small wood and leaf litter (Table 3). Water flow was slow (0.09 m/s), predominantly run habitat with no deep or shallow pools. Small debris jams were present along the reach. Downstream of the SEV reach the channel surface water was dry, with subsurface flow for approximately 30 m, before surface water returned just upstream of the culvert under Woodlands Road. Riparian vegetation consists of mature and regenerating native species dominated by nikau and tree fern. Streambanks at site Armstrong_Project are 0.2- 0.7 m high with no areas of active erosion.

- *Armstrong_receiving*

Discharge from the Huia WTP enters the stream channel some 35 m upstream of the Watercourse Armstrong_receiving survey reach. The SEV survey reach was confined by upstream and downstream natural waterfalls. The reach has an average channel width of 1.0 m with a mixed streambed of bedrock, large cobbles, boulders and areas of silt/sand (Table 3). Woody debris was rare, while leaf litter was uncommon. Water flow was slow (0.06 m/s) and the channel a mixture of run and riffle habitat, with small chutes, waterfalls and deep and shallow pools. Bryophytes were abundant along stream edges without recent erosion. Riparian vegetation is

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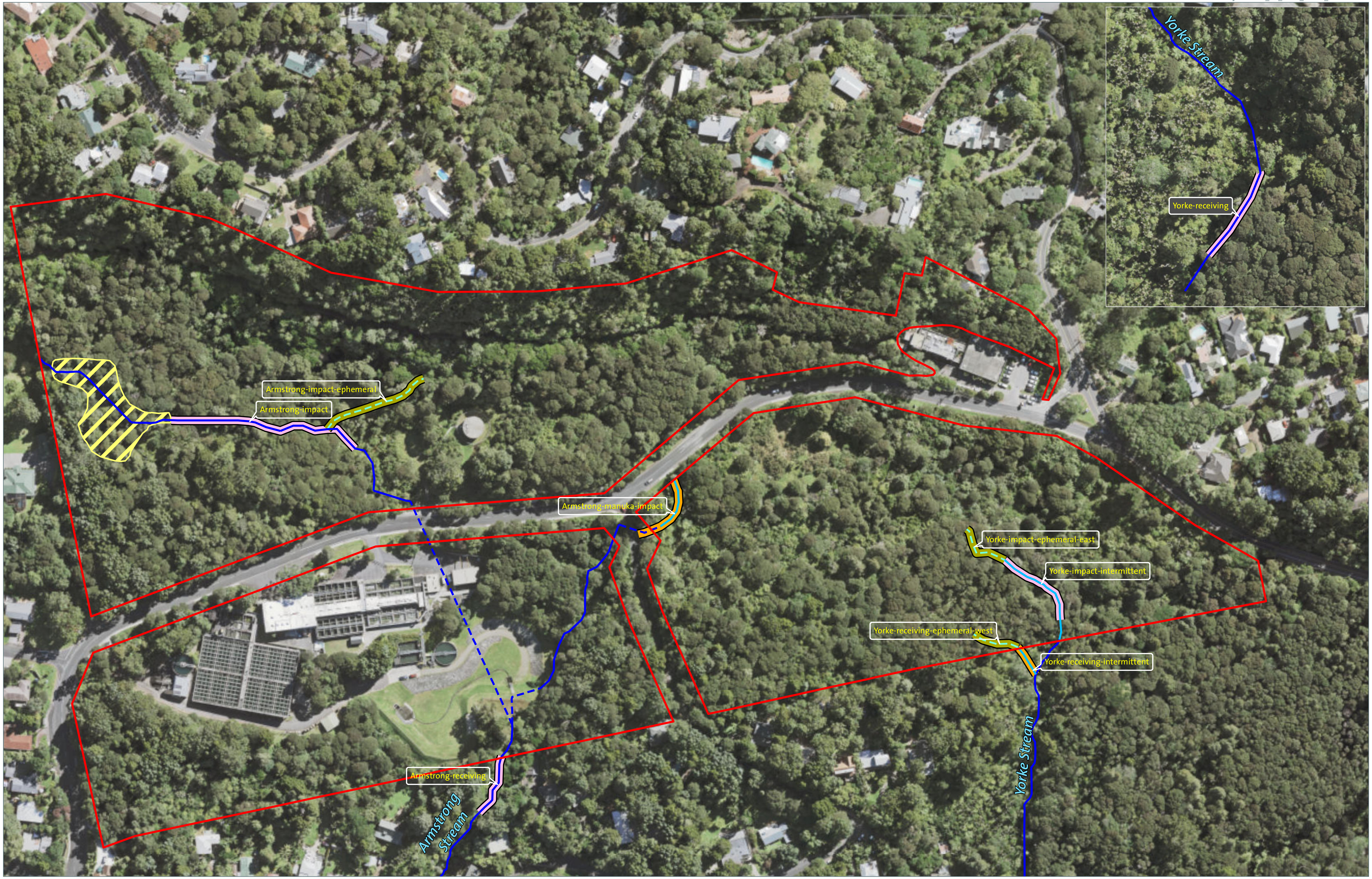

Legend

Streams
- Permanent
- Permanent Piped
- Intermittent
- Ephemeral
- Swamp Area
- SEV Site
- ARC Habitat Assessment
- Visual Assessment
- Site Boundary
- Land Parcels

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Data Sources: LINZ Data Service (Aerials, Cadastre), Auckland Council, GHD, Boffa Miskell

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055 HUIA WTP ALTERNATIVES ASSESSMENT

Figure 17 Fresh Water Habitat

Date: 15 May 2019 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: Rachel.deLambert@boffamiskell.co.nz | *Drawn:* SGa | *Checked:* KMc regenerating native forest with emergent large kauri and podocarps, with patches of weedy groundcover (tradescantia and Kahili ginger). Armstrong_receiving is located within a steep gully. Streambanks range from 3 – 6 m in height with some bank sections near vertical. The stream bank is mainly clay and finer sediments, with some areas of hard bedrock banks.

Numerous areas of active and historical erosion are present along the SEV reach, as detailed in Table 14. The largest area of active erosion is located at the upstream end of the SEV reach surrounding the pool at the base of the waterfall. Surrounding this pool is a large active escarpment of approximately 3 m x 3 m. The pool itself was filled with fine silt/sand and recently fallen coarse woody debris (See Table 3 and 14).

Evidence of historic erosion prevention works were noted along reach Armstrong_receiving with waratahs, steel reinforcing bar and varying types of mesh present at various locations (See Table 5). All these measures look to be some years old and are no longer providing any protection from erosion. Above the SEV reach, between the Huia WTP outfall and the SEV reach, the stream bed and banks have been lined in places with a plastic trellis mesh with cobbles placed on top.

***Table 13**: Images of Armstrong Gully survey sites.*

Armstrong_Project

Armstrong _receiving

Armstrong_Manuka

Armstrong_ephemeral

- *Armstrong_manuka*

Streambanks at site Armstrong_manuka vary between 0.1 m in the upper section, to 0.3 m in the lower section. No active erosion was present on these stream banks.

The open channel is fed by a 0.2 m diameter pipe flowing from under Woodlands Park Road. A 10 m long culvert is located in the middle of the reach, below an old access-way. The morphology of the watercourse differs somewhat above and below the culvert (Table). Upstream of the culvert the channel is 0.2 m wide with a silt/sand streambed infested with tradescantia.

***Table 14**: Erosion assessment at Armstrong_receiving Site. Note: All measurements are distance upstream from the downstream end of the SEV reach.*

True Left Bank	
7 – 8 m	BRIDGE
13 – 15 m	Large old bank slump present approximately 8 m wide by 6 m high. Fine chicken wire present at the base of slump. Growth of bryophytes, ferns, parataniwha. Dead juv. Kauri at top of slip.
16 m	Waratah driven deep into bank
22 – 24 m	Old erosion scar present. Waratahs present, vegetation growing. Some areas of loose soil still present.
25 – 26 m	Small recent erosion scar
30 – 31 m	Recent erosion scar
True Right Bank	
1.5 – 2 m	Small recent erosion scar
7 – 8 m	BRIDGE
9 m	Recent fern/ponga fallen across stream channel
12 – 16 m	Recent erosion scar, clay eroded in stream. No vegetation re-growth on erosion scar face.
21 – 24 m	Large old erosion scar with debris still present. Steel bars in ground, looks like old erosion control. Dead trees. Stream channel has silt and fine sediment within. Channel wider.

***Table 15**: Images of selected erosion hotspots within the Armstrong_receiving Site. Note: All measurements are distance upstream from the downstream end of the SEV reach.*

True Left Bank	**True Right Bank**
	
47-50 m: Erosion surrounding pool	*21-24 m: Large old erosion scar.*

13-15 m: Old erosion scar

12-16 m: Recent Erosion Scar

Most of the upper section of the reach had no surface water, other than a single pool approximately 0.2 m deep. Below the culvert, a moderate size pool 0.65 m deep was present at the culvert outlet while the average water depth in the remaining stream channel (approximately 0.2 m wide), was 0.01 m with. No water flow was present. The riparian vegetation at the upper and lower sections was a mixture of low native and exotic scrub, with a heavily weed-infested groundcover and abundant climbing asparagus and jasmine. No water was flowing into either the culvert within the reserve or the culvert under Manuka Road at the time of the survey.

- *Armstrong_ephemeral*

Watercourse Armstrong_ephemeral is a small ephemeral watercourse that is located north of Woodlands Park Road, along the base of the steep hill, and flows into Armstrong_Project.

Macroinvertebrates

Macroinvertebrate community samples were collected from Sites Armstrong_Project and Armstrong_receiving. A single replicate sample was collected from each reach. Macroinvertebrates were not sampled from site Armstrong_manuka or Armstrong_ephemeral.

- *Armstrong_Project*

Site Armstrong_Project had limited aquatic habitat abundance or diversity along the survey reach, with small amounts of woody debris and stream edge providing the primary macroinvertebrate habitat.

A total of 17 macroinvertebrate taxa and 2291 individuals were recorded from the kick-net sample. The community was dominated by the amphipod *Paraleptamphopus*, and the chironomid midges (*Polypedilum* and *Tanypodinae*), accounting for 49 % and 34 % of individuals, respectively. The amphipod *Paraleptamphopus* is a crustacean and it is commonly found throughout New Zealand in slow-flowing, soft bottom streams with moderate to good water quality. The midge *Polypedilum* is commonly found in streams of varying water quality, from bush covered hard-bottom streams to soft-bottom farmland streams (Landcare Research, 2018). The snail *Potamopyrgus* and the finger clam (Sphaeriidae) were also relatively abundant (6 % each). Other invertebrate taxa were present in low numbers including beetles (*Scirtidae*), springtails (*Collembola*), spiders, flatworms (Platyhelminthes) and segmented worms (oligochaetes).

There were no EPT taxa present within the sample.

MCI-sb score was 95.3 which is indicative of 'Fair' water quality, and possible moderate pollution. The MCI score falls just below the MCI guideline for Auckland rivers and streams (for native forest, MCI guideline = 123) as outlined in Table E1.3.1 of the AUP-OIP.

- *Armstrong_receiving*

Site Armstrong_receiving had a moderate habitat diversity with woody debris, undercut banks, cobble and the occasion overhanging vegetation present.

Macroinvertebrate taxonomic richness was high, with a total of 26 macroinvertebrate taxa and 481 individuals recorded from the kick-net samples. The chironomid midge *Polypedilum* dominated the community, accounting for 31 % of individuals. This was closely followed by the net-building caddis *Orthopsyche* accounting for 25 % of individuals. The presence of *Orthopsyche,* particularly when in conjunction with mayflies and stoneflies, is an indication of good water quality (Landcare Research, 2018). Other invertebrate taxa present included Dobsonfly, beetles, true flies, springtails (*Collembola*), spiders. The snail *Potamopyrgus* was also abundant comprising 18 % of individuals. The amphipod *Paraleptamphopus* that was present upstream at site Armstrong_Project was present, albeit in very low abundance (0.8 %).

Six EPT taxa were present; one mayfly taxa (*Zephlebia*) and five caddisflies (*Hydrobiosis, Oeconesidae, Orthopsyche, Polyplectropus* and *Psilochorema).* No stonefly taxa were present. EPT taxa accounted for 23% of taxa present and 31 % of individuals present.

The MCI score was 106, which is indicative of 'Good' water quality, with possible mild pollution. The MCI score falls just below the MCI guideline for Auckland rivers and streams (for native forest, MCI guideline = 123) as outlined in Table E1.3.1 of the AUP-OIP.

Fish

Fish populations were surveyed using electric fishing at sites Armstrong_Project, Armstrong_wetland and Armstong_receiving. Fish populations were not surveyed at site Armstrong_manuka or Armstrong_ephemeral.

- *Armstrong_Project*

Electric fishing was undertaken along a 50m reach at Site Armstrong_Project. No fish species were caught or observed along the reach.

- *Armstrong_receiving*

A single shortfin eel was the only fish observed at Site Armstrong_receiving, within one of the larger pools within the reach (Table 6).

***Table 16**: Fish species caught at Sites within the Armstrong Gully catchment.*

Site	Species	Threat Status	Size (mm)
Armstrong_receiving	Shortfin Eel (*Anguilla australis*)	Not Threatened	600

Stream Ecological Valuation

- *Armstrong_Project*

Site Armstrong_Project scored an SEV value of 0.747 indicative of a good quality stream (Table 17).

Hydraulic functions are a measure of the naturalness of the stream channel, the flow regime connectivity to the floodplain and connectivity for species migration within the reach. Site Armstrong_Project achieved the highest possible score (1.00) for this group of functions, indicating a natural, stable stream channel with no external modifications inputting stormwater or preventing access to the full floodplain during storm events.

Biogeochemical functions are a measure of the in-stream biological and chemical conditions of the stream that drive ecosystem productivity. The calculation of the biogeochemical function score includes measurements of stream water velocity, water depth and macrophyte abundance. This group scored 0.90, indicating that is functioning well in terms of these elements. Functions of water temperature control and decontamination of pollutants scored less well due to patchy shading by vegetation, and the predominantly silt / sand substrate which provides limited surface area for biofilms.

Habitat Provisions functions measure fish spawning habitat and physical habitat available for aquatic fauna. The quality of spawning habitat for Galaxiidae fish is driven by the availability of well shaded and damp bank areas, whereas Gobiidae fish spawning area requires the availability of in-stream hard surfaces such as cobbles and gravels. The quality of physical habitat diversity and availability is related to the hydraulic and geochemical functions, and upstream catchment shade and imperviousness. This function scored 0.36, indicating poor habitat for aquatic fish and fauna. This score is predominantly driven by the unsuitable spawning habitat for fish due to the lack of low-growing bank-side vegetation and gravels, or instream gravels and cobbles.

Biodiversity Provision functions is a combined measure of the fish and macroinvertebrate communities present within the reach and the condition of the adjoining riparian vegetation. This function scored moderately low at 0.41, as no fish species or high value EPT taxa were present within the community, though riparian vegetation intactness scored reasonably well.

- *Armstrong_receiving*

Site Armstrong_Project scored an SEV value of 0.770 indicative of a good quality stream (Table 17). Hydraulic functions within site Armstrong_Project scored a value of 0.83, indicating moderate hydraulic functionality. The channel itself appears moderately natural but is highly incised in parts, reducing the floodplain effectiveness. The channel also has unnatural loading of fine sediments in some sections of the reach, reducing the natural connectivity to groundwater.

Biogeochemical functions showed good functionality, scoring 0.85. Dissolved oxygen levels and organic matter input were excellent. Reduced functionality in water temperature control was due to patches of low shade along the reach.

Habitat provisions showed moderate functionality, scoring 0.60, mainly due to unsuitable *Galaxiidae* spawning habitat along the reach. Gobiidae spawning scored high in this reach.

Biodiversity provisions scored moderately well (0.65), due to a poor fish population but a good abundance of EPT taxa (6 EPT taxa present), and good riparian condition and connectivity.

3.7.1 Yorke Gully

The portion of the Project Site to the south of Woodlands Park Road and east of Manuka Road is within the headwater catchment of the Yorke Gully. Watercourses running through this footprint discharge into the open channel of the Yorke Gully Stream which intersects the adjoining Clarks Bush Reserve.

The watercourses termed *Project* are located within Project Site (Yorke_Project_ephemeral; Yorke_Project_intermittent) (Figure 17). The *receiving* sites, including a small intermittent channel (Yorke_receiving_intermittent) and the larger main stream (Yorke_receiving), are located within Clarks Bush Reserve.

Table 17: *SEV attributes scores for Sites draining into the Armstrong Gully Stream.*

Function	Armstrong_Project *Permanent*	Armstrong_receiving *Permanent*
Natural Flow Regime	1.00	0.81
Floodplain Effectiveness	1.00	0.60
Connectivity for natural species migrations	1.00	1.00
Natural connectivity to groundwater	1.00	0.89
Hydraulic Functions	**1.00**	**0.83**
Water temperature control	0.82	0.62
Dissolved oxygen levels	1.00	1.00
Organic matter input	1.00	1.00
Instream particle retention	1.00	0.90
Decontamination of pollutants	0.68	0.72
Biogeochemical Functions	**0.90**	**0.85**
Fish Spawning Habitat	0.10	0.50
Habitat for aquatic fauna	0.62	0.78
Habitat Provisions Functions	**0.36**	**0.64**
Fish Fauna Intact	0.00	0.37
Invertebrate Fauna Intact	0.44	0.78
Riparian Vegetation Intact	0.80	0.80
Biodiversity Provision Functions	**0.41**	**0.65**
SEV Score (Maximum Value 1)	**0.747**	**0.770**

An SEV survey was undertaken at Yorke_Project_intermittent and Yorke_receiving. At the time of surveying Yorke_Project_intermittent there was no flowing water, with only three small isolated pools of water present. The survey was undertaken within the month of October (19 October 2017), with flowing water present within the channel at a scoping visit some two weeks prior (6 October 2017). As a consequence of only three very small isolated pools being present a number of stream attributes such as water velocity were unable to be collected and no fishing or macroinvertebrate samples were collected during the survey. Visual assessments were undertaken on reaches Yorke_ephemeral and York_intermittent_receiving. A visual assessment was also undertaken on the Yorke Gully stream between the Yorke_receiving reach and Yorke_Project_intermittent reach.

Habitat Descriptions

- *Yorke_Project_intermittent*

Watercourse *Yorke_Project_intermittent* has an average bank to bank width (not wetted width) of 0.5 m (Table 18). The streambed is entirely silt/sand with moderate amounts of roots present across the stream channel, creating what would be small cascades during times of water flow. Three isolated pools of water were present with average water depth of 0.05 m. Shading along the stream channel is moderate, with nikau trees dominating the canopy. Ground cover is sparse, with some small areas of tradescantia present in the downstream end of the reach. The downstream section of the reach has steeper stream banks with some bryophyte patches.

Stream banks were typically higher in the downstream section of the reach (0.3 m) than the upstream (0.15 m). There were small areas of undercut banks in the lower section of the reach. There was no active erosion present, but there was historical erosion evident around a pool located at the upstream extent of the reach.

***Table 18**: Images of Yorke Gully survey sites.*

Yorke_Project_intermittent

Yorke_ephemeral_east

Yorke_receiving

Yorke_receiving_intermittent

Yorke_Project_ephemeral_west

- *Yorke_Project_ephemeral_east*

Yorke_Project_ephemeral_east is upstream of site Yorke_Project_intermittent. This watercourse extends to a cascade where the downstream intermittent channel begins. The ephemeral reach is short and was covered in leaf litter, with juvenile nikau and hangehange the predominant riparian species (Table 18). The reach has no discernible stream banks and no erosion was evident.

- *Yorke_receiving*

Watercourse *Yorke_receiving* is a substantial stream with an average width of 1 m and streambanks in excess of 6 m high in places (Table 18). The stream bed is mainly bedrock with a variety of cobbles and gravels. Silt/sand substrate was generally concentrated around recent areas of erosion and the bottom of pools. Woody debris and leaf litter were present, albeit also rare. Water velocity varied between 0.03 – 0.57 m/s (average of 0.9 m/s) across the site. The reach has high hydrologic heterogeneity, with pools, riffles, runs, chutes and waterfalls present. Shading along the reach varies from low to very high, with the majority of the reach having high (71-90 %) shading. Periphyton was present on the stream bed in areas of low shading with green short filamentous and brown film algae present. Riparian vegetation cover comprises broadleaved indigenous scrub and secondary forest. Dense parataniwha covers the stream margins, and bryophytes are abundant along banks.

The stream is located within a gully and has steep, high stream banks. The lower streambanks are a mixture of bedrock, large boulders and areas of soil. Upper streambanks are well vegetated. A number of areas of both active and historical erosion are detailed in Table 19 below. A large area of bank slumping was restricting water flow downstream and had created a pool behind the debris.

***Table 19**: Erosion assessment at Yorke_receiving Site. Note: All measurements are distance upstream from the downstream end of the SEV reach.*

True Left Bank	
15 – 17.5 m	Debris has created a pool upstream.
True Right Bank	
0 – 2 m	Active area of bank slumping.
38.7 - 40.8 m	Area of bank slumping which is partially blocking the watercourse; predominantly comprises clay and small gravels.

- *Yorke_receiving_intermittent*

This is an intermittent reach approximately 30 m in length feeds into the main Yorke Gully Stream, bound upstream by a waterfall approximately 2 m in height, and downstream at the confluence. The reach itself contains a waterfall approximately 1.5 m high. The majority of the reach had no surface water at the time of the survey (Table 18). A small pool was present at the base of the upstream waterfall, and a 2 m section of flowing water was present between the lower waterfall and the main Yorke Gully Stream. Average channel width is 0.3 m, with a silt/sand bed. Channel shading is moderate with riparian cover of nikau, parataniwha, hange hange, puriri, pate and small patches of Kahili ginger.

The channel is small and incised, with almost vertical banks 1 – 2 m in height. Small areas of active erosion were present along the majority of the channel and at the base of both waterfalls along the reach. The waterfalls are overhanging, with undercutting present where roots do not provide stabilisation.

- *Yorke_Project_ephemeral_west*

A small ephemeral reach extends upstream of Yorke_receiving_intermittent. A waterfall defines the extent of the reach and the start of the downstream intermittent channel. The channel comprises a small depression in the forest floor (Table 18). The channel contained high amounts of leaf litter, juvenile nikau and ground ferns. The reach has no discernible stream banks and no erosion was evident.

A large erosion hotspot was identified on the Yorke Gully stream TLB, outside of the survey reaches (refer Figure 17). This hotspot was approximately 15 m^2 and had released a large slump of sediment into the stream; blocking the stream channel. The eroded bank section still had healthy vegetation intact and it appeared that water had flowed over the newly eroded surface.

Located on the TRB of this erosion hotspot was an old buried concrete culvert, approximately 0.4 m diameter, that was sitting perched some 1 m above the stream bed. This culvert was located some 1 m below the top of the stream bank and was dry at the time of the survey with roots growing out. The inlet end of the culvert could not be located.

Macroinvertebrates

Macroinvertebrate community samples were only collected from Site Yorke_receiving, where a single replicate sample was collected. Macroinvertebrates were not sampled from sites Yorke_Project, Yorke_ephemeral_east/west, or Yorke_receiving_intermittent. At the time of the survey the reach Yorke_Project only contained water within three small, isolated pools that were not suitable for macroinvertebrate community sampling.

Aquatic habitat diversity at the Yorke_Receiving site scored moderately high with woody debris, riffles, undercut banks, root mats and cobbles all present within the reach, though cobble was the most common. Riffles and stream edge habitat provided the primary kick-net sampling habitat.

Macroinvertebrate taxonomic richness at the Yorke_Receiving site was high, with 30 taxa and 256 individuals present. The community was dominated by the EPT taxa double gill may fly (*Zephlebia*) which comprised 31 % of individuals present. The snail *Potamopyrgus* (13 %) and the double gill mayfly *Arachnocolus* (9 %) were also abundant. The rest of the community showed high diversity with the majority of taxa being either rare (1-4 individuals), or common (5-19 individuals). Other taxa present included the water strider (Microvelia), dobsonfly (*Archichauliodes*), beetles, true flies, springtails (*Collembola*), crustaceans, spiders, and the snail *Potamopyrgus*.

EPT taxa richness and abundance at the Yorke_Receiving site was high within this reach, with EPT accounting for 40 % of taxa and 55 % of individuals present. EPT Taxa present included Mayflies (*Arachnocolus, Austroclima, Coloburiscus, Deleatidium, Neozephlebia*), Stoneflies (*Austroperla, Zelandoperla*) and caddisflies (*Ecnomina, Orthopsyche, Polyplectropus, Psilochorema*). The good diversity and abundance of EPT taxa is an indication of good water quality.

The MCI score at the Yorke_Receiving site was 119, which is the threshold between ‘Good’ (100 – 119) and ‘Excellent’ (> 119) water quality. The MCI score falls just below the MCI guideline for Auckland rivers and streams (for native forest, MCI guideline = 123) as outlined in Table E1.3.1 of the AUP-OIP.

Fish

Fish community surveys were only undertaken at site Yorke_receiving as there was not enough available water at site Yorke_Project.

The at the Yorke_Receiving site was fished along the 50 m SEV reach and a total of 10 individuals were observed from the three species; longfin eel, inanga and koura (Table 20). Two of the species present, of which four individuals were observed, are listed as At Risk – Declining.

Table 20: Fish species caught at Sites within the Yorke Gully catchment. [1]Goodman et al., 2014.

Site	Species	Threat Status[1]	Size (mm)
Yorke_receiving	Longfin Eel (*Anguilla dieffenbachia*)	At Risk - Declining	600; 600.
	Inanga (*Galaxis maculatus*)	At Risk - Declining	30; 30.
	Koura (*Paranephrops planifrons*)	Not Threatened	15; 20; 20; 20; 15; 15.

Stream Ecological Valuation

- *Yorke_Project*

Site Yorke_Project was classified as intermittent and at the time of the survey water within the reach was reduced to three small isolated pools (Table 20). As a consequence, a number of stream attributes were unable to be measured and an SEV score was unable to be calculated for this site. However, the results of those attributes that were able to be measured are discussed below.

Site Yorke_Project achieved the highest possible score (1.00) for this hydraulic function, indicating a natural, stable stream channel with no external modification or inputs of stormwater and full access to the floodplain during storm events.

Biogeochemical function score includes measurements of stream water velocity, water depth and macrophyte abundance. While water depth was measured where possible, water velocity and macrophyte abundance were unable to be measured. Dissolved oxygen levels, and organic matter input both scored 1.00 showing high functionality. Functionality of pollutant decontamination and shade were both moderate, a result of patchy shade provided by overhead vegetation and the predominantly silt / sand substrate which provides limited surface area for biofilms.

This reach scored poorly for habitat provisions functions, mainly due to the unsuitability of fish spawning habitat, both for Galaxiidae and Gobiidae species.

Fish and macroinvertebrate communities were not surveyed as part of this SEV and are not included in the Biodiversity Provision functions score. Riparian condition and connection scored 0.80, demonstrating good functionality.

- *Yorke_receiving*

Site Yorke_receiving scored an SEV value of 0.845 indicative of an excellent quality stream (Table 21).

Hydraulic functions within Site Yorke_receiving scored highly at 0.93, indicating good hydraulic functionality. The channel was highly incised in places with some patches of fine sediment caused by bank slips which reduced the hydraulic functionality.

Biogeochemical functionality was moderate to high with a score of 0.87. Dissolved oxygen levels and organic matter input all scored 1.00. However, there were patches of open canopy which reduced the shading to the stream channel. The stream bed had a high proportion of bedrock substrate which reduces hydraulic functionality.

Habitat provisions demonstrated high functionality with a score of 0.87. The availability of Galaxiidae and Gobidae spawning areas was high, although the Galaxiidae spawning habitat quality was only moderate.

Biodiversity provisions scored moderately well with a score of 0.67. This score was primarily driven by relatively low fish diversity. The macroinvertebrate community returned a good MCI score with good EPT abundance and community diversity. Riparian condition and connectivity was very good.

Table 21: *SEV attributes scores for Sites draining into the Yorke Gully Stream.*

Function	Yorke_Project *Intermittent*	Yorke_receiving *Permanent*
Natural Flow Regime	1.00	0.93
Floodplain Effectiveness	1.00	0.84
Connectivity for natural species migrations	1.00	1.00
Natural connectivity to groundwater	1.00	0.97
Hydraulic Functions	**1.00**	**0.93**
Water temperature control	0.64	0.72
Dissolved oxygen levels	1.00	1.00
Organic matter input	1.00	1.00
Instream particle retention	-*	0.96
Decontamination of pollutants	0.48	0.70
Biogeochemical Functions	**-***	**0.87**
Fish Spawning Habitat	0.05	0.88
Habitat for aquatic fauna	0.56	0.87
Habitat Provisions Functions	**0.31**	**0.87**
Fish Fauna Intact	-*	0.47
Invertebrate Fauna Intact	-*	0.73
Riparian Vegetation Intact	0.80	0.80
Biodiversity Provision Functions	**-***	**0.67**
SEV Score	**-***	**0.845**

Note: * unable to be calculated.

Wetland Invertebrates

A single kicknet invertebrate sample was collected from the maire tawake – pukatea – kahikatea wetland. A total of 2,057 individuals from 16 taxa were present.

The chironmid midge *Polypedilum* was the most abundant taxa present (34% of individuals), while the amphipod species *Paraleptamphopus* was the second most abundant species (30% of individuals). *Polypedilum* are commonly found in both hard and soft-bottom streams where they often burrow into soft plant matter (LandcareResearch, 2018). They are found in watercourses of varying water quality. *Paraleptamphopus* are one of the most common freshwater amphipod genera, being abundant in slow-flowing, soft bottom watercourses. They can be abundant in watercourse with moderate to good water quality.

Other species present include the worms *Oligochaetes* (12 %), the water flea *Cladocera* (10 %) and the midge *Paradixa* (5 %). Both *Oligochaetes* and *Cladocera* are found from pristine streams to sewage treatment plants, while *Paradixa* are commonly found along the margins of wetlands with moderate to good water quality.

Of particular interest is the presence of the snail *Glyptophysa* (1%) which has become increasingly rare over recent decades.

Freshwater habitats were varied across the Project Site and receiving environments of the Huia replacement WTP. The permanent watercourses within the receiving environments of the Armstrong Gully and Yorke Gully are incised gully streams of high ecological value. Armstrong_Project stream reach is a permanent watercourse is of moderate-high ecological value. Other freshwater habitats within the Project Site are intermittent or ephemeral in nature, and intermittent watercourses are of moderate-low ecological value, with limited surface water at the time of sampling.

4.0 Ecological Significance

4.1 Auckland Unitary Plan

The AUP has mapped Significant Ecological Areas throughout the Auckland Region on the basis of 5 factors (with sub-factors) that are used to determine whether a site has significant ecological value. Schedule 3 of the AUP lists the full set of factors, sub-factors and associated explanations (Appendix 8). The 5 main factors include:

(a) representativeness;

(b) stepping stones, migration pathways and buffers;

(c) threat status and rarity;

(d) uniqueness or distinctiveness; and

(e) diversity.

We have re-evaluated the site against the Schedule 3 factors with reference to ecological data compiled from field surveys in order to validate the AUP overlay and identify the specific features of the site that contribute to its ecological significance.

Representativeness

The indigenous vegetation types (as a proxy for ecosystem units) identified within the Project Site are generally consistent with characteristic mature and successional forest communities of the Waitakere Ranges and reflect environmental gradients, particularly those of topography, fertility and soil moisture. It also reflects forest fragmentation as a result of landuse intensification (primarily residential development and associated roading infrastructure) throughout the catchment.

Areas of mahoe scrub with a large component of exotic species, and patches of grassland and weedfield, are not representative of original ecosystem types in the Waitakere E.D.

Stepping-stones, Migration Pathways and Buffers

Common native bird species permanently or intermittently inhabit forest areas within the Project Site. Modified mahoe scrub (though it contains a significant component of weed species) is immediately adjacent to higher-quality ecosystem units identified as significant under the ‘threat status and rarity’ factor and is therefore significant as a buffer. The Project Site forms part of a largely intact forested corridor that extends around the head of the catchment (generally defined by Scenic Drive) which connects forest in the Lower Nihotupu Reservoir and Little Muddy Creek catchments. We note that this corridor is not wholly uninterrupted, as Woodlands Park Road and Manuka Road form effective barriers to dispersal for small, flightless fauna such as lizards and many invertebrates. Nevertheless, the Project Site as a whole supports the resilience and ecological integrity of the Little Muddy Creek catchment and forms part of a network of forested areas within the wider Waitakere foothills that together make an important contribution to the provision of lowland kauri-podocarp forest in the landscape.

Threat Status and Rarity

A site qualifies under this factor if it comprises an indigenous habitat, community or ecosystem assessed (using the IUCN threat classification system) to be threatened, supports plant, animal or fungi species with a national conservation status of threatened or at risk; or a regional threatened conservation status of Gradual Decline ore above, or is indigenous vegetation that occurs in Land Environments New Zealand Category IV where less than 20% native vegetation cover remains.

All later-successional and mature phase forest ecosystems present within the Waitakere Ranges are regarded as endangered or critically endangered (based on the IUCN classification in Singers et al. 2017), including kauri, podocarp and broadleaf - dominated forest types that make up approximately 50% of the forest in the 21,000 ha Waitakere Ranges Heritage Area (Auckland Council 2018) and cover a similar proportion of the 15.2 ha Project Site.

Wetland (including swamp forest) ecosystems are heavily depleted relative to their original (pre-human) extent due to reclamation and drainage, and therefore fall well within the Land Environments of New Zealand Category IV where less than 20% remains. Hence, the wetland feature meets “threat status and rarity” factors.

Kauri and several climbing ratas, all classed as Threatened – Nationally Vulnerable, are present throughout the sites (though infrequent in modified scrub and not observed in grassland / weedfield), while maire tawake (Nationally Critical) is present in the wetland. A few mature pohutukawa tees (including a pohutukawa – northern rata hybrid) are present within the Project Site. A single *Metrosideros carminea* is present on the escarpment below Exhibition Drive. Kanuka (Nationally Vulnerable) is a dominant component of the vegetation cover throughout much of the site, and manuka (At Risk) is occasionally present. A mature specimen of *Elaeocarpus hookerianus* (Regionally Critical) is present in kauri-podocarp forest adjacent to Manuka Road.

Uniqueness and Distinctiveness

The project site is not known to meet any of the factors for uniqueness or distinctiveness.

Diversity

Indigenous vegetation within the site and surrounding continuous forest contains a variety of ecosystem types that reflect underlying environmental gradients. Vegetation assemblages and associated species richness are characteristic of the vegetation types present.

4.2 Waitakere Ranges Heritage Area (2008)

The Project Site is covered by the Waitakere Ranges Heritage Area Act (WRHA 2008), which identifies the WRHA as of national significance. The objectives of the Act broadly include protection, restoration, and enhancement of the area and its heritage features. The Act aims to ensure that impacts on the WRHA as a whole (including cumulative effects) are considered when decisions are made affecting any part of it; and to manage aquatic and terrestrial ecosystems in the area to protect and enhance indigenous habitat values.

4.3 BCG Recommended Draft National Policy Statement on Biodiversity

The Biodiversity Collaborative Group (BCG) is a stakeholder-led group that was established by the Minister for the Environment. The BCG has developed a draft National Policy Statement on Indigenous Biodiversity[16] (BCG NPS) and recommendations to the Government on complementary and supporting measures to maintain indigenous biodiversity. While the BCG NPS has no statutory weight as yet, it is considered here as it sets out the direction in relation to biodiversity offsetting and compensation that a future NPS is likely to take.

The BCG NPS includes 6 objectives, three of which (Objective 3: maintaining indigenous biodiversity and enhancing ecosystems; Objective 4: integrated and evidence-based management; and Objective 5: people and partnerships) are directly relevant to decisions concerning ecological effects of development on biodiversity.

Specified principles for offsetting effects on indigenous biodiversity in the BCG NPS are essentially the same as the AUP (Appendix 8) framework for using biodiversity offsets.

As set out in this report, ecological constraints have been the primary determinant of the WTP and reservoir footprint locations within the Project Site. Watercare has sought to avoid effects on permanent watercourses and areas with the highest ecological integrity as much as possible, and the footprint was progressively reduced through a series of iterative design layouts. However, the project cannot altogether avoid direct effects on the significant natural area associated with forest clearance fragmentation, impacts on connectivity, and the loss of forest extent, and are addressed through mitigation and compensatory measures consistent with offsetting principles.

Indigenous vegetation within the Project Site meets Unitary Plan SEA criteria of representativeness, rarity, diversity, buffering and connective linkages. We acknowledge the appropriateness of the site's inclusion within both the WRHA and the wider Waitakere Ranges SEA_T_5539 and note that vegetation types are generally consistent with characteristic forest communities of the Waitakere Ranges.

5.0 Summary of Site Ecological Value

Assigning ecological value is a subjective process, though it relies on consideration of the putative importance of specific ecosystem components that can be objectively identified and measured. Ecological value has aspects of both quantity (rarity or extent) and quality (integrity, functionality or condition) and incorporates an array of attributes across multiple levels of ecological organisation (species, communities, habitats and ecosystems). Environment Institute of Australia and New Zealand (EIANZ) impact assessment guidelines (EIANZ 2018) provide a summary scale whereby a site's value is assessed as the extent to which an area or site exemplifies qualities of representativeness, rarity/ distinctiveness, diversity and pattern, and ecological context characteristic of its ecosystem type.

[16] Biodiversity Collaborative Group's Draft National Policy Statement on Biodiversity – released 25 October 2018

EIANZ (2018) Ecological values are ranked on a scale of Negligible, Low, Moderate, High, or Very High (Table 22).

***Table 22**: EIANZ (2018) criteria for ascribing ecological value.*

Value	Description
Very high	Area rates High for 3 or all of the four assessment matters (representativeness, rarity/ distinctiveness, diversity/pattern, ecological context)
High	Area rates High for 2 of the assessment matters, Moderate and Low for the remainder, or Area rates High for 1 of the assessment matters, Moderate for the remainder
Moderate	Area rates High for one matter, Moderate and Low for the remainder, or Area rates Moderate for 2 or more assessment matters Low or Very Low for the remainder
Low	Area rates Low or Very Low for majority of assessment matters and Moderate for one. Limited ecological value other than as local habitat for tolerant native species.
Negligible	Area rates Very Low for 3 matters and Moderate, Low or Very Low for remainder.

Representativeness

The vegetation, habitats and taxa present within the site are generally characteristic of vegetation types present within the Waitakere Ecological District, though the forest structure and composition is modified from its 'original' (i.e., pre-1840[17]) state as a result of episodes of partial or complete forest clearance and subsequent regeneration, periods of occupancy and installation of structures, dwellings and gardens, and the establishment of invasive and/ or naturalised plants and animals. Flora and fauna species richness and abundance is depleted relative to the pre-1840 baseline, though comparable to that present in forest and scrub habitats throughout the Waitakere foothills. Anthropogenic influences vary across the site, such that some parts are highly modified, and others are largely intact. Vegetation classification and ecological integrity evaluation identified a gradient in the quality and condition of the ecosystem within the Project Site, to the extent that the more modified parts of the site qualify as SEA only on the basis of their contextual value as buffers and connective linkages to areas of better quality. Therefore, the Project Site achieves an overall representativeness ranking of **MODERATE**.

Rarity / Distinctiveness

Rarity is a measure of the scarcity of species, communities, habitats or ecosystem types encountered in a specified Ecological District or Region.

The site has potential habitat value for significant indigenous fauna known to be present in surrounding catchments and the Waitakere Ranges forest environments more generally, however no populations of threatened or at risk fauna were detected.

[17] 1840 (the date of European arrival) is a commonly used baseline against which representativeness is assessed since there are often documents, paintings and other records from this time (EIANZ 2018).

Threatened ecosystems (kauri forest, kauri-podocarp forest, regenerating broadleaved forest, and kahikatea-dominated swamp and floodplain forest types) cover two thirds of the Project Site, and the site contains populations of threatened and at-risk plants. Therefore, the Project Site achieves an overall rarity/ distinctiveness ranking of **HIGH**.

Diversity and Pattern

Diversity is a measure of the number of different types of species or habitat types that exist in an area, and includes both physical and biological diversity, and ecological processes.

Based on results from our fauna surveys, the Project Site harbours species assemblages with a level of richness and diversity that is generally characteristic of Waitakere forest remnants. We do not consider the site represents core habitat for itinerant indigenous fauna populations, though significant fauna may incidentally utilise the site. The Project Site consists of high quality potential habitat for native birds and reptiles in terms of its structure and composition (the site may contain native lizard populations that remain undetected in surveys), however, mammalian pests including rats and stoats are likely a key factor limiting population sizes of these fauna.

The Project Site and adjoining forest areas contain forest in early, mid- and mature successional stages, with a relatively low level of fragmentation. This mosaic pattern of age structure supports the long-term viability of forest ecosystems that rely on disturbance to regenerate. The vegetation composition also reflects underlying moisture, topography and fertility gradients to a reasonable degree, despite the historic influence of anthropogenic disturbance. Therefore, the Project Site achieves an overall diversity and pattern ranking of **HIGH**.

Ecological Context

Ecological context concerns a site's role in ecosystem functioning through its relationship with its surroundings, including its contribution to wider ecological networks, linkages and processes; its importance for fauna or flora life history stages / the protection and exchange of genetic material; and its contribution to ecosystem resilience to environmental perturbations or pressure from the surrounding anthropogenic landscape.

Catchment-wide fragmentation analysis shows moderate to high levels of fragmentation on ridgelines and coastal headlands associated with residential development and roads, while gully systems and steep escarpments retain continuous forest cover. The Project Site forms part of a largely intact forested corridor that extends around the head of the catchment (generally defined by Scenic Drive) which connects forest in the Lower Nihotupu Reservoir and Little Muddy Creek sub-catchments. Therefore, the Project Site achieves an overall ecological context ranking of **HIGH**.

Summary Ranking of Ecological Value

The Project Site rates High for three out of four assessment matters (rarity/ distinctiveness, diversity/pattern, ecological context). Therefore, the Project Site achieves an overall ecological value ranking of **VERY HIGH**.

6.0 Assessment of Ecological Effects

6.1 Overview

Ecological constraints have been the primary determinant of the WTP and reservoir footprint locations within the Project Site. As a priority, the footprint was developed to avoid permanent watercourses and to avoid areas with the highest ecological integrity, and the footprint was progressively reduced through a series of iterative design layouts. As detailed in the GHD and Beca site layout development reports (GHD 2019, Beca 2019) the construction and operational requirements of the proposed facility offered limited flexibility to fragment or further reduce the extent of either footprint, and the proposed footprint has been minimised as much as is practicable. The intent is that effects on areas with 'moderate to high' integrity would be minimised. Figures 18 and 19 show the location and extent of the proposed WTP and reservoir footprints in relation to vegetation communities and ecological integrity respectively. The WTP and reservoir footprints together encompass 4.3 ha of the 15 ha Project Site.

Policy D9.3(2) of the AUP identifies adverse effects on indigenous biodiversity values in significant ecological areas that are required to be avoided, remedied, mitigated or offset may include (but are not limited to) any of the following:

(a) **fragmentation of, or a reduction in the size and extent of, indigenous ecosystems and the habitats of indigenous species;**

(b) **fragmentation or disruption of connections between ecosystems or habitats;**

(c) **changes which result in increased threats from pests on indigenous biodiversity and ecosystems;**

(d) **loss of buffering of indigenous ecosystems;**

(e) **loss of a rare or threatened individual, species population or habitat;**

(f) loss or degradation of originally rare ecosystems including wetlands, dune systems, lava forests, coastal forests;

(g) **a reduction in the abundance of individuals within a population, or natural diversity of indigenous vegetation and habitats of indigenous fauna;**

(h) loss of ecosystem services*;

(i) **effects which contribute to a cumulative loss or degradation of habitats, species populations and ecosystems;**

(j) impacts on species or ecosystems that interact with other activities, or impacts that exacerbate or cause adverse effects in synergistic ways;

(k) **loss of, or damage to, ecological mosaics, sequences, processes, or integrity;**

(l) **downstream effects on wetlands, rivers, streams, and lakes from hydrological changes further up the catchment;**

(m)	**a modification of the viability or value of indigenous vegetation and habitats of indigenous fauna as a result of the use or development of other land, freshwater, or coastal resources;**
(n)	a reduction in the historical, cultural, and spiritual association held by Mana Whenua or the wider community;
(o)	the destruction of, or significant reduction in, educational, scientific, amenity, historical, cultural, landscape, or natural character values;
(p)	disturbance to indigenous fauna that is likely or known to increase threats, disturbance or pressures on indigenous fauna; or
(q)	increases in the extinction probability of a species.

*Not defined in the AUP. Broadly understood as "benefits that humans freely gain from the natural environment".

Items highlighted in bold in the above list are ecological effects that may arise as a result of the proposed project development. The context in which effects arise, and their magnitude and level, are described in the following sections. Note that some of the effects listed in D9.3(2) pertain to human or cultural valuations of indigenous biodiversity and ecosystems, and are beyond the scope of this report.It should also be noted that this assessment does not take into account measures to avoid, remedy or mitigate adverse effects, nor does it take into account any compensation measures proposed.

6.2 Site Effects

6.2.1 Forest Clearance

Removal of intact native forest and scrub that covers 3.5 ha of the 4.3 ha works footprint (including the replacement WTP and the reservoir sites) is the primary ecological impact arising from the proposed development. Details of the extent and characteristics of vegetation to be removed are set out in the following paragraphs, while subsequent sections describe effects on communities and habitats of flora and fauna arising from the site clearance and disturbance.

WTP Footprint

The proposed WTP footprint encompasses an area of 2.7 ha. As noted in the overview, the footprint of the plant has been designed to avoid areas assessed as of highest ecological integrity (Figure 19), including mature kauri forest, kauri – podocarp forest and swamp forest ecosystem units. However, the development will result in the removal of 2.5 ha of ecologically significant native forest and scrub (within the wider 24,000 ha SEA).

- 1.2 ha of kanuka – mamangi forest (moderate – high integrity)
- 0.7 ha of kanuka – mahoe forest and scrub (moderate integrity)
- 0.6 ha of mahoe scrub (moderate to low integrity)

In addition, 0.2 ha of rough grass and weedfield (lowest integrity but potential lizard habitat) will also be removed.

At least 34 canopy or emergent, mid-late successional native trees are present within (or on the boundary of) the proposed WTP footprint, including 16 kahikatea between 44 and 90 cm in diameter, along with other podocarp and broadleaved species (Figure 18). These specimens have not been aged, but comparison with other studies (e.g., Smale et al., 2005; Burns 200) indicates that the kahikatea are likely to be in the order of 80 – 120 years old, comprising the remnants of a cohort that established sometime after the first wave of European forest clearance in the Waitakere Ranges (i.e., from 1840 onwards; Esler 1983).

Average stem density and diameter of kanuka trees estimated from transect data indicates approximately 4 kanuka trees per 100 m^2, with an average stem diameter of 25 cm, in the high-integrity areas, with smaller diameters (average 14 cm) and much patchier density distribution in the lower integrity parts of the footprint.

Reservoir 1

The proposed construction footprint for Reservoir 1 (north of Woodlands Park Road) and NH2 shaft encompasses an area of 0.8 ha. As with the WTP footprint, the works are designed to avoid highest integrity forest areas in the western portion of the Project Area. Construction of the proposed Reservoir 1 and NH2 shaft will require clearance of 0.6 ha of ecologically significant native forest, mainly comprising kanuka forest (moderate integrity) and patches of kahikatea-kanuka forest (moderate – high integrity). Average stem diameter for kanuka trees in kanuka-dominant forest types is 25 cm, with approximately 4 - 10 trees per $100m^{2-}$.

The Reservoir 1 footprint will necessitate the removal of nine canopy or emergent, mid-late successional indigenous trees (mainly kahikatea; refer Figure 18). The kahikatea trees appear to be of a similar age to the kanuka population cohort, as no large trees are present in old aerial photographs.

Reservoir 2

The Reservoir 2 footprint covers 0.8 ha, of which 0.4 ha is ecologically significant native vegetation (predominantly kanuka-mamangi forest). Two totara and three rewarewa trees adjacent to the road will be removed, and one pohutukawa at the south side of the resovoir footprint.

6.2.2 Edge Effects

Clearance of vegetation within the works footprint has the potential to result in poor health or failure of adjacent trees due to exposure, root damage, altered drainage patterns, etc.

Fragmentation of a single large forest patch into smaller patches creates new forest edge environments. Warmer, drier and sunnier conditions within the forest interior results in a progressive change in forest interior vegetation communities, particularly in the vegetation composition of lower canopy tiers. Such changes include expansion of disturbance-tolerant species and communities, and increased weed incursions. Forest clearance that exposes mature forest trees to an edge environment can also undermine their health and stability. Of particular concern is the likely change to the kauri-podocarp forest community adjacent to the south-western corner of the WTP footprint, which is close to a group of large, old-growth podocarps.

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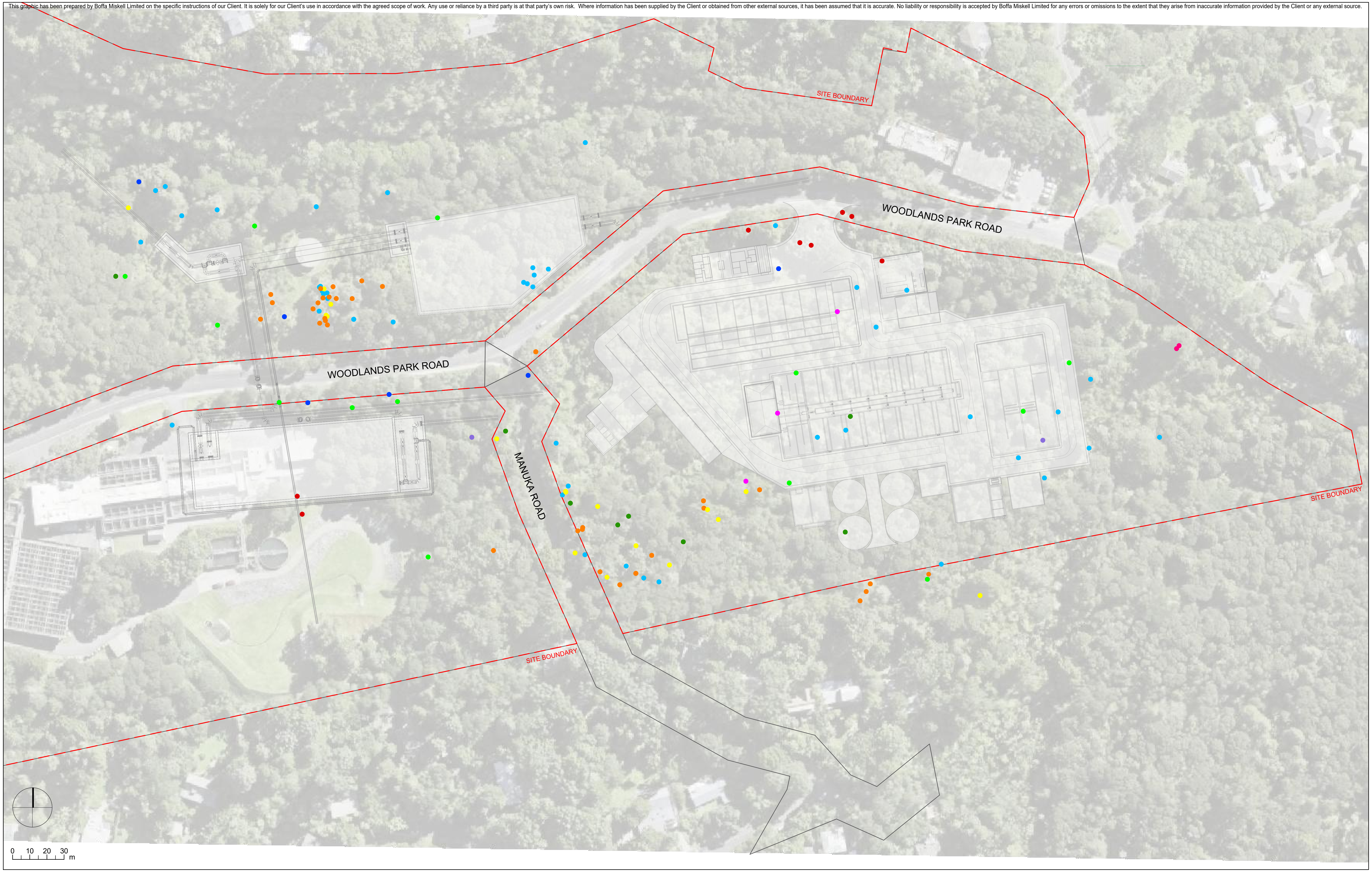

ORIGINAL IN COLOUR

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GREENSCENENZ
ENHANCING AND PROTECTING LIVING ENVIRONMENTS

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NOTES

CONTRACTORS TO VERIFY ALL DIMENSIONS ON SITE PRIOR TO COMMENCING WORK;

CONTRACTORS ARE RESPONSIBLE FOR CONFIRMING THE LOCATION OF ALL UNDERGROUND SERVICES ON SITE PRIOR TO COMMENCING WORK;

FIGURED DIMENSIONS TO BE TAKEN IN PREFERENCE TO SCALED DIMENSIONS.

TREE DATA SUPPLIED BY GREENSCENE NZ.

KEY

- Kahikatea (*Dacrycarpus dacrydioides*)
- Kauri (*Agathis australis*)
- Rimu (*Dacrydium cupressinum*)
- Rewarewa (*Knightia excelsa*)
- Macrocarpa (*Cupressus macrocarpa*)
- Tanekaha (*Phyllocladus trichomaniodes*)
- Totara (*Podocarpus totara*)
- Pohutukawa (*Metrosideros excelsa*)
- Pukatea (*Laurelia novae zelandiae*)
- Puriri (*Vitex lucens*)

REV	DATE	DESCRIPTION
1	26.07.19	FIGURE 18

HUIA WTP UPGRADE

VEGETATION TO BE CLEARED WITHIN WORKS FOOTPRINT

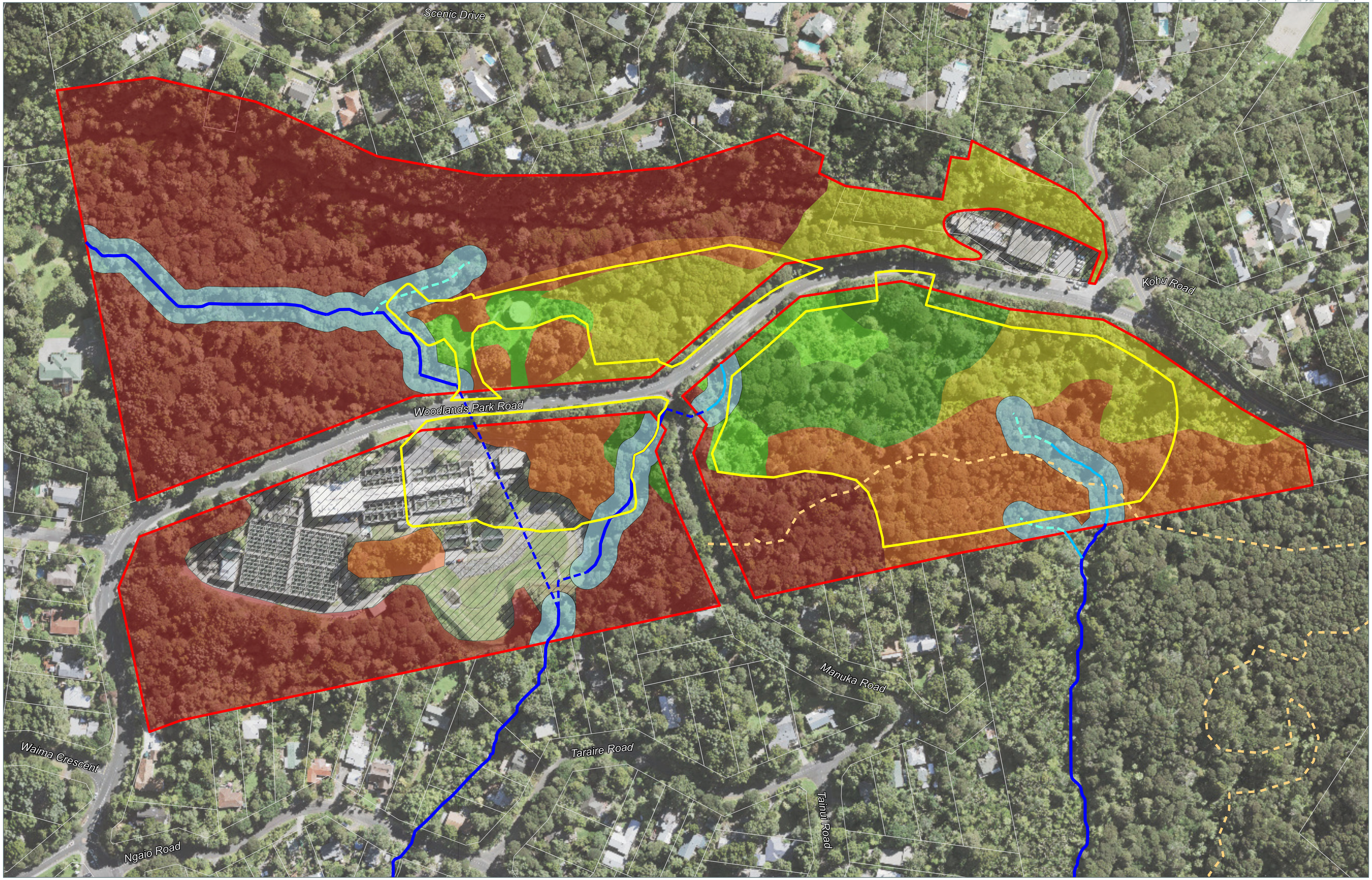
Design	Scale	Date
Drawn WHa	1:750 @ A1	26.07.2019
Check PGo	1:1500 @ A3	

DRAWING NO. FIGURE 18

REVISION 1

U:\2016\A16055C_IBo_Huia_WTP_Ecology_Assessment_of_Effects\TParty\Greenscene_Tree_Locations\A16055C_Sheet_Tree Location Plan.dwg

File Ref: A16055C_Huia_WTP_AEE.aprx/A16055C_19_Ecological_Integrity_Impacted_By_Works_Footprint



Boffa Miskell
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0 — 1,000 m
1:2,000 @ A3

Data Sources: Boffa Miskell, GHD, Tonkin + Taylor, LINZ, Auckland Council

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

- Site Boundary
- Extent of Construction Footprint
- Track

Ecological Integrity
- 1 Highest
- 2
- 3
- 4
- 5 Lowest
- Existing Infrastructure

Stream
- Permanent
- Permanent Piped
- Intermittent
- Ephemeral
- 10m Stream Buffer

A16055 HUIA WTP UPGRADE

Figure 19: Ecological Integrity Impacted by Works Footprint

Date: 15 May 2019 | Revision: 1

Plan prepared by Boffa Miskell Limited

Project Manager: **Rachel.deLambert@boffamiskell.co.nz** | *Drawn:* ATy | *Checked:* SFi

7.4 Groundwater effects

WTP Site and Reservoir 2

As described in the Groundwater and Settlement Effects report (T+T 2019), earthworks will be undertaken at or above the groundwater table. As such, will be no effect on the groundwater regime and no drawdown-related settlement for the replacement WTP or Reservior 2 sites.

Reservoir 1

According to T+T (2019), the Reservoir 1 site has a complex perched and under-drained groundwater system that ranges in depth from 4 to 9 m, while the reservoir structure will extend to 15 m below existing ground level. Groundwater drawdown and settlement can therefore be expected to occur. However, according to T+T (2019), drawdown effects will be localised to within ~50-70 m of the works footprint, and will be temporary (for the duration of construction). Ongoing recharge from rainfall and surface water flows off the escarpment will provide sufficient soil moisture to prevent drought stress in adjacent vegetation during the construction period. Therefore, no adverse effects or permanent changes in environmental conditions within adjacent wet forest ecosystems are anticipated.

6.2.3 Loss of Threatened / at Risk Flora

The proposed forest clearance will result in the removal of areas of kanuka-dominated forest, planted specimen pohutukawa trees, a few manuka and vegetation containing common and widespread climbing rata species. All these species are identified as threatened or at risk (de Lange et al. 2018), though they have large and widespread populations. Given that the rationale for classifying these species as threatened arises from disease risk rather than scarcity or habitat loss, the loss of the populations within the proposed development footprint has no bearing on the viability of the threatened / at risk species. Hence, we have assessed the effect of removing these threatened / at risk populations from within the footprint *per se* as minor.

Other threatened species recorded within the Project Site, including maire tawake, pokaka and *Metrosideros carminea,* were recorded outside the proposed development footprint and will remain unaffected.

6.2.4 Spread of Kauri Dieback Disease

The pathogen that causes kauri dieback disease, *Phytophthora agathicida*, is primarily soilborne. Initial infection is through part of the root system and that the infection spreads along the large surface roots, eventually reaching the lower trunk. Soil biassays (Bellgard et al 2013) from excavated root systems of diseased kauri confirmed the presence of *P. agathicida* in surface soil layers, coincides with the concentration of roots at the soil surface, but no *Phytophthora* species were recovered by soil bioassay below a depth of 20 cm (Bellgard et al 2013).

Mature kauri trees are present in the immediate vicinity of the proposed replacement WTP footprint and reservoirs (occasional kauri seedlings and saplings were also encountered within the WTP footprint). The root systems of trees have the potential to harbour kauri dieback disease, and movement of machinery, equipment and people between sites during construction work is a key pathway for the spread of kauri dieback.

Areas within three times the radius of the canopy dripline of any kauri tree will be defined as “kauri containment zones” (KCZ). Works within these zones, removal of soil and organic matter, and movement of personnel, equipment and machinery will adhere to the following protocols:

1) Any clearance of soil and organic material from within a KCZ will be undertaken in stages, under the supervision of the Project Ecologist.
2) Trees and dense vegetation will be felled and disposed of at a landfill approved to receive kauri dieback infected material. Logs may be cut into sections, but no plant material may be chipped or mulched.
3) Remaining vegetation, organic material and soil to a depth of 1 m will be stripped and disposed of as above.
4) Machinery will be cleaned and sterilised with an approved disinfectant and used to strip a further 1 m layer of soil within the KCZ. Soil material removed from this layer will be disposed of at an approved facility as above. Machinery used for excavation will be cleaned and sterilised before further use.
5) Remaining soil excavated from the KCZ will be reused on-site or removed to an approved clean-fill facility.

Elsewhere within the works footprint, standard kauri dieback protocols for cleaning footwear and equipment will be implemented to ensure all footwear, tools and equipment and machinery are totally soil-free prior to moving on and off-site (including movements between the reservoir and replacement WTP sites). Gravelled hard-stand areas (maintained to a depth of 500 mm) will be formed to ensure haulage trucks and large plant are not operating on bare soil. Where possible, machinery and vehicles will remain on site for the duration of works.

6.2.5 Impacts on Fauna Populations and Habitats

Herpetofauna

While only copper skinks were detected during field surveys, we consider that the availability of suitable lizard habitat on the site offers a reasonable likelihood that other lizard species previously recorded in the surrounding environs are present. In particular, mature kanuka forest and individual large tree specimens (e.g., mature totara and rimu that have abundant crevices) within the development footprint have high quality habitat potential for arboreal geckos. The lack of gecko observations may reflect either their absence, or search difficulties associated with the tall tree-dominated character of much of the site, which makes detection of geckos extremely difficult.

Vegetation clearance is likely to impact lizard populations primarily by way of direct mortality, along with habitat loss and intensification of competition as resident lizards are displaced to adjacent territories. Mortality of lizards is more likely if vegetation clearance is undertaken during cooler months when lizards are relatively inactive, or if trees are felled without an opportunity or strategy to salvage lizards.

Bats

Acoustic monitoring and habitat surveys undertaken within the Project site indicate it is unlikely to be important habitat for long-tailed bats, as no bats were detected in surveys undertaken through the breeding season. Long-tailed bats usually select the oldest trees in the landscape for breeding, largely because these trees are well insulated, and protect the vulnerable young when the mothers are out feeding at night (O'Donnell 2018). As identified in Section 3.3 of this report, the nearest recorded maternity roost site for long-tailed bats is 7.5 km from the Project Site. However, long-tailed bats have large home ranges, and individual bats tend to space themselves in different parts of the landscape to reduce competition (O'Donnell 2001; Dekrout

2009). Hence, individuals may occasionally utilise the Project Site for foraging and/ or solitary roosts.

In our assessment, there is a very small risk of direct mortality via removal of occupied solitary day roosts during vegetation clearance. Long-tailed bats use a network of daytime and night-time roosts, often switch between roosts on a nightly basis, and infrequently use the same roosts. While long-tailed bats are very selective in their choice of maternity roost trees, they will utilise a wide range of vegetation for solitary roosts (including tree ferns, cabbage trees and epiphytes). Consequently, pre-emptive identification of solitary roost trees (other than immediately prior to clearance) is not feasible. Vegetation clearance during cooler months of the year increases the risk of mortality to roosting bats as they spend longer in torpor and are less likely to be roused.

Birds

A variety of native and exotic bush birds inhabit the Project Site and surrounds, comprising species that commonly inhabit fragmented landscapes that contain both natural areas and human- environments. Vegetation clearance is likely to impact these populations primarily by way of habitat loss and intensification of competition as resident birds are displaced to adjacent territories. Mortality of chicks and nesting birds is also probable if vegetation clearance is undertaken during bird breeding season. Clearance of the site will result in the loss of numerous mature kahikatea and other fruit and nectar producing trees, though surrounding areas of more intact, mature forest to be retained produces periodically abundant food sources (e.g., during mast kahikatea fruiting seasons) most likely to occasionally attract wide-ranging species such as kaka.

Invertebrates

Field surveys indicated that the invertebrate fauna present is generally representative of the wider Waitakere Ranges. Some less-common invertebrate taxa were observed, but these were found in their characteristic mature forest habitats, including intact kauri forest and wet kahikatea forest. These observations to some extent reinforce our assumption that higher biodiversity values (including for invertebrates) are likely to be associated with the areas of higher ecosystem integrity that have been excluded from the development footprint.

6.2.6 Effects on Freshwater Ecology

Armstrong Gully – Reservoir 1 and NH2 Shaft

All permanent and intermittent stream reaches within the Armstrong Gully catchment have been avoided and there is no loss or diversion of any watercourse proposed. We have shown a 10 m riparian buffer alongside the waterways as context for the application (Figure 11).

The construction of the NH2 shaft will require removal of a small section of the vegetation surrounding the permanent stream section of Armstrong Gully. Some 0.03 ha of riparian vegetation comprising rank grassland and weedy exotic scrub will be lost. One sizeable kahikatea will be removed.

The Groundwater and Settlement Effects Report (T+T 2019) concludes that the relatively deep nature of the groundwater on the reservoir site means that the Armstrong Gully Stream sits at an elevation above the groundwater table and is independent of it. As such, earthworks undertaken at the reservoir site that encounter groundwater will not affect the flows within Armstrong Gully stream. Furthermore, the assessment of groundwater drawdown shows that the western-most extent of groundwater drawdown on the Reservoir 1 site will be limited to the reservoir excavation itself and will not impact surface water flows (T+T 2019).

However, we note that the close proximity of the stream to the NH2 tunnel shaft excavation means there is some potential for groundwater drawdown associated with the shaft construction to affect flows in the creek (T&T 2019). T&T (2019) have concluded that drawdown of the static groundwater table is not expected to negatively affect the flows with the stream.

We note that discharges to the Armstrong Gully currently authroised by consent 26979 (allowable stormwater discharge) and consent 35534 (for overflow discharges) will remain the same under the proposed application, even though a new consent is being applied for. Similarly, no amendments are proposed to the current resource consent (no. 35534) which authorises scheduled overflow discharges (off-spec discharges) from the existing WTP to Armstrong Gully. Accordingly we do not expect any change to the effects of stormwater discharges on Arsmtrong Gully.

We note that as part of compliance with resource consent 35534, Watercare is required to carry out visual inspections along the Armstrong Gully following any planned discharge (from the retention pond) event. The most recent planned discharge was undertaken on 15 August 2018. T+T report (Armstrong Gully Stream Inspection, 2018) concluded that the section of Armstrong Gully between the discharge outlet and Ngaio Road culvert is characterised by generally steep vegetated banks, and historical bank slumps and slips are common.

The visual inspection is carried out to assess effects on bank and channel scour, and identify evidence of fish kills, sedimentation, debris accumulation, and potential channel or culvert blockages. For the planned discharge on 15 August 2018, T+T (2018b) noted that there was some erosion to the banks, but this was due to precipitation and run off from the adjacent land.

Water Quality shall be addressed through the construction of two proprietary devices on the HRWTP site. A stormfilter vault is proposed to provide treatment for the majority of HRWTP catchment, while the smaller catchment within the HRWTP site (discharges to Armstrong Gully) shall also be treated by a proprietary device.

Armstrong Gully – Reservoir 2

The footprint of Reservoir 2 encroaches closely alongside the western bank of the Armstrong_manuka stream (Figure 19). This will result in the loss of some 0.07 ha of riparian vegetation[18].

Yorke Gully

Ephemeral and intermittent watercourses running through this footprint discharge into the open channel of the Yorke Gully Stream. The proposed WTP footprint requires the reclamation of approximately 53 m of intermittent stream (Figure 17), leading to its re-alignment along a diversion at least 70 m in length. No fish habitat is present up-stream so fish passage is not a consideration for upstream migration. Details of the stream diversion are included in section 7.3.4 below. The stream diversion will also receive collected and treated stormwater from the replacement WTP site. Delivery of treated stormwater to the diversion channel will replicate the intermittent nature of the existing stream, and support flows in the Yorke Gully stream downstream.

[18] We are aware that the construction footprint for Reservoir 2 as shown on some plans lies across the Armstrong_Manuka tributary. We have confirmed with the project team, that in fact the construction footprint does not cross the Armstrong_Manuka tributary stream, but does lie up to the top of the true right bank of the stream. Hence there will be no instream works, but there is the potential for some loss and modification to the riparian area.

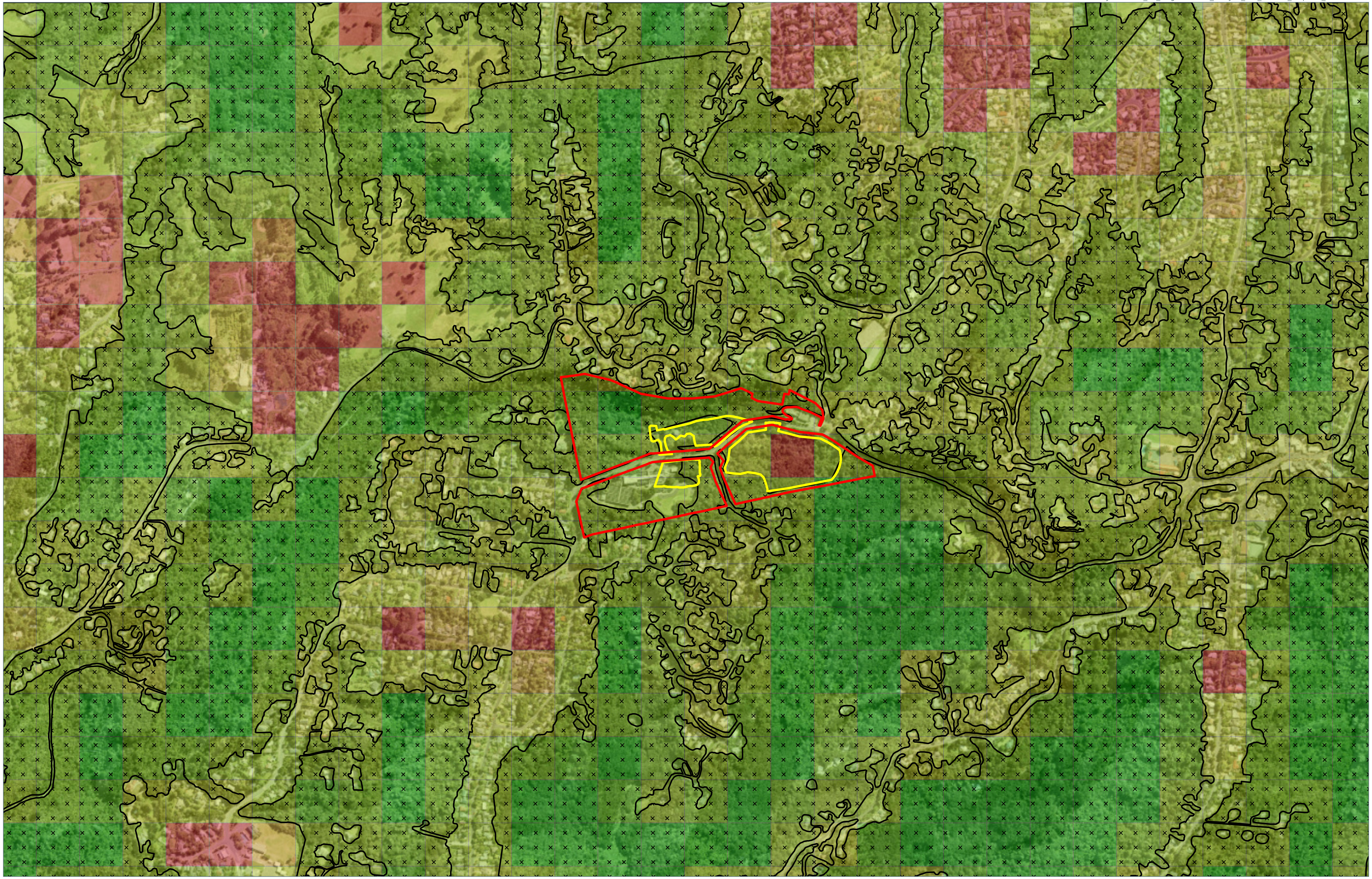
Areas of active and historic erosion were evident downstream within Yorke Gully Stream. Increased flow water velocities from the project site may exacerbate streambed and streambank scour, causing instability in streambank leading to erosion and increased sediment entering the freshwater and downstream upper harbour environment. Where necessary, energy-reducing engineered structures will be located at the boundary to minimise scour and erosion at this point and further downstream. Retention of stormwater on site may assist in management of flood flows, reduce peak flood flows and further reduce the risk of erosion downstream.

T+T (2019) concludes that all earthworks on the replacement WTP site will be undertaken at or above the groundwater table and there will be no effect on the groundwater regime or drawdown (baseflows) on Yorke Gully stream, though the civil infrastructure report (Cook Costello 2018) notes that the contributing catchment area to the Yorke Gully stream will be reduced once the construction of the WTP has been completed. The intermittent flow characteristics of the re-aligned stream will be retained, and treated stormwater entering the diversion will ensure that flows are maintained downstream in Yorke Gully stream.

6.3 Catchment-Scale Effects

The project entails the removal of native forest and scrub that covers 3.5 ha of the 4.3 ha works footprint (including the replacement WTP and the reservoir sites). At a broader scale, the 15 ha Project Site (including the existing WTP site) encompasses 12.6 ha of native forest and scrub, and the ~990 ha Little Muddy Creek catchment contains approximately 720 ha of native forest that forms part of the 24,000 ha Waitakere Ranges SEA. These figures illustrate that the extent of bush clearance proposed constitutes a small, peripheral part of a much larger natural area, the integrity of which will not be undermined as a result of the proposed development.

Nevertheless, at a catchment scale, the proposed clearance and development introduces localised fragmentation into the vegetated corridor across the top of the Little Muddy Creek catchment that is, at present, relatively intact (relative to other parts of the catchment where there is more residential development and associated roading infrastructure). Hence, while the proposed forest clearance amounts to a small proportion of the indigenous forest present in the Little Muddy Creek catchment, the gap created will further reduce connectivity across the (already somewhat fragmented) local landscape, and between mature and regenerating forest patches in the immediate environs of the Project Site (Figure 20).



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Data Sources: LINZ Data Service (Aerials), Auckland Council (SEAs), Boffa Miskell

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Figure 20: Fragmentation Analysis post development

Date: 7 May 2019 | Revision: 0

Plan prepared by Boffa Miskell Limited

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6.4 Summary of Ecological Effects

6.4.1 Effect Magnitude

The proposed criteria consider the extent of the effects on ecological components on the Project Site and associated zone of influence. The contribution of the particular example of the ecological component to the wider population or ecosystem is also considered, e.g. as a proportion of the wider forest ecosystem.

EIANZ (2018) provides guidelines for assessing the magnitude of ecological effects, on a scale of Negligible, Low, Moderate, High, or Very High (Table 23).

***Table 23**: EIANZ (2018) guideline for ascribing ecological effect magnitude.*

Magnitude	Description
Very high	Total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally changed and may be lost from the site altogether; AND/OR Loss of a very high proportion of the known population or range of the element/feature
High	Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed; AND/OR Loss of a high proportion of the known population or range of the element/feature
Moderate	Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed; AND/OR Loss of a moderate proportion of the known population or range of the element/feature
Low	Area rates Low or Very Low for majority of assessment matters and Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns; AND/OR Having a minor effect on the known population or range of the element/feature
Negligible	Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation; AND/OR Having negligible effect on the known population or range of the element/feature

***Table 24**: Magnitude of ecological effects on ecological values*

ATTRIBUTE		MAGNITUDE OF EFFECT			
		Vegetation clearance	**Edge Effect/ fragmentation**	**Fauna impacts**	**Aquatic ecosystem effects**
	Representativeness	Communities present within the footprint are well represented within the catchment and wider Waitakere Ranges, hence the loss represents a small proportion of the overall ecosystem type. **LOW**	Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but composition and quality of condition will be similar to pre-development state. **LOW**	Fauna species assemblages present around the Project Site and wider catchment will be similar to pre-development state. **LOW**	Diversion of small, intermittent headwater stream reach of moderate-low ecological value. **MODERATE**
	Rarity/ distinctiveness	Change arising from the loss/alteration discernible, but overall composition of remaining forest will be similar to pre-development with respect to threatened species; minor effect on the known population or key species. **LOW**	Edge effect/ fragmentation will have minor or negligible impact on threatened/ at risk species. **LOW**	No threatened or at risk fauna populations known to be present within the project footprint. **LOW**	No threatened or at risk aquatic species populations known to be present in the stream reach within the project footprint. **LOW**
	Diversity/ pattern	Permanent loss of early and mid-successional vegetation, within a wider area containing early, mid- and mature successional stages, that locally has a relatively low level of fragmentation. Reduced connectivity between stands of varying age may have some effect on forest regeneration processes. **HIGH**	Edge effects may reduce the extent of forest interior environment, reducing diversity of ecological niches and interrupting some ecotonal gradients in the Project Site and surrounds. **MODERATE**	Good quality habitat will be lost from the site; development will have a minor effect on the distribution and abundance of fauna species recorded due to the extent of similar habitat elsewhere in the catchment. **MODERATE**	Diversity and range of freshwater habitat features will be similar to pre-development patterns; minor effect on the extent of headwater stream reaches in the catchment. **LOW**
		Partial loss of connectivity within forested corridor on northern catchment boundary; and between different-aged forest patches. **MODERATE**	Edge effect may increase opportunities for weed encroachment, degrading indigenous character of ecosystems surrounding the Project Site. **MODERATE**	Edge effect and fragmentation may increase vulnerability of fauna to predation and further constrain opportunities for dispersal and genetic exchange. **MODERATE**	Potential to partially change post-development composition and/or attributes of high-quality receiving environment. **MODERATE**

Using the EIANZ guidance, we have assessed the magnitude of each of the effects described above on each of the ecological value attributes (Table 24). While the magnitude of effect ranges from low to high depending on the attribute assessed, the overall magnitude of ecological effects is **Moderate**.

6.4.2 Level of Effect

EIANZ (2018) provides a matrix framework to guide assessment of the overall level of effect (Table 25). In our assessment, the level of ecological effect arising from the proposed development is **High**, as a consequence of a moderate overall magnitude of ecological effects on a site with very high ecological values.

***Table 25**: Framework for assessing level of effect (from EIANZ 2018)*

		ECOLOGICAL VALUE				
		Very High	High	Moderate	Low	Negligible
MAGNITUDE	Very High	Very High	Very High	High	Moderate	Low
	High	Very High	Very High	Moderate	Low	Very Low
	Moderate	High	High	Moderate	Low	Very Low
	Low	Moderate	Low	Low	Very Low	Very Low
	Negligible	Low	Very Low	Very Low	Very Low	Very Low
	Positive	Net gain	Net gain	Net gain	Net gain	Net gain

7.0 Effect Management Strategy

7.1 Mitigation Hierarchy

Our approach to the management of effects resulting from the proposed Huia replacement WTP has been to follow the “mitigation hierarchy”, as advanced in EIANZ guidelines for ecological impact assessment (EIANZ 2015), Biodiversity offsetting under the RMA (Biodiversity Working Group 2018), and relevant sections of the AUP. The AUP contains policies that describe a mitigation hierarchy around managing effects of activities on indigenous biodiversity values that are identified as significant ecological areas (Policy D9.3), and also Chapters E.15 (Vegetation management and biodiversity) and E.3 (Lakes, rivers, streams and wetlands). The AUP (Appendix 8 in the Plan) also sets out a framework of principles for biodiversity offsetting, which is to be read in conjunction with the New Zealand Government Guidance on Good Practice Biodiversity Offsetting in New Zealand document[19]. The EIANZ (EIANZ 2015) guidance follows a similar framework.

19 New Zealand Government, 2014.

The fundamental principle of the mitigation hierarchy is that avoidance of adverse effects is prioritised, with remediation then mitigation, before finally considering the appropriateness of offsetting or compensating any residual adverse effects that are significant and where they have not been able to be mitigated, through protection, restoration and enhancement measures.

7.2 Avoidance and Remediation

Our detailed ecological values assessments, ecosystem classification and integrity evaluation enabled the project design team to give priority to avoiding areas of highest value, including permanent watercourses, threatened ecosystem types and areas of mature forest. Particular emphasis has been placed on avoidance of old-growth kauri, including individual trees which have provenance value.

The design brief then focused on minimising the extent of the works footprint and configuring the plant and laydown areas to utilise lower-value parts of the site to the greatest extent possible within the constraints of the design brief. Detailed design also focused on limiting losses of intermittent watercourses and individual mature, later-successional trees (particularly kauri).

7.3 Mitigation

7.3.1 Disturbance and Edge Effects

Both the WTP and reservoir footprints are to be cleared and developed within areas of indigenous vegetation, and the intent is to retain and enhance the remaining ~11 ha of native vegetation within the Project Site that is outside of the developed area. Any construction in this tight area will be challenging to implement and poses risks to the surrounding existing vegetation. Potential impacts to the surrounding vegetation may occur as a result of:

- Accidental encroachment
- Damage to adjacent vegetation
- Edge effects
- Effects from changes to water table and / or soils (on large, old trees in particular)

Risks associated with accidental encroachment or damage to adjacent vegetation can be avoided or remedied through clear site protocols and careful demarcation of the work site and associated laydown areas. Development of site specific protocols is recommended as a condition of consent.

Risks associated with impacts of edge effect, works close to large, old trees, changes to the soil environment and water table etc., are more uncertain and difficult to manage. Recommendations to address these potential effects include a requirement for an arborist to advise detailed design at the building consent stage to ensure large trees close to the development footprint are appropriately protected, including specifying earthworks setbacks if necessary.

Natural regeneration is generally favoured over planting within natural bush environments, however exposed bush edges, old tracks and open areas within forest remnants in the Project

Site will be revegetated with fast-growing forest edge species to buffer the forest interior, inhibit weed encroachment, and accelerate regeneration.

Edge habitats are favoured by lizard species and there may be potential to enhance these areas for lizards by planting low-growing, lizard-friendly vegetation such as pohuehue and shrubby *Coprosma* species. Both reservoirs will have green roofs, which will also provide opportunities to create favourable lizard habitats through establishment of appropriate planting and refugia.

The riparian buffer zone between the Armstrong Stream channel and site entrance adjacent to the proposed reservoir footprint will be restored with early successional wet forest species to buffer and enhance the watercourse and adjacent forest area.

7.3.2 Animal Pest and Weed Control

Weed and animal pest management is proposed to enhance the ecological values and ecosystem integrity of remaining forest areas within the Project Site as mitigation for loss of flora and fauna habitat, in order to enhance the viability of remaining populations. Control of vertebrate pests within the site will be part of the wider offset package addressed in Section 7.4 below.

Bush to be retained within the Project Site will be subject to ongoing weed control as part of its protection and management. A large proportion of existing weed infestations are within the Replacement WTP footprint and will be removed as a result of the development. Patchy weed infestations are present throughout the site, with a variety of ornamental garden escapes near boundaries with the road and residential properties. Kahili ginger seedlings are sparse but ubiquitous, while climbing asparagus and jasmine are locally common to abundant, particularly on the escarpment below Exhibition Drive.

7.3.3 Pre-works Fauna Survey and Salvage

Bats

The lack of recorded bat activity within the Project Site and vicinity indicates an absence of favoured maternity roost trees. However, as individual long tailed bats may occasionally utilise the Project Site for foraging and/ or solitary roosts, pre-clearance bat monitoring is recommended.

Pre-clearance bat monitoring will ensure possible roost trees are not occupied at the time of clearance, avoiding injury or mortality of bats. Prior to vegetation clearance commencing, potential bat roosting areas will need to be visually assessed by the Bat Specialist. If trees are identified in these areas that provide potential bat roost features (i.e. cavities, deadwood, loose bark and epiphytes), then further acoustic surveys will be required for these potential bat roost trees immediately prior to felling.

Potential bat roosting areas present within the footprint include:

- Stands of mature native conifer and broadleaved forest trees that contain trees and tree ferns ≥ 15 cm diameter at breast height (dbh);
- Stands of mature exotic trees (not pine) that contain trees ≥ 15 cm dbh; and
- Standing dead trees ≥ 15 cm dbh.

Trees / tree ferns within the above ‘potential bat roosting areas’ offering potential bat roost habitat have one of more of the following features:

- Crack, crevices, cavities and / or fractured limbs large enough to support roosting bat(s);
- Sections of loose flaking bark large enough to support roosting bat(s);
- A hollow trunk, stem or branches;
- Deadwood in canopy or stem of sufficient size to support roost cavities or hollows; or
- Bat droppings, grease marks and / or urine staining around cavities.

If bats are confirmed to be occupying a tree scheduled for removal, a buffer will be placed around the active roost within which no works can be undertaken until the roost is vacated. If active roosts are identified immediately adjacent to the development footprint, a 50 m buffer will be retained for the duration of roosting to preserve microclimate conditions and protect the tree(s) from windthrow.

The Department of Conservation (DOC) has a competency database for bat specialists. Under the competency database, bat specialists can get certified as competent for various bat research and management skills (Table 26).

The Bat Specialist implementing the tree removal protocols is to hold a Bat Ecologists certification at levels A, B, C2 and D. Competency can be certified by the Leader of the Department of Conservation Bat Recovery Group (Colin O'Donnell) or any other Class E Bat Ecologist.

***Table 26**: Bat Competency Classes supplied by DOC in July 2017.*

Class	Key field activity	Competency	Individual Experience/Knowledge
A	ABMS	Setting up Automatic Bat Detector Monitoring Systems (ABMS).	Recent previous experience in installing ABMS in at least 2 comprehensive surveys.
B	Analysing ABMS	Setting up ABMS and analysing and interpreting results.	Recent previous experience at analysing and interpreting ABMS results in at least 2 comprehensive surveys.
C1	Identifying bat roosts (short-tailed bats)	Finding and identifying short-tailed bat roosts that are either occupied or unoccupied. This competency may also include arborists.	Recent extensive experience in searching for and finding active and inactive roosts (by radio tracking, exit observations, and/or visual inspections).
C2	C2 Identifying bat roosts (long-tailed bats)	Finding and identifying long-tailed bat roosts that are either occupied or unoccupied. This competency may also include arborists.	Recent extensive experience in searching for and finding active and inactive roosts (by radio tracking, exit observations, and/or visual inspections).

Avifauna

Pre-felling surveys are required to check for nests of native bush birds if vegetation clearance is undertaken during the bird breeding season (August-February). The nest survey protocol is as follows:

1. Any vegetation scheduled for removal will be surveyed for nests within 24 hours prior to clearance;

2. If an active nest is identified during the visual inspection, all vegetation removal within 20 m of the nest is to cease until the Project Ornithologist has confirmed that the nest has either failed or the chicks have fledged. This area will be clearly demarcated to ensure the vegetation is not accidentally felled;
3. Once an area of vegetation has been confirmed clear of active nests, vegetation clearance should be initiated as soon as possible to prevent birds establishing further nests.

An appropriately qualified (MSc or above) and experienced field ornithologist will undertake all avifauna survey work including the sighting and deployment of acoustic recorders, analysis of sound files and nest surveys.

Lizards

Pre-works surveys for lizards will comprise salvage operations within the delineated earthworks footprint immediately prior to and during vegetation clearance. Methods will include (in order of preference):

i. Visual inspection and / or destructive searching of potential habitat features (including trees and groundcover habitats).

ii. Supervised felling - where high-quality lizard habitat cannot be adequately searched (e.g., some tall, dense tree species), felling should be supervised to allow a herpetologist to search through fallen trees for resident lizards.

iii. Passive dispersal - placing the felled vegetation outside of the works footprint to allow lizards to disperse. This method is not preferred as a standalone lizard management tool but may be suitable in some instances (for example, lower-quality potential habitat, or following hand-searching if trees must be felled out of season).

Lizard salvage must be carried out between October and April (as site clearance proceeds) to coincide with peak lizard activity periods. Given the scale of the works, we recommend that searching for lizards targets only high quality habitat (kanuka forest, mature trees with crevices and loose bark, etc.), and that felling proceeds in a staged manner, allowing low quality habitats to be cleared outside of the lizard activity period. Site clearance can be commenced in the years prior to construction to minimise conflicts with the earthworks timetable.

A DOC authorised herpetologist will need to be present during vegetation clearance in high quality habitat areas within the works footprint to direct clearance and the relocation of woody debris (if vegetation is to be used to supplement available habitats, or to allow for passive dispersal), and to capture and relocate lizards if required. Lizards will be captured by hand and held in individual cloth bags in a secure container and will be released within 4 hours at a pre-determined release site.

Mature native forest remnants within the Project Site that will remain undisturbed by site development works are the preferred location for translocated fauna (subject to pre-salvage assessments to confirm suitable microsites are present). If required, habitat enhancement (placement of piles of logs, planting specific food and cover species) will be carried out to provide additional refuges and food for lizards.

Intensive pest control will be required in and around release sites prior to translocation of any target fauna. Predator control will include rodent, possum, cat and mustelid management and may include both trapping and poison baits.

All salvage and translocation efforts will be conducted in accordance with Wildlife Act Authority (WAA) requirements. No formal baseline or post-translocation monitoring will be undertaken as there is no effective protocol for evaluating the success of small-scale fauna translocations of small-size release groups and would require unnecessary handling and / or disturbance of individuals. If a large number of lizards are released into a release site in one season (i.e., 20 lizards or more), post release monitoring to assess species presence and breeding will be carried out at Year 2 and Year 5 following release to assess presence and breeding success (i.e., juveniles present).

Any native lizard capture and translocation requires that the specialist (herpetologist) undertaking the work holds a current WAA for that activity. The WAA is approved by specialists within DOC who assess the competency of the applicant based on previous experience.

7.3.4 Freshwater Management

Stream Reclamation and Diversion

As outlined in section 6.2.6 above, the replacement WTP project will result in the reclamation of some 53 m of intermittent stream within the Yorke Gully (Figure 19). The portion of stream that will be diverted has poor habitat (and unsuitable for fish habitat) but high instream and riparian function (as assessed using SEV attributes). The ecological values of the intermittent stream were ranked as moderate-low (section 6.4). The loss of stream reach will be mitigated by way of a stream diversion at least 70 m in length (refer Figure 19). This will be an intermittent watercourse that collects clean water from the upper catchment, bypassing the earthworks and the final developed site, and will collect treated stormwater from the site to discharge downstream. A Stream Ecological Valuation Plan has been prepared for the resource consent application that sets out the rationale for the proposed compensation (Appendix 9).

The final diversion alignment will follow a similar alignment to the clean water diversion that is proposed during the construction works. In reflecting the existing stream and the steepness of the site, consideration will need to be given to energy dissipation to avoid scour within the realigned stream. We expect the final diversion design to comprise a sequence of pools and cascades along its length and meandering across the contours to the boundary of the site, where it enters the mainstem of Yorke Gully. The diversion will be longer than the reclaimed watercourse, and meanders will result in a slightly shallower gradient in part, allowing a greater diversity and abundance of habitat features to be included (e.g., pools and cascades), but some sections will be much steeper and incised. The final design will likely, but not exclusively, include some reaches and weirs which will be rock-lined for stability, but that will also provide enduring habitats. The diversion channel will be designed to maintain and improve the existing SEV values, including enhancement to the riparian margins, and will provide improved overall aquatic ecological benefit, and we recommend that a condition of consent be prepared to ensure this occurs. We note that the stream design will need to incorporate the SEVm-P assumptions, in order to meet the proposed mitigation offset.

A 10 m average planted riparian zone on both sides of the diversion is recommended. However, it is anticipated that the banks of the diversion will likely to be more sinuous in width (i.e., a mix of wider and narrower margins) due to the nature and requirements of construction activities. It is recommended that a riparian planting plan be developed as part of the stream diversion design. In particular improvement to the vegetated lower stature ground cover close the stream will improve instream habitat.

Additional mitigation to meet the requirements of the Stream Valuation Plan will result in the removal of culverts and the daylighting of lengths of the Armstrong_Manuka Stream. Investigations of the potential for daylighting are underway but we have factored daylighting into our Stream Ecological Valuation Plan. If required erosion protection works within the Yorke Gully outside of the Watercare site will provide additional benefit as a compensatory measure.

Stormwater Management

Where possible surface water runoff from roof and impervious areas is to be conveyed into the water treatment system (Cook Costello 2019). The pipe network shall discharge to one of two discharge points. The majority of the replacement WTP will discharge to Yorke Gully via proprietary devices (e.g., storm filters or similar). Any flow from the storm filters and overflow will then discharge to a dry pond and then into the diverted stream.

The stormwater management will control flows to predevelopment rates in events up to a 1 in 100-year storm (Cook Costello 2019). A secondary pipe network will discharge to Armstrong Gully via the existing attenuation basin within the existing HWTP. Flows will be limited to those under predevelopment conditions and in accordance with the existing stormwater discharge consents.

As noted above, the discharge of stormwater from the outlet of the reclaimed stream reach at the boundary of the replacement WTP site has the potential to increase streambed and streambank scour from increased water velocities in Yorke Gully stream. Where necessary, energy-reducing engineered structures will be located at the boundary to minimise scour and erosion at this point and further downstream. The retention of stormwater on site in events up to a 1 in 100-year storm will reduce the risk of erosion downstream.

Water Quality

Surface water runoff from roof and impervious areas is to be conveyed into the water treatment system (Cook Costello 2019). The pipe network shall discharge to one of two discharge points. The majority of the stormwater will discharge to Yorke Gully via proprietary devices (e.g., storm filters or similar). Any flow from the storm filters and overflow will then discharge to a dry pond and then into the diverted stream. Two proprietary devices will be used on the HRWTP site. A stormfilter vault is proposed to provide treatment for the majority of HRWTP catchment, while the smaller catchment within the replacement WTP site (discharges to Armstrong Gully) will also be treated by a proprietary device (Cook Costello 2019).

Cook Costello (2019) outline the following design principels for stormwater management for the replacement WTP:

- Replicate as much as possible the pre-development scenario in terms of catchment areas and points of discharge.
- Renew the existing discharge consents for the existing HWTP but continue to limit discharge in accordance with the discharge rates and limits of the existing consents
- Manage stormwater runoff to predevelopment levels through the detention / attenuation of flows within both the Armstrong and Yorke Gullies up to the 1 in 100 year event.

The stormwater management will improve the quality of stormwater being discharged downstream to both Armstrong and Yorke Stream gullies to at least pre-development levels.

The discharge of stormwater from the proposed WTP site has the potential to increase streambed and streambank scour from increased water velocities in Yorke Gully stream. To avoid scour, energy-reducing engineered structures will be located at the boundary where the diversion outflows into the Yorke Gully Stream. The retention of stormwater on site in events up to a 1 in 100-year storm will reduce the risk of erosion downstream.

Erosion and Sediment Control

Earthworks and the associated mobilisation of sediment may adversely affect high quality freshwater habitats and associated aquatic organisms in the vicinity and downstream of the project site if not managed. The quantities of cut and fill are detailed in Table 27.

***Table 27**: Earthwork cut and fill volumes for the proposed Huia replacement WTP and Reservoir sites (from Cook Costello 2019).*

Value	HRWTP Site	Reservoir Site 1	Reservoir Site 2
"Disturbed Area" Footprint	27,200 m^2	9,200 m^2	7,200 m^2
Cut Volume (including topsoil stripping)	41,460 m^3	41,400 m^3	4,000 m^3
Fill Volume	30,400 m^3	2,000 m^3	2,550 m^3

An Erosion and Sediment Control Plan (ESCP) has been prepared by Cook Costello (2019). The Plan covers the construction activities associated with the proposed Huia Water Treatment Plant and provides details and proposed mitigation measures to minimise surface erosion and prevent the discharge of sediment laden water from the site during and immediately following earthworks.

Erosion and sediment control measures will be installed prior to the commencement of earthworks activities and constructed in accordance with Auckland Council GD05. The measures proposed include:

- Stabilised Entry / Exit points and wash down facilities.
- Catchpit Inlet Protection.
- Dust Control.
- Silt Fences & Super Silt Fences.
- Dirty Water conveyance channels.
- Dewatering of excavations.
- Sediment Retention Ponds.
- Cleanwater diversion channels.

Maintenance and inspection procedures are detailed in Cook Costello (2019). Accordingly, we are confident that sediment management and releases will be controlled to a standard that will not result in adverse effects on downstream environments.

NH2 Shaft

The construction of the NH2 shaft will result in the loss of some 0.03 ha of vegetation associated with the riparian margin of the Armstrong Gully stream. The construction activity does not impact on the permanent stream margin or the immediate margins of the stream. The loss of 0.03 ha of poor quality riparian vegetation will be mitigated with further planting and enhancement of the riparian margin of the stream.

We note that the construction footprint comes very close to the permanent section of the Armstrong Stream, but does not encroach into the stream bed. We recommend that a physical barrier, or a temporary construction wall, is erected to ensure that the permanent section of the Armstrong Stream is not affected by the construction works.

Reservoir 2

The construction of reservoir 2 will result in the loss of some 0.07 ha of vegetation associated with the riparian margin of the Armstrong Gully_manuka stream. The construction activity does not impact on the stream margin or the immediate margins of the stream. The loss of 0.07 ha of riparian vegetation will be mitigated with further planting and enhancement of the riparian margin of the stream, and the mainstem of the Armstrong gully stream.

We note that the construction footprint comes very close to the permanent section of the Armstrong Gully_manuka stream, but does not encroach into the stream bed. We recommend that a physical barrier, or a temporary construction wall, is erected to ensure that the permanent section of the Armstrong Gully tributary stream is not affected by the construction works.

Freshwater Management Concluding Comments

Overall, the effects of the Huia Replacement WTP project on freshwater values will be the reclamation and diversion of some 53 m of moderate-low value intermittent stream in the headwaters of Yorke Gully stream. The watercourse will be re-aligned as a stream diversion of at least 70 m in length and will be an intermittent watercourse that collects clean water from the upper catchment to bypass the earthworks and the final developed site and will collect treated stormwater from the site to discharge downstream.

The final stream diversion design will comprise a sequence of pools and cascades along its length and will meander across the contours to the boundary of the site, where it re-joins the mainstem of Yorke Gully stream. The final diversion will be designed to maintain and improve the existing SEV attributes to provide an improved overall aquatic ecological benefit, including enhancements to the riparian margins A Stream Ecological Valuation Plan has been prepared for the resource consent application that sets out the rationale for the proposed mitigation and compensation (Appendix 9). A package is proposed that encompasses both the creation of a stream diversion channel to mitigate on-site effects, and the removal of culverts and the daylighting of lengths of the Armstrong_Manuka Stream. Investigations of the potential for daylighting are underway but we have factored daylighting into our Stream Ecological Valuation Plan. If required erosion protection works within the Yorke Gully outside of the Watercare site will provide additional benefit as a compensatory measure.

The stream reclamation and diversion channel will have some minor temporary effects during the construction phase that will be mitigated by the proposed environmental management measures. These effects will be short-term, with any residual effects appropriately mitigated for through the stream diversion channel design and Yorke Gully erosion protection works. As a result, there will not be any permanent adverse effects on freshwater ecological function as a result of the replacement WTP project and will provide an overall ecological enhancement.

Improvements to water quality will occur through enhancement of the riparian margins and the proposed stormwater management. Planting will strengthen the integrity of the riparian margins and stream banks, to improve bank stanbility and prevent bank erosion. The proposed stormwater management will result in discharges of water quality better than the present quality of stormwater discharged from the site, and enhanced to pre-development levels. This will benefit the downstream water quality, and ultimately the water reaching the downstream estuarine environment.

In conclusion, there will not be any permanent adverse effects on freshwater ecological condition or function, or water quality, as a result of the construction and operation of the replacement WTP project. Overall, the replacement WTP project will provide an overall ecological enhancement for waterways on the site, and in the downstream receiving environment.

7.4 Management of Significant Residual Effects (Offsetting/ Compensation)

7.4.1 Proposed Waima Biodiversity Management Plan

Proposal for the management of significant residual effects

Our proposal for the management of residual ecological effects from the construction of the replacement WTP is to establish a Waima Biodiversity Management Plan (BMP). Details of the proposal are set out below.

Rationale

Forested parts of the Little Muddy Creek catchment are identified as SEA, with biodiversity values comparable to that present within the Project Site. The choice of the Little Muddy Creek catchment as the focus of proposed biodiversity management meets the AUP principle that offsetting/ compensation to address adverse ecological effects "should be undertaken close to the location of development, where this will result in the best ecological outcome".

In the context of the largely bush covered Little Muddy Creek catchment and wider Waitakere Ranges, we consider that management to protect and restore remaining indigenous ecosystems is a higher priority, and will provide greater biodiversity outcomes, than creation of new habitat though revegetation. This assessment aligns with Auckland Council's Biodiversity Strategy, which prioritises protection of remnant existing ecosystems and habitats, and management of the region as a network of protected habitats which are buffered and linked, within a matrix of land use which supports their ecological function.

Auckland Council's SEA maps convey that ecosystems span both public and private land, and the Auckland Biodiversity Strategy identifies effective partnerships between agencies, mana whenua and people as a key tenet of Auckland Council's vision.

The rationale underpinning the proposed Waima BMP is that "landscape matrix" habitat quality is an important complement to intensive management of high value priority areas and is key to ensuring the viability of indigenous species conservation in human-modified landscapes (Franklin & Lindenmayer 2009). Meaningful biodiversity gains require appropriate (large) scale and defensible boundaries, with a mechanism to enable adequate, long-term resourcing of projects.

We arrived at the spatial extent of the proposed Waima Biodiversity Initiative management area and the level of investment proposed, on the basis of our professional judgement, taking into account the following assumptions:

- Natural 'defensible boundaries' in the landscape will assist with control operations and slow reinvasions;
- Biodiversity gains increase with the size and complexity of the management area, as a large area is more likely to contain a full, representative range of indigenous flora and fauna, including refuge populations of species that would benefit from pest management;
- Successful control of a large area offers 'critical mass', as an area with a large interior: edge ratio is more resistant to reinvasion, and is likely to have sufficient carrying capacity to support minimum viable populations of beneficiary fauna;
- The proposed management area encompasses the community-led Waima-Laingholm Pest Free Zone initiative, which will provide a foundation for positive collaboration with this group;

- Up-front funding of a large project will create economies of scale, and enable ongoing funding to be generated through investment of capital.

Proposed Management Area

A number of effects arising from the permanent loss of 3.5 ha of indigenous forest cover within the Project Site cannot be fully mitigated through on-site restoration and management, including:

- Reduction in extent of significant ecological area within the Little Muddy Creek catchment, including mature secondary forest and modified broadleaved scrub communities.
- Degraded ecosystem functions, including partial loss of connectivity within the forested corridor below Scenic Drive, on the northern boundary of Little Muddy Creek catchment; disruption of ecological sequences in the Project Site and immediate surrounds; and a potential reduction in the quality of forest habitat on the perimeter of the Project Site.

The Little Muddy Creek catchment is the focus of a biodiversity management project proposed to address adverse residual ecological effects.

The Waima BMP management area (Figure 21) encompasses the suburbs of Waima, Woodlands Park and Laingholm. Continuous forest within Waitakere Ranges Regional Parkland extends to the west, while Scenic Drive, Huia Road/ Little Muddy Creek define the northern catchment boundaries to the north, and to the east. The Waima BMP management area boundaries largely reflect those of the 2014 Muddy Creeks Plan (a Local Area Plan for Parau, Laingholm, Woodlands Park and Waimā prepared by the Waitakere Ranges Local Board), with the exclusion of Parau and regional parkland to the north and west of this settlement. The Waima BMP also encompasses all of the area within the Waima-Laingholm Pest Free Zone.The proposed management area encompasses 990 ha in total, approximately 720 ha of which is bush-covered and classified as SEA in the AUP. The vegetation is a mosaic of regenerating and mature kanuka forest, secondary podocarp forest and kauri forest, interspersed with roads, residential development, recreational open space and associated services and amenities. The most intensive suburban-density subdivision occurs amongst remnant old growth kauri forest on ridgelines.

Management is proposed for both public and private land including:

- 320 ha of regional parkland and Council reserves;
- 608 ha of private land (1,976 properties);
- 53 ha of forested land owned by Watercare.

Residential development is the dominant land use throughout the catchment, and most properties are 1 ha or smaller, though a few large properties are present (Table 28).

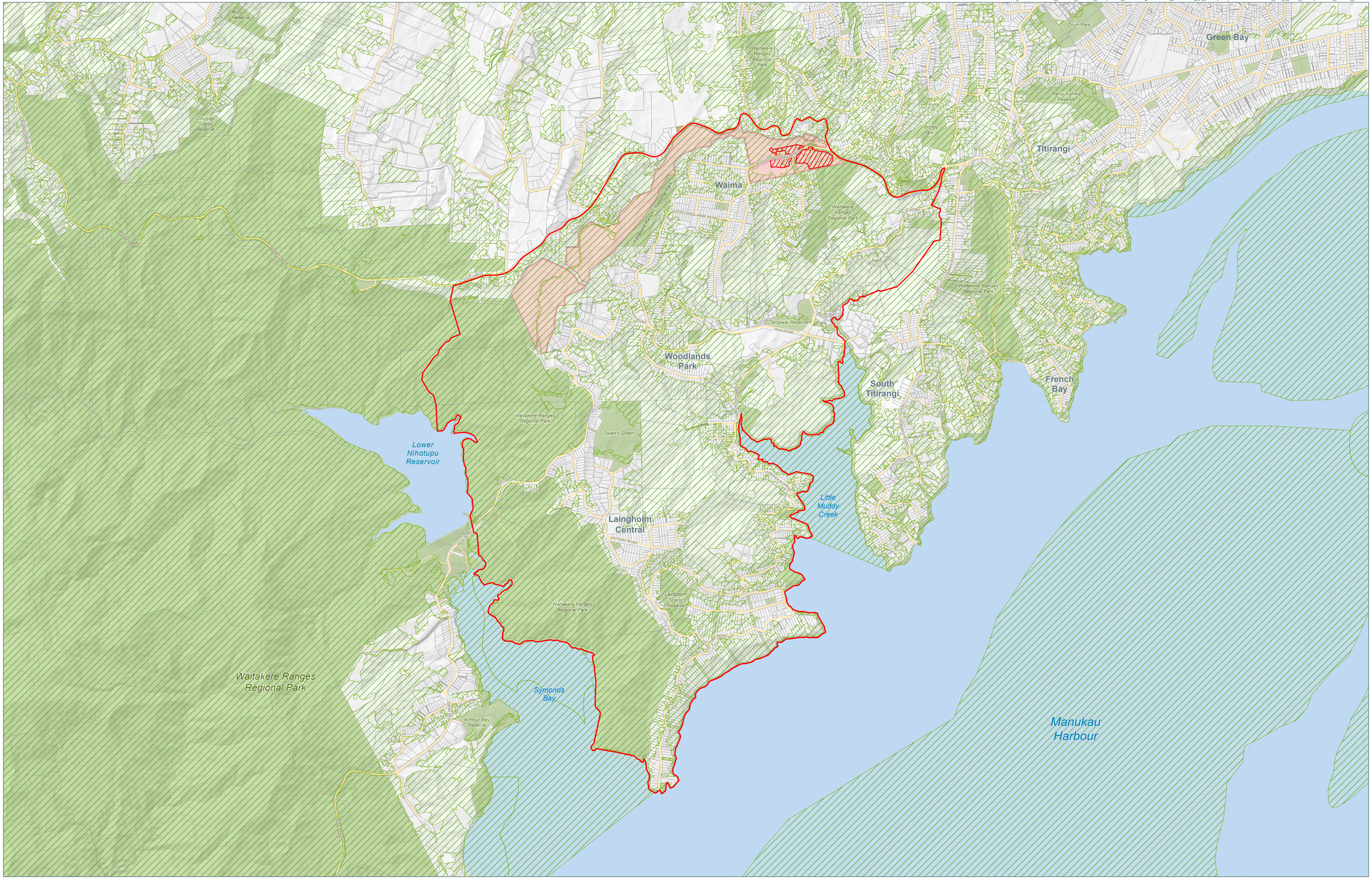
***Table 28**: Number and size range of private properties within the Muddy Creek Management Area*

Size (ha)	Number of properties
<0.1	463
0.1 - 1	1437
1 - 2	43
2 - 5	24
5 - 10	6
>10	3

The SEA overlay in the AUP provides a measure of protection to bush cover in the Little Muddy Creek catchment, as rules constrain clearance of native vegetation. However, the remaining indigenous ecosystem faces significant pressures on biodiversity associated with invasive species and human activity. Predation by vertebrate pests is the major threat to wildlife (birds, lizards, invertebrates and potentially bats), while kauri dieback, browsing animals and competition from weeds all impact on the health, diversity and integrity of the plant community. Argentine ants are also an emerging biodiversity threat, and have been detected in localised sites in the catchment.

Council Funds and Existing Initiatives within the Little Muddy Creek Catchment

Auckland Council's pest management in parks and reserves within the catchment to date has been intermittent, and essentially focused on possum control. Council's proposed Regional Pest Management Plan (PRMP; 2018) includes a 10-year budget of $142.44m, funded through a Natural Environment Targeted Rate (NETR), to cover region-wide biosecurity management on all parkland. Watercare's Project Ecologists met with Auckland Council's biodiversity and biosecurity team members to ascertain how and where Council will prioritise funds for biosecurity management. While the Council team is clear that SEAs are to be a key focus, including those on private land and in local reserves, specific information on resource allocations and how management is to be implemented are not available.



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Data Sources: Boffa Miskell, LINZ, Auckland Council

Projection: NZGD 2000 New Zealand Transverse Mercator

Legend

- Proposed Pest Management Area (989.4 ha)
- Extent of Construction Footprint
- Watercare Designation (57.7 ha)
- Significant Ecological Areas (721.2 ha within Area)
- Public Open Space (323.3 ha within Area)

A16055C Huia WTP Ecology Assessment of Effects

Figure 21: Proposed WBI Area

Date: 17 May 2019 | Revision: 0

Plan prepared by Boffa Miskell Limited

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The PRMP currently identifies that comprehensive possum control will be implemented across the entirety of rural mainland Tāmaki Makaurau / Auckland, though Auckland Council's 10-year plan budget does not include the Waitākere Ranges as part of the rural control area. The PRMP indicates that the Waitākere Ranges will be prioritised for control of pigs, deer and goats.

Auckland Council's 10-year plan has allocated funds to construction of tracks and hygiene stations to reduce the spread of kauri dieback disease, but does not identify funding to manage kauri on private land.

Council's allocation of the NETR includes a region-wide budget of $3.6m over the next 10 years to supporting local, community-led Pest Free Auckland initiatives, including a digital platform to coordinate initiatives and compile region-wide data, and a $300,000 fund for a "Community Coordination and Facilitation Grant Programme[20]" to provide funding support for community coordinators or facilitators to *"strategically increase collaboration, capacity and on the ground delivery of natural environment outcomes*". However, it does not cover commercial contractors to do the on the ground work, or allow applications for multi-year grants.

The 2014 Muddy Creeks Local Area Plan includes ideas and visions for the future to provide a long-term direction for Council, iwi and community action in the area. It identifies features important to the community and proposes objectives and actions to achieve desired outcomes. Key ecology-related themes include recognition of the heritage value of the kauri forest that the community inhabits, and the kaitiakitanga shown through local initiatives (e.g., the Sustainable Neighbourhood groups or Waituna Action Group). The Muddy Creeks Plan includes an ecological objective of fostering healthy, safe and connected ecosystems through managing kauri dieback, restoration of ecological corridors and advocacy for pest management.

Existing community-led pest management activity (Waima-Laingholm Pest Free Zone, in operation since early 2017) includes active maintenance of ~142 possum traps, mainly located at 100 m intervals along Exhibition Drive and through Clarks Bush. Individual landowners operate a similar number of possum traps at unspecified locations throughout the catchment, and limited rat control is also undertaken. Consistent catch rates (M. Harvey pers. comm) indicate that the current level of control is not effective to suppress the possum population to the extent that significant biodiversity gains will be achieved. Other conservation-focused community groups in the catchment are listed on "citizen science/ conservation" websites including NatureSpace and the Gecko Trust, though in general these appear to be run fairly informally.

Project Goals and Objectives

Goals of the proposed Waima BMP are:

Goal 1: Community-wide engagement in stewardship and sustainable environmental management of the Little Muddy Creek catchment.

Goal 2: Coordinate and increase conservation efforts to protect and restore native flora and fauna within the Little Muddy Creek catchment.

Goal 3: Repair and strengthen connective linkages throughout the catchment through promoting natural forest regeneration and improve the health and resilience of remnant kauri forest.

Key actions to achieve specified goals include:

[20] https://www.aucklandcouncil.govt.nz/grants-community-support-housing/grants/regional-grants

1. Establishment of an accountable administrative structure that coordinates and implements conservation work on public and private land throughout the catchment to maximise ecological benefits and foster community engagement.

Measurable targets include:
▪ Establishment of a charitable trust before work commences, with representation of key stakeholders on the Trust funded by Watercare; ▪ Willing acceptance of landowners and residents in Waima Biodiversity Initiative activities on their properties; ▪ Delivery of annual report to stakeholder groups, setting out financial position, progress against targets and updates to strategic and annual plans.

2. Multi-species vertebrate pest management (possums, rats, mustelids, hedgehogs and pigs), throughout the Little Muddy Creek catchment. Configuration of trap / bait station locations will be developed following community liaison and catchment analysis by biosecurity experts and detailed in a Waima Biodiversity Initiative Management Plan. Specific thresholds and predator monitoring methods will be derived for the site as part of the management plan, with an implementation schedule set out in an Annual Plan.

   Monitoring and management of some pest species (e.g., mice, feral cats, invertebrate pests) are not well developed at present, however detection and control technology is likely to improve for these species, and for target species identified in the Waima Biodiversity Initiative We anticipate that the Trust will expand the suite of target pest species as detection and control methods become viable, while Board oversight will ensure appropriate business case analysis is undertaken and expanded activities are sustainable and meet the core objectives of the Trust.

Measurable targets include:
▪ Within 2 years of the Trust's establishment, recruitment of the owners of at least 400 private properties, appropriately dispersed across the whole of the catchment, to secure access for vertebrate pest control; ▪ Suppression of pests below threshold values derived from robust density-impact functions shown to deliver biodiversity gains (e.g., Norbury et al. 2015). Targets may be seasonal and will be set in accordance with biodiversity trends.

3. Weed management throughout Watercare-owned land (and public reserve land as required); and funding for contractors to undertake weed management on private land. Priority will be given to targeting invasive species of forest interior environments that pose the greatest threat to forest habitats and processes (e.g., climbing asparagus, wild ginger, etc.). Target species will be consistent with Auckland Council priorities, while weed presence and abundance would be monitored enabling target species to be reviewed annually. Target species and control methods would be documented in the Waima Biodiversity Initiative management plan.

Measurable targets include:
▪ Progressive recruitment of the owners of private properties containing native forest (e.g., at a minimum target rate of 20% per year) to secure access for weed control; ▪ Suppression of target species to the extent that infestations are controlled before they propagate / disperse.

4. “Kauri rescue”, including (but not limited to) tree health assessment, installation of matting to protect kauri tree roots and phosphite treatment[21] of diseased kauri will be funded for private landowners throughout the Little Muddy Creek catchment, along with monitoring and reporting on the ongoing effectiveness of these initiatives.

> Measurable targets include:
>
> - Within 1 year of the Trust’s establishment, identification and contact with all landowners/ residents in properties located among mature kauri stands to seek access for kauri tree health assessment and site-specific management;
> - Identification, containment and surveillance of all symptomatic trees in the catchment where access is granted, including an assessment of the long-term effectiveness of symptom suppression treatments in controlling disease progression and infection risk;
> - Development and implementation of site-specific management plans for all mature kauri stands on private property where access is granted, in collaboration with landowners.

5. Monitoring of Argentine ants with control implemented provided infestations are found to be localised and feasible to contain or eradicate. Specific monitoring methods, control targets and thresholds will be developed in consultation with DOC and Landcare-Manaaki Whenua experts and included in the detailed Waima Biodiversity Initiative management plan.

> Measurable targets include:
>
> - Implementation of a surveillance framework for Argentine ants throughout the catchment within two years of the Trust’s establishment, to establish whether this species is absent, localised or widespread;
> - Effective eradication of localised populations (where assessed as viable).

6. Biodiversity monitoring using key indicator species / guilds. Specific indicator species/ guilds and monitoring methods will be selected following a catchment-wide habitat assessment and review of available literature and technology. Specific targets and biodiversity monitoring methods will be derived for the site as part of the detailed Waima Biodiversity Initiative management plan, with an implementation schedule set out in an Annual Plan.

> Measurable targets include:
>
> - Implementation of a monitoring plan and framework within 6 months of the Trust establishment that delivers quantitative data on trends in forest condition and observation frequency of indicator species;
> - Delivery of baseline monitoring report of data from monitoring array within 1 year of the Trust’s establishment, including review of outputs and recommended modifications to monitoring methods.

7. An annual (April-May) review and update of the Waima Biodiversity Initiative Management Plan and Annual Plan will be undertaken following compilation and analysis

[21] 20 ml injections of 4% phosphite solution every 40cms around the trunk above bleeds may suppress kauri dieback disease symptoms.

of monitoring data, to confirm pest management and biodiversity trends and adjust methodology as required.

Indicator species and monitoring methods and targets will be reviewed five-yearly, enabling incorporation of innovative technology (camera traps, remote detection systems, etc..) to supplement data derived from conventional methods (bird counts, browse indices, abundance of palatable species, ACO devices, tracking tunnels, acoustic monitors, etc.).

Measurable targets include:

- Annual reporting of results and trends, including recommendations of revisions to management actions or monitoring methods as required.

Funding and Administrative Framework

The proposed Waima BMP will be funded and coordinated through a charitable trust that will be established to hold and administer the project. We envisage the Trust Board will comprise representatives from local community-led conservation project leaders, residents, Watercare, Auckland Council and iwi. The board will also include an independent corporate trustee supervisor.

The Trust will employ an operations manager and project coordinator to undertake strategic and operational planning, facilitate implementation of project initiatives, and undertake ongoing evaluation against targets.

The proposed Waima Biodiversity Management Trust is intended to provide an administrative structure that coordinates and implements conservation work on public and private land throughout the catchment to maximise ecological benefits. Brown (2018) acknowledges the potential value of "catalyst agencies" that coordinate conservation initiatives, noting these have proven effective in the few cases where these are established (e.g., Wild for Taranaki).

The Waima BMP will involve a strong component of community leadership and advocacy and encompasses conservation management of private land. However, implementation work will not rely on volunteers, and should not be equated with "community conservation" ("conservation activities primarily planned, led and executed by volunteers" – Brown, 2018).

Funding will be provided by Watercare as a 'lump sum' payment at the inception of the Waima Biodiversity Management Trust. This funding approach will secure a minimum of ten years of funding for the project, while funds received at the outset of the project can be invested (e.g., a conservative index fund might yield 5% per annum). In this way, a portion of the work can be funded from dividend payments, as roll-out of project initiatives throughout the catchment will be staged over several years. Nevertheless, the emphasis is on utilising funds to implement the specified work, rather than establishing a sustainable Trust fund.

Risk management

While the outcome of the proposed strategy relies on a proportion of private landowners accepting weed and pest management on their properties, non-participant sites benefit from a 'halo' effect of management on surrounding properties. Glen et al. (2017) examined effects of varying levels of landholder participation in landscape-scale programs to control invasive predators using modelled scenarios and found non-participation by individual small properties had a negligible effect on the efficacy of predator control, while trap deployment could be adjusted to limit reinvasion from larger patches of non-participating properties. Predator control will thus be effective even if some landholders choose not to participate. While control methods on private land and local parks are likely to utilise kill traps rather than toxic baits, deployment of traps at appropriate densities is a viable means of pest suppression.

For example, 'Predator Free Crofton Downs' (130 hectares core area) is a community-led initiative in a suburb of Wellington that commenced in 2014 and is ongoing at a participation rate of approximately 140 of ~500 households (the target for effective participation was one in five properties). Suppression of pests below target levels was achieved in the first year of control, and a kaka nest within the suburb successfully fledged chicks, the first recorded in Wellington outside the Zealandia Sanctuary since they were reintroduced in 2002. The subsequent four years of pest management within Crofton Downs and other inner-city suburbs has seen a measurable increase in bird numbers, including threatened endemic species that have dispersed from predator free sanctuaries (McArthur et al. 2017).

We anticipate a high level of community engagement with this project as it is consistent with the aspirations expressed in the Muddy Creeks Local Area Plan, and strongly voiced by locals who attended public meetings and open days. Nevertheless, in the event that landowner recruitment is well below the target threshold of 20%, or ongoing engagement at this target level proves difficult to maintain, the Trust Deed can include a five-year review clause that enables funds to be directed to other biodiversity management initiatives (e.g., Pest-Free Zones in adjacent catchments) if expected progress is not achieved. Similarly, the Trust Deed will allow sufficient flexibility that the specified actions of the Waima BMP can be adapted to ensure these complement rather than duplicate or conflict with Auckland Council's developing works programme.

7.4.2 Role of Offsetting and Compensation

The RMA requires councils, when considering applications for resource consent, to have regard to measures proposed to ensure positive effects on the environment that offset or compensate for any adverse effects on the environment.

Government guidance documents on biodiversity offsetting in NZ[22] define a **biodiversity offset** as:

*Measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The **goal of biodiversity offsets is to achieve no net loss** and preferably a net gain of biodiversity on the ground.*

According to the NZ Government guidelines, an action only qualifies as a biodiversity offset when "no net loss" can be demonstrated. Demonstrating no net loss involves explicit identification and quantification of biodiversity losses and gains, and their balancing in an accounting system. No net loss can only relate to quantified biodiversity values (or their "robustly supported surrogates"), from both the impact and offset sites, that have been assessed and balanced in a model or accounting framework.

Demonstrating no net loss is not possible where insufficient baseline and benchmark data is available to support the claim. Guidance documents acknowledge that measurement of all biodiversity is not possible, but the extent to which measurable biodiversity components can be used more widely as surrogates, or indeed, what qualifies as 'no net loss', remains difficult to objectively determine. Offset model guidance proposes the use of 'defensible estimates' in the

[22] Maseyk et al (2018); https://www.doc.govt.nz/about-us/our-policies-and-plans/guidance-on-biodiversity-offsetting, accessed 02/10/18.

absence of measured data, however there is not yet widespread consensus among ecologists as to how to establish such estimates.

Environmental compensation is defined as:

"Actions offered as a means to address residual adverse effects on the environment arising from project development where no net loss or net gain of biodiversity on the ground is not intended or able to be measured."

Environmental compensation can range from financial payments to specific management actions aimed at improving habitats or species populations, or both. The fundamental difference between environmental compensation and a biodiversity offset is that compensation is not designed to demonstrate, a priori, no net loss or a net gain in biodiversity.

The AUP (Appendix 8) framework for biodiversity offsetting does not draw a distinction between explicitly quantified offsets and compensation where no net loss is inferred. Key requirements set out in the AUP framework are (in summary) that an offset:

- Is demonstrably additional to what otherwise would occur;
- Is close to the location of development, where this will result in the best ecological outcome;
- Achieves no net loss, and preferably a net gain in ecological/ indigenous biodiversity values;
- Restores values similar to those being lost.

Our analysis does not attempt to demonstrate 'no net loss' by assessing explicit equivalence of measurable targets and indices, as we consider that in the context of this project, limitations of the data (for example, low detectability or local absences of potentially important components) would necessitate heavy reliance on conjecture and estimated values in the model, which inevitably undermines any assertion of robustness and objectivity.

Guidance on biodiversity offsetting (Maseyk et al 2018) advocates for the use of offsets over compensation wherever possible, on the basis that offset accounting provides an objective, robust and transparent means of ensuring 'No Net Loss' is achieved, while compensation does not explicitly balance losses and gains. However, as identified in Brown (2014) offset accounting may lead to emphasis on conserving and managing ecosystems / components that are discrete, easily identified and measured, and can be directly manipulated. This can result in rejection of projects that benefit cryptic, complex, or process-oriented components on the basis that biodiversity gains cannot be readily quantified.

Our approach to demonstrating an overall net benefit is to contrast the advantages and limitations of the proposed Waima Biodiversity Management Plan and the status quo (Table 29). We have also included analysis of a hypothetical 'conventional' revegetation project as a baseline for comparison, as relatively recent infrastructure projects (e.g., Puhoi – Warkworth motorway; Redoubt Rd – Mill Rd Corridor) have been granted resource consent using revegetation as a means to offset bush clearance.

***Table 29**: Comparison of Waima Biodiversity Initiative outcomes with status quo*

Option	Benefits	Limitations
No development (3.5 ha of SEA retained)	• Indigenous forest community, habitats and associated biota is retained. • Potentially supports unobserved/ suppressed indigenous flora and fauna populations that would recover with effective ecosystem management. • Local connections to surrounding forest ecosystems are maintained.	• Ongoing community-led, resource-limited pest management is unlikely to alter viability of native species populations within the site or wider catchment. • Site is small, with limited carrying capacity for density-dependent species, even if effectively managed. • Ecosystem values are local-scale.
Waima BMP (720 ha of SEA managed)	• Based on size, complexity and existing database records for the catchment, likely to support unobserved/ suppressed indigenous flora and fauna populations that would recover with effective ecosystem management. • Ongoing pest management at the scale and intensity proposed will be sufficient to create pest-suppressed areas and improve the viability of native species populations within the management area. • The management area is large, with a relatively high potential carrying capacity, even for density-dependent species (e.g., birds); creates a safe buffer zone for 'spillover' populations dispersing out from regional parkland / Ark in the Park. • The Waima Biodiversity Initiative supports and complements regionally and nationally significant biodiversity restoration initiatives on adjoining regional parkland, increasing the likelihood of successful outcomes. • Large scale facilitates whole-of-community engagement and social investment. • Large scale offers flexibility to adapt where obstacles are identified.	• ~60% of the management area is privately owned and will not be covenanted under the proposed Waima Biodiversity Initiative, hence landowners will not be compelled to accept pest management on their properties. AUP planning provisions also allow for modest bush clearance if required to build a single dwelling on residential land. • Requires involvement of private landowners and Council in addition to Watercare.

Option	Benefits	Limitations
	• Ecological gains begin to accrue immediately following effective control of invasive predator/ competitor species	
'Conventional' restoration project *revegetation, covenanting and pest control of an area [several orders of magnitude greater than impact site]*	• Revegetation offers a certain, tangible outcome (bush cover) with targets that are easy to specify and measure. • Revegetation replaces the physical extent of bush cover lost through forest clearance. • Like-for-like trade insofar as trees are planted to replace those felled (with multipliers to account for time lag, lack of community or habitat complexity, age structure, etc.). • Covenanting is a well established, legally binding mechanism for ensuring the ongoing protection of an ecosystem feature. • Revegetation reduces soil loss and runoff and improves water quality (though not a like-for-like trade).	• No suitable sites of sufficient size found proximate to the impact site. • Revegetation sites are generally depleted of biota; effective ecosystem management is unlikely to facilitate a measurable recovery of suppressed indigenous flora and fauna populations, at least in the medium term. • Revegetated forest ecosystems are only superficially similar to naturally established forest (at least for many decades), and landscape context strongly influences the ecological value of revegetated areas. • Because most forest biota is initially absent from the revegetated site, and natural dispersal is the main mechanism relied upon to reintroduce species, there is substantial uncertainty around which species will eventually re-establish in a revegetated landscape. • Long lag time before anticipated ecological gains are achieved, as anticipated habitat complexity and species richness is largely associated with mature forest. • Even with a legally-binding covenant, a trust or similar mechanism is necessary to ensure ongoing effective management of the feature. • Even with a multiplier of 10 – 20 times the impact site, the offset revegetation site would be medium-sized, with modest carrying capacity for density-dependent species. • Ecosystem values of revegetation would be local-scale.

As identified in the summary analysis, all scenarios rely on effective ecosystem management (primarily control of introduced predators and competitors) to realise their biodiversity potential, while the Waima BMP will produce the best outcome of the options presented because it is adequately resourced, is strategically located and of a sufficiently large scale, and is likely to contain existing suppressed populations of biota that will immediately benefit from management.

7.4.3 Additional Biodiversity Benefits from Proposed Biodiversity Management

Council's 10-year budget provides funds for a substantial expansion in biosecurity management to be deployed in parkland across the region. Nevertheless, in our assessment, Council's allocated budget will not be sufficient to undertake comprehensive weed and pest control over all its parks and reserves and does not fully fund biosecurity management on private land.

We understand[23] that Auckland Council plans to target priority weeds throughout all SEAs on reserve land in order to enable enforcement of a 500 m containment buffer in neighbouring properties, while recognising that this will impose a significant cost to some landowners with heavily infested properties and may not be readily achievable. We consider that funding of this work through the Waima BMP will provide a means for Council to realistically achieve its objective of sustainable suppression of target species in the catchment, with a reduced risk of collateral damage to sensitive vegetation and habitats .

We also understand[24] that Council's vertebrate pest management activity in Waitakere prioritises regional parkland and is largely confined to possum control. We consider that the expansion of comprehensive vertebrate pest and argentine ant management into local parks and private land as part of the proposed Waima Biodiversity Initiative will achieve biodiversity benefits over and above the status quo.

We have intentionally included the eastern flank of the Waitakere Ranges regional parkland within the proposed Waima BMP management area, notwithstanding that Council is likely to prioritise biosecurity management in this area, as the intent of this 'overlap' in stewardship responsibility is to facilitate coordinated, complementary activities between the Trust and Council, and to ensure continuity of management effort if Council priorities shift away from this area.

A review of community-led conservation initiatives in New Zealand (Brown 2018) states that that the future of conservation in New Zealand is likely to depend on whole-of-landscape projects designed to achieve economy of scale and identifies the funding shortfall as the greatest barrier to effective conservation. This is the case for existing community-led pest management within the Little Muddy Creek catchment, which at present is not sufficiently well resourced to achieve more than localised, transient biodiversity gains.

Effective vertebrate pest control throughout the Little Muddy Creek catchment will reduce predation on populations of birds, lizards and invertebrates, palatable plants and propagules, and increase food resources. Comprehensive, catchment-wide possum control will reduce browsing impacts on forest canopy vegetation (while leaves are the main part of their diet, possums eat new shoots, buds, flowers and fruit, and their selective browsing impacts the growth and life-cycle of a wide variety of plant species).

[23] Holly Cox, Pers. Comm. 21/02/19

[24] Malcolm Harrison, Pers. Comm., 21/02/19

The improvement in forest habitat throughout the catchment (and in particular, the ~ 500 ha of SEA outside of the Waitakere Ranges Regional Park that is unlikely to be prioritised for comprehensive pest and weed management) compensates for a reduction in the quality and extent of forest habitat within and immediately surrounding the Project Site, and for degraded ecosystem functions that may affect seed dispersal movement of fauna within the forested corridor on the northern margin of the catchment. The increased viability of palatable plants, including secondary forest trees, throughout the catchment's forest ecosystem will provide partial compensation for the loss of 3.3 ha of vegetation, including some mature secondary forest trees, within the Project Site footprint.

Increased stewardship of kauri populations on private land throughout the catchment will enhance the health and long term viability of and will compensate for the loss of a single mature kauri tree within the Project Site footprint.

The proposal offers a significant buffer / halo to the adjoining Waitakere Ranges regional parkland (as per Parkes et al. 2017), which will be particularly beneficial if Auckland Council uses its increased biodiversity funding to more intensively manage core areas such as Ark in the Park. Management of the Little Muddy Creek catchment will prevent migration of pests back into the parkland and diversify pest-free habitat to incorporate a portion of the Waitakere lowland environment. The importance of pest-suppression in forest habitats on the fringes of the Waitakere Ranges will increase as populations of re-introduced species (kokako, robin, whitehead, kakariki) reach carrying capacity and disperse from intensively managed habitats.

Other constraints to effective conservation initiatives are poor coordination between stakeholder groups, inadequate capacity and capability on the part of volunteers, and limited technical oversight of projects. Brown (2018) noted that successful programmes were generally those that were professionalised, politically connected and with a clearly articulated purpose. Brown (2018) emphasises the need for adequate administrative support structures for community conservation and streamlined funding processes that are prioritised, based on ecological need and clear objectives. Establishment of a charitable trust for the Waima Biodiversity Initiative establishes a leadership structure that is diverse, well-connected and not over-reliant on one or a few motivated individuals, and the formalised framework of the project clarifies goals and recognises progress, which in itself fosters stakeholder engagement.

In summary, a number of biodiversity gains are anticipated through existing and anticipated biodiversity and biosecurity management measures within the Waima/ Little Muddy Creek catchment and wider Waitakere Ranges which are not included an our assessment of additional benefits to compensate the loss of 3.5 ha of SEA. The additionality that the Waima BMP offers is in filling the gaps between these existing initiatives, for example:

- Funding and coordinating management on private land in order to produce consistent and effective outcomes;
- Reducing reliance on volunteer efforts to undertake physical works;
- Providing a dedicated and staffed "umbrella' organisation to coordinate and streamline inter-agency work;
- Supporting the work of Council in public reserve land by reducing reinvasion of pests;
- Reducing mortality rates of avian fauna that disperse from intensively managed areas into the suburban matrix.

8.0 Summary and Conclusions

The Project Site is part of the Waitakere Ranges SEA, and is located in the ~750 ha Little Muddy Creek catchment (including the headwaters of Waiohua Creek and Waituna Stream) which retains approximately 80% of indigenous forest cover. However, landuse intensification has caused habitat fragmentation throughout the catchment, disproportionately affecting older-growth kauri forest remnants concentrated along ridgelines, while kanuka-dominated gully systems and steep escarpments retain relatively continuous forest cover.

A forested corridor of remnant and secondary native forest south of Scenic Drive connects the Project Site to regional parkland west of the site, and the Project Site is one of a network of forest patches on public and private land in the Titirangi-Waima area. The Project Site therefore has an important connecting function within the local context.

While historical forest clearance and modification strongly influence current vegetation patterns within the Project Site, mature forest remnants are present, while forest succession is well-advanced in secondary forest types that comprise much of the vegetation within the site.

The Project Site contains populations of threatened and at-risk plants, though the threat classification for most of these (kauri and all myrtles, including manuka, kanuka, etc..) derives from the disease risk of kauri dieback and myrtle rust, rather than due to scarcity of individuals. Threatened ecosystems (kauri forest, kauri-podocarp forest, regenerating broadleaved forest and kahikatea-dominated swamp and floodplain forest types; as per Singers et al 2017) makes up ~8 ha of the vegetation cover within the Project Site.

Component vegetation communities within the Project Site were assessed against a set of metrics to provide a relative gauge of ecological integrity across the site. The purpose of this analysis was to prioritise avoidance of the most intact and diverse ecological features, which were identified as continuous forest areas containing examples of:

- Kauri forest;
- Kauri-podocarp forest;
- Kahikatea-kanuka forest;
- Kanuka - kohekohe - mahoe - nikau forest and scrub; and
- Maire tawake- pukatea-kahikatea swamp forest.

Specific surveys were undertaken to assess the values of the Project Site for avifauna, herpetofauna, bat and invertebrate populations and aquatic habitat, where available also using existing data from the surrounding catchment and wider Waitakere Ranges to provide context. Key findings are as follows:

- The number and diversity of native lizards detected within the Project Site were both very low, and no threatened or at risk species were encountered, despite the availability of suitable habitat on the site. Other species recorded in the vicinity may be present but undetected due to low population densities.
- The absence of bat activity within the Project Site during the breeding season indicates that the site does not contain favoured maternity roost trees. Long-tailed bats may use the Project Site occasionally for foraging and possibly for solitary roosts.

- The assemblage of native birds and invertebrate fauna detected within the project site is representative of similar habitat in the wider Waitakere Ranges.
- No threatened or at risk fauna species were recorded within the Project Site.
- Available data on invasive pests within the Little Muddy Creek catchment and wider Waitakere regional parkland gives weight to the assumption that native fauna populations within the Project Site face significant pressure from mammalian predators, while Argentine ants also pose a serious threat in vulnerable habitats.
- The headwater reach of Armstrong Stream within the Project Site is a permanent watercourse which is of moderate-high ecological value. Other freshwater habitats within the Project Site are intermittent or ephemeral in nature, while receiving environments are streams of high ecological value.

As a whole, indigenous vegetation within the Project Site meets Auckland Unitary Plan SEA criteria of representativeness, rarity, diversity, buffering and connective linkages. According to the Ecological Institute of Australia and New Zealand (EIANZ) method for assessment of ecological value, the Project Site rates “High” for three out of four assessment matters (rarity/ distinctiveness, diversity/pattern, ecological context), and achieves an overall ecological value ranking of “Very High”.

The total extent of the works footprint for the replacement treatment plant (including the WTP facility and reservoirs) covers 4.3 ha. Ecological constraints have been the primary determinant of the WTP and reservoir footprint locations within the Project Site. As a priority, permanent watercourses and areas with the highest ecological integrity (particularly intact kauri, podocarp, swamp and floodplain forest types) were avoided, and the footprint was progressively refined through a series of iterative design layouts. Nevertheless, the development will result in the removal of 3.5 ha of ecologically significant native forest and scrub, including approximately 45 mature, mid- successional native trees (mainly kahikatea; note that this figure excludes kanuka and other abundant, early-successional species).

Vegetation clearance will have a number of local-scale effects, including loss and/ or displacement of native flora and fauna populations currently present within the footprint, and a change in the surrounding forest environment associated with creation of new forest edge. A short section of intermittent stream will require diversion, and comprehensive erosion and sediment control measures will be required to ensure sediment discharges to the receiving environment during works (and associated potential impacts) are minimised.

Some catchment-scale effects are anticipated, particularly associated with further fragmentation of the forest corridor around the head of the Little Muddy Creek catchment. Earthworks also carry some risk of kauri dieback disease transmission which will need to be carefully managed through the application of appropriate controls.

The overall level of ecological effect (as per EIANZ 2018 criteria) of the proposed development is “High”, because of a moderate overall magnitude of ecological effects on a site with very high ecological values.

On site mitigation will include retention and enhancement of the remaining ~11 ha of native vegetation within the Project Site that is outside of the developed area. Exposed bush edges, old tracks and open areas within forest remnants in the Project Site will be revegetated with fast-growing forest edge species to buffer the forest interior and inhibit weed encroachment.

Ephemeral and intermittent watercourses running through the WTP site discharge into the open channel of the Yorke Gully Stream. The proposed WTP footprint requires the reclamation of a small section of intermittent stream which will be diverted to a new channel outside of the footprint.

The intermittent flow characteristics of the re-aligned stream will be retained, and treated stormwater entering the diversion will ensure that flows are maintained downstream in Yorke Gully stream. Approximately 53 m of intermittent stream length will be diverted to form a diversion channel at least 70 m long. Adverse effects resulting from earthworks during construction and stormwater during operation will be minimised through the implementation of accepted standards and guidelines.

All permanent and intermittent stream reaches within the Armstrong Gully catchment will be avoided and there is no loss or diversion of any watercourse within this catchment.

Risks associated with kauri dieback spread, sediment discharge or accidental damage to adjacent vegetation can be avoided, remedied and mitigated through clear site protocols, to be developed as a condition of consent. Pre-works fauna survey and salvage operations will be undertaken to minimise impacts on native fauna.

On-site mitigation measures to minimise effects on fauna and adjacent vegetation include scheduling vegetation clearance works to as far as possible avoid bird breeding season and winter torpor for lizards and bats; roost checks and nest checks as required prior to harvest; lizard salvage and relocation as the site is cleared; establishing protective measures for trees around the periphery of the works footprint; and facilitating the closure and rehabilitation of old, informal tracks and open areas through the bush within the site,

As permanent loss of native forest and scrub cannot be mitigated on-site, we have developed a plan to fund the management of the remainder of the catchment ecosystem. The Waima Biodiversity Management Plan includes long term management of weeds, pests and kauri dieback containment throughout the 990 ha Waima Biodiversity Management Area (including 720 ha of SEA). The proposal includes monitoring targets to enable measurement of the Waima Biodiversity Trust's performance against specific objectives to be set out in its Deed. The Trust's goal is to set up and implement biosecurity management and biodiversity monitoring on private land, integrated with Council programmes, to leave a legacy of improved and forest ecosystem health, and a framework and administrative body to enable effective long-term biodiversity management within the Little Muddy Creek catchment.

The benefits of the proposed compensation meet or exceed the 'High' overall level of effect. We consider that the 'magnitude' of benefit is 'High', as we anticipate the return and/ or range expansion of suppressed biota as a result of the proposed management, along with improved forest condition, regeneration processes and habitat values within the managed forest areas. The ecological value of the receiver catchment is comparable to the impact site and therefore 'very high'.

In our estimation, these positive effects on the environment appropriately compensate for the loss of forest extent, and associated impacts on connectivity which are the key residual adverse effects arising from the Replacement WTP development.

9.0 References

Anderson P, Bell T, Chapman S, Corbett K. 2012. SRARNZ NZ Lizards Conservation Toolkit – a resource for conservation management of the lizards of New Zealand. A SRARNZ Miscellaneous Publication. Society for the Research on Amphibians and Reptiles of New Zealand (www.srarnz.org.nz). 69 pages.

Atkinson, I.A.E. 1985: Derivation of vegetation mapping units for an ecological survey of Tongariro National Park, North Island, New Zealand. New Zealand Journal of Botany 23: 361–378.

Auckland Council 2018: Whakarāpopoto: Te āhua o te Rohe o Te Ika Whenua o Waitākere 2018 - State of the Waitākere Ranges Heritage Area.

Beca 2019. Huia Replacement Water Treatment Plant: Reservoir Site Layout Development Report. Prepared for Watercare Services Limited.

Boffa Miskell Limited 2017. Huia WTP Upgrade assessment of ecological values. Prepared for Watercare Services Limited.

Brown, M. 2018: Transforming community conservation funding in New Zealand. Catalyst Group report prepared for the Predator Free NZ trust.

Brown, M. 2014: Towards Robust Exchanges: Evaluating Ecological Compensation in New Zealand. Thesis, Doctor of Philosophy (PhD). University of Waikato, Hamilton, New Zealand.

Cook Costello 2018: Huia Replacement Water Treatment Plant, Woodlands Park Road: Civil Infrastructure Report. Report prepared for Watercare Services Limited.

Dawson D.G., Bull P.C. 1975. Counting birds in New Zealand forests. Notornis 22:101–109.

de Lange, P.J.; Rolfe, J.R.; Barkla, J.W.; Courtney, S.P.; Champion, P.D.; Perrie, L.R.; Beadel, S.M.; Ford, K.A.; Breitwieser, I.; Schonberger, I.; Hindmarsh-Walls, R.; Heenan, P.B.; Ladley, K. 2018: Conservation status of New Zealand indigenous vascular plants, 2017. New Zealand Threat Classification Series 22. Department of Conservation, Wellington. 82 p.

GHD 2018: Huia Replacement Water Treatment Plant Consenting Phase Site Layout Development Report. May 2019.

Leersnyder, H., Bunting, K., Parsonson, M., and Stewart, C. (2016). Erosion and sediment control guide for land disturbing activities in the Auckland region. Auckland Council Guideline Document GD2016/005. Prepared by Beca Ltd and SouthernSkies Environmental for Auckland Council.

Maseyk, F., Ussher, G., Kessels, G., Christensen, M., Brown, M. (2018): Biodiversity offsetting under the Resource Management Act: A guidance document. Prepared for the Biodiversity Working Group on behalf of the BioManagers Group.

Martineau, A 2010: Management and predator control in a ‘Mainland Island’ ecosystem: Assessment of rodent control efficiency. Internship at Royal Forest & Bird Society of NZ.

McArthur, N.; Flux, I. and Harvey, A. 2017. State and trends in the diversity, abundance and distribution of birds in Wellington City. Client report prepared for Greater Wellington Regional Council. Wildlife Management International Ltd, Blenheim.

Singers, N., Osborne, B., Lovegrove, T., Jamieson, A., Boow, J., Sawyer, J., Hill, K., Andrews, J., Hill, S., Webb, C. 2017. Indigenous terrestrial and wetland ecosystems of Auckland. Edited by J. Connor. Auckland Council.

Shonfield, J., and E. M. Bayne. 2017. Autonomous recording units in avian ecological research: current use and future applications. Avian Conservation and Ecology 12(1):14. https://doi.org/10.5751/ACE-00974-120114

Landcare Research, 2018. Freshwater Invertebrates Guide. https://www.landcareresearch.co.nz/resources/identification/animals/freshwater-invertebrates

Stanley, R., de Lange, P.J., Cameron, E. 2005. Auckland Regional Threatened and Uncommon Plant List. Auckland Botanical Society Journal 60: 152-157.

Tierney G.L., Faber-Langendoen, D., Mitchell, B.R., Shriver, W.g., Gibbs, J. P. 2009. Monitoring and evaluating the ecological integrity of forest ecosystems. Frontiers in Ecology and Environment 2009; 7(6): 308–316.

Tonkin & Taylor Ltd. 2012. Huia Water Treatment Plant Ecological Assessment. Prepared for Watercare Services Limited.

Tonkin & Taylor Ltd. 2018. Huia Water Treatment Plant - Armstrong Gully Stream Inspection August 2018. Letter report prepared for Watercare Services Limited, September 2018.

Tonkin & Taylor Ltd. 2019. Groundwater and Settlement Effects Report. Prepared for Watercare Services Limited, October 2018.

Appendix 1: Waima Invertebrate Fauna Report

FIELD STUDIES

PETER MADDISON Ph.D., F.R.E.S.

Report 18/5/1

WAIMA INVERTEBRATE FAUNA

Report on Survey 2017-2018

May 2018

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INTRODUCTION

Watercare is proposing the replacement of its existing Huia Water Treatment Plant in Woodlands Park Road, Waima to a site adjacent to the current one but on the opposite side of Manuka Road, with an associated reservoir between Woodlands Park Road and Exhibition Drive. This area is contiguous with, but forms the southern limit of the Waitakere Forest, the Great Forest of Tiriwa.

The work described here documents a survey of the invertebrate fauna found in Waima, roughly between Scenic Drive, Exhibition Drive, the Huia Aquaduct Track and Manuka road/Clark's Bush Reserve. This formed part of an ecological survey by Boffa Miskell, which focussed primarily on the effects of the proposed developments on the vegetation. Given that the forest links to the neighbouring Waitakere Forest, so that the more mobile flying insects associated with vegetation are by their behaviours more widespread, the survey concentrated on soil, litter and ground level faunal elements.

METHODOLOGY

SAMPLING

Three main sampling methods were used :

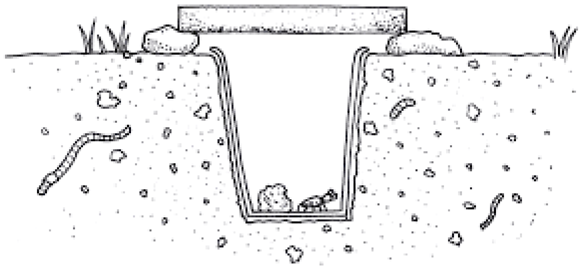
- Pitfall trapping
- Malaise trapping
- Litter extraction

[Note : no special attempt was made to light trap for Lepidoptera]

Pitfall trapping. This method of trapping is used for collected surface active invertebrates. There is great variability in the distribution of invertebrates on the forest floor, which not only reflects the forest floor topology, but the vegetation cover and leaf litter type and features such as the disposition of ant nests and the proximity to any decomposing animal or plant remains. So the traps were placed fairly regularly in the areas, avoiding tree roots and site liable to flooding where possible.

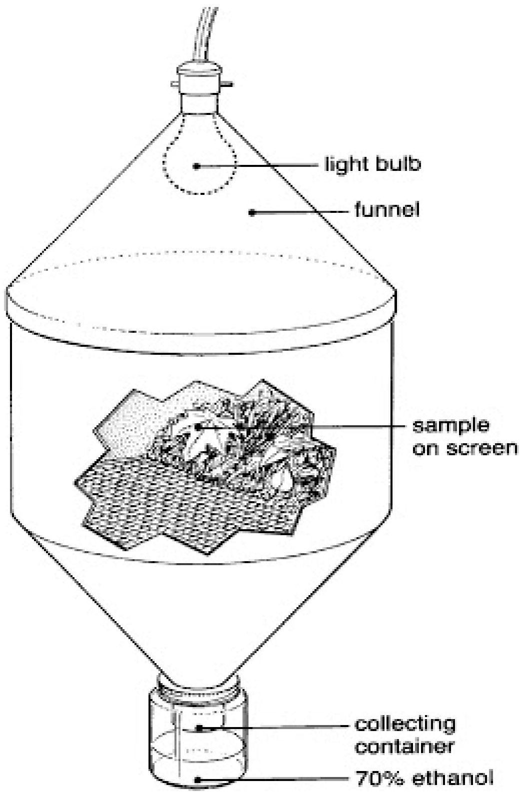
To get a good coverage of the site, pitfall traps were used at Clark's Bush Track, a kahikatea site on Woodlands Park Road, opposite the existing Treatment Plant, and along the Huia Aquaduct Track.

At each site pitfall traps were established and positioned using GPS. These traps were used pet food containers, provided with lids and a small gap (1 cm.) to allow invertebrates through. Glycerol (antifreeze) was used to kill the invertebrates falling into the trap. The traps will be left operating for 5 months, but collected at regular intervals. Samples from the field were transferred to labelled plastic jars. [Note : Given the sudden rainfall events during the survey period a few traps were flooded.]



Malaise trapping. This form of trapping is designed to collect low-flying insects. The aim is to “funnel” the insects into the capture jar (top left in photo). Because the sides of the trap connect with vegetation, this trap also collects invertebrates crawling on the ground and nearby bushes.
Two Malaise traps were used – one in the kahikatea area and the other near Clark’s Bush Track. Samples were regularly collected over a 5-month period.

Litter extraction. This method involves the collection of leaf litter and the extraction of animals by the slow desiccation of the litter under a light source. It is useful for collecting the fauna living in the litter area, particularly small invertebrates. Litter was collected into old pillowcases (c. 2 litres in volume), kept out of the sun and transferred as soon as possible to the extraction funnels at Landcare Research, Tamaki. The Tullgren funnels separate the litter placed on a sieve from a light source above (20 watt); a funnel below the sieve directs the animals into the collecting jar with 70-90% ethanol below. Samples were extracted for one week.



All samples were examined under a dissecting microscope (X20) and sorted and recorded by recognisable taxonomic unit (RTU) – this is hopefully equivalent to “species”. Samples sorted into separate tubes were preserved in 90% ethanol and labelled according with appropriate collection data. Some insect specimens that were suitable for dry-mounting (beetles, wasps, larger specimens of flies, etc.) were either pinned or card-pointed to help further identification. [This is an on-going process and though some specimens are easily identified by reference to existing specimens (e.g. in the National Arthropod Collection), others require examination by expert taxonomists or systematists. [Note : it was beyond the brief of this work to get detailed taxonomic identification.]

RESULTS and DISCUSSION

The data from the collections are given in the Appendix Tables – these are collected together in the folder “Waima Appendix Tables”. They are
WAIMA KAHIKATEA AREA MALAISE TRAP 5/12/17-4/3/18
CLARK’S BUSH MALAISE TRAP
WAIMA LITTER SAMPLES
WAIMA – Litter Sample 27/7/17
CLARK’S BUSH TRACK Pitfall Traps 1-5 16/7-26/8/17
CLARK’S BUSH TRACK Pitfall Traps 26/8/17-12/11/2017
HUIA AQUADUCT PITFALL TRAPS 5/8-17/9/2017
HUIA AQUADUCT PITFALL TRAPS 17/9-12/11/2017
KAHIKATEA AREA PITFALL TRAPS 15/10-5/12/2017

These give the raw data and were used for summarising the invertebrates found. Over 10000 specimens were collected and summarised in the file
WAIMA INVERTEBRATE FAUNA SUMMARY
– also in the folder “Waima Appendix Tables”. This should be read in parallel with the file :
WAIMA INVERTEBRATE FAUNA TEXT, which describes and illustrates features of the important fauna groups.

The data shows that, at present there were 732 RTUs (equivalent to “species”) found in the areas sampled. In general the invertebrate fauna found, as with the vegetation can be said to be comparable with that of similar areas of the southern Waitakere Ranges. The invertebrate fauna also showed little presence of adventive species and no sign of the Argentine ant, *Linepithema humile,* was found. The Kahikatea Swamp area had some specialised fauna (Ostracoda, Copepoda and Turbellaria) that is unusual – as is the kahikatea swamp area – in this part of the ecological district. The two areas of typical forest sampled in Clark’s Bush and the Huia Aquaduct had a large component of native (and mostly endemic) species associated typically with kauri (*Agathis australis*), puriri (*Vitex lucens*) and mamangi (*Coprosma arborea*), in some places successional to kanuka (*Kunzea robusta.*)

INTERESTING and NOTABLE FINDINGS

1. A species of peripatus, *Peripatoides*, was found both in Clark’s Bush and along the Huia Aquaduct Track. This group of animals is thought to be the “missing link” between Annelids (worms) and Arthropoda like Chilopoda (centipedes.)
2. An unusual “shellless” snail, *Otoconcha,* found at Clark’s Bush.

3. An unusually large number of peri-aquatic organisms at the kahikatea site – Copepoda{copepods), Ostracoda (seed shrimps) and Turbellaria (flatworms). This may indicate that the water level in the area rose to the level of the pitfall traps or may be a special feature of this site.
4. Most of the ants found belonged to New Zealand native species. The lack of invasive ant species and particularly of Argentine ant, *Linepithema humile,* is notable. Argentine ant has recently been found nearby in South Titirangi and Woodland Park, where measures aimed at control/eradication are already underway – this ant can have serious debilitating effects on ground-living invertebrates and it is recommended that measures are taken to prevent its introduction to the Waima area.
5. A large ground beetle, *Mecodema,* is indicative of a low presence of rodents. This is probably associated with pest control activities in the area.
6. The presence of millipedes of the family Polyxenidae is notable. Little is known of their biology.
7. Though the collecting methods are generally poor in collecting native snails, the finding of 18 species of endemic small land snail, and the larger *Rhytida* indicate that these are an important element of the fauna. The kauri snail, *Paryphanta busbyi,* has been found along Exhibition Drive.
8. The wedge-shaped beetle, *Allocinops brouni*, is unusual in this area. It was found in Clark's Bush. [The only record on iNaturalist is from Wellington.] Little is known of this species in New Zealand, but members of this family (Riphiphoridae) have larvae (planidia) which parasitize wasps, bees and cockroaches.
9, In the past 30 years, the first part of Exhibition Drive (= Hillary Trail), has been the place for a number of nightwalks – designed to educate local people in the night-active invertebrates of the area. Regularly seen are glow-worms, kawakawa looper caterpillars, native snails, stick insects – including one species regarded by the late Dr. Graeme Ramsay as "new to science" - and a very large colony of large cave weta, *Gymnoplectron,* in the pipe tunnels. It is recommended that long-term planning takes credence of this asset and ensures its persistence.

ACKNOWLEDGMENTS

I thank Watercare for allowing access to the site and to their staff for useful discussions. Considerable help with the field work was received form a number of people – particularly Rosemary Gilbert and locally Tina Hamlin. I thank Landcare Research, and particularly Grace Hall, for help with litter extractions at the Tamaki site. Several people have helped with the mounting and labelling of specimens – Rosemary Gilbert, Janet Price and Peggy Herbert in particular. I am also grateful to Landcare Research, as a research associate, for providing access and facilities to the New Zealand Arthropod Collection to allow identifications of the specimens. Finally thanks to Ian Boothroyd at Boffa Miskell for their long tolerance of my submitting this report.

Appendix 2: Auckland Regional Council Stream Habitat Assessment Methodology

Habitat Assessment - Field Data Sheet

Stream Name:	
Date:	
Location:	
Field Crew:	

Weather Conditions

	Current
Clear/sunny	☐
Cloudy	☐
Rain	☐

Has there been heavy rain in the past week? Yes ☐ No ☐

Photo(s)
Film No.
Photo No.(s)

Site location map

Predominant surrounding land use

Native forest	☐
Native scrub	☐
Planted forest	☐
Lifestyle	☐
Horticulture	☐
Pasture	☐
Urban	☐

Litter present ☐

Evidence of livestock access

Left bank	☐
Right bank	☐

Habitat Assessment - Field Data Sheet

Channel shading (%) ☐

Filamentous algae coverage (%) ☐

Periphyton

	Rare	Common	Abundant
Diatom			
Mat algae			
Filamentous algae			
Bryophytes (moss, liverworts)			

Note: Rare = <10% cover
Common = 10-50% cover
Abundant = >50% cover

	Rare	Common	Abundant
Macrophytes			

Water Quality

Temperature (°C) ______ pH ______

Conductivity at temp (µS) ______ Turbidity (NTU) ______

Conductivity at 25 °C (µS) ______

Dissolved oxygen (mg/l) ______

Dissolved oxygen (%) ______

Time of day ______

WQ instrument(s) used:

Water Odour
- Normal/none ☐
- Petroleum ☐
- Anaerobic ☐
- Sewage ☐
- Chemical ☐

Water Clarity
- Clear ☐
- Slightly turbid ☐
- Turbid ☐

Water surface oils ☐
Anerobic sediment odour (H_2S) ☐

Macroinvertebrate Sampling - Habitat Details

Substrates Sampled (%)

Soft Bottomed	Rep 1	Rep 2	Rep 3
Woody debris			
Bank			
Macrophyte			

Hard Bottomed	Rep 1	Rep 2	Rep 3
Boulder (>256mm)			
Cobble (64-256mm)			
Gravel (2-64mm)			

Packing of cobble *(determined by kicking substrate)*

Tightly packed ☐ Moderately packed ☐ Loose ☐

Cobble Periphyton Sampled

Diatom ☐ Bryophytes ☐ Mat algae ☐ Filamentous algae ☐ None ☐

Qualitative Habitat Assessment

Stream: ______________________

Scorer: ______________________ Date: ______________________

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Aquatic Habitat Abundance	> 50% of channel favourable for epifaunal colonisation and fish cover; includes woody debris, undercut banks, root mats, rooted aquatic vegetation, cobble or other stable habitat. Also includes macrophyte dominated streams.	30-50% of channel contains stable habitat.	10-30% of channel contains stable habitat.	< 10% of channel contains stable habitat. *Note: Algae does not constitute stable habitat.*
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Aquatic Habitat Diversity	Wide variety of stable aquatic habitat types present including: woody debris, riffles, undercut banks, root mats, rooted aquatic vegetation, cobble or other stable habitat.	Moderate variety of habitat types; 3-4 habitats present including woody debris.	Habitat diversity limited to 1-2 types; woody debris rare or may be smothered by sediment.	Stable habitats lacking or limited to macrophytes (a few macrophyte species scores lower than several).
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Hydrologic Heterogeneity	Mixture of hydrologic conditions i.e. pool, riffle, run, chute, waterfalls; variety of pool sizes and depths.	Moderate variety of hydrologic conditions; deep and shallow pools present (pool size relative to size of stream).	Limited variety of hydrologic conditions; deep pools absent (pool size relative to size of stream).	Uniform hydrologic conditions; uniform depth and velocity; pools absent (includes uniformly deep streams).
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Channel Alteration	Natural channel and meander pattern; no evidence of historic channel alteration e.g. dredging, channelisation stabilisation, or other human activity.	Natural channel. Minimal channel alteration. Channel shape and form may be influenced by recent sediment deposition.	Channelised. Channel form and shape unconstrained. Channel made of natural materials.	Channelised. Channel form and shape constrained by man-made materials (e.g. culverts, gabions, concrete).
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Bank Stability (water level to bank full channel)	Stable: <5% bank effected; evidence of erosion or bank failure absent; minimal potential for future problems.	Moderately stable: 5-30% affected; areas of erosion mostly healed over; some potential for future problems.	Moderately unstable: 30-60% affected; high erosion potential during floods.	Unstable: 60-100% affected; eroded areas along runs and bends; bank sloughing and erosion scars common.
Left bank	10 9	8 7 6	5 4 3	2 1 0
Right bank	10 9	8 7 6	5 4 3	2 1 0

	Optimal	Suboptimal	Marginal	Poor
6. Channel Shade	>80% of water surface shaded. Full canopy.	60 - 80% of water surface shaded; mostly shaded with open patches.	20 - 60% of water surface shaded; mostly open with shaded patches.	<20% of water surface shaded. Fully open; lack of canopy cover.
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Riparian Vegetation Integrity (within 20 meters)	No direct human activity in the last 30 years; mature native tree canopy and intact native understory	Minimal human activity; mature native tree canopy or native scrub; understory shows some impact (e.g. weeds, feral animal grazing).	Extensive human activity affecting canopy and understory; trees exotic (pine, willow, poplar); understory native or exotic.	Extensive human activity; little or no canopy; managed vegetation (e.g. livestock grazing, mowed); permanent structures may be present (e.g. building, roads, carparks).
Left bank	10 9	8 7 6	5 4 3	2 1 0
Right bank	10 9	8 7 6	5 4 3	2 1 0

Comments:

- fish observed
- fish habitat
- barriers to fish passage
- evidence of stable pools
- catchment erosion
- seaps or springs
- discharges or outfalls
- evidence of grazing stock access
- unique features
- crossings / tracks
- litter, shopping trollies, batteries, tyres
- descriptions of sediment
- stock / feral grazing
- high water marks
- Age / maturity of trees

Number of crayfish (koura) released.
To be added to macroinvertebrate data

Rep 1	Rep 2	Rep 3

Quantitative Habitat Assessment **Stream:** ____________________

Scorer: ____________________ **Date:** ____________________

Legend	Riparian zone (L)		Bank *(True Left)*	Aquatic Substrate			Bank *(True Right)*	Riparian zone (R)	
	5-20m	0-5m		Inorganic				0-5m	5-20m
	Canopy		Stability	Organic			Stability	Canopy	
	Understory		Bank Type	Wetted width (m)	Max depth	Flow type	Bank Type	Understory	
0									
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

Appendix 3: List of Native Flora Recorded within the Project Site

Gymnosperms (7)

Agathis australis
Dacrydium cupressinum
Dacrydium dacrydioides
Phyllocladus trichomanoides
Podocarpus totara
Prumnopitys ferruginea
Prumnopitys taxifolia

Monocotyledon trees and shrubs (3)
Cordyline australis
Cordyline banksii
Rhopalostylis sapida

Dicotyledon trees and shrubs (37)
Alectryon excelsus
Alseuosmia macrophylla
Aristotelia serrata
Beilschmiedia tawa
Brachyglottis repanda
Carpodetus serratus
Coprosma arborea
Coprosma grandifolia
Coprosma robusta
Coprosma rhamnoides
Corynocarpus laevigatus
Dysoxylum spectabile
Elaeocarpus hookerianus
Fuchsia excorticata
Geniostoma ligustrifolium
Hedycarya arborea
Hoheria populnea
Knightia excelsa
Kunzea robusta
Leucopogon fasciculatum
Melicytus ramiflorus
Melicytus micranthus
Myrsine australis
Myrsine salicina
Nestegis lanceolata
Olearia rani
Pennantia corymbose
Piper excelsum
Pittosporum tenuifolium
Pomaderris kumeraho
Pseudopanax arboreus
Pseudopanax crassifolius
Pseudopanax lessonii
Schefflera digitata
Sophora chathamica
Syzygium maire
Vitex lucens

Ferns and fern allies (20)
Adiantum aethiopicum
Asplenium bulbiferum
Asplenium flaccidum
Asplenium oblongifolium
Asplenium polyodon
Blechnum novaezelandiae
Blechnum filiformis
Blechnum fraseri
Cyathea dealbata
Cyathea medullaris
Dicksonia squarrosa
Grammitis billardieri
Lastreopsis hispida
Lygodium sp
Microsorum pustulatum
Microsorum scandens
Pneumatopteris pennigera
Pyrrosia eleagnifolia
Tmesipteris tannensis

Lianes, epiphytes (9)
Astelia solandri
Calystegia sepium
Clematis paniculata
Freycinetia baueriana
Metrosideros carminea
Metrosideros diffusa
Metrosideros perforata
Parsonsia heterophylla
Ripogonum scandens

Herbs (4)
Dianella nigrum
Elatostema rugosum
Nertera ciliata
Nertera scapanioides

Orchids (2)
Nematoceras aff. *trilobum*
Pterostylis agathicola

Grasses, rushes, sedges (5)
Carex dissita
Gahnia pauciflora
Oplismenus imbecillis
Uncinia uncinata
Uncinia zotovii

Total: 82 species

Appendix 4: Atkinson (1985) Structural Classes

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Derivation of vegetation mapping units for an ecological survey of Tongariro National Park, North Island, New Zealand

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Abstract A method of deriving vegetation mapping units from quantitative data is described based on results from an ecological survey of Tongariro National Park. A particular aim was to develop a repeatable procedure. The method of classifying the samples uses a polythetic agglomerative technique in which the sorting strategy has as a priority the combining of similar entities that are closest together in the field. This allows class boundaries to be made more nearly coincidental with map boundaries. A naming system for vegetation mapping units is further refined from an earlier published system. The names convey both structural and compositional information about the vegetation in such a way that diagnostic field criteria for most mapping units are summarised by the unit names. Although emphasising cover estimates, both the classificatory method and naming system are independent of the sampling technique used to estimate cover. The method is suitable for a wide range of terrestrial habitats.

Keywords growth forms; structural classification; Tongariro National Park; vegetation classification; vegetation mapping; vegetation naming; vegetation sampling

INTRODUCTION

An ecological survey of Tongariro National Park was made between 1960 and 1966 in which data were collected on the Park's flora, vegetation, soils, and vertebrates. Based on this survey, a 1:50 000 vegetation map was prepared, together with brief descriptions of the mapping units or types of community that were separated (Atkinson 1981). As this map is likely to be used for other kinds of ecological surveys in the Park, it is important to describe the method used in separating and naming the mapping units. A brief introduction to the method was given by Atkinson (1962) and the present paper modifies and extends the earlier suggestions.

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AIMS OF VEGETATION MAPPING IN TONGARIRO NATIONAL PARK

In mapping the Park's vegetation, three main aims were kept in mind:

1. Inventory and evaluation: To find out "what is there" in terms of the size, numbers, and growth form of plant species in different parts of the area. These data allow the vegetation continuum to be subdivided into areas whose botanical, wildlife, hydrological and soil conservation significance can be assessed.
2. Understanding factors of vegetation development: Whether the changes in vegetation composition across a mapped boundary are abrupt or gradual, the question arises: "What is the explanation for the difference?" The nature of the boundary can give information on the nature of the controlling factors. An answer is sometimes clear, as for example, where fire or other disturbance has left a sharp line of difference between two areas of vegetation of contrasting composition. In other cases there is no obvious answer. Thus boundaries on a vegetation map can be used to generate hypotheses which, with testing, can promote understanding of the factors or processes involved in vegetation development.
3. Providing a baseline for measuring future vegetation change: A vegetation map records the composition of the plant cover at a particular time. The greater the accuracy and degree of repeatability that can be achieved in the mapping, the more value will the map have in the future as a baseline for measuring the amount of change that has occurred.

REQUIREMENTS FOR THE DERIVATION OF VEGETATION MAPPING UNITS

A vegetation map based solely on qualitative data is sometimes adequate for both inventory work and elucidating factors of vegetation development. Such maps also have value for following long-term changes. If, however, a quantitative dimension can be incorporated in the mapping, the power of the mapping technique to detect changes, when the area is re-mapped in the future, is increased. Though quantitative parameters for vegetation are relatively few, the possible ways of treating the data to separate mapping units are many. Furthermore, when criteria are established as to what mapping units should be separated, there still remains the question of where to place boundaries between them. A degree of subjectivity in answering such questions is inevitable and no method will be without faults. Unless the mapper states clearly the procedure used, a future mapper has little chance of making valid comparisons; changes in the vegetation will be confounded with differences resulting from failure to use a similar derivation procedure.

An important requirement for an objective derivation procedure is that it should be able to accommodate any kind of vegetation revealed by the sampling. If a mapper begins with his qualitative observations and creates categories into which all samples are subsequently allocated, there is the likelihood that important differences in sample composition will be included in categories that obscure these differences. An alternative approach is to begin with the quantitative data from each sample and by grouping or separating the samples according to some measure of similarity, synthesise the mapping units through a sequence of comparison, grouping, further comparison and grouping. The resulting mapping units can be tested qualitatively or quantitatively with additional field observations at any stage. For reasons of scale, not all ecologically distinct kinds of vegetation can be shown on the map.

More information can be conveyed by naming rather than merely numbering the mapping units. A logical system of naming can be symbolised to become a shorthand method of showing the structure and composition of the vegetation mapped.

The above requirements can be summarised in relation to the manner in which they were applied to the Tongariro survey:

(i) Mapping units were based primarily on quantitative data recorded in the samples rather than on preconceptions derived from the general appearance of the vegetation.

(ii) A procedure for comparing the results of each sample and then grouping samples to form mapping units was standardised so that valid comparisons with mapping by subsequent workers would be possible.

(iii) A procedure for deciding boundary positions between mapping units was also standardised although there remained a significant element of subjectivity.

(iv) A naming system was adopted which conveyed both structural and compositional information about each mapping unit. In the majority of cases, the names of mapping units summarised the diagnostic field criteria for distinguishing each unit.

FIELD PROCEDURE

Sampling pattern

Some details of the field mapping procedure were given by Atkinson (1962) when the survey was still in progress. Three appearance types in the vegetation were distinguishable from the black and white vertical airphotos: forest, tussock-shrubland, and open communities. The sample lines or traverses were positioned to ensure an adequate sampling of each appearance type; some traverses crossed boundaries between them. Originally it was intended to cover the Park with an open grid of traverses in which distances between grid lines were about 3 km. The realities of topography, access, and weather prevented this from being achieved. Where the vegetation was more variable, distances between traverses were reduced to less than 1 km but in a few places, where reconnaissance showed the canopy to be relatively homogeneous, distances between adjacent traverses or other quantitative samples were increased to 4 km (see reliability map, Atkinson 1981).

The majority of traverses followed compass lines or contour lines at right angles to the radial drainage pattern of the mountains. This allowed the effects of topography and water table, which appeared to be major factors influencing vegetation composition at any one altitude, to be examined. Comparison with traverses higher up or lower down the slope allowed the effects of altitude to be estimated. A few traverses followed the line of greatest slope and thus gave a more complete picture of altitudinal variation.

Both starting points and directions for traverses were predetermined from the airphotos before going into the field. The chief consideration was to ensure that no substantial part of any appearance type was omitted from the quantitative sampling. When it became apparent during sampling that the vegetation was more variable than usual, as for example on some of the slopes of Mt Hauhungatahi, extra traverses were positioned between those originally planned.

To minimise personal bias, samples were spaced regularly by pacing (200, 300, or 400 paces) between samples along the line of the traverse, usually 10 samples per traverse. All effort was made to maintain inter-sample distances as nearly alike as possible for each traverse but unavoidable variation in pace length resulted in a sample spacing that became a stratified-random rather than a systematic pattern of sampling.

Parameters measured

A variety of physical and biological parameters were recorded at each sampling site so that vegetation composition and the presence of vertebrate animals could be related to site factors where appropriate. For the specific purpose of vegetation mapping, two types of measurement were made:

(i) in non-forest vegetation: point intercepts to estimate the percentage crown cover of each species in the canopy layers. In tussockland, shrubland, and open communities, these were obtained using a step-point method in which the uppermost plant crown at the centre-point of the toe of the boot was recorded at every pace along two parallel lines each 25 paces long and spaced 10 paces apart (Atkinson 1962). In dense scrub, the uppermost plant crown above a short pointed stick, held at arm's length and at right angles to the direction of travel, was recorded at every pace along a single 25-pace line.

(ii) in forest: trunk diameter (dbh) measurements to estimate the percentage basal area of each species in the canopy layers. These were obtained from trunk diameter measurements of the five canopy trees nearest to the stopping point for the sample (Atkinson 1962). In forest, percentage basal area was used rather than percentage crown cover because it is easier to measure quickly. No assumptions are made here about the relationship between the two parameters, a relationship that varies from place to place.

The term "canopy" was defined as the layer or layers formed by the uppermost plant crowns or their parts and it was applied to all kinds of vegetation encountered (cf. Atkinson et al. 1968). In forest, a "canopy tree" was defined as one having half or more of its crown exposed to direct radiation from the sky (Atkinson 1962). Although useful in this survey for deciding what trees to measure for basal area, this latter definition is not satisfactory for delimiting the canopy because many plants with less than half their crowns exposed to the sky contribute to the canopy.

When moving between samples, a continuous watch was kept for spatial changes in structure or composition of the vegetation and any changes noted for future reference when drawing boundaries.

Sampling intensity

Quantitative information was obtained from 1 472 samples distributed along 154 traverses. A further 147 quantitative samples were placed in areas of vegetation that were distinct on the airphotos but too small to allow traverse sampling. In these cases the sample positions were determined before going into the field so that each sample was likely to be representative of the vegetation judged from the airphoto. The total area mapped was 85 215 ha and 75 mapping units were distinguished. The average sample density was 1.9 samples/100 ha and the number of samples per mapping unit varied from 1 to 150. As mentioned below, some mapping units were based on both qualitative and quantitative observations.

COMPARISON AND GROUPING OF SAMPLE RESULTS

The following steps were used in deriving the mapping units:

1. *Samples checked for continuity between each other*
Samples from one traverse were treated initially as a single group. If, however, some samples were recognised in the field as clearly distinct in structure and composition from that generally found in the vegetation along the traverse, then these samples were separated at the beginning of the analysis, i.e., samples that were very clearly distinct in height, growth form and canopy composition, such as patches of forest within tussockland or patches of open vegetation within shrubland or scrub. Whether or not these patches appeared on the map depended on their size. When only a small proportion of the samples (< 20%) from a traverse represented a distinct kind of vegetation, these were either eliminated from the mapping-unit analysis (but not necessarily from the vegetation description) or, if possible, grouped with samples of similar kind from neighbouring traverses to form a mosaic mapping unit.

2. *Three leading species identified in each group of samples*
(a) Point-intercept samples In each group of samples, the number of times each species reached 20% or more of the canopy cover was counted and then the three species with the highest counts were listed. When two species among the leading four had equal cover values, preference was given to the taller. When fewer than three species reached 20% cover, all species between 10 and 19% cover were counted in order to determine the three leading species. In open communities it was sometimes necessary to count all species exceeding 5% or 1% cover to determine the leading species.
(b) Basal area samples The frequency of each species was determined among all samples of a group. The three species with the highest frequencies were then listed, giving preference to species with the larger basal area when two among four species had equal frequencies.

3. *Primary grouping of samples*
The aim was to examine the samples within each traverse for compositional similarity. All samples containing one or more of the *three* leading species

identified in step 2 (above) were grouped together and their cover or basal area values averaged. The cover or basal area values of any sample excluded from the initial averaging were then compared with the group average by using an index of dissimilarity that was based on *four* canopy species (*see below*). Inclusion or exclusion of these samples from the traverse group was decided according to the degree of dissimilarity found and the cover or basal area value for the new combined group were averaged when appropriate.

A primary sample group most frequently consisted of a group of samples from a single traverse (= traverse group). Where, however, mixtures of distinct kinds of vegetation occurred together, primary sample groups included samples from more than one traverse.

4. *Secondary grouping of samples*
Qualitative assessment in the field was used to estimate the most frequent kind of stand in the area in question. The traverse group containing the highest proportion of this frequently-occurring stand became the starting point for the secondary grouping. Depending upon the value of the dissimilarity index, other primary sample groups were either grouped with or separated from this first sample group, *beginning with sample groups from the nearest traverses and progressing to those more distant.* The nearest traverse was determined from distance alone, regardless of whether two adjacent traverses were parallel, at right angles, or end to end.

5. *Mapping units*
Grouping of samples was continued only to the point where the index of dissimilarity (DI values, see below) reached 50. Where a certain kind of vegetation occurred only in one place, derivation of the mapping unit sometimes required no more than a primary grouping of samples. Where a kind of vegetation occurred in several geographically separated areas, further group comparisons were sometimes needed to decide whether two or more locally-based mapping units should be combined as a single unit.

Index of dissimilarity

The index of dissimilarity (DI) used was based on a comparison of the four species which showed the highest values of cover or basal area in each sample or group of samples. Although a more comprehensive index of dissimilarity could be obtained by comparing all species in the samples, it was found that the additional information did not justify the extra work. Use of four species gave an index with sufficient power to separate samples or sample groups without unnecessary computation.

To compare two sample groups (or samples), A and B, the values of each of these four species were subtracted and then the absolute differences obtained were added together:

$$DI = \sum_{i=1}^{4} | A_i - B_i |$$

where A1–4 are the cover or basal area values of the four species having highest values for cover or basal area in sample group A and B1–4 are the values for the same four species in sample group B. Where sample groups A and B have a different set of high-value species, two comparisons are possible. However, the sequence of comparisons (discussed under 4 above) determined that the four species of highest cover or basal area in group A samples were used as the basis for comparison rather than those of group B.

When the summed differences (DI value) reached an arbitrary level of 50 or greater, the samples (or sample groups) were separated. Samples with DI values less than 50 were grouped together, their cover or basal area values averaged, and the new values obtained were then used in further comparisons with other sample groups.

DI values can vary between 0 and a theoretical maximum of 200, this maximum value being associated with a comparison between two samples or sample groups each 100% dominated by a single but different species. The arbitrary value of 50, chosen as a threshold value for separating sample groups, was arrived at by a trial and error search to find what could be shown clearly at a scale of 1:50 000, i.e., it is a scale-related value. Lower threshold values of the index may be more useful for separating samples when mapping vegetation at scales larger than 1:50 000.

Use of presence/absence of leading species in steps 2 and 3 to derive primary sample groups from each traverse allows grouping and averaging of a relatively wide range of sample variation. This is necessary as a result of the rather small size of each site sample. The sample group obtained from each traverse is a synthetic sample that in composition will reflect that of the most frequently occurring stands in the field.

The dissimilarity index is much more discriminating than the leading species in the range of sample variation that it will allow to be synthesised. However, the index is not brought into use until a primary sample group is obtained that can be compared with other sample groups that appear distinct.

Where excluded samples contributed less than 20% of the traverse samples they did not contribute further to the analysis; it was common for one or two samples to be excluded from a sample group, particularly in some heterogeneous tussock-shrublands and in open vegetation. Thus in total some-

Table 1 Grouping of samples in traverse HH 4.

Sample No.	% cover of the more common species* Cr	L	E	Dl	G	Ls	Pt	Sp	Primary grouping
4/1	66	26	2	4	-	-	-	-	Included
4/2	12	46	36	-	-	-	-	-	Included
4/3	50	8	8	20	-	-	-	-	Included
4/4	10	40	16	-	16	12	2	-	Included
4/5	20	38	18	2	2	12	4	-	Included
4/6	8	14	42	-	6	6	2	6	Included
4/7	18	14	16	10	18	6	6	4	Included
4/8	24	20	10	6	-	12	14	6	Included
4/9	20	36	24	6	-	8	-	-	Included
4/10	8	28	20	-	-	2	12	28	Included
Average cover values for all samples	24	27	19	5	4	6	4	4	traverse group (n = 10)

*The three leading species (those most frequently ⩾ 20% cover) are Cr (*Chionochloa rubra*), L (*Lepidosperma australe*) and E (*Empodisma minus*). Other species in table are: Dl (*Dracophyllum longifolium*), G (*Gleichenia dicarpa*), Ls (*Leptospermum scoparium*), Pt (*Phormium tenax*) and Sp (*Schoenus pauciflorus*).

thing between 10 and 20% of the samples did not contribute to the mapping units derived for these kinds of vegetation. Although too small to map, some of these samples were of special interest in demonstrating particular ecological relationships and it would be necessary to include them in any more comprehensive analysis of the Park's vegetation. In forest and scrub the level of sample exclusion was lower, usually not exceeding 5–10% of the samples.

If the excluded samples contributed 20% or more of the traverse samples, the same grouping procedure was applied to them. Usually this showed that aggregation of a majority of the excluded samples was possible and a mosaic mapping unit of two dissimilar kinds of vegetation would result. In exceptional cases (see Example 2 below), although a mosaic mapping unit was used, it was still only possible to show a fraction of the vegetation variation on the map.

EXAMPLES OF THE DERIVATION OF MAPPING UNITS

The procedure is illustrated below with four examples from three different kinds of vegetation taken from the results of the Tongariro survey.

Example 1 Tussock, sedge and rush vegetation north of Mt Hauhungatahi bounded by State Highways 4 and 47.

Grid ref. 180 220 (Atkinson 1981). The area was sampled with four traverses (40 samples): HH 4, 9, 10, and 20.

Step 1: Continuity check. Observations showed that variation between samples in the field was generally continuous.

Step 2: Leading species. The three leading species were identified in each traverse; these were not identical for all traverses (Tables 1, 2).

Step 3: Primary grouping of samples. The grouping for two traverses is shown in Tables 1 and 2 and the resultant averages for all four traverses are summarised at the beginning of Table 3.

Steps 4 and 5: Secondary grouping of samples and derivation of mapping units. Sedge communities dominated by lepidosperma (*Lepidosperma australe*) and red tussock (*Chionochloa rubra*) appeared in the field to be by far the most frequent kind of stand in this area. Therefore, the sample group from traverse HH 9, which contained the highest proportion of these stands, was used as a starting point for the sequential comparison of Table 3. Thus the appropriate four species in traverse HH 9 were used for calculating the dissimilarity index and deciding whether to group or separate the samples of HH 10. The dissimilarity index for this particular comparison was 31 (Table 3) indicating that the sample results from these two traverses could be grouped and averaged to give a new synthetic sample group. With each subsequent comparison it was always the four species with highest cover values in the most recently synthesised sample group in the sequence that were used for calculating the dissimilarity index.

As there were no other areas of similar vegetation in the Park, the average cover values for the combined sample group from HH 4, 9, 10, and 20 were used for the quantitative description of the mapping unit.

Table 2 Grouping of samples in traverse HH 20.

	% cover of the more common species*								Primary grouping	
Sample No.	Cr	L	E	Dl	G	Ls	Pt	Cv	(i)	(ii)
20/1	62	–	–	6	–	2	–	30	Included	Included
20/2	38	8	–	–	–	14	2	38	Included	Included
20/3	38	26	14	–	6	6	6	–	Included	Included
20/4	38	–	–	4	–	2	–	54	Included	Included
20/5	36	10	8	2	8	–	8	14	Included	Included
20/6	–	–	16	2	28	–	16	–	Excluded	Excluded
20/7	4	24	4	6	–	4	24	10	Included	Included
20/8	32	20	–	–	–	4	–	42	Included	Included
20/9	28	26	6	4	–	–	8	24	Included	Included
20/10	66	4	–	10	–	2	12	4	Included	Included
Average cover values for all samples excluding 20/6	38	13	3.5	3.5	1.5	4	6.5	24	traverse group (n = 9)	
Differences in cover values between sample group (i) and 20/6†	38	13					9.5	24	DI = 84.5; sample 20/6 must be excluded from primary group	

*The three leading species (those most frequently ⩾ 20% cover) are Cr (*Chionochloa rubra*), Cv (*Calluna vulgaris*) and L (*Lepidosperma australe*). Other symbols for species as in Table 1.
†Dissimilarity index (DI) calculated using the four species of highest cover in the first sample grouping (i) as a basis for comparison.

Example 2 Vegetation south-east of Mt Ngauruhoe
Grid ref. 430 200 (Atkinson 1981). The area was sampled with four traverses (40 samples): OT 1–4.
Step 1: Continuity check. Observations showed a discontinuous and complex mixture of bare scoria, partly vegetated scoria, tussock, shrub and forest vegetation. Many areas were separated by distinct boundaries and there was scarcely a pair of samples from any one traverse with similar floristic composition. Much of the scoria field, tussock land, and some scrub and forest occurred in areas large enough to map separately (17 samples). The remaining 23 samples required further analysis and were first subdivided according to major differences in structure (Table 4). From this it was apparent that the two most abundant kinds of vegetation were partly-vegetated gravelfield (12 samples) and shrubland (5 samples). Since only two kinds could be shown on the map (see Boundaries and the Demarcation of Mapping Units p. 369), derivation of mapping units was restricted to these samples.

Steps 2 and 3: Leading species and primary grouping of samples. The three leading species were identified in each group of samples and the samples grouped accordingly (Tables 5, 6).

Steps 4 and 5: Secondary grouping of samples and derivation of mapping units. In this example no secondary grouping of samples was possible and the two groups became the basis of a mosaic mapping unit (see Boundaries and the Demarcation of Mapping Units).

Example 3 Podocarp forest on Mt Hauhungatahi
Lower western slopes of Mt Hauhungatahi. Grid ref. 175 165 (Atkinson 1981). These slopes were sampled with five traverses : HH 1, 2, MK 3, 4, and 7 (50 samples).
Step 1: Continuity check. Observations did not reveal any structurally distinctive stands that warranted separation from the remaining forest.
Step 2: Leading species. The three leading species for each traverse were determined from the frequencies of all species in the samples. These included only rimu (*Dacrydium cupressinum*), miro (*Prumnopitys ferruginea*), matai (*P. taxifolia*) and kamahi (*Weinmannia racemosa*) for the five traverses.
Step 3: Primary grouping of samples. In each traverse, one or more of the three leading species were represented in each sample. Thus the sample results were averaged for each traverse to give five primary sample groups (Table 7).

Table 3 Grouping of samples from traverses HH 4, 9, 10, 20.

Sample Groups with number of samples (n)	av. % cover of the more common species*								Dissimil-arity Index (DI)	Secondary Grouping
	Cr	L	E	Dl	G	Ls	Pt	Cv		
HH4 (n = 10)	24	27	19	5	4	6	4	–		
HH9 (n = 10)	24	38	12	3	1	2	9	5		
HH10 (n = 10)	23	18	3	9	8	11	10	11		
HH20 (n = 9)	38	13	3.5	3.5	1.5	4	6.5	24		
Differences in cover values between HH9 vs HH10†	1	20	9				1		31	Included
Average cover values for HH9 + HH10	23.5	28	7.5	6	4.5	6.5	9.5	8		
Differences in cover between HH9 + 10 vs HH4†	0.5	1					5.5	8	15	Included
Average cover values for HH9 + HH10 + HH4	24	28	11	6	4	6	8	5		
Differences in cover between HH9 + 10 + 4 vs HH20†	14	15	7.5				1.5		38	Included
Average cover values for all sample groups (HH9 + 10 + 4 + 20)	27	24	9	5	3.5	6	7	10		

*Symbols for species as in Tables 1, 2.
†Dissimilarity index calculated using the four species of highest cover in the first-listed sample group of the comparison.

Table 4 Structural classes for 23 samples from traverses OT 1–4.

Structural class (see Table 9)	Samples in class
Partly vegetated gravelfield	OT 1/1, 1/5, 1/8 1/10, 2/5, 3/2, 3/6 3/7, 4/2, 4/3, 4/4, 4/5
Shrubland	OT 1/3, 1/7, 2/3, 2/4, 3/1
Scrub	OT 1/2, 1/6, 2/1
Gravelfield (within larger areas of partly vegetated gravelfield and shrubland)	OT 1/9, 2/2, 4/1

Steps 4 and 5: Secondary grouping of samples and derivation of mapping units. Observations showed that the most frequent kind of stand in this forest contained both a high proportion of rimu and a significant amount (> 10% basal area) of kamahi in the canopy. The samples of traverse HH 2 typified this composition most closely and hence this sample group was used as the starting point for the secondary grouping. In subsequent comparisons (Table 7) the dissimilarity indices never reached 50, so that the cover values of all five sample groups were averaged to give values for a single mapping unit.

Example 4 Cut-over forest east of Rongokaupo trig
Grid ref. 175 005 (Atkinson 1981).
Cut-over forest is characteristically very heterogeneous and this is illustrated by traverse RK 5 from forest logged in the 1930s and 40s. Some samples

Table 5 Grouping of samples from partly vegetated gravelfields in traverses OT 1–4.

	% cover of bare ground and common species*						Primary Grouping	
Sample No.	Gravel	Dr	Dlf	Pn	Gc	R	(i)	(ii)
1/1	52	–	–	–	4	26	Excluded	Included
1/5	28	18	14	8	4	2	Included	Included
1/8	42	12	10	14	2	–	Included	Included
1/10	36	10	–	–	2	–	Included	Included
2/5	42	2	10	8	12	6	Included	Included
3/2	50	–	–	–	2	12	Excluded	Included
3/6	28	8	–	–	2	8	Included	Included
3/7	32	4	8	4	6	–	Included	Included
4/2	40	6	–	12	–	–	Included	Included
4/3	66	12	–	2	–	–	Included	Included
4/4	38	6	–	–	–	–	Included	Included
4/5	44	14	–	–	–	–	Included	Included
Average cover values for all samples excluding OT 1/1 and 3/2	39.5	9	4	5	3	1.5		
Differences in cover values between sample group (i) and 1/1†	12.5	9	4	5			DI = 30; sample 1/1 can be included with primary group	
Differences in cover values between sample group (i) and 3/2†	10.5	9	4	5			DI = 28.5; sample 3/2 can be included with primary group	
Average cover values for all samples	41	8	3.5	4	3	4.5	Sample group (n = 12)	

*The three leading species (those most frequently ⩾ 8% cover) are Dr (*Dracophyllum recurvum*), Dlf (*Lepidothamnus laxifolius*) and Pn (*Podocarpus nivalis*). Other species in table are Gc (*Gaultheria colensoi*) and R (*Racomitrium lanuginosum*).
†Dissimilarity index (DI) calculated using the four species of highest cover in the first sample grouping (i) as a basis for comparison.

Table 6 Grouping of samples from shrubland in traverses OT 1–4.

	% cover of bare ground and common species*						
Sample No.	Gravel	Dr	Dlf	Pn	Pa	Dl	Primary Grouping
1/3	16	32	–	–	–	–	Included
1/7	12	26	6	32	–	–	Included
2/3	36	4	2	16	–	22	Included
2/4	22	8	20	10	20	10	Included
3/1	–	20	6	22	–	10	Included
Average cover values for all samples	17	18	7	16	4	8	Sample group (n = 5)

*The three leading species (those most frequently ⩾ 10% cover) are Pn (*Podocarpus nivalis*), Dr (*Dracophyllum recurvum*) and Dl (*Dracophyllum longifolium*). Other species in table are Dlf (*Lepidothamnus laxifolius*) and Pa (*Phyllocladus aspleniifolius* var. *alpinus*).

Table 7 Grouping of samples from traverses HH1, 2, MK3, 4 and 7 (50 samples).

Sample groups (Sample number for each traverse = 10)	% basal area of common species*				Dissimilarity index (DI)	Secondary grouping
	D	Pf	Wr	Ps		
Average cover values for HH1	58	9	7	13		
Average cover values for HH2	50	11	20	11		
Average cover values for MK3	33	23	11	16		
Average cover values for MK4	52	1	8	14		
Average cover values for MK7	27	17	31	7		
Differences in cover values between HH2 and HH1†	8	2	13	2	25	Included
Average cover values for HH2 + HH1	54	10	13.5	12		
Differences in cover between HH2 + HH1 vs MK3	21	13	2.5	4	40.5	Included
Average cover values for HH2 + HH1 + MK3	47	14	13	13		
Differences in cover between HH2 + HH1 + MK3 vs MK7	20	3	18	6	47	Included
Average cover values for HH2 + HH1 + MK3 + MK7	42	15	17	12		
Differences in cover between HH2 + HH1 + MK3 + MK7 vs MK4	10	14	9	2	35	Included
Average cover values for all sample groups	44	12	15.5	12		

*Symbols for species are: D (*Dacrydium cupressinum*), Pf (*Prumnopitys ferruginea*), Wr (*Weinmannia racemosa*) and Ps (*Prumnopitys taxifolia*).
†Dissimilarity indices calculated using the four species of highest cover in the first listed sample group of each comparison. In this example the species were the same for each comparison.

of this traverse contain five different species among the canopy count of five individual trees. Such traverses were treated in the same way as those for more homogeneous forest : the three most frequent canopy species were identified and then basal area values of all samples containing these species were averaged together while remaining samples were excluded (Table 8).

BOUNDARIES AND THE DEMARCATION OF MAPPING UNITS

The sequence of steps in deciding what boundaries were to be shown on the map was as follows:

1. Distinct boundaries, that were associated with distinct spatial differences in structure or composition, could be seen easily in the field and on the aerial photographs. These included boundaries between the three appearance types mentioned under field procedure. Such boundaries were transferred directly to the map. The scale of the map determined the lower size limit of area that could be shown. Where two or more different kinds of mapping unit occurred together in a pattern that was too intricate for their separate areas to be shown, the two most abundant units were mapped as a mosaic unit. A minimum of 20% of the samples was set for any one kind of vegetation to qualify as part of a mosaic mapping unit.
2. Where the composition of the vegetation changed gradually from place to place, with no easily distinguishable boundaries, whether or not to subdivide the area was decided by asking three questions:

(a) If the area was subdivided, would the mapping units so formed show clearly on the map? If not, there was no case for subdivision.
(b) Was the difference in canopy composition, judged by the averages for the sample groups composing the potential mapping units, sufficiently great

Table 8 Grouping of samples from traverse RK5.

Sample	Numbers of each species in samples																Primary grouping
	Aristotelia serrata	*Carpodetus serratus*	*Coprosma grandifolia*	*Coprosma tenuifolia*	*Cyathea smithii*	*Dacrydium cupressinum*	*Dicksonia squarrosa*	*Griselinia littoralis*	*Nestegis cunninghamii*	*Olearia rani*	*Prumnopitys ferruginea*	*Prumnopitys taxifolia*	*Pseudopanax arboreus*	*Pseudowintera colorata*	*Rubus cissoides*	*Weinmannia racemosa*	
5/1			1					1								3	Included
5/2						1			1		2					1	Included
5/3				2	2			1									Included
5/4		1	1					2	1								Included
5/5		1		1			1			1						1	Included
5/6								1	1		1			1		1	Included
5/7	3													1	1		Excluded
5/8		1			2				1							1	Included
5/9	1													3		1	Included
5/10												1	1			3	Included
Frequency	2	3	2	2	2	1	1	4	4	1	2	1	1	3	1	7	Primary group of samples from tra-
% basal area	3	4	1	2	6	8	2	13	15	2	13	4	2	5	1	19	verse = 9 samples

to justify separation? An arbitrary criterion of what constituted a "sufficiently great" difference was used, this being the values obtained from applying the same index of dissimilarity (DI) described earlier. Where two potential areas for separation, represented by sample groups A and B, had differing sets of leading species, two comparisons were possible. The first comparison calculated the DI value using the four species with highest cover or basal area values in sample group A. The second comparison used the appropriate four species of sample group B to calculate the DI. A DI value of 50 had to be reached in at least one of the comparisons if the two areas were to be shown as separate units.

(c) What physical difference could be associated with the vegetation difference? Having decided, on the basis of the difference level derived from the index of dissimilarity, that an area should be subdivided into two units, a boundary was drawn wherever possible to coincide with a topographic discontinuity that could be identified in the future, e.g., a difference in slope, aspect, landform, rock type that had some topographic expression, or stream course. Altitudinal differences were also used for boundary placement but such differences were usually not related to topographic discontinuities. In these cases, the upper or lower altitudinal limit of a particular plant species was used as a practical boundary criterion. For example, the upper limit of rimu was used to separate rimu and rimu/kamahi forests from Hall's totara-kaikawaka (*Podocarpus hallii-Libocedrus bidwillii*) forest on parts of Hauhungatahi.

At first sight, drawing a vegetation boundary to coincide with a topographic discontinuity, as described above, may suggest that the vegetation itself was no longer being mapped in places where spatial change was gradual. However, the decision to draw a boundary was made as a consequence of spatial differences in the vegetation; it was only the exact position of that boundary that was fixed by the topographic feature. The most important consideration was that the feature chosen to demarcate the boundary, however arbitrary, should be identifiable for future observers.

NAMING OF MAPPING UNITS

A satisfactory naming system for vegetation mapping units should convey as much information as possible about what has been mapped without becoming difficult to comprehend. The procedure adopted was that of distinguishing structural classes of vegetation based on growth forms of the canopy plants or, in open communities, on ground-surface textures. These classes were then subdivided according to the floristic composition of the canopy. Thus, each mapping unit was given a two-part name, the first part characterising floristic composition of the canopy and the second indicating structure as determined by the leading growth form, or the kind of ground surface present where the vegetation was open. Names such as bog, swamp, heath, fellfield, etc. which have been used in various ways, were avoided.

Steps in the naming procedure were as follows:
1. Structural names: Using the averaged values for canopy cover or basal area, the structural class of the mapping unit was determined from the proportion of each growth form in the canopy or, in the case of open communities, the proportion of each kind of ground surface (Table 9).

2. Compositional names: The compositional name of the mapping unit was derived from the names of the major canopy species composing the vegetation as follows:
(a) In most cases, all those species ⩾ 20% of cover or basal area.
(b) Where no species reached the 20% level, the two most abundant species ⩾ 15, 10, 5, or 1% cover or basal area, whichever was the appropriate level.
(c) Where the plant cover was less than 1% the mapping unit was named solely from the nature of the open ground surface.
The 20% level of composition is useful for naming because it is seldom that more than three species need to be named and thus unwieldiness is avoided. When the vegetation was very heterogeneous no species reached the 20% level and so the next lower level (⩾ 15%) was checked for species from which the vegetation could be named. The lowest compositional levels (1–10%) were usually needed for naming open vegetation. With species contributing less than 5% of the total cover, precedence was given to species that were longest lived.

3. Range of % composition. The ranges of % cover or basal area found for the species used in naming the mapping unit were indicated by a system of underlining and brackets incorporated into the unit name. This is illustrated in Table 10.

4. Conspicuous species. Both square and curved brackets (indicating % composition) were used for drawing attention to conspicuous plants in closed vegetation. For example kaikawaka, when emergent above a more or less continuous canopy of mountain beech (*Nothofagus solandri* var. *cliffortioides*), frequently contributed less than 20% of the canopy cover and thus did not at first qualify for inclusion in the name of the mapping unit. However, the conical crowns of this species were conspicuous above the beech canopy and a name that did not mention the species would not convey a realistic picture of the vegetation. Thus, stands in which kaikawaka reached only 10–19% of the canopy were named (kaikawaka)/mountain beech and symbolised by (Lb)/Nc. The criterion for inclusion was that a conspicuous plant must appear in half or more of the samples. The question of what constitutes a "conspicuous" plant remains as a subjective decision of the mapper.

5. Multiple canopy layers. Structural information, in addition to that provided by the structural class name, was incorporated by using hyphen (-) and diagonal sign (/) symbols to convey height relationships between the named species (cf. Atkinson *in* Druce 1959):
(a) Hyphens link species, not greatly different in height, that form part of the same canopy layer, e.g. mountain beech-pink pine (*Halocarpus biformis*) scrub.
(b) Diagonal signs link species that differ significantly in height and that form two or more separate canopy layers, the taller species placed to the left of the diagonal sign symbol, e.g., kanuka/manuka (*Leptospermum ericoides*/*L. scoparium*) scrub.

6. Choice of names. Common names were used in preference to scientific names because they are usually shorter and more often used.

Difficulties of wording are likely with any vegetation naming system that attempts to be logical in structure and the present system is no exception. Thus, because red tussock tussockland is an awkward combination, it was replaced with red-tussock land, part of the compositional name being used to indicate the structural class. This principle was applied to other cases, e.g., wire-rush rushland became wire-rush land.

The naming system need not be restricted to areas of vegetation of mappable size. It can be applied to individual samples although in the case of forest sampled with 5 canopy trees/sample, as in this study, there is too little information to name a single sample unless the forest is relatively homogeneous.

Classification of vegetation structural classes

A classification of vegetation structural classes, based on the growth forms of the canopy species, was described by Atkinson (1962). In its original form this classification included two-part names for each class, e.g., tussock-fernland, gravel-lichenfield. This allowed the secondmost important growth form or ground-surface to be added as a prefix to the name for the main structural class. Subsequent testing, both within Tongariro National Park and elsewhere, has shown this two-part naming to be somewhat unwieldy and complicated for general use in naming veg tion mapping units. For the Tongariro mapping, and in Table 9, the original

Table 9 Diagnostic criteria for terrestrial vegetation structural classes (modified and extended from Atkinson 1962).

Structural class	Diagnostic criteria for structural classes and definitions of growth forms
1. FOREST	Woody vegetation in which the cover of trees and shrubs in the canopy is > 80% and in which tree cover exceeds that of shrubs. Trees are woody plants ⩾ 10 cm dbh. Tree ferns ⩾ 10 cm dbh are treated as trees.
2. TREELAND	Vegetation in which the cover of trees in the canopy is 20–80%, with tree cover exceeding that of any other growth form, and in which the trees form a discontinuous upper canopy above either a lower canopy of predominantly non-woody vegetation or bare ground e.g., mahoe/bracken treeland. (Note: Vegetation consisting of trees above shrubs is classified as either forest or scrub depending on the proportion of trees and shrubs in the canopy).
3. VINELAND	Vegetation in which the cover of *unsupported* (or artificially supported) woody vines in the canopy is 20–100% and in which the cover of these vines exceeds that of any other growth form or bare ground. Vegetation containing woody vines that are supported by trees or shrubs is classified as forest, scrub or shrubland. Examples of woody vines occur in the genera *Actinidia, Clematis, Lonicera, Metrosideros, Muehlenbeckia, Ripogonum, Vitis* and others.
4. SCRUB	Woody vegetation in which the cover of shrubs and trees in the canopy is > 80% and in which shrub cover exceeds that of trees (cf. FOREST). Shrubs are woody plants < 10 cm dbh.
5. SHRUBLAND (including tussock-shrubland)	Vegetation in which the cover of shrubs in the canopy is 20–80% and in which the shrub cover exceeds that of any other growth form or bare ground. It is sometimes useful to separate tussock-shrublands as a sub-class for areas where tussocks are > 20% but less than shrubs. (Note: The term scrubland is not used in this classification).
6. TUSSOCKLAND (including flaxland)	Vegetation in which the cover of tussocks in the canopy is 20–100% and in which the tussock cover exceeds that of any other growth form or bare ground. Tussocks include all grasses, sedges, rushes, and other herbaceous plants with linear leaves (or linear non-woody stems) that are densely clumped and > 10 cm height. Examples of the growth form occur in all species of *Cortaderia, Gahnia*, and *Phormium*, and in some species of *Chionochloa, Poa, Festuca, Rytidosperma, Cyperus, Carex, Uncinia, Juncus, Astelia, Aciphylla*, and *Celmisia*. It is sometimes useful to separate *flaxland** as a subclass for areas where species of *Phormium* are dominant.
7. FERNLAND	Vegetation in which the cover of ferns in the canopy is 20–100% and in which the fern cover exceeds that of any other growth form or bare ground. Tree ferns ⩾ 10 cm dbh are excluded as trees (cf. FOREST).
8. GRASSLAND	Vegetation in which the cover of grass in the canopy is 20–100% and in which the grass cover exceeds that of any other growth form or bare ground. Tussock-grasses are excluded from the grass growth-form.
9. SEDGELAND	Vegetation in which the cover of sedges in the canopy is 20–100% and in which the sedge cover exceeds that of any other growth form or bare ground. Included in the sedge growth form are many species of *Carex, Uncinia*, and *Scirpus*. Tussock-sedges and reed-forming sedges (cf. REEDLAND) are excluded.
10. RUSHLAND	Vegetation in which the cover of rushes in the canopy is 20–100% and in which the rush cover exceeds that of any other growth form or bare ground. Included in the rush growth form are some species of *Juncus* and all species of *Sporadanthus, Leptocarpus*, and *Empodisma*. Tussock-rushes are excluded.

*The term "flaxland" could not be used outside New Zealand because elsewhere the name flax is widely applied to species of *Linum*.

Table 9 *cont.*

Structural class	Diagnostic criteria for structural classes and definitions of growth forms
11. REEDLAND	Vegetation in which the cover of reeds in the canopy is 20–100% and in which the reed cover exceeds that of any other growth form or open water. Reeds are herbaceous plants growing in standing or slowly-running water that have tall, slender, erect, unbranched leaves or culms that are either hollow or have a very spongy pith. Example include *Typha, Bolboschoenus, Scirpus lacustris, Eleocharis sphacelata,* and *Baumea articulata.*
12. CUSHIONFIELD	Vegetation in which the cover of cushion plants in the canopy is 20–100% and in which the cushion-plant cover exceeds that of any other growth form or bare ground. Cushion plants include herbaceous, semi-woody and woody plants with short densely packed branches and closely spaced leaves that together form dense hemispherical cushions. The growth form occurs in all species of *Donatia, Gaimardia, Hectorella, Oreobolus,* and *Phyllachne* as well as in some species of *Aciphylla, Celmisia, Centrolepis, Chionohebe, Colobanthus, Dracophyllum, Drapetes, Haastia, Leucogenes, Luzula, Myosotis, Poa, Raoulia,* and *Scleranthus.*
13. HERBFIELD	Vegetation in which the cover of herbs in the canopy is 20–100% and in which the herb cover exceeds that of any other growth form or bare ground. Herbs include all herbaceous and low-growing semi-woody plants that are not separated as ferns, tussocks, grasses, sedges, rushes, reeds, cushion plants, mosses or lichens.
14. MOSSFIELD	Vegetation in which the cover of mosses in the canopy is 20–100% and in which the moss cover exceeds that of any other growth form or bare ground.
15. LICHENFIELD	Vegetation in which the cover of lichens in the canopy is 20–100% and in which the lichen cover exceeds that of any other growth form or bare ground.
16. ROCKLAND	Land in which the area of residual bare rock exceeds the area covered by any one class of plant growth-form. Cliff vegetation often includes rocklands. They are named from the leading plant species when plant cover $\geqslant$ 1% e.g., [koromiko] rockland.
17. BOULDERFIELD	Land in which the area of unconsolidated bare boulders (> 200 mm diam.) exceeds the area covered by any one class of plant growth-form. Boulderfields are named from the leading plant species when plant cover $\geqslant$ 1%.
18. STONEFIELD/ GRAVELFIELD	Land in which the area of unconsolidated bare stones (20–200 mm diam.) and/or gravel (2–20 mm diam.) exceeds the area covered by any one class of plant growth-form. The appropriate name is given depending on whether stones or gravel form the greater area of ground surface. Stonefields and gravelfields are named from the leading plant species when plant cover $\geqslant$ 1%.
19. SANDFIELD	Land in which the area of bare sand (0.02–2 mm diam.) exceeds the area covered by any one class of plant growth-form. Dune vegetation often includes sandfields which are named from the leading plant species when plant cover $\geqslant$ 1%.
20. LOAMFIELD/ PEATFIELD	Land in which the area of loam and/or peat exceeds the area covered by any one class of plant growth-form. The appropriate name is given depending on whether loam or peat forms the greater area of ground surface. Loamfields and peatfields are named from the leading plant species when plant cover $\geqslant$ 1%.

Table 10 Naming of mapping units: symbols for showing ranges in % cover or % basal area of plant components using vegetation containing Dracophyllum recurvum as an example.

Name of mapping unit	% cover of Dracophyllum recurvum	Map symbol
Mountain inaka shrubland (or scrub)	⩾ 50 (> 80 in scrub)	Dr
Mountain inaka shrubland	20–49 (shrub cover > gravel cover of open ground)	Dr
Mountain inaka gravelfield	20–49 (gravel cover > shrub cover)	Dr
(Mountain inaka) gravelfield	10–19 (gravel cover > shrub cover)	(Dr)
[Mountain inaka] gravelfield	1–10 (gravel cover > shrub cover)	[Dr]
Gravelfield	< 1 (gravel cover > shrub cover)	GF

system was simplified although slightly extended. Only single names are now used for each major structural class, the names depending on the dominant growth forms. However, because of its widespread importance at Tongariro, "tussock-shrubland" was retained as a subclass of shrubland (Atkinson 1981). It may be found that this subclass, or other subclasses based on the 1962 system, are useful in particular situations elsewhere. The simplified system does not preclude the use of the earlier system provided the two-part names are applied to subclasses of the main divisions (Table 11).

Diagnostic criteria for each of the structural classes of Table 9 are based on the percentage crown cover of plant growth-forms in the canopy or percentage cover of materials forming the ground surface in open ground. As indicated earlier, in the Tongariro survey basal area was used in forest rather than crown cover.

There has been some debate over the desirability of extending the tussock growth-form to include plants, other than grasses, of diverse taxonomic affinity. Such extensions can be expected in any classification that emphasises growth-forms and occurs in this classification with the forest, scrub, shrubland and cushionfield classes as well as tussockland. Webster's 'Third New International Dictionary' (1976) defines tussock grass as "any of various grasses or sedges that typically grow in tussocks" and Jackson's 'A Glossary of Botanic Terms' (1928) says "Tussock, a tuft of grass or grass-like plants". Tussocks are one of the most distinctive non-woody growth forms in New Zealand and the fact that the same form can be seen in genera as taxonomically distinct as *Chionochloa, Cortaderia, Gahnia, Astelia*, and *Phormium* is likely to have adaptational significance. Equally, the difference in habitat and life-span of tussock-grasses and many pasture grasses justifies separation of tussock-grasses from the remainder.

Vineland and cushionfield are new structural classes introduced since the Tongariro survey was completed. If the classification is applied to vegetation in the New Zealand cultural landscape (as for example by N.Z. Soil Bureau *in prep.*), the importance of orchards containing vines necessitates a vineland class. Work carried out during the 1983/84 summer by the Protected Natural Area survey teams has confirmed that cushion plants are sufficiently abundant in some areas to warrant a structural class to accommodate this very distinctive growth form.

Not all categories of the classification are independent of taxonomic classes. Fernland, mossfield, and lichenfield are closely related to their respective taxonomic classes but each is characterised by particular kinds of growth form so that the basis of the classification is not weakened.

Choice of the suffix -land or -field in this classification has been influenced by common usage. There is no logical reason why -land could not be used throughout except that terms such as 'herbland' 'lichenland', 'stoneland' and 'sandland' would seem more strange to some people than the alternatives. For some surveys of large areas where detail is not required, it may prove more convenient to map the open communities of classes 16–20 as 'openlands'.

In using the system it is important to remember that the same species can sometimes develop a different growth-form in different habitats or at different stages in its life-cycle. A species should not be pigeon-holed into a growth-form class without checking to see how it is actually growing.

Examples of the naming of mapping units

The procedure for naming can be illustrated with examples including those used earlier to illustrate the derivation of mapping units.

Example 1

The final average figures for the secondary sample

Table 11 Naming of structural classes in various kinds of vegetation: some examples.

Canopy composition of vegetation (% cover)		Structural class
	%	
trees	81	forest
shrubs	19	
trees	19	scrub
shrubs	81	
trees	50	forest
shrubs	50	
trees	49	scrub
shrubs	51	
trees	81	forest
tussocks	19	
trees	80	treeland
tussocks	20	(subclass: tussock-treeland)*
trees	50	treeland
tussocks	50	(subclass: tussock-treeland)*
trees	49	tussockland
tussocks	51	(subclass: tree-tussockland)*
trees	20	shrubland
shrubs	40	(subclass: tussock-shrubland)*
tussocks	40	
trees	20	tussockland
shrubs	39	(subclass: shrub-tussockland)*
tussocks	41	
trees	49	vineland
unsupported vines	51	(subclass: tree-vineland)*
trees	30	treeland
shrubs	20	(subclass: tussock-treeland)*
tussocks	20	Lower canopy is predominantly
grasses	20	non-woody
sedges	10	
trees	30	tussockland
shrubs	10	(subclass: tree-tussockland)*
tussocks	35	
grasses	20	
sedges	5	
shrubs	20	rockland
herbs	25	(subclass: herb-rockland)*
residual rock	40	
mosses	15	
boulders	15	gravelfield
stones	30	(subclass: stone-gravelfield)*
gravel	35	
plants	20	

*The use of these subclasses, based on Atkinson (1962), is not strongly advocated. They are included to make clear that these options are available for descriptive or mapping purposes if local needs make their use desirable.

grouping of Table 3 showed tussocks to be greater in % cover than sedges but, as stated earlier, by far the most frequently occurring stand was that represented by the samples of traverse HH 9. For this reason the area was named a sedgeland rather than a tussockland.

Red-tussock formed an upper canopy layer and consistently overtopped the lepidosperma. However, to name this vegetation from the tussock and sedge components alone would have failed to recognise the conspicuous appearance of flax (*Phormium tenax*) which overtopped the red tussock and, although only averaging 7% of the cover, occurred in more than half the samples (29 of 39 samples). Accordingly, the name given to this mapping unit was [flax]/red tussock/lepidosperma sedgeland, symbolised by [Pt]/Cr/L.

Example 2

In the first part of this mosaic mapping unit, whose derivation is shown in Table 5, the cover of gravel exceeded the shrub cover making it a gravelfield in which mountain inaka (*Dracophyllum recurvum*) and snow totara (*Podocarpus nivalis*) were of greatest physiognomic importance. Both species were present in the 1–10% range of cover. In the second part of the mapping unit the shrub cover exceeded the gravel cover making it a shrubland in which mountain inaka and snow totara were again of greatest importance. Both were present in the 10–19% range of cover. In neither part of the mapping unit was there any significant height difference between the main species. Thus the name given was [mountain inaka-snow totara] gravelfield + (mountain inaka-snow totara) shrubland symbolised by [Dr-Pn] + (Dr-Pn).

It may be noted that *Racomitrium lanuginosum* (R) has a slightly higher cover than snow totara in the overall averages of Table 5. It was excluded from the name on the grounds that its cover was likely to fluctuate from year to year in comparison with the long-lived snow totara.

Example 3

Rimu was the only species in the forest group shown in Table 7 which reached or exceeded the 20% level. General observations and the data of Table 7 showed that it most frequently formed 50% or more of the canopy cover. Thus, the name given was rimu forest symbolised by D.

Example 4

In this cut-over forest illustrated in Table 8 no species reached the 20% level of basal area. The two leading species in the 10 to 19% range were black maire (*Nestegis cunninghamii*) at 15% and kamahi at 19%. Accordingly, when considered as a whole this stand could be named (kamahi-black maire) forest. In fact its samples were grouped with those from other traverses to form a kamahi forest mapping unit symbolised by Wr.

Example 5

Sampling of the "tussock" vegetation north and east of the Chateau Tongariro gave the following composition for growth forms (based on fusion of six sample groups): shrubs 28%, tussocks 27%, ferns 8%, herbs 5%, other growth forms, litter and bare ground 32%. The only species to reach 20% or more of the canopy was red tussock at 24%. Since shrubs were greatest in quantity but a tussock species was the only plant sufficiently common to qualify for inclusion in the unit name, the mapping unit was called red tussock tussock-shrubland, abbreviated to red tussock shrubland, and symbolised by Cr.

Further examples to show how structural class names are given to various kinds of vegetation are given in Table 11.

SOURCES OF BIAS IN DERIVING THE MAPPING UNITS

Notwithstanding the attempt made to eliminate personal bias from both the field sampling and the subsequent treatment of the results, some bias still remains. It is important to identify the various sources of bias present.

1. Differences in intensity of sampling. At any given density of sampling, kinds of vegetation that occurred in larger areas were more frequently sampled and therefore better characterised than those of smaller areas. This is a source of bias difficult to avoid, but where the vegetation pattern was intricate, increasing the density of sampling was sometimes essential if sufficient information to draw a meaningful map was to be obtained. Equally, a reduced density of sampling was used in extensive areas of very homogeneous vegetation to avoid needless repetitive sampling.
2. Positioning of samples. The stratified-random distribution of the samples ensured that only a small amount of bias occurred. This bias resulted mainly from changes of direction associated with moving past large trees or avoiding topographic obstacles and tangles of bush lawyer (*Rubus cissoides*).
3. Grouping of sample results. Although this was largely a mechanical and therefore repeatable procedure, disagreement between observers could occur concerning the most frequent kind of vegetation stand in an area, especially if field observations were limited. This would affect the sequence of sample group comparisons and thus sometimes the composition of the mapping unit derived.
4. Demarcation of boundaries. With regard to distinct structural or floristic boundaries, this step is repeatable provided the map scale is not changed.

Where gradational change and indistinct boundaries are being remapped, this step is repeatable only insofar as use is made of identifiable physical boundaries and the nature of these boundaries is recorded in a retrievable manner.

5. Naming of mapping units. With adequate numbers of samples the procedure is mechanical and therefore repeatable. The recognition of what constitutes a "conspicuous" plant remains as a subjective element but this is expressed only in the name of the mapping unit, not the compositional averages for the unit.

DISCUSSION

Any map that shows differences in vegetation implies a classification. In Küchler's (1967:167) discussion of mapping and classification, the present method would be recognised as a physiognomic-floristic system that uses an *a posteriori* rather than an *a priori* mode of classifying. It is also a numerical classification that employs an hierarchial clustering strategy in which the groups or clusters do not necessarily exhibit the same homogeneity (Clifford & Stephenson 1975). Two main kinds of clustering strategy have been used for ecological work: agglomerative pathways in which, beginning with the data for individual samples, the final groupings or clusters are found by a series of fusions, and divisive pathways in which, beginning with all the data, the final groupings result from a series of fissions.

The present method, though developed independently of other studies, combines attributes of both divisive and agglomerative methods. Because many of the major structural classes such as forest, scrub, tussockland, gravelfield, etc. (Table 9) are easily distinguished in the field and thus can immediately be separated on a map, a prestratification of the data using structural properties is possible. This initial step is essentially divisive in character. The subsequent grouping of sample data within each of these structural classes is an agglomerative procedure. More specifically, it is a polythetic agglomerative technique since a number of attributes (% cover or % basal area of several species) are used to calculate the dissimilarity index for each comparison rather than a single attribute as in monothetic techniques (Williams 1971). (More strictly, because only a few rather than all species are used in each comparison, the method is oligothetic rather than completely polythetic).

In discussing polythetic agglomerative clustering methods, Clifford & Stephenson (1975) distinguish a number of different procedures. Although the present method has features of some of these, it differs from them because the sorting strategy had as a priority the combining of similar entities that were closest together in the field. Thus groups of samples that showed dissimilarity index values less than a threshold value of 50 were combined together in order of geographical proximity. This proved to be a practical way of making class boundaries more nearly coincidental with map boundaries.

Mr J. Leathwick (pers. comm.) has pointed out that when transect data are aggregated in order of geographical proximity the probability of two transects, spaced some distance apart along a compositional gradient, being linked together will be dependent on whether other transects are located between them. The net result is that mapping units derived in areas where vegetational changes are abrupt will tend to be more homogeneous in composition than those from areas where the change is gradual. This may not be a disadvantage provided that the user remembers that the level of homogeneity (i.e., range of variation) is not always comparable between mapping units.

Although the total number of samples for the present study is large, the computations associated with any one mapping unit involve only a limited number of samples: each of the various kinds of vegetation mapped occupy a limited part of the whole area surveyed. Nevertheless, although the present analysis was carried out manually, computer sorting and classification of the sample data would be desirable if this approach was repeated or applied elsewhere.

The method of deriving the mapping units is independent of the sampling method. Only two parameters (% cover of plant crowns and % basal area of trees) using rapid field methods were used. More accurate, although more time-consuming, methods could be used for mapping vegetation but would not necessarily provide more useful information. However, in forest the use of 5 canopy trees/sample site at Tongariro was occasionally inadequate as a canopy sample for the site when the canopy was very heterogeneous. When combined with other samples from a large area, sufficient information for mapping purposes was obtained; but a larger sample size, if practicable, would be preferable. Increasing the number of trees/sample does not necessarily solve the problem. There is firstly a large increase in sampling time associated with locating, identifying and measuring, for example, the nearest 10 trees on the sample site. Secondly, in tall forest or broken topography it is sometimes difficult to find 10 trees on a similar site without overlapping onto sites of a different kind. A possible solution may be to replace the basal area sampling with a point-intercept method made along paired line transects, one either side of the sample centre, with intercepts at appropriate spacing.

The method may prove less than satisfactory where large areas of single-dominant forest or scrub cannot be readily subdivided on the basis of canopy composition; additional attributes such as understorey composition or height class would be needed.

With respect to the naming system, vegetation with a particularly heterogeneous but closed canopy containing 20 or more species, none of them contributing more than 5% of the cover, could not be given a satisfactory compositional name. This seldom occurs in New Zealand but it is not uncommon in warmer latitudes.

Although direct comparisons of boundary positions could be made in the future with those mapped in the present study, the most definitive comparisons are clearly those between samples made along the same traverse lines. All traverse lines with points of origin and spacing distances between samples have been recorded and their positions plotted on aerial photographs.

The method can be applied to reconnaissance surveys where time for quantitative sampling is limited. In such cases, quantitative sampling is best concentrated in kinds of vegetation of particular interest, so that in these areas at least, a reasonable sampling density is reached, e.g., Atkinson *in* Healy (1980). In any case, naming of vegetation units is not dependent on quantitative sampling. Using the criteria of Table 9, estimates of the percentage cover of growth forms and species can be made in rapid inventory surveys to derive "first approximation" vegetation names. These can be modified in the light of subsequent quantitative sampling should the need arise.

Although percentage cover of growth forms in the canopy is the major parameter emphasised in this system, the technique of estimating percentage cover does not affect the use of either the classification or naming procedures. The method can be applied to a wide range of terrestrial habitats whether or not they have a significant plant cover.

Because the present classification was developed specifically for mapping, other kinds of classification, such as indicator species analysis (Hill et al. 1975), ordination methods including detrended correspondence analysis (Hill & Gauch 1980), and the gradient analysis method of Austin et al. (1984), may prove more useful for analysing relationships between environmental gradients and vegetation. This is not to imply that some of these other classifications may not be useful for mapping purposes as well.

ACKNOWLEDGMENTS

I am indebted to Dr T. R. Partridge, Messrs G. Stephenson, J. R. Leathwick and A. P. Druce for critical comment of earlier drafts of this paper. With respect to the naming system proposed I am particularly indebted to Tony Druce who, over a period of many years and in many discussions, has helped me to refine the system in a logical manner.

REFERENCES

Atkinson, I. A. E. 1962: Semi-quantitative measurements of canopy composition as a basis for mapping vegetation. *Proceedings of the New Zealand Ecological Society 9*: 1–8.

——— 1981: Vegetation map of Tongariro National Park, North Island, New Zealand. 1:50 000. Botany Division, Department of Scientific and Industrial Research, Wellington, New Zealand.

Atkinson, I. A. E.; Jenkins, P. F.; Druce, A. P. 1968: Definitions and discussion of some concepts and terms relating to terrestrial ecosystems. *Tuatara 16*: 98–110.

Austin, M. P.; Cunningham, R. B.; Fleming, P. M. 1984: New approaches to direct gradient analysis using environmental scalars and statistical curve-fitting procedures. *Vegetatio 55*:11–27.

Clifford, H. T.; Stephenson, W. 1975: An introduction to numerical classification. Academic Press, New York.

Druce, A. P. 1959: An empirical method of describing stands of vegetation. *Tuatara 8*: 1–12.

Healy, W. B. 1980. Pauatahanui Inlet — an environmental study. *New Zealand Department of Scientific and Industrial Research Information Series 141*: 65–74.

Hill, M. O.; Bunce, R. G. H.; Shaw, M. W. 1975: Indicator species analysis, a divisive polythetic method of classification and its application to a survey of native pinewoods in Scotland. *Journal of ecology 63*: 597–613.

Hill, M. O.; Gauch, H. G. 1980: Detrended correspondence analysis, an improved ordination technique. *Vegetatio 42*: 47–58.

Küchler, A. W. 1967: Vegetation mapping. Ronald Press Co. New York. 472 pp.

N.Z. Soil Bureau, *In prep*. Soil Description Handbook. Department of Scientific and Industrial Research, Soil Bureau District Office Report.

Williams, W. T. 1971. Principles of clustering. *Annual review of ecology and systematics 2*: 303–326.

Appendix 5: Dominance and basal area of key canopy species

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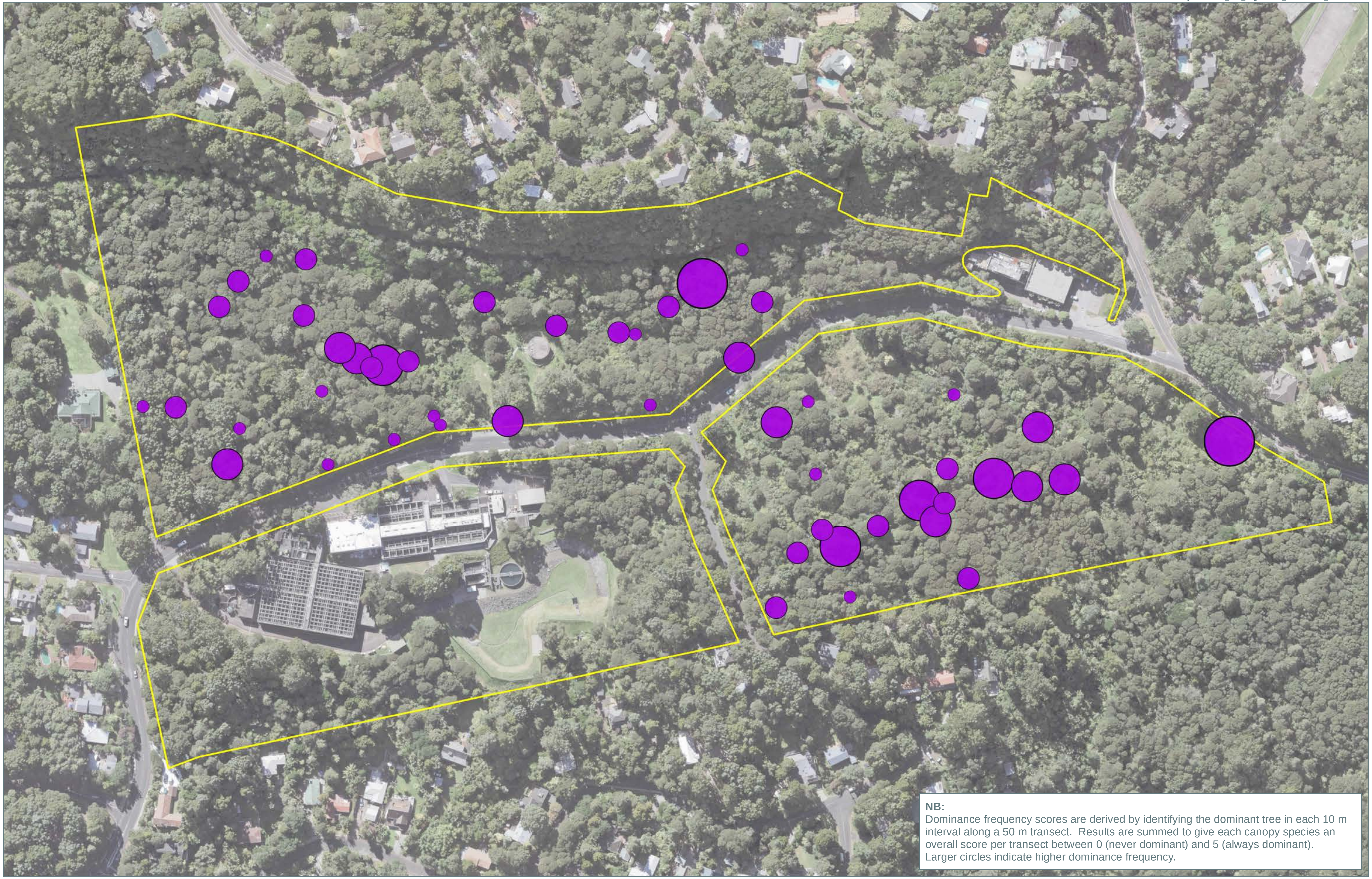


NB:
Dominance frequency scores are derived by identifying the dominant tree in each 10 m interval along a 50 m transect. Results are summed to give each canopy species an overall score per transect between 0 (never dominant) and 5 (always dominant). Larger circles indicate higher dominance frequency.

Boffa Miskell
www.boffamiskell.co.nz

0 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

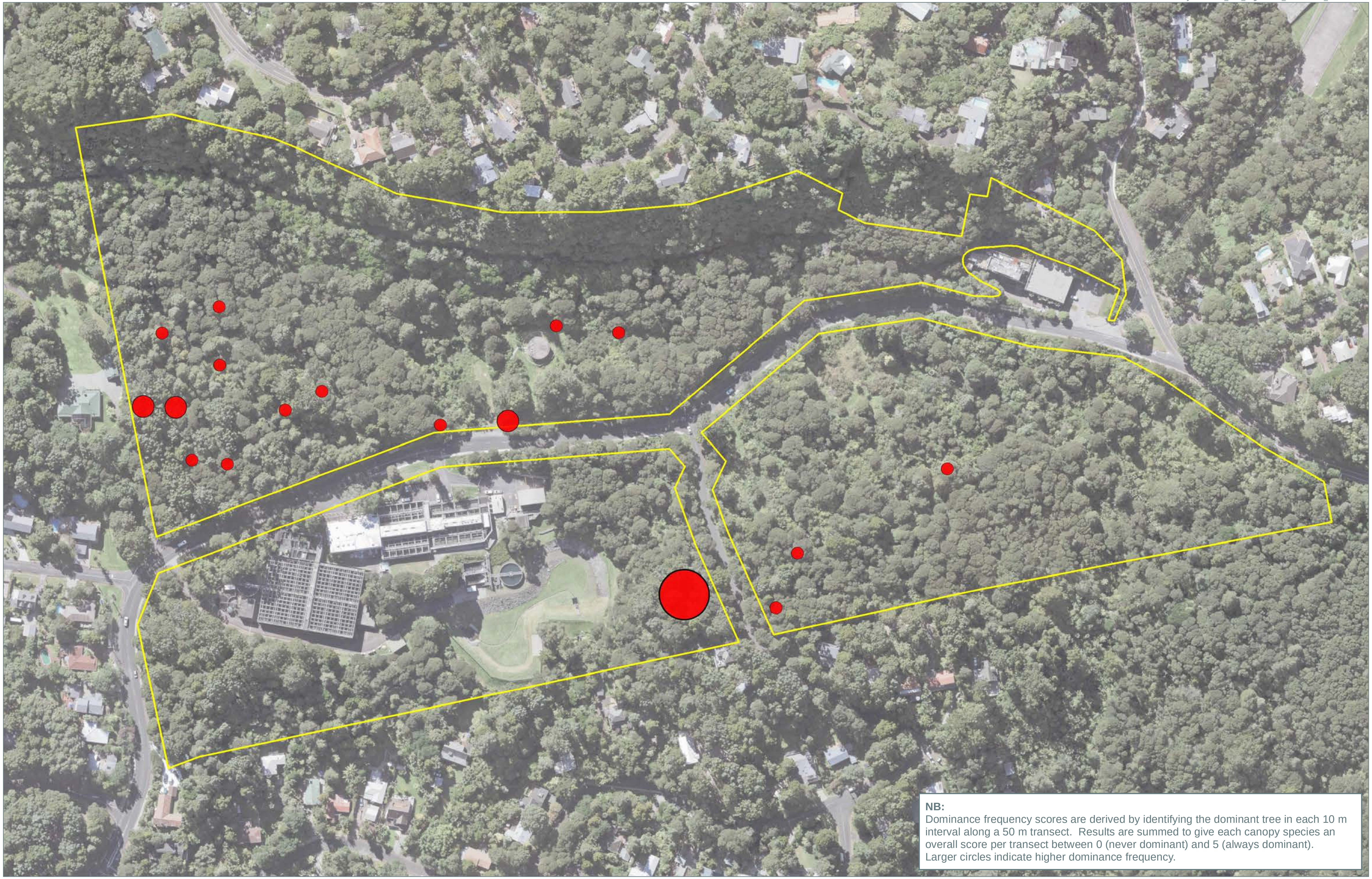
A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5a: Dominance Frequency - Kanuka

Date: 16 April 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: ian.boothroyd@boffamiskell.co.nz | *Drawn:* GCu | *Checked:* SFl



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Dominance frequency scores are derived by identifying the dominant tree in each 10 m interval along a 50 m transect. Results are summed to give each canopy species an overall score per transect between 0 (never dominant) and 5 (always dominant). Larger circles indicate higher dominance frequency.

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0 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5b: Dominance Frequency - Kauri

Date: 16 April 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **ian.boothroyd@boffamiskell.co.nz** | *Drawn:* GCu | *Checked:* SFI

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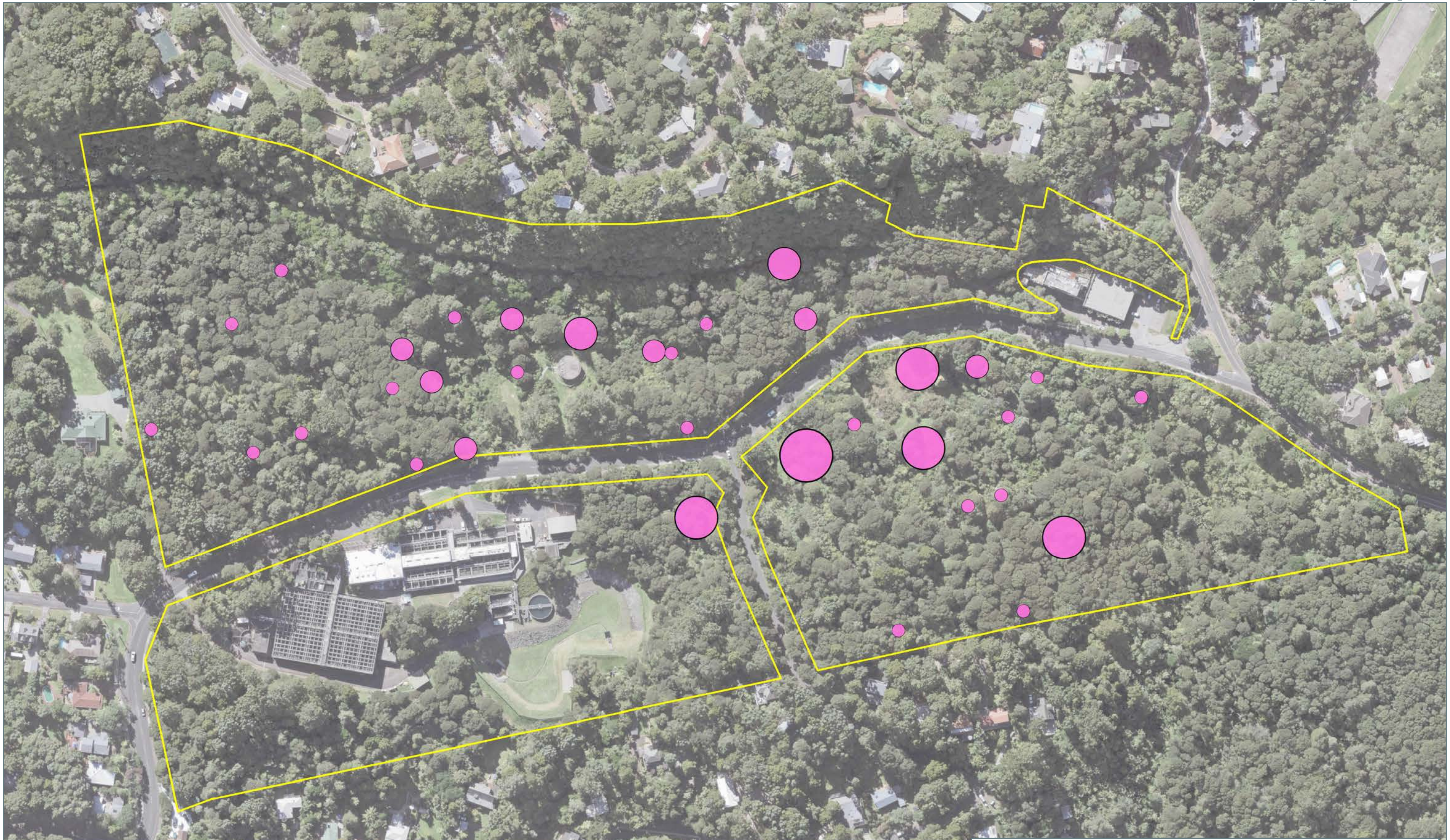

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Dominance frequency scores are derived by identifying the dominant tree in each 10 m interval along a 50 m transect. Results are summed to give each canopy species an overall score per transect between 0 (never dominant) and 5 (always dominant). Larger circles indicate higher dominance frequency.

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0 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5c: Dominance Frequency - Mahoe

Date: 16 April 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **ian.boothroyd@boffamiskell.co.nz** | *Drawn:* GCu | *Checked:* SFl

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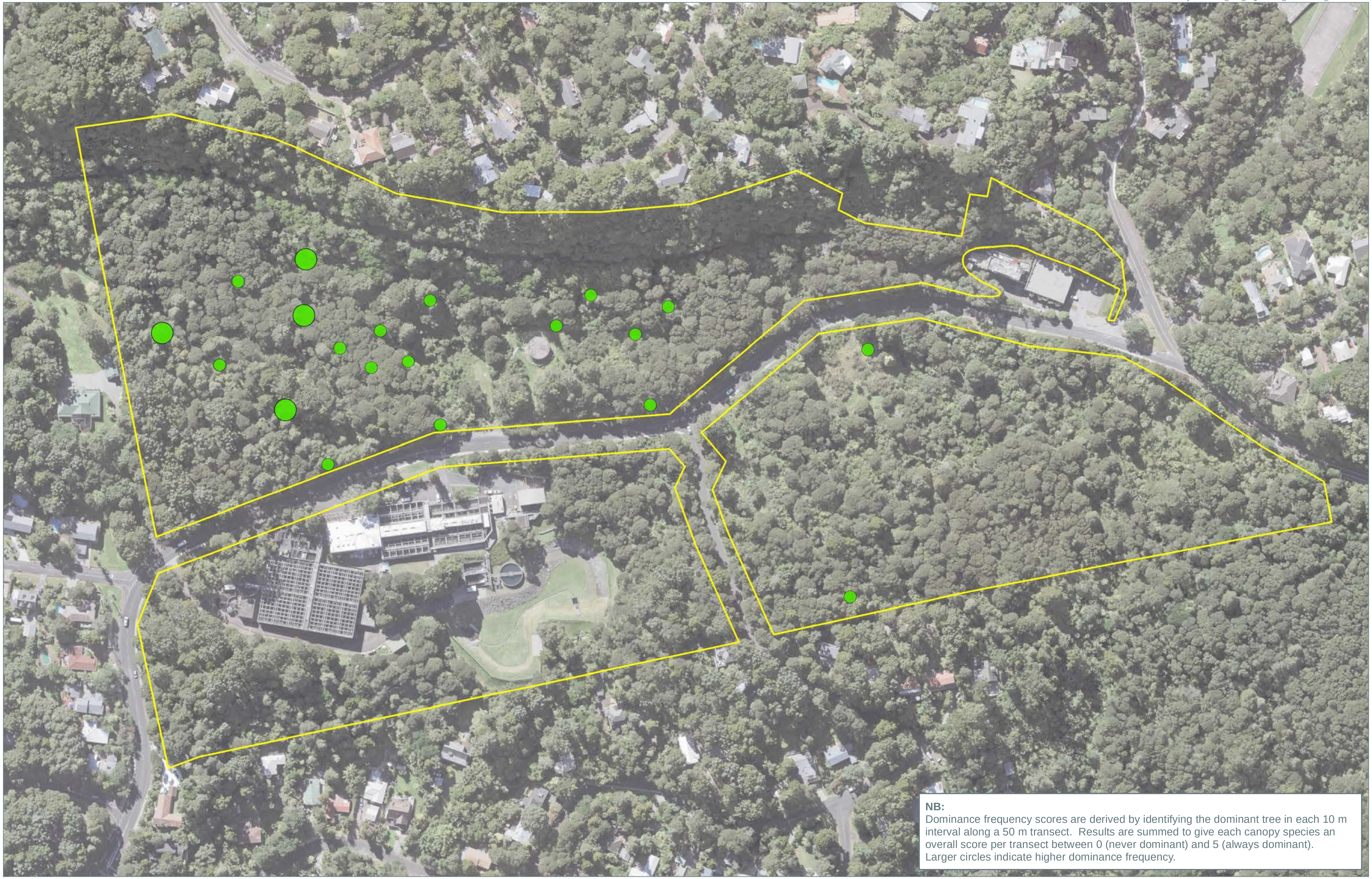

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Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5d: Dominance Frequency - Kahikatea

Date: 16 April 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **ian.boothroyd@boffamiskell.co.nz** | *Drawn:* GCu | *Checked:* SFl

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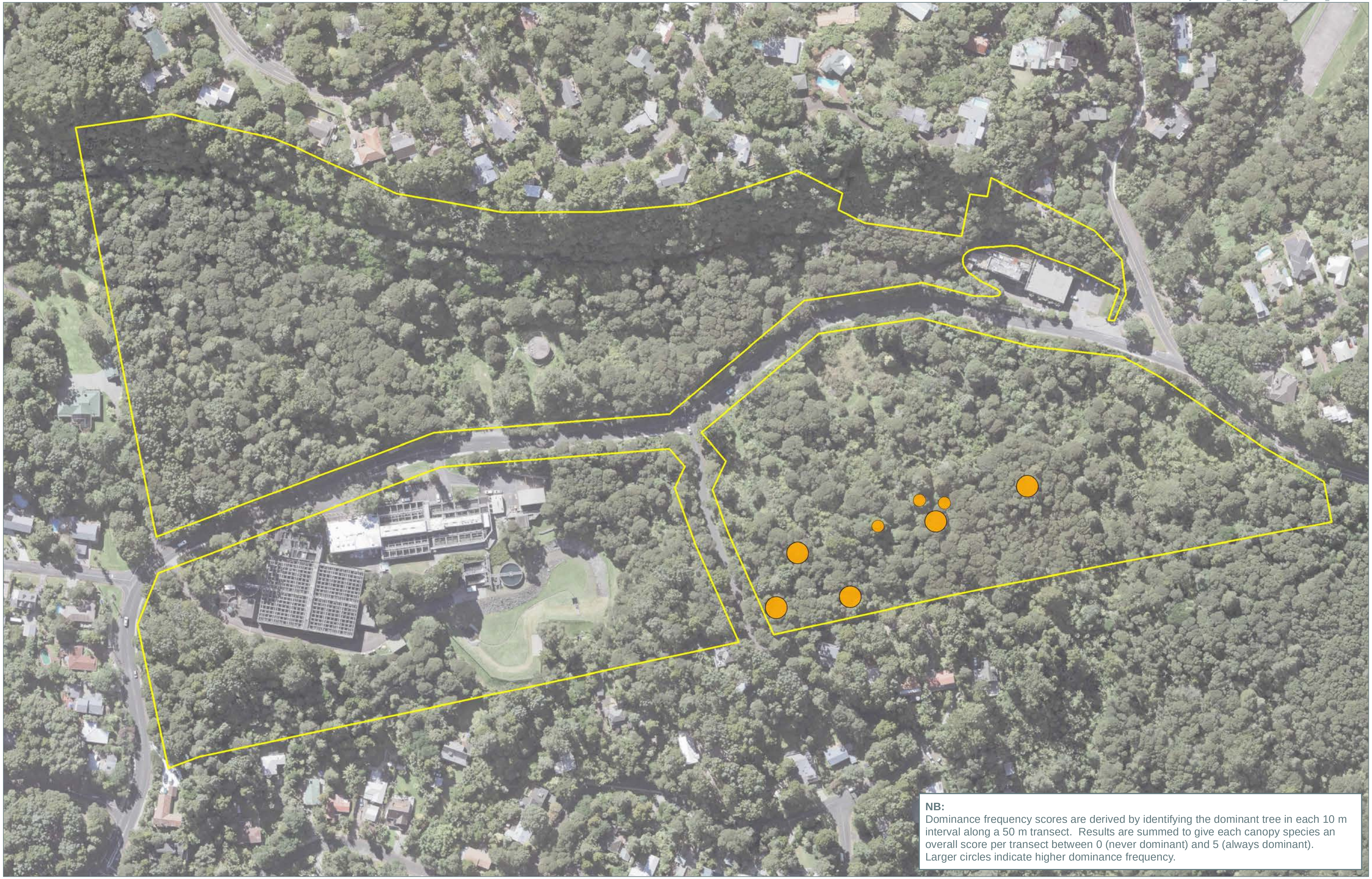

NB:
Dominance frequency scores are derived by identifying the dominant tree in each 10 m interval along a 50 m transect. Results are summed to give each canopy species an overall score per transect between 0 (never dominant) and 5 (always dominant). Larger circles indicate higher dominance frequency.

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0 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5e: Dominance Frequency - Mamangi (*Coprosma arborea*)

Date: 16 April 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: ian.boothroyd@boffamiskell.co.nz | *Drawn:* GCu | *Checked:* SFl

File Ref: A16055C_03_Vegetation_Dominance_Plots.mxd

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0 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5f: Basal Area per Sample Unit - Kahikatea

Date: 24 January 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: ian.boothroyd@boffamiskell.co.nz | *Drawn:* MDu | *Checked:* SFl

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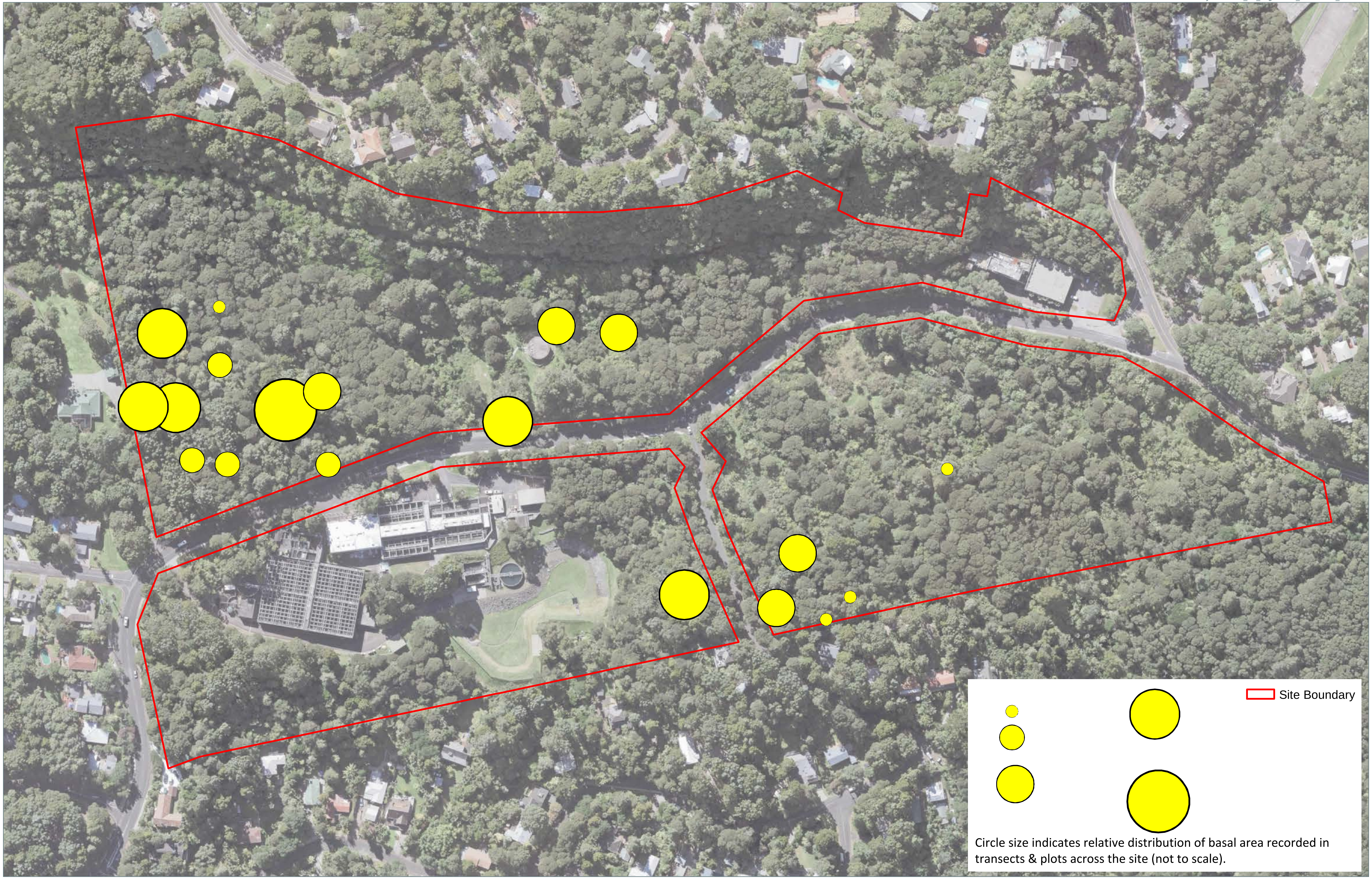

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0 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

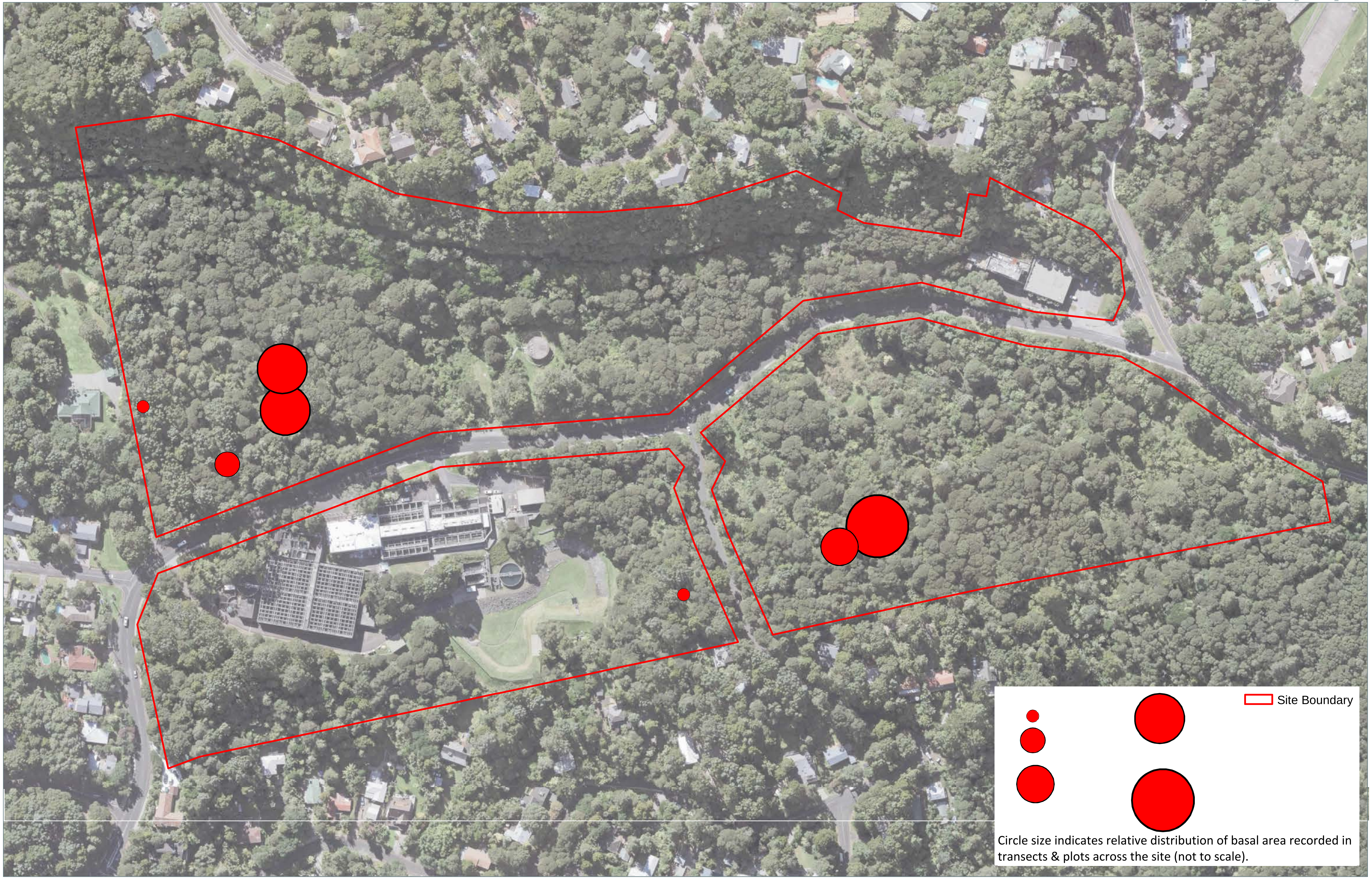
A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5g: Basal Area per Sample Unit - Kauri

Date: 24 January 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **ian.boothroyd@boffamiskell.co.nz** | *Drawn:* MDu | *Checked:* SFl



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0 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5h: Basal Area per Sample Unit - Rimu

Date: 24 January 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: ian.boothroyd@boffamiskell.co.nz | Drawn: MDu | Checked: SFl

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5i: Basal Area per Sample Unit - Matai

Date: 24 January 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **ian.boothroyd@boffamiskell.co.nz** | *Drawn:* MDu | *Checked:* SFI

0 — 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

Boffa Miskell
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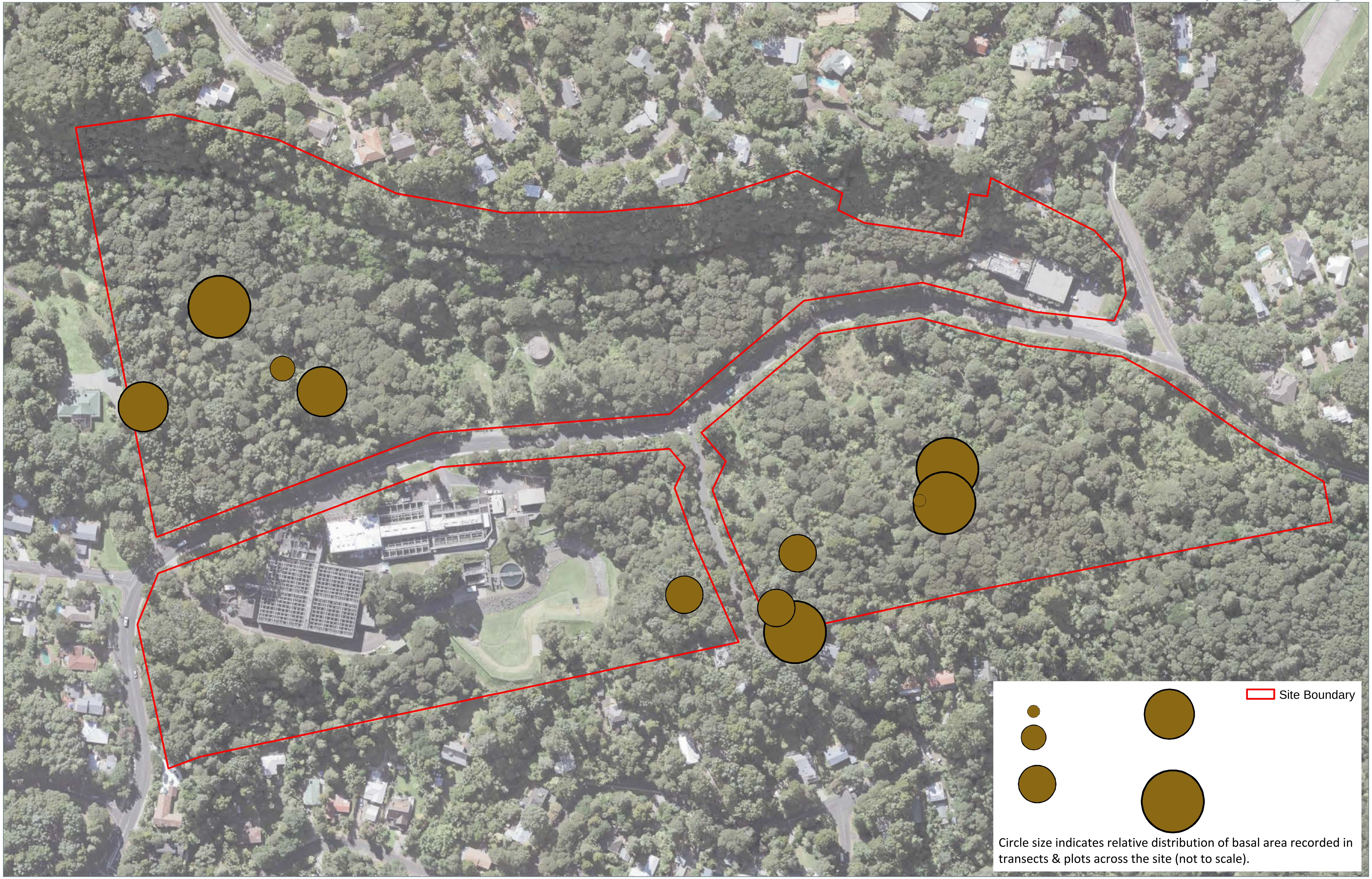

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Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

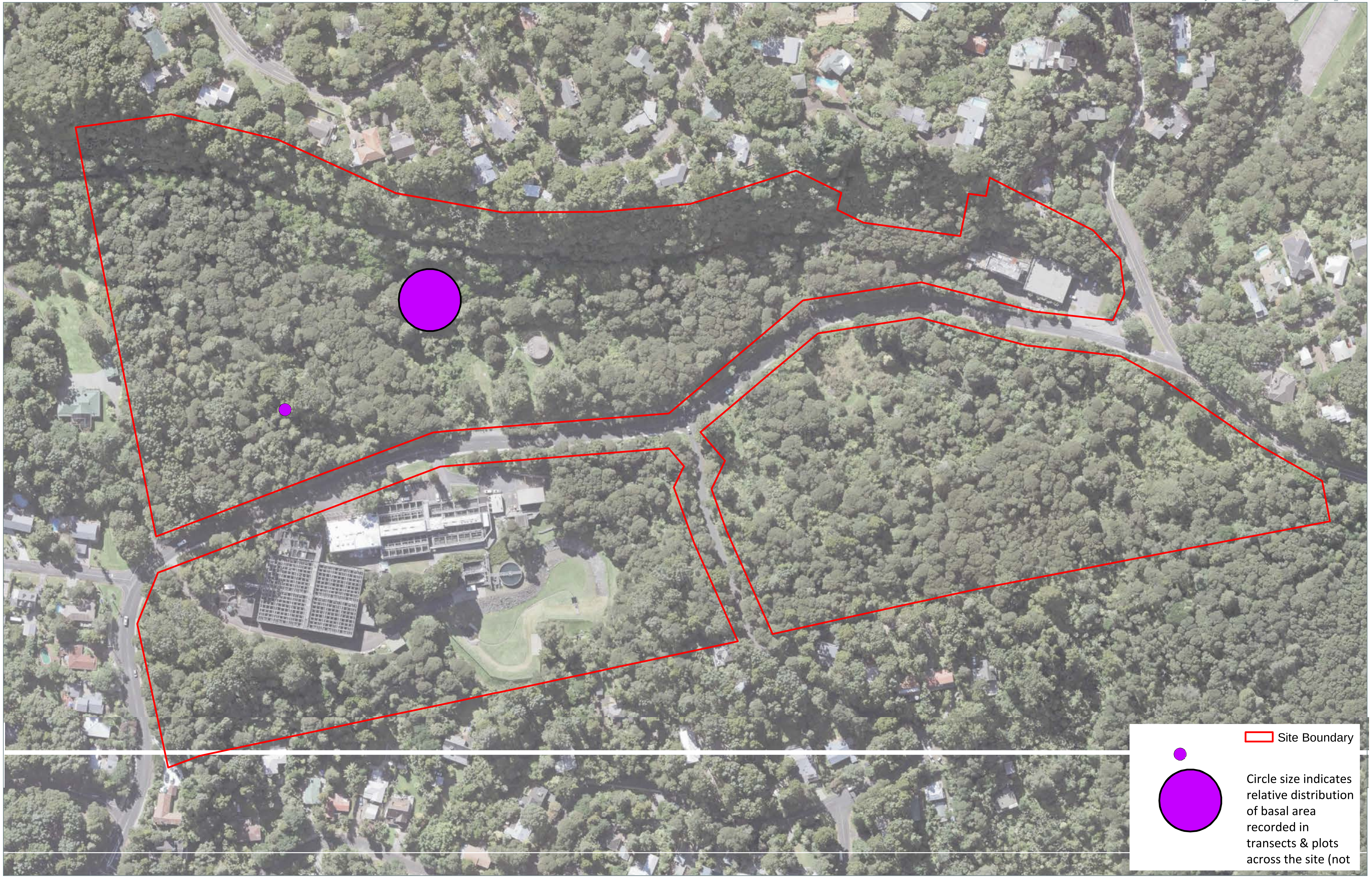
A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5j: Basal Area per Sample Unit - Tanekaha

Date: 24 January 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **ian.boothroyd@boffamiskell.co.nz** | *Drawn:* MDu | *Checked:* SFl



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0 40 m
1:2,000 @ A3

Data Sources: LINZ, BML

Projection: NZGD 2000 New Zealand Transverse Mercator

A16055C HUIA WTP ECOLOGY ASSESSMENT OF EFFECTS

Appendix 5k: Basal Areas per Sample Unit - Totara

Date: 24 January 2018 | Revision: 0

Plan prepared by Boffa Miskell Limited

Project Manager: **ian.boothroyd@boffamiskell.co.nz** | *Drawn:* MDu | *Checked:* SFl

Appendix 6: Average number of individual birds per species recorded at eight 5MBC sites across six count periods (± S.D.)

Species	Average ± SD							
	SITE 1	SITE 2	SITE 3	SITE 4	SITE 5	SITE 6	SITE 7	SITE 8
Fantail	0.33 ± 0.52	0.50 ± 0.55	0.33 ± 0.52	0.83 ± 0.98	0.33 ± 0.52	0.33 ± 0.52	0.33 ± 0.52	0.00 ± 0.00
Grey warbler	1.17 ± 0.75	0.67± 0.82	0.17± 0.41	1.00± 0.63	1.00± 0.00	1.00± 0.00	0.50± 0.55	0.83 ± 0.41
Kingfisher	0.17 ± 0.41	0.33 ± 0.52	0.33 ± 0.52	0.33 ± 0.52	0.67 ± 0.82	0.67 ± 0.82	0.00 ± 0.00	0.33 ± 0.52
Kereru	0.00 ± 0.00	0.83 ± 0.98	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.41	0.00 ± 0.00
Shining cuckoo	0.33 ± 0.52	0.33 ± 0.52	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.33 ± 0.52	0.00 ± 0.00	0.00 ± 0.00
Silvereye	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.41	0.00 ± 0.00	0.33 ± 0.52	1.50 ± 2.07	0.50 ± 0.55	0.50 ± 0.84
Tui	3.00 ± 0.89	2.17 ± 1.17	3.33 ± 3.39	1.67 ± 0.82	2.00 ± 1.55	1.67± 0.82	1.50 ± 0.55	1.50± 0.84
Chaffinch	0.33 ± 0.52	0.33 ± 0.52	0.00 ± 0.00	0.17 ± 0.41	0.50 ± 0.55	1.00 ± 0.63	0.83 ± 0.41	0.33 ± 0.52
Rosella	0.67 ± 0.82	0.00 ± 0.00	0.17 ± 0.41	0.67 ± 1.03	0.00 ± 0.00	0.00 ± 0.00	0.50 ± 0.84	0.17 ± 0.41
Blackbird	0.17 ± 0.41	0.67 ± 0.82	0.33 ± 0.52	0.50 ± 0.55	0.50 ± 1.22	0.17 ± 0.41	0.50 ± 0.84	0.17 ± 0.41
Myna	0.17 ± 0.41	0.17 ± 0.41	0.50 ± 0.55	0.33 ± 0.52	0.17 ± 0.41	0.17 ± 0.41	1.00 ± 0.89	0.33 ± 0.52
House sparrow	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.41	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Thrush	0.17 ± 0.41	0.67 ± 0.52	0.83 ± 1.17	0.17 ± 0.41	0.00 ± 0.00	0.50 ± 0.84	0.00 ± 0.00	0.00 ± 0.00
Greenfinch	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.41	0.17 ± 0.41	0.17 ± 0.41

Appendix 6: Average number of individual birds per species recorded at eight 5MBC sites across six count periods (± S.D.)

Appendix 7: OSNZ records (derived from surveys undertaken in 1999-2004) obtained for the 10 km x 10 km “square” within which the proposed project site is located

Species	Conservation status
Australasian bittern	Threatened Nationally Critical
Australasian harrier	Not Threatened
Australian magpie	Introduced
Banded rail	At Risk Declining
Barbary dove	Introduced
Black shag	At Risk Naturally Uncommon
Black swan	Introduced
Blackbird	Introduced
Budgerigar	Introduced
California quail	Introduced
Canada goose	Introduced
Chaffinch	Introduced
Domestic duck	Introduced
Eastern rosella	Introduced
Fantail	Not Threatened
Feral goose	Introduced
Feral turkey	Introduced
Fernbird	At Risk Declining
Golden pheasant	Introduced
Goldfinch	Introduced
Greenfinch	Introduced
Grey duck	Threatened Nationally Critical
Grey warbler	Not Threatened
Hedge sparrow	Introduced
House sparrow	Introduced
Kookaburra	Introduced
Little black shag	At Risk Naturally Uncommon
Little shag	Not Threatened
Long-tailed cuckoo	At Risk Naturally Uncommon
Mallard	Introduced
Marsh Crake	At Risk Declining
Morepork	Not Threatened
Myna	Introduced
New Zealand dabchick	At Risk Recovering
New Zealand kingfisher	Not Threatened
New Zealand pigeon	Not Threatened
New Zealand pipit	At Risk Declining
New Zealand tomtit	Not Threatened
New Zealand shoveler	Not Threatened

North Island Kaka	At Risk Recovering
Paradise shelduck	Not Threatened
Parakeet spp	Introduced
Peafowl	Introduced
Pied shag	At Risk Recovering
Pukeko	Not Threatened
Redpoll	Introduced
Reef heron	Threatened Nationally Endangered
Ring-necked pheasant	Introduced
Rock Pigeon	Introduced
Shining cuckoo	Not Threatened
Silvereye	Not Threatened
Skylark	Introduced
Song thrush	Introduced
Spotless crake	At Risk Declining
Spotted dove	Introduced
Spotted shag	Not Threatened
Spur-winged plover	Not Threatened
Sulphur-crested cockatoo	Introduced
Tufted guinea fowl	Introduced
Tui	Not Threatened
Welcome swallow	Introduced
White-faced heron	Not Threatened
Yellowhammer	Introduced

Appendix 8: Auckland Unitary Plan Schedule 3

Schedule 3 Significant Ecological Areas – Terrestrial Schedule

Factors for assessing ecological value [rps]

An area shall be considered to have significant ecological value if it meets one or more the sub-factors 1 to 5 below. These factors are also referred to in B7.2.2(1).

These factors have been used to determine the areas included in Schedule 3 Significant Ecological Areas – Terrestrial Schedule, and will be used to assess proposed future additions to the schedule.

Factors:

(1) REPRESENTATIVENESS

Sub-factor:

(a) It is an example of an indigenous ecosystem (including both mature and successional stages), that contributes to the inclusion of at least 10% of the natural extent[1] of each of Auckland's original ecosystem types[2] in each ecological district of Auckland (starting with the largest, most natural and intact, most geographically spread) and reflecting the environmental gradients of the region, and is characteristic or typical of the natural ecosystem diversity of the ecological district and/or Auckland.

(2) THREAT STATUS AND RARITY

Sub-factors:

(a) It is an indigenous habitat, community or ecosystem that occurs naturally in Auckland and has been assessed (using the IUCN threat classification system) to be threatened, based on evidence and expert advice (including Holdaway et al. Status assessment of NZ naturally uncommon ecosystems[3]).

(b) It is a habitat that supports occurrences of a plant, animal or fungi that has been assessed by the Department of Conservation and determined to have a national conservation status of threatened or at risk; or

(i) it is assessed as having a regional threatened conservation status including Regionally Critical, Endangered and Vulnerable and Serious and Gradual Decline.

(c) It is indigenous vegetation that occurs in Land Environments New Zealand Category IV where less than 20% remains.

[1] "Natural extent" is intended to mean a combination of our understanding of the historic pre-human diversity, distribution and extent of ecosystems in Auckland and what we would expect this to be given past and current environmental drivers.

[2] The Department of Conservation's ecosystem classification system described over 135 ecosystems in New Zealand (Singers and Rogers in press). Of these 35 ecosystems are known to have occurred in Auckland and these are what is meant by original ecosystems. They include the more recent indigenous dominated shrub and scrublands that have evolved as a result of human modification of the landscape.

[3] Status Assessment of New Zealand's Naturally Uncommon Ecosystems, ROBERT J. HOLDAWAY, SUSAN K. WISER and PETER A. WILLIAMS. Conservation Biology. Volume 26, Issue 4, pages 619–629, August 2012

(d) It is any indigenous vegetation or habitat of indigenous fauna that occurs within an indigenous wetland or dune ecosystem.

(e) It is a habitat that supports an occurrence of a plant, animal or fungi that is locally rare; or

(i) it has been assessed by the Department of Conservation and determined to have a national conservation status of Naturally Uncommon, Range Restricted or Relict.

(3) DIVERSITY

Sub-factors:

(a) It is any indigenous vegetation that extends across at least one environmental gradient resulting in a sequence that supports more than one indigenous habitat, community or ecosystem type e.g., an indigenous estuary to an indigenous freshwater wetland.

(b) It supports the expected indigenous ecosystem diversity for the habitat(s).

(c) It is an indigenous habitat type that supports a typical species richness or species assemblage for its type.

(4) STEPPING-STONES, MIGRATION PATHWAYS AND BUFFERS

Sub-factors:

(a) It is an example of an indigenous ecosystem, or habitat of indigenous fauna that is used by any native species permanently or intermittently for an essential part of their life cycle (e.g. known to facilitate the movement of indigenous species across the landscape, haul-out site for marine mammals) and therefore makes an important contribution to the resilience and ecological integrity of surrounding areas.

(b) It is an example of an ecosystem, indigenous vegetation or habitat of indigenous fauna, that is immediately adjacent to, and provides protection for, indigenous biodiversity in an existing protected natural area (established for the purposes of biodiversity protection); or

(i) it is an area identified as significant under the 'threat status and rarity' or 'uniqueness' factor. This includes areas of vegetation (that may be native or exotic) that buffer a known significant site. It does not include buffers to the buffers.

(c) It is part of a network of sites that cumulatively provide important habitat for indigenous fauna or when aggregated make an important contribution to the provision of a particular ecosystem in the landscape.

(d) It is a site which makes an important contribution to the resilience and ecological integrity of surrounding areas.

(5) UNIQUENESS OR DISTINCTIVENESS

Sub-factors:

(a) It is habitat for a plant, animal or fungi that is endemic to the Auckland region (i.e. not found anywhere else).

(b) It is an indigenous ecosystem that is endemic to the Auckland region or supports ecological assemblages, structural forms or unusual combinations of species that are endemic to the Auckland region.

(c) It is an indigenous ecosystem or a habitat that supports occurrences of a plant, animal or fungi that are near-endemic (i.e., where the only other occurrence(s) is within 100km of the council boundary).

(d) It is a habitat that supports occurrences of a plant, animal or fungi that is the type locality for that taxon.

(e) It is important as an intact sequence or outstanding condition in the region.

(f) It is a habitat that supports occurrences of a plant, animal or fungi that is the largest specimen or largest population of the indigenous species in Auckland or New Zealand.

(g) It is a habitat that supports occurrences of a plant, animal or fungi that are at (or near) their national distributional limit.

Table: Significant Ecological Areas – Terrestrial Schedule (SEA_T) [dp]

ID	Factor met
SEA_T_100	1
SEA_T_1001	2, 3
SEA_T_1005	2
SEA_T_1006	1, 2, 3, 4
SEA_T_101	1, 2, 3
SEA_T_1010	2, 3, 4
SEA_T_1011	2, 3
SEA_T_1012	2
SEA_T_1015	2
SEA_T_1017	1, 2, 4
SEA_T_1018	2
SEA_T_1019	1, 2
SEA_T_102	1
SEA_T_1021	3
SEA_T_1023	2, 3, 4
SEA_T_1024	2, 3
SEA_T_1025	3
SEA_T_1026	2, 3
SEA_T_1029	1, 2
SEA_T_103	1
SEA_T_1030	3
SEA_T_1031	3, 4
SEA_T_1032	2, 3
SEA_T_1033	2
SEA_T_1037	1, 2
SEA_T_1038	3
SEA_T_1039	1, 2
SEA_T_103a	1, 2
SEA_T_1040	3, 4
SEA_T_1041	2
SEA_T_1043	2, 3
SEA_T_1045	3, 4
SEA_T_105	1, 2
SEA_T_1050	1, 2
SEA_T_1052	3
SEA_T_1056	3
SEA_T_1057	1, 2
SEA_T_1058	1, 3
SEA_T_106	1
SEA_T_1061	2
SEA_T_1062	1, 2

ID	Factor met
SEA_T_1063	2, 3
SEA_T_1067	3
SEA_T_1069	1, 2
SEA_T_107	1, 2
SEA_T_1070	1, 3, 4
SEA_T_1072	1, 2, 3
SEA_T_1073	3, 4
SEA_T_1073a	1, 3
SEA_T_1074a	3
SEA_T_1074B	3
SEA_T_1077	1, 2
SEA_T_1078	2, 3
SEA_T_1079	1, 2, 3
SEA_T_108	1, 2
SEA_T_1080	2, 3
SEA_T_1083	2, 4
SEA_T_1084	3
SEA_T_1085	3
SEA_T_1087a	2, 3
SEA_T_1088	2, 3
SEA_T_1089	2, 3
SEA_T_109	1, 2
SEA_T_1090	2, 3
SEA_T_1091	2, 3
SEA_T_1096	3
SEA_T_1097	1, 2, 3
SEA_T_1098	2, 3
SEA_T_1099	2, 3
SEA_T_110	1, 2
SEA_T_1101	2, 3
SEA_T_1105	2, 3
SEA_T_1106	1, 2, 3
SEA_T_1107	1, 2, 3
SEA_T_1108	3
SEA_T_1109	2, 3
SEA_T_111	1, 2
SEA_T_1110	2
SEA_T_1111	2, 3, 4
SEA_T_1112	2, 3, 4
SEA_T_1113	2, 3
SEA_T_1114	4

ID	Factor met
SEA_T_1115	3, 4
SEA_T_1116	4
SEA_T_1117	2
SEA_T_1119	2, 3
SEA_T_112	1, 2
SEA_T_1120	2, 3, 4
SEA_T_1123	3
SEA_T_1124	1, 2
SEA_T_1128	1, 2, 3
SEA_T_113	1, 2
SEA_T_1130	1, 4
SEA_T_1130a	1, 4
SEA_T_1131	4
SEA_T_1132	2, 3
SEA_T_1133	1
SEA_T_1135	4
SEA_T_1136	1, 3, 4
SEA_T_1137	1
SEA_T_114	1, 2
SEA_T_1140	3
SEA_T_1141	3
SEA_T_1142	4
SEA_T_1143	2, 3, 4
SEA_T_1144	4
SEA_T_1146	2
SEA_T_1147	3
SEA_T_1148	3, 4
SEA_T_1149	2, 3
SEA_T_115	1, 2
SEA_T_1151	3
SEA_T_1153	1, 2
SEA_T_1154	1, 2, 4
SEA_T_1156	4
SEA_T_1158	4
SEA_T_1159	4
SEA_T_116	1, 2
SEA_T_1160	4
SEA_T_1161	4
SEA_T_1162	2, 4
SEA_T_1166	4
SEA_T_1167	3

ID	Factor met
SEA_T_117	2, 3
SEA_T_1170	3, 4
SEA_T_1172	1, 2
SEA_T_1173	3
SEA_T_1174	2
SEA_T_1175	1, 2
SEA_T_1178	2, 4
SEA_T_1179	4
SEA_T_118	1, 2
SEA_T_1183	4
SEA_T_1186	4
SEA_T_1188	4
SEA_T_1189B	2
SEA_T_119	1, 2
SEA_T_1190	2
SEA_T_1191	1, 2, 4
SEA_T_1192	3, 4
SEA_T_1193	4
SEA_T_1194	2, 4
SEA_T_1195	1, 2
SEA_T_1197	1, 2
SEA_T_1198	1, 2, 4
SEA_T_1199	2, 3
SEA_T_121	1, 2
SEA_T_122	1, 4
SEA_T_123	1, 2, 3
SEA_T_125	1, 2, 3
SEA_T_127	1, 2, 4
SEA_T_131	1, 2, 4
SEA_T_132	1
SEA_T_133	1, 2, 3
SEA_T_136	2
SEA_T_139	2, 4
SEA_T_148	2
SEA_T_150	2
SEA_T_151	2, 4
SEA_T_153	2
SEA_T_154	2
SEA_T_155	2
SEA_T_156	2
SEA_T_157	2, 3
SEA_T_158	2
SEA_T_159	1

ID	Factor met
SEA_T_161	2, 3
SEA_T_163	1, 2
SEA_T_164	1
SEA_T_168	2, 3, 4
SEA_T_169	1
SEA_T_170	3
SEA_T_172	2, 3
SEA_T_173	1, 2
SEA_T_175	2
SEA_T_176	2
SEA_T_177	2
SEA_T_179	2, 4
SEA_T_180	2
SEA_T_181	4
SEA_T_183	4
SEA_T_184	4
SEA_T_185	4
SEA_T_193	2
SEA_T_194	2
SEA_T_196	2, 3, 4, 5
SEA_T_197	1, 2, 3
SEA_T_199	2
SEA_T_2000	3, 4
SEA_T_2001	3
SEA_T_2003	2
SEA_T_2004	3
SEA_T_2005	2
SEA_T_2007	1, 2
SEA_T_201	1, 2
SEA_T_2010	3, 4
SEA_T_2011	3, 4
SEA_T_2013	2, 3, 4, 5
SEA_T_2015	1, 4
SEA_T_2016	2, 4
SEA_T_2017	1, 4
SEA_T_2018	2, 3, 4
SEA_T_2019	4
SEA_T_202	2, 3, 4
SEA_T_2020	2
SEA_T_2021	2, 3
SEA_T_2027	3
SEA_T_2028	1, 2, 3

ID	Factor met
SEA_T_2029	2, 3, 4
SEA_T_203	2, 3, 4
SEA_T_2030	3
SEA_T_2031	3
SEA_T_2032	2
SEA_T_2033a	1, 2, 3, 4
SEA_T_2033B	1, 2, 3, 4
SEA_T_2034	2
SEA_T_2037	3, 4
SEA_T_2039	2
SEA_T_204	1, 2, 3, 4
SEA_T_2040	4
SEA_T_2041	2
SEA_T_2042	2
SEA_T_2043	2
SEA_T_2044	3, 4
SEA_T_2049	2, 3
SEA_T_205	1, 2, 3, 4
SEA_T_2050	1, 2, 3, 4
SEA_T_2056	2
SEA_T_2057	3, 4
SEA_T_206	1, 2, 3
SEA_T_2065	2, 4
SEA_T_2066	2, 3, 4
SEA_T_2068	4
SEA_T_2069	4
SEA_T_206a	1, 2, 3
SEA_T_207	1, 2, 3
SEA_T_2074	2, 3
SEA_T_2075	3
SEA_T_2077	2
SEA_T_2078	1, 2, 3
SEA_T_208	1, 2, 3, 4
SEA_T_2080	2, 3
SEA_T_2082	3
SEA_T_2083	4
SEA_T_2087	1, 3
SEA_T_2089	3
SEA_T_209	1, 2, 3,

ID	Factor met
	4
SEA_T_2097	1, 3
SEA_T_210	3, 4
SEA_T_2101	3, 4
SEA_T_2103	5
SEA_T_2105	4
SEA_T_2106	3
SEA_T_211	1, 2, 3, 4
SEA_T_2113	2
SEA_T_2114	4
SEA_T_2115	4
SEA_T_2117	1, 2, 3
SEA_T_2118A	4
SEA_T_2118B	3, 4
SEA_T_2119	2, 3, 4
SEA_T_212	2, 3, 4
SEA_T_2120	1, 3
SEA_T_2121	1, 2, 4
SEA_T_2123	3
SEA_T_2124	3
SEA_T_2125	2, 3
SEA_T_213	1, 2, 3, 4
SEA_T_2132	4
SEA_T_2134	2
SEA_T_2140	1, 3
SEA_T_2141	1
SEA_T_2143	4
SEA_T_2147	4
SEA_T_2149	1, 2, 3, 4
SEA_T_215	1, 2, 3
SEA_T_2150A	2, 3, 4
SEA_T_2150C	2, 3, 4
SEA_T_2151	1, 2, 3
SEA_T_2153	1, 3, 4
SEA_T_2157	3
SEA_T_2159	1, 4
SEA_T_216	3
SEA_T_2160	1, 4
SEA_T_2161a	2
SEA_T_2161b	2
SEA_T_2162	2, 3

ID	Factor met
SEA_T_2163	1, 2, 4
SEA_T_2164	3
SEA_T_2165	2, 3, 4
SEA_T_2165A	2
SEA_T_2166	2, 3, 4
SEA_T_2167	2, 4
SEA_T_2167a	2, 4
SEA_T_2167b	2, 4
SEA_T_2168	2, 3
SEA_T_2169	1, 2, 3, 4
SEA_T_217	1, 2
SEA_T_2170	3
SEA_T_2171	2, 3, 4
SEA_T_2172	1, 3
SEA_T_2173	3
SEA_T_2174	4
SEA_T_2175	1, 2, 3
SEA_T_2175A	3
SEA_T_2176	3
SEA_T_2177	1, 3, 4
SEA_T_2179	3
SEA_T_2180	1, 2, 4, 5
SEA_T_2181	1
SEA_T_2182	1, 2, 3
SEA_T_2184	1, 2, 3
SEA_T_2184a	2
SEA_T_2184B	2
SEA_T_2188	1, 4
SEA_T_2189	1, 3, 4
SEA_T_219	1, 2, 4
SEA_T_2190	1, 2, 3, 4
SEA_T_2191	2, 3, 4
SEA_T_2192	2, 3
SEA_T_2192a	1, 2, 3, 4
SEA_T_2193	3
SEA_T_2194	1, 2, 3
SEA_T_2195	1
SEA_T_2196	2, 3
SEA_T_2197	3
SEA_T_2198	1, 3, 4

ID	Factor met
SEA_T_2199	1, 2, 4
SEA_T_2199a	4
SEA_T_2200	1, 2
SEA_T_2201	1, 2, 3
SEA_T_2202	1, 3
SEA_T_2204	2
SEA_T_2205	1, 3
SEA_T_2206	3
SEA_T_2207	1, 3, 4
SEA_T_2208	1, 3
SEA_T_2209	2, 3
SEA_T_2212	2, 3
SEA_T_2213	1, 3
SEA_T_2214	3, 4
SEA_T_2214a	4
SEA_T_2214B	4
SEA_T_2215	1
SEA_T_2217	1
SEA_T_2218	2
SEA_T_222	4
SEA_T_2220	1, 2
SEA_T_2222	1, 4
SEA_T_2223	1, 4
SEA_T_2224	1, 2, 3
SEA_T_2225	1, 2
SEA_T_2226	1
SEA_T_2226a	4
SEA_T_2226b	4
SEA_T_223	2, 3, 4
SEA_T_224	2, 3
SEA_T_2241	4
SEA_T_2242	3
SEA_T_2244	2, 3
SEA_T_2245	1, 2
SEA_T_2246	1, 2, 3
SEA_T_2247	4
SEA_T_2248	1, 2
SEA_T_2249	1
SEA_T_225	2, 3
SEA_T_2250	2
SEA_T_2251	1, 2, 3
SEA_T_2251a	2
SEA_T_2252	1, 2, 5

ID	Factor met
SEA_T_2253	1, 2
SEA_T_2254	1
SEA_T_2255	2
SEA_T_2256	2, 3
SEA_T_2257	1
SEA_T_2258	1, 2
SEA_T_2259	3
SEA_T_226	2
SEA_T_2260	1, 2, 4, 5
SEA_T_2261	3, 4
SEA_T_2262	1, 2
SEA_T_2264	4
SEA_T_2265	3, 4
SEA_T_2266	1
SEA_T_2267	3, 4
SEA_T_2268	3
SEA_T_227	2, 3
SEA_T_2270	2
SEA_T_2272	1, 2
SEA_T_2273	1
SEA_T_2274	2, 3
SEA_T_2275	1
SEA_T_2276	1, 4
SEA_T_2277	1, 3
SEA_T_2277a	1
SEA_T_2278	1, 4
SEA_T_2279	1, 2
SEA_T_2280	4
SEA_T_2281	3
SEA_T_2282	2
SEA_T_2283	1
SEA_T_2284	4
SEA_T_2285	1, 2, 4
SEA_T_2286	2, 4
SEA_T_2287	1, 2
SEA_T_2288	1
SEA_T_2289	2, 3, 4
SEA_T_229	2, 3
SEA_T_2290	3
SEA_T_2291	2, 4
SEA_T_2292	4
SEA_T_2294	2, 4, 5
SEA_T_2295	1, 2, 3
SEA_T_2296	2, 3, 4
SEA_T_2297	2, 4
SEA_T_2298	2, 3, 4, 5
SEA_T_2299	1, 2, 3
SEA_T_230	1, 2, 3
SEA_T_2301	1, 2, 4, 5
SEA_T_2302	1, 2, 3
SEA_T_2304	1, 2, 3, 4
SEA_T_2305	1, 3, 4
SEA_T_2306	1, 2, 4
SEA_T_231	1
SEA_T_2310	3, 4, 5
SEA_T_2311	1, 2, 3
SEA_T_2316	1, 2
SEA_T_2317	1, 3
SEA_T_2318	4
SEA_T_2319	3
SEA_T_232	4
SEA_T_2320	1
SEA_T_2326	4
SEA_T_2328	4
SEA_T_2329	2, 3
SEA_T_233	1
SEA_T_2336	2
SEA_T_234	1, 2, 3
SEA_T_2340	1
SEA_T_2343	2
SEA_T_2344	3, 4
SEA_T_2346a	1
SEA_T_2348	1
SEA_T_2349	1, 3
SEA_T_2350	2, 3
SEA_T_2352	4
SEA_T_2353	2
SEA_T_2355	2
SEA_T_2356	2
SEA_T_2357	1, 2, 3
SEA_T_2358	2
SEA_T_2359	2
SEA_T_236	1
SEA_T_2364	2
SEA_T_2366	4
SEA_T_2367	1, 2, 3
SEA_T_2368	1, 3, 4
SEA_T_2368a	1, 4
SEA_T_2369	1
SEA_T_237	1, 3, 4
SEA_T_2370	1, 4
SEA_T_2371	1, 2
SEA_T_2372	2
SEA_T_2373	1
SEA_T_2375	1, 2
SEA_T_2377	1, 2
SEA_T_2378	1, 4
SEA_T_2379	2, 5
SEA_T_2381	2
SEA_T_2382	1
SEA_T_2383	1
SEA_T_2384C	1, 2, 4
SEA_T_2385	4
SEA_T_2386	4
SEA_T_2387	3, 4
SEA_T_2388	4
SEA_T_2391	4
SEA_T_2392	4
SEA_T_2393	4
SEA_T_2395	4
SEA_T_2396	3, 4
SEA_T_2397	3
SEA_T_2398	2, 3
SEA_T_2399	2, 3
SEA_T_240	1, 2, 4
SEA_T_2400	2, 4
SEA_T_2402	1, 2
SEA_T_2405	4
SEA_T_2407	3, 4, 5
SEA_T_2409	2
SEA_T_241	1, 2, 3
SEA_T_2410	1, 2, 3
SEA_T_2411	1, 3, 4
SEA_T_2412	1, 3, 4
SEA_T_2413	1, 2
SEA_T_2414	3

ID	Factor met
SEA_T_2415	2
SEA_T_2416	2, 3, 4
SEA_T_2417	3, 4
SEA_T_2418	3, 4
SEA_T_2419	3
SEA_T_2422	1, 2
SEA_T_2423	1, 2
SEA_T_2424	2
SEA_T_2425	2
SEA_T_2426	2
SEA_T_2428	4
SEA_T_2429	4
SEA_T_2430	3
SEA_T_2431	1, 2, 3
SEA_T_2431a	2, 4
SEA_T_2433	1, 4
SEA_T_2434	4
SEA_T_2435	1, 2, 3, 4
SEA_T_2435A	1
SEA_T_2436	1, 2
SEA_T_2437	1, 2, 3
SEA_T_2438	1
SEA_T_2439	1, 2, 3
SEA_T_2439a	1, 2
SEA_T_244	2, 3
SEA_T_2440A	3, 4
SEA_T_2440B	3
SEA_T_2440C	3
SEA_T_2440D	3
SEA_T_2441	1, 2, 3, 4
SEA_T_2442	1
SEA_T_2443	1, 2
SEA_T_2444	1, 3, 4
SEA_T_2444a	1, 2
SEA_T_2445	1, 2
SEA_T_2446	1, 3, 4
SEA_T_2447	1, 4
SEA_T_2448	3
SEA_T_2449	1, 4
SEA_T_245	3
SEA_T_2450	2, 3
SEA_T_2451	1, 3

ID	Factor met
SEA_T_2452	2, 3
SEA_T_2454	1
SEA_T_2455	4
SEA_T_2456	1
SEA_T_2458	1, 3, 4
SEA_T_2460	2, 4
SEA_T_2460a	1, 2, 3
SEA_T_2461	2, 3
SEA_T_2463	2, 4
SEA_T_2464	1, 2, 3, 4
SEA_T_2468	3
SEA_T_247	1, 2
SEA_T_2472	3, 4
SEA_T_2475	1
SEA_T_2476	1
SEA_T_2478	2, 3
SEA_T_2479	3
SEA_T_248	3, 4
SEA_T_2481	4
SEA_T_2484	2, 4
SEA_T_2485	2
SEA_T_249	4
SEA_T_2491	3
SEA_T_2492	2, 3, 4
SEA_T_2493	1, 2, 3, 4
SEA_T_2494	2, 3
SEA_T_2495	1, 3, 4
SEA_T_2496a	2, 3
SEA_T_2497	1, 2
SEA_T_25	2, 3
SEA_T_250	3
SEA_T_2500c	4
SEA_T_2502	1
SEA_T_2503	1
SEA_T_2504	3
SEA_T_2506	2
SEA_T_2507	4
SEA_T_2511	1, 2
SEA_T_2512	1
SEA_T_2514	1
SEA_T_2515	1, 3
SEA_T_2516	1

ID	Factor met
SEA_T_2518	1
SEA_T_2521	2, 4
SEA_T_2522	1, 2
SEA_T_2523	1
SEA_T_2524	4
SEA_T_2525	3
SEA_T_2526	3, 4
SEA_T_2527	2, 3, 4
SEA_T_2528	1, 2, 3
SEA_T_2529	3, 4
SEA_T_2530	1
SEA_T_2531	1, 2, 4
SEA_T_2532	1, 2, 3, 4
SEA_T_2533	1, 2, 3
SEA_T_2534	1
SEA_T_2535	2
SEA_T_2538	1, 2, 3
SEA_T_2539	2, 4
SEA_T_254	2
SEA_T_2544	2, 4
SEA_T_2545	1, 4
SEA_T_2546	4
SEA_T_2549	1, 4
SEA_T_2550	1, 2, 3, 4
SEA_T_2553	2
SEA_T_2554	1, 2
SEA_T_2555	2
SEA_T_2557	2
SEA_T_2558	2, 3
SEA_T_2560	2, 3
SEA_T_2562	1, 2
SEA_T_2565	1, 2, 3, 4
SEA_T_2566	1, 2
SEA_T_2569	1, 3
SEA_T_2570	3
SEA_T_2572	2, 3
SEA_T_2573	4
SEA_T_2574	3, 4
SEA_T_2576	2, 4
SEA_T_2577	4
SEA_T_2579	5

ID	Factor met
SEA_T_2580	1, 4
SEA_T_2583	2, 4
SEA_T_2586	1, 3
SEA_T_2587	1, 2
SEA_T_2588	4
SEA_T_2589	4
SEA_T_259	1, 3
SEA_T_2590	2
SEA_T_2592	1, 2
SEA_T_2592a	2, 4
SEA_T_2592B	2, 4
SEA_T_2592c	2, 4
SEA_T_2593	4
SEA_T_2596	1
SEA_T_2597	2
SEA_T_2598	4
SEA_T_2599A	4
SEA_T_2599B	4
SEA_T_2600	2, 3
SEA_T_2601	2, 3, 4
SEA_T_2602	4
SEA_T_2603	1
SEA_T_2606	2, 3, 4, 5
SEA_T_2607	3, 4
SEA_T_2608	4
SEA_T_2609	1, 2
SEA_T_2610	1, 3
SEA_T_2613	4
SEA_T_2614	3, 4
SEA_T_2614a	3, 4
SEA_T_2617	2, 3
SEA_T_2618	3, 4
SEA_T_262	1, 2, 3
SEA_T_2621	1, 3
SEA_T_2622	2, 3, 4
SEA_T_2623	1, 2, 3, 4
SEA_T_2624	3
SEA_T_2625	2, 3, 4
SEA_T_2628	3
SEA_T_2629	4
SEA_T_263	1
SEA_T_2630	1, 2, 4

ID	Factor met
SEA_T_2631	2
SEA_T_2632	2, 3
SEA_T_2633	1, 3
SEA_T_2634a	1
SEA_T_2635	2, 3, 4
SEA_T_2636	3, 4
SEA_T_2637	3, 4
SEA_T_2638	1
SEA_T_2639	3, 4
SEA_T_2641	1
SEA_T_2642	1, 4
SEA_T_2643	1, 4
SEA_T_2645A	3, 4
SEA_T_2647	2, 3, 4
SEA_T_2648	4
SEA_T_2649	1
SEA_T_2650	1, 2
SEA_T_2652	4
SEA_T_2653	1, 3, 4
SEA_T_2654	1, 2, 4
SEA_T_2655	1
SEA_T_2658	1, 2
SEA_T_266	1, 2, 3
SEA_T_2661	1, 2, 3
SEA_T_2661a	3, 4
SEA_T_2664	1, 2
SEA_T_2665	1, 2
SEA_T_2666	4
SEA_T_2666a	4
SEA_T_2667	4
SEA_T_2669	1, 2, 3
SEA_T_267	2, 3, 4
SEA_T_2678	1, 2, 3, 4
SEA_T_2678a	2, 3, 4
SEA_T_2679	3, 4
SEA_T_268	2, 4
SEA_T_2680	4, 5
SEA_T_2681	3, 4, 5
SEA_T_2682	3, 4
SEA_T_2682a	1, 2, 3, 4
SEA_T_2685	3, 4, 5
SEA_T_2686	1, 2, 3,

ID	Factor met
	4
SEA_T_269	1, 3, 4
SEA_T_2690	3, 4
SEA_T_2691	1, 2, 4
SEA_T_2693	2, 3, 4
SEA_T_2693a	4
SEA_T_2694	2, 3
SEA_T_2694a	1, 2, 3, 4
SEA_T_2696	4
SEA_T_2697	2, 3, 4
SEA_T_2699	2, 3, 4
SEA_T_2700	2, 4
SEA_T_2701	2, 4
SEA_T_2702	2, 3, 4
SEA_T_2703	2, 3, 4
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SEA_T_2707	2, 3, 4
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SEA_T_2716	2, 4
SEA_T_2717	2, 4
SEA_T_2718	2, 4
SEA_T_2719	2, 4
SEA_T_2720	2, 4, 5
SEA_T_2721	3, 4
SEA_T_2722	1, 2, 3, 4
SEA_T_2723	2, 3, 4
SEA_T_2724	2
SEA_T_2726	1, 2, 3
SEA_T_2727	2, 4
SEA_T_2734	1, 2, 3, 4
SEA_T_2736	1, 2, 3, 4, 5

ID	Factor met
SEA_T_2738	3, 4
SEA_T_2739	2, 4
SEA_T_2740	1, 2, 3, 4
SEA_T_2741	2, 3
SEA_T_2742	1, 2, 3, 4
SEA_T_2742a	1, 2, 3
SEA_T_2743	1, 2, 3, 4
SEA_T_2746	1, 2, 4
SEA_T_2750	2, 3, 4
SEA_T_2752	2
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SEA_T_2763	1, 2
SEA_T_2765	1, 2, 3
SEA_T_2767	2, 3
SEA_T_2770	1, 2, 3
SEA_T_2772	1, 2
SEA_T_2774a	2, 4
SEA_T_2774B	2, 4
SEA_T_2780	1, 2
SEA_T_2783	3
SEA_T_2783A	4
SEA_T_2784	3, 4
SEA_T_2785	3
SEA_T_2787	3, 4
SEA_T_2789	1, 2
SEA_T_2789c	1, 2
SEA_T_279	3, 4
SEA_T_2793	1, 2
SEA_T_2794	1, 2
SEA_T_2795	1, 2
SEA_T_2797	1, 2
SEA_T_2798	3, 4
SEA_T_2799	2, 3
SEA_T_280	3
SEA_T_2802	2
SEA_T_2803	2, 3
SEA_T_2804	2
SEA_T_2805	2
SEA_T_2809	1, 2, 3
SEA_T_2810	1, 2

ID	Factor met
SEA_T_2811	1, 2
SEA_T_2812	1, 2
SEA_T_2813	1, 2
SEA_T_2814	1, 2
SEA_T_2815	1, 2, 3
SEA_T_2816	2, 3
SEA_T_2817	1, 2
SEA_T_2818	3, 4
SEA_T_2820	4
SEA_T_2821	3, 4, 5
SEA_T_2821a	3, 4, 5
SEA_T_2822	2, 3
SEA_T_2823	2
SEA_T_2828	1
SEA_T_2829	1, 2
SEA_T_2830	1, 3, 4
SEA_T_2832	1, 2, 4
SEA_T_2835	1, 2, 3, 4
SEA_T_2836	2, 4
SEA_T_2837	3
SEA_T_284	3, 4
SEA_T_2840	2, 3, 4
SEA_T_2842	3, 4
SEA_T_2846	2, 4, 5
SEA_T_2862	4
SEA_T_2866	4
SEA_T_2873	3, 4
SEA_T_2878	1, 2, 3, 4
SEA_T_288	1, 2
SEA_T_2880	4
SEA_T_2885	4
SEA_T_2886	1, 4
SEA_T_289	1, 3
SEA_T_29	1
SEA_T_2925	2, 4
SEA_T_2927	4
SEA_T_2969	2, 3, 4, 5
SEA_T_2974	2, 4
SEA_T_2982	2, 3, 4
SEA_T_2989	2, 3, 4, 5

ID	Factor met
SEA_T_2994	3, 4
SEA_T_30	1, 2, 3, 4
SEA_T_3022	3
SEA_T_3037	2, 3, 4
SEA_T_3043	2, 3, 4
SEA_T_305	3
SEA_T_307	2, 3
SEA_T_3078	2, 4
SEA_T_308	2, 3, 4
SEA_T_3081	2, 3, 4, 5
SEA_T_309	2, 3, 4
SEA_T_31	2, 3, 4, 5
SEA_T_310	1, 2, 3
SEA_T_3117	2, 3, 4, 5
SEA_T_313	2
SEA_T_3133	2, 4
SEA_T_3137	2, 3, 4
SEA_T_314	3
SEA_T_3140	4
SEA_T_3144	2, 3, 4
SEA_T_3145	3
SEA_T_316	3, 4
SEA_T_3161	2, 3, 4, 5
SEA_T_3174	4
SEA_T_3177	3, 4
SEA_T_3185	4
SEA_T_3187	4
SEA_T_319	2
SEA_T_3190	2, 3, 4
SEA_T_3196	3, 4
SEA_T_320	3, 4
SEA_T_322	1, 2, 3
SEA_T_323	1
SEA_T_3230	5
SEA_T_3238	3, 4
SEA_T_3240	1, 2, 3, 4
SEA_T_325	1, 3, 4
SEA_T_326	2
SEA_T_3262	2, 3

ID	Factor met
SEA_T_3265	2, 3, 5
SEA_T_3269	2, 3, 5
SEA_T_3270	2, 3, 5
SEA_T_33	1, 2, 4
SEA_T_330A	1
SEA_T_331	4
SEA_T_3339a	2, 3, 5
SEA_T_334	1, 3, 4
SEA_T_3341	2, 3, 4
SEA_T_3356	2, 3, 4
SEA_T_336	2, 3, 4
SEA_T_3364	2, 3, 4
SEA_T_337	2, 3, 4
SEA_T_3370	4
SEA_T_3377	2, 4
SEA_T_3377a	2, 3, 4
SEA_T_339	1
SEA_T_3391	2, 4
SEA_T_34	2, 3
SEA_T_3406	2, 3, 4
SEA_T_3409	2, 4
SEA_T_341	1, 2, 3, 4
SEA_T_342	4
SEA_T_3422	2, 3
SEA_T_3432	3, 4
SEA_T_3433	4
SEA_T_3458	2, 3, 4
SEA_T_3460	4
SEA_T_3462	2, 4
SEA_T_3467	2, 4, 5
SEA_T_3490	2, 4
SEA_T_3491	2, 4
SEA_T_3496	2, 4
SEA_T_3497	2, 4
SEA_T_3526	2, 3, 4, 5
SEA_T_3540	3, 4
SEA_T_357	4
SEA_T_358	3
SEA_T_3590	2, 3
SEA_T_3601	2, 3, 4
SEA_T_361	3
SEA_T_3624	2, 4, 5

ID	Factor met
SEA_T_3626	2, 4
SEA_T_363	3
SEA_T_3638	2, 4
SEA_T_364	3
SEA_T_3652	2, 4
SEA_T_3658	2, 4
SEA_T_366	4
SEA_T_3668	4
SEA_T_3669	3, 4
SEA_T_3672	2, 4
SEA_T_3673	4
SEA_T_3676	4
SEA_T_3680	2, 4
SEA_T_3687	3, 4
SEA_T_369	2, 3
SEA_T_3692	2
SEA_T_3694	2, 3, 4
SEA_T_3696	2, 4
SEA_T_370	1, 2, 3
SEA_T_371	1, 2
SEA_T_3714	2, 3, 4
SEA_T_3715	2, 3, 4
SEA_T_3718	4
SEA_T_3719	2, 3, 4
SEA_T_372	2, 3
SEA_T_3721	3
SEA_T_3725	2, 3, 4
SEA_T_3731	4
SEA_T_3737	2
SEA_T_3738	2, 5
SEA_T_3739	2, 3, 4, 5
SEA_T_374	1, 2, 3
SEA_T_3752	2, 3, 4
SEA_T_3754	2, 4
SEA_T_377	2
SEA_T_3772	2,4,5
SEA_T_3773	2, 3, 4
SEA_T_378	2, 3
SEA_T_379	3, 4
SEA_T_38	2, 3, 4
SEA_T_380	1, 2
SEA_T_3802	2, 3, 4

ID	Factor met
SEA_T_381	1, 2
SEA_T_3815	3, 4
SEA_T_383	4
SEA_T_3854	2, 4
SEA_T_3859	4
SEA_T_386	4
SEA_T_389	3, 4
SEA_T_3894	4
SEA_T_3900	2, 3, 4
SEA_T_391	3, 4
SEA_T_3924	2, 3, 5
SEA_T_3940	2, 4
SEA_T_3944a	3
SEA_T_3949	2
SEA_T_3950	2, 4, 5
SEA_T_3953	2, 3, 5
SEA_T_3957	2, 3, 4
SEA_T_396	2, 4
SEA_T_3961	2, 4, 5
SEA_T_3963	4
SEA_T_3964	2, 3, 4, 5
SEA_T_3966	2, 3, 4
SEA_T_3972E	2, 4, 5
SEA_T_3997	2, 3, 4, 5
SEA_T_3997a	4
SEA_T_40	4
SEA_T_403	2, 4
SEA_T_4037	2
SEA_T_405	2
SEA_T_4060	2, 4
SEA_T_407	4
SEA_T_409	1, 2, 3
SEA_T_4090	2
SEA_T_4097	2, 4
SEA_T_4098	4
SEA_T_41	3, 4
SEA_T_410	3, 4
SEA_T_4100	4
SEA_T_4101	2, 4
SEA_T_4102	2, 4
SEA_T_4103	2
SEA_T_4104	4

ID	Factor met
SEA_T_4105	2
SEA_T_4107	4
SEA_T_4109	2
SEA_T_4110	2, 4
SEA_T_4112	2
SEA_T_4117	2
SEA_T_4120	4
SEA_T_4122	4
SEA_T_4123	2, 4
SEA_T_4124	2
SEA_T_4125	2, 4
SEA_T_4126	2
SEA_T_4127	2
SEA_T_413	3
SEA_T_4130	2, 3, 4
SEA_T_4131	2
SEA_T_4132	4
SEA_T_4136	2, 3
SEA_T_4137	4
SEA_T_4138	2, 3, 4
SEA_T_4139	2, 4
SEA_T_414	2, 3
SEA_T_4140	4
SEA_T_4143	2, 4
SEA_T_4145	3
SEA_T_4147	2
SEA_T_4148	2
SEA_T_415	2
SEA_T_4153	4
SEA_T_4155	2
SEA_T_4157	2
SEA_T_4158	2, 3
SEA_T_4159	2
SEA_T_4161	4
SEA_T_4164	4
SEA_T_4166	1, 2
SEA_T_4167	2, 4
SEA_T_4169	2, 4
SEA_T_417	3, 4
SEA_T_4171	4
SEA_T_4172	2, 3
SEA_T_4173	2, 3
SEA_T_4174	2, 3

ID	Factor met
SEA_T_4176	2
SEA_T_4178	2, 3, 4
SEA_T_4178a	2, 3, 4
SEA_T_418	4
SEA_T_4180	2
SEA_T_4181	2, 4
SEA_T_4182	2, 4
SEA_T_4186	2, 4
SEA_T_4187	4
SEA_T_4188	2
SEA_T_4189	4
SEA_T_419	4
SEA_T_4190	2, 3, 4
SEA_T_4191	4
SEA_T_4192	4
SEA_T_4202	1, 2, 3, 4
SEA_T_4203	4
SEA_T_4204	4
SEA_T_4205	2
SEA_T_4206	4
SEA_T_4208	2, 4
SEA_T_421	1, 2
SEA_T_4210	4
SEA_T_4211	2
SEA_T_4214	2
SEA_T_4215	2, 4
SEA_T_4219	2, 4
SEA_T_4223	2, 4
SEA_T_4225	4
SEA_T_4226	1, 2, 3, 4
SEA_T_4226a	3, 4
SEA_T_4227c	4
SEA_T_4227d	2, 3
SEA_T_4227e	2, 3, 4
SEA_T_4229	1, 2, 3, 4
SEA_T_4232	3
SEA_T_4235	2, 4
SEA_T_4237	2, 3
SEA_T_4239	2, 3, 4
SEA_T_4239a	2, 4
SEA_T_424	1, 2, 3,

ID	Factor met
	4
SEA_T_4244	2
SEA_T_4245	2, 4
SEA_T_4245A	2
SEA_T_4246	2, 4
SEA_T_4247	2, 4
SEA_T_4249	2, 4
SEA_T_4251	2, 4
SEA_T_4253	4
SEA_T_4254	2, 3, 4
SEA_T_4255	4
SEA_T_4257	4
SEA_T_4258	2
SEA_T_4263	4
SEA_T_4264	4
SEA_T_427	3
SEA_T_4274	4
SEA_T_4275	4
SEA_T_4279	4
SEA_T_428	2, 3
SEA_T_4280	4
SEA_T_4285	2, 3, 4
SEA_T_4286	2
SEA_T_4287	2
SEA_T_4291	4
SEA_T_4294	2, 4
SEA_T_4294a	1, 2, 3, 4
SEA_T_4296	4
SEA_T_4297	2, 3
SEA_T_4299	1, 2
SEA_T_43	2, 4
SEA_T_430	2, 3
SEA_T_4300	4
SEA_T_4301	2
SEA_T_4303	2
SEA_T_4303a	2
SEA_T_4304	4
SEA_T_4306	3, 4
SEA_T_4307	4
SEA_T_4308	1, 2, 3, 4
SEA_T_431	2, 3
SEA_T_4310	2, 3, 4

ID	Factor met
SEA_T_4311	4
SEA_T_4315	4
SEA_T_4317	1, 2, 3
SEA_T_432	2
SEA_T_4321	4
SEA_T_4327	1, 2
SEA_T_4330	2, 4
SEA_T_4332	4
SEA_T_4334	1, 2
SEA_T_4345	2, 4
SEA_T_4346	2
SEA_T_4347	4
SEA_T_4348	2, 4, 5
SEA_T_435	4
SEA_T_4350	2, 4
SEA_T_4351	2, 4
SEA_T_4352	2
SEA_T_4353	2, 3, 4
SEA_T_4356	1, 2
SEA_T_4357	1, 2, 4
SEA_T_4358	1, 2
SEA_T_4359	1, 4
SEA_T_436	2, 3, 4
SEA_T_4360	1
SEA_T_4361	1, 2, 3
SEA_T_4362	1, 2
SEA_T_4363	1, 2
SEA_T_4364	1, 2
SEA_T_4365	1, 2
SEA_T_4366	1, 2
SEA_T_4367	1, 2
SEA_T_4368	1, 2
SEA_T_4369	1, 2
SEA_T_437	2, 3
SEA_T_4370	1, 2
SEA_T_4371	1, 2
SEA_T_4372	1
SEA_T_4373	1
SEA_T_4374	1, 2
SEA_T_4375	1, 2, 3
SEA_T_4376	1, 2
SEA_T_4377	1
SEA_T_4378	1, 2

ID	Factor met
SEA_T_4379	1, 2
SEA_T_4380	1, 2
SEA_T_4381	1, 2
SEA_T_4382	1, 2
SEA_T_4383	1, 2
SEA_T_4384	1, 2
SEA_T_4385	1, 2
SEA_T_4387	1
SEA_T_4388	1, 4
SEA_T_4389	1
SEA_T_439	2
SEA_T_4390	1
SEA_T_4391	1
SEA_T_4392	1
SEA_T_4393	1, 2
SEA_T_4394	1, 2
SEA_T_4395	1, 2
SEA_T_4396	1, 2
SEA_T_4397	1, 2
SEA_T_4398	1, 2
SEA_T_4399A	1, 2
SEA_T_44	3
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SEA_T_4401	1, 2
SEA_T_4402A	1, 2, 3
SEA_T_4403	1, 2, 3
SEA_T_4404	1, 4
SEA_T_4405	1, 2
SEA_T_4406	1, 2
SEA_T_4407	1
SEA_T_4408	1, 2
SEA_T_4409	1, 2
SEA_T_4410	1, 2
SEA_T_4411	1, 2, 4
SEA_T_4412	1, 2
SEA_T_4413	1, 2
SEA_T_4414	1, 2
SEA_T_4415	1, 2
SEA_T_4416	1, 2
SEA_T_4417	1, 2
SEA_T_4418	1, 2
SEA_T_4419	1, 2
SEA_T_4420	1, 2

ID	Factor met
SEA_T_4421	2, 4
SEA_T_4422	2
SEA_T_4423	1, 2
SEA_T_4424	1, 2
SEA_T_4425	1, 2
SEA_T_4426	1, 2
SEA_T_4427	2, 4
SEA_T_4428	1, 2
SEA_T_4429	1, 2, 3, 4
SEA_T_443	3
SEA_T_4430	1, 2, 3, 4
SEA_T_4431	1, 4
SEA_T_4432	1, 2
SEA_T_4433	1, 2, 4
SEA_T_4434	1, 2, 4
SEA_T_4435	1
SEA_T_4436	1, 2
SEA_T_4437	1, 2
SEA_T_4438	1, 2, 3, 4
SEA_T_4439	1, 2
SEA_T_4440	1, 2, 3, 4
SEA_T_4441	1, 2, 4
SEA_T_4442	1, 2
SEA_T_4443	1, 2, 3
SEA_T_4444	1, 2
SEA_T_4445	1, 3
SEA_T_4446	1, 2, 4
SEA_T_4447	1, 2
SEA_T_4449	1, 2, 3, 4, 5
SEA_T_4450	1, 2
SEA_T_4451	1, 2
SEA_T_4452	1, 2, 3
SEA_T_4453	1, 2
SEA_T_4454	1, 2
SEA_T_4456	2, 4
SEA_T_4457	1, 2
SEA_T_4458	1, 2
SEA_T_4459	1, 2, 3, 4
SEA_T_446	3

ID	Factor met
SEA_T_4461	1, 2
SEA_T_4463	1, 2, 3
SEA_T_4464	1
SEA_T_4465	1, 4
SEA_T_4466	1, 2
SEA_T_4467	1, 2, 3, 4
SEA_T_4468	1, 3
SEA_T_4469	1
SEA_T_4470	1, 2
SEA_T_4471	1, 2
SEA_T_4473	1, 2
SEA_T_4477	2, 4
SEA_T_4479	3
SEA_T_448	2
SEA_T_4480	1, 2
SEA_T_4481	1, 2, 3, 4
SEA_T_4482	1, 2
SEA_T_4483	4
SEA_T_4484	1, 2, 3
SEA_T_4485	1
SEA_T_4486	1
SEA_T_4487	2
SEA_T_4488	1
SEA_T_4489	1, 2
SEA_T_449	2, 3
SEA_T_4493	1
SEA_T_4494	4
SEA_T_4496	4
SEA_T_4496a	2
SEA_T_4499	2, 4
SEA_T_450	2, 3
SEA_T_4500	2
SEA_T_4501	1, 2, 3
SEA_T_4503	1, 2, 3
SEA_T_4504	1, 2
SEA_T_4505	1, 2, 3
SEA_T_4506	1
SEA_T_4507	1
SEA_T_4508	1
SEA_T_4509	1, 2
SEA_T_451	1, 2
SEA_T_4510	2

ID	Factor met
SEA_T_4511	1, 2, 3
SEA_T_4512	2
SEA_T_4513	1, 2
SEA_T_4514	2
SEA_T_4516	3
SEA_T_4518	2, 3, 4
SEA_T_4519	4
SEA_T_4521	3
SEA_T_4524	4
SEA_T_4528	1, 2, 3, 4
SEA_T_4529	3, 4
SEA_T_453	1
SEA_T_4532	4
SEA_T_4536	4
SEA_T_4537	3, 4
SEA_T_4539	2
SEA_T_454	2
SEA_T_4541	1, 2
SEA_T_4545	3
SEA_T_4548	2, 3
SEA_T_4549	2, 3
SEA_T_4550	4
SEA_T_4551	3
SEA_T_4552	2, 3
SEA_T_4554B	3, 4
SEA_T_4554C	4
SEA_T_4556	2, 3, 4
SEA_T_4558	3, 4
SEA_T_4559	2, 4
SEA_T_456	1
SEA_T_4560	2
SEA_T_4561	2, 3, 4
SEA_T_4562	3, 4
SEA_T_4563	3, 4
SEA_T_4565	2
SEA_T_4568	2, 3
SEA_T_4569	3, 4
SEA_T_4570	3, 4
SEA_T_4571	2, 3, 4
SEA_T_4573	3, 4
SEA_T_4575	3, 4
SEA_T_4576	2

ID	Factor met
SEA_T_4577	3, 4
SEA_T_4579	2, 3
SEA_T_4584	3, 4, 5
SEA_T_4585	3, 4
SEA_T_4588	1, 2, 3, 4
SEA_T_4589	3, 4
SEA_T_4599	4
SEA_T_4602	1, 2, 3
SEA_T_4605	4
SEA_T_4608	3
SEA_T_4617	4
SEA_T_4621	1, 3
SEA_T_4625	1, 3
SEA_T_4626	3
SEA_T_4631	2, 4
SEA_T_4633	2, 4
SEA_T_4636	2
SEA_T_4637	3, 4
SEA_T_464	1, 2, 3
SEA_T_4640	2
SEA_T_4641	2
SEA_T_4645	2, 3, 4
SEA_T_4654	3
SEA_T_466	1, 2, 3
SEA_T_4661	2, 4
SEA_T_4665	3
SEA_T_4670	1, 2, 3
SEA_T_4671	1, 2, 3
SEA_T_4672	1, 2, 3, 4
SEA_T_4673	1, 2, 3
SEA_T_4675	2
SEA_T_468	2, 3
SEA_T_4681	1, 2, 3
SEA_T_4685	2, 4
SEA_T_4686	2, 4
SEA_T_4688	2, 4
SEA_T_4689	2, 4
SEA_T_469	3
SEA_T_4690	2, 4
SEA_T_4691	2, 4
SEA_T_4692	2, 4
SEA_T_47	2

ID	Factor met
SEA_T_470	2, 3
SEA_T_471	1, 2, 3
SEA_T_4711	2
SEA_T_4712	2
SEA_T_472	2, 3
SEA_T_4726	2
SEA_T_4729	2, 4
SEA_T_4733	2, 4
SEA_T_4735	2
SEA_T_474	1, 2, 3
SEA_T_4740	2
SEA_T_4743	2
SEA_T_4744	2
SEA_T_4747	2, 3
SEA_T_4748	4
SEA_T_475	2, 3, 4
SEA_T_4758	2
SEA_T_476	2, 3, 4
SEA_T_4765	2
SEA_T_4774	4
SEA_T_4779	2, 4
SEA_T_478	1, 2, 3
SEA_T_4783	2, 4
SEA_T_4784	3
SEA_T_4787	2, 4
SEA_T_479	2, 3, 4
SEA_T_4791	2, 4
SEA_T_48	4
SEA_T_480	2, 3, 4
SEA_T_4811A	2
SEA_T_4814	2
SEA_T_4822	4
SEA_T_4825	2, 4
SEA_T_4828	2, 4
SEA_T_483	2, 3
SEA_T_4830	4
SEA_T_4849	4
SEA_T_485	1, 2, 3, 4, 5
SEA_T_4866	4
SEA_T_4867	1, 2, 3
SEA_T_4870	1, 2, 3
SEA_T_4872	2

ID	Factor met
SEA_T_4874	2
SEA_T_4875	4
SEA_T_4877	2
SEA_T_4878	2
SEA_T_4882	1, 2, 3, 4, 5
SEA_T_489	2
SEA_T_4891	1, 2, 3, 4
SEA_T_4899	2
SEA_T_4901	2
SEA_T_4902	2
SEA_T_4904	4
SEA_T_4905	4
SEA_T_4907	2, 3, 5
SEA_T_491	2, 3
SEA_T_4913	3, 4
SEA_T_4916	2, 4
SEA_T_4917	2, 4, 5
SEA_T_4919	4
SEA_T_492	2, 3
SEA_T_493	4
SEA_T_4932	2, 4
SEA_T_4938	3
SEA_T_494	1, 2, 3
SEA_T_4946	4
SEA_T_4950	4
SEA_T_4959	2
SEA_T_4960	2
SEA_T_4961	2
SEA_T_4963	4
SEA_T_4965	4
SEA_T_4969	4
SEA_T_4976	4
SEA_T_4978	2, 4
SEA_T_4980	2
SEA_T_4987	2, 4
SEA_T_4989	2
SEA_T_4990	2
SEA_T_4995	2
SEA_T_4997	2, 5
SEA_T_4999	2, 4
SEA_T_50	2, 4
SEA_T_500	3

ID	Factor met
SEA_T_5001	2, 5
SEA_T_5007	4
SEA_T_501	2, 3
SEA_T_5012	2, 4, 5
SEA_T_5020	4
SEA_T_5032	2
SEA_T_504	3
SEA_T_505	4
SEA_T_5074	2, 4
SEA_T_5077	4
SEA_T_508	1, 2
SEA_T_509	1, 2, 3
SEA_T_5093	4
SEA_T_509B	2
SEA_T_510	3
SEA_T_5103	4
SEA_T_5105	2, 4
SEA_T_5114	1, 2, 3, 4
SEA_T_5124	2, 4
SEA_T_513	3
SEA_T_514	4
SEA_T_519	2, 4
SEA_T_521	2
SEA_T_5241	1, 2, 3, 4
SEA_T_5242	1, 2, 3, 4, 5
SEA_T_5243	2, 4
SEA_T_5244	2
SEA_T_5245	4
SEA_T_5246	1, 2, 3, 4
SEA_T_5247	2, 4
SEA_T_5248	1, 2
SEA_T_525	2, 4
SEA_T_5250	2, 3, 4
SEA_T_5253	2
SEA_T_5254	2
SEA_T_5257	2
SEA_T_5258	2, 4
SEA_T_5259	1, 2, 3
SEA_T_5261	1, 2
SEA_T_5262	2, 4

ID	Factor met
SEA_T_5263	2, 3
SEA_T_5264	1, 2, 3
SEA_T_5265	1, 2, 4
SEA_T_5266	1, 2, 3, 4
SEA_T_5267	1, 2, 3
SEA_T_5268	1, 2, 3, 4
SEA_T_5269	1, 2, 4
SEA_T_526a	2, 4, 5
SEA_T_5270	1, 2
SEA_T_5271	1, 2, 4
SEA_T_5272	1, 4
SEA_T_5273	1, 3
SEA_T_5274	2, 4
SEA_T_5276	2, 3, 4
SEA_T_5277	2, 3, 4
SEA_T_5278	1, 2
SEA_T_5280	1, 2
SEA_T_5281	1, 2
SEA_T_5282	1, 2
SEA_T_5282a	1, 2
SEA_T_5283	1, 2, 3, 4
SEA_T_5284	1, 2
SEA_T_5285	1, 2
SEA_T_5287	2, 3
SEA_T_5288	2, 5
SEA_T_5289	1, 2, 3
SEA_T_529	4
SEA_T_5291	2, 3
SEA_T_5293	2, 4
SEA_T_5294	1, 2, 4
SEA_T_5295	1, 4
SEA_T_5296	1, 2, 3, 4
SEA_T_5297	1, 2, 3, 4
SEA_T_5298	2
SEA_T_53	1, 2
SEA_T_530	2, 4
SEA_T_5300	1, 2, 4
SEA_T_5301	1, 2, 4
SEA_T_5302	2, 4
SEA_T_5303	1, 2, 3,

ID	Factor met
	4
SEA_T_5308	2
SEA_T_5309	2, 3
SEA_T_530b	2
SEA_T_531	1, 2
SEA_T_5310	1, 2, 3, 4
SEA_T_5311	3
SEA_T_5312	2, 3, 4
SEA_T_5316	1, 2
SEA_T_5317	2, 3
SEA_T_5318	2, 3
SEA_T_532	1
SEA_T_5320	2, 3, 4, 5
SEA_T_5321	2
SEA_T_5323	1, 2, 3, 4
SEA_T_5324	3, 4
SEA_T_5325	1, 2
SEA_T_5326	1, 2
SEA_T_5327	1, 2
SEA_T_5328	1, 2
SEA_T_5329	1, 2
SEA_T_533	1, 2
SEA_T_5330	1, 2
SEA_T_5331	1, 2
SEA_T_5332	1, 2, 4
SEA_T_5333	1, 2, 4
SEA_T_5334	1, 2, 3, 4
SEA_T_5335	2, 4
SEA_T_5336	1, 2, 4, 5
SEA_T_5337	2
SEA_T_5338	4
SEA_T_5339	1, 2
SEA_T_534	1, 2, 3
SEA_T_5340	1, 2
SEA_T_5341	2
SEA_T_5342	3
SEA_T_5344	1, 2, 3
SEA_T_5346	1, 2, 3, 4
SEA_T_5347	1, 2, 3

ID	Factor met
SEA_T_5348	1, 2, 3, 4
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SEA_T_535	1, 2
SEA_T_5350	1, 2, 3
SEA_T_5351	1, 2
SEA_T_5352	1, 2
SEA_T_5353	1, 2
SEA_T_5354	1, 2
SEA_T_5355	1, 2
SEA_T_5356	2, 3, 4
SEA_T_5357	2, 3
SEA_T_5357a	2
SEA_T_5357e	4
SEA_T_5357f	1, 2, 3, 4
SEA_T_5357g	2
SEA_T_5358	3
SEA_T_5359	2, 3, 4
SEA_T_536	1, 2
SEA_T_5360	2, 3, 4, 5
SEA_T_5361	2, 4
SEA_T_5361a	4
SEA_T_5362	4
SEA_T_5363	1, 2, 3
SEA_T_5365	1, 2, 3
SEA_T_538	1, 2
SEA_T_5380	2, 3, 4
SEA_T_5381	2, 3, 4
SEA_T_5382	1, 2
SEA_T_5383	1, 2, 3
SEA_T_5384	1, 2, 3
SEA_T_5386	2, 4
SEA_T_5388	2, 4
SEA_T_5389	1, 2, 4
SEA_T_538a	1, 2, 4
SEA_T_538b	1, 2, 4
SEA_T_538c	1, 2, 4
SEA_T_539	1, 2
SEA_T_5390	4
SEA_T_5391	2, 4
SEA_T_5393	3, 4
SEA_T_5394	3, 4

ID	Factor met
SEA_T_5395	1, 2, 3, 4
SEA_T_5396	1, 2, 3, 4
SEA_T_5397	2, 3, 4
SEA_T_5398	4
SEA_T_54	1, 2
SEA_T_540	1
SEA_T_5404	4
SEA_T_5405	1, 2, 3, 4
SEA_T_5406	3, 4
SEA_T_5407	2, 3, 4
SEA_T_5408	2, 4
SEA_T_5408a	2, 4
SEA_T_5409	4
SEA_T_5409a	4
SEA_T_540a	1
SEA_T_540c	1
SEA_T_540d	2
SEA_T_5410	1, 2
SEA_T_5411	4
SEA_T_5414	4
SEA_T_5414a	4
SEA_T_5415	4
SEA_T_5416	2, 5
SEA_T_5417	4
SEA_T_5419	3
SEA_T_5419a	4
SEA_T_542	2, 4
SEA_T_5420	4
SEA_T_5421	2, 3, 4
SEA_T_5421b	4
SEA_T_5422	4
SEA_T_5423	1, 2, 3, 4
SEA_T_5423a	2, 3, 4
SEA_T_5424	4
SEA_T_5425	1, 3, 4
SEA_T_5426a	4
SEA_T_5427	4
SEA_T_5428	4
SEA_T_5429	4
SEA_T_5430	3, 4

ID	Factor met
SEA_T_5431	1, 3, 4
SEA_T_5432	4
SEA_T_5433	4
SEA_T_5434	2
SEA_T_5435	4
SEA_T_5436	4
SEA_T_5437	3
SEA_T_5438	4
SEA_T_5439	2, 3
SEA_T_544	2
SEA_T_5440	1, 2, 4
SEA_T_5441	4
SEA_T_5442	1, 2, 3, 4, 5
SEA_T_5443	1, 2
SEA_T_5446	4
SEA_T_5447	1, 2
SEA_T_5448	3
SEA_T_5448a	4
SEA_T_5448b	4
SEA_T_545	1, 2
SEA_T_5451	1, 3, 4
SEA_T_5452	4
SEA_T_5452a	4
SEA_T_5452B	4
SEA_T_5452c	4
SEA_T_5453	4
SEA_T_5453a	4
SEA_T_5454	2, 3
SEA_T_5454a	3
SEA_T_5454B	3
SEA_T_5454C	4
SEA_T_5454D	4
SEA_T_5454e	2, 3
SEA_T_5454f	4
SEA_T_5454g	2, 3
SEA_T_5455	4
SEA_T_5457	4
SEA_T_5458	2, 3, 4
SEA_T_5461	1, 2, 4
SEA_T_5462	4
SEA_T_5462a	4
SEA_T_5462B	4

ID	Factor met
SEA_T_5462c	4
SEA_T_5466	1, 2, 3, 4
SEA_T_5467	4
SEA_T_5468	3, 4
SEA_T_5469	4
SEA_T_5470	4
SEA_T_5473	1, 2, 3, 4, 5
SEA_T_5475	2
SEA_T_5476	2, 4
SEA_T_5477	4
SEA_T_5478	2, 4
SEA_T_5479	2, 4, 5
SEA_T_5480	1, 2, 4
SEA_T_5482	3, 4
SEA_T_5486	4
SEA_T_5487	2, 3, 4
SEA_T_5488	2, 4
SEA_T_5490	2, 3, 4
SEA_T_5492A	1, 2, 3
SEA_T_5492C	1, 2, 3
SEA_T_5492D	2
SEA_T_5493	1, 2, 3, 4
SEA_T_5494	2, 3, 4
SEA_T_5495	2, 3, 4
SEA_T_5496	2, 3, 4
SEA_T_5497	1, 2, 3, 4
SEA_T_5498	2, 3, 4, 5
SEA_T_5498a	2, 3, 4
SEA_T_5499	4
SEA_T_5499a	1, 2, 3, 4
SEA_T_55	2, 3
SEA_T_5501	2, 3, 4, 5
SEA_T_5502	4
SEA_T_5503	2, 4
SEA_T_5504	4
SEA_T_5505	2, 4
SEA_T_5506	2, 3, 4
SEA_T_5507	2, 4

ID	Factor met
SEA_T_5507a	2, 4
SEA_T_5507c	4
SEA_T_5507d	2, 4
SEA_T_5508	1, 2, 3, 4
SEA_T_5509	2, 3, 4
SEA_T_5510	2, 3, 4
SEA_T_5516	2, 4
SEA_T_5517	2
SEA_T_5518	2, 4
SEA_T_5519	2, 4
SEA_T_5520	2, 4
SEA_T_5521	1, 2, 3
SEA_T_5522	2, 3, 4
SEA_T_5524	1, 2, 3, 4, 5
SEA_T_5525	1, 2, 3
SEA_T_5526	1, 2, 3, 4
SEA_T_5527	2, 4
SEA_T_5530	1, 2
SEA_T_5531	1, 2, 3
SEA_T_5532	1
SEA_T_5533	2, 3
SEA_T_5534	1, 2
SEA_T_5535	1, 2
SEA_T_5536	2, 3
SEA_T_5537	2, 3
SEA_T_5539	1, 2, 3, 4, 5
SEA_T_5539a	2
SEA_T_5540	1, 2, 3, 4
SEA_T_5541	2, 3, 4
SEA_T_5541a	2
SEA_T_5547	2, 4
SEA_T_5548	2, 4, 5
SEA_T_5548a	2, 4
SEA_T_5548b	2, 4
SEA_T_5548c	1, 2, 3, 4
SEA_T_5549	1, 2, 3, 4
SEA_T_5549a	2
SEA_T_5552	4

ID	Factor met
SEA_T_5562	1, 2, 3, 4
SEA_T_5573	3, 4
SEA_T_5576	2, 4
SEA_T_5577	2, 3, 4
SEA_T_5578	2
SEA_T_5588	2, 3, 4
SEA_T_5588b	2, 3, 4
SEA_T_559	3
SEA_T_5592	1, 2, 3
SEA_T_5596	2, 3
SEA_T_5598	1, 2, 3
SEA_T_56	1, 2, 3
SEA_T_560	3, 4
SEA_T_5600	2, 3
SEA_T_5601	2, 3
SEA_T_5602	2, 3
SEA_T_5603	2, 3
SEA_T_5604	2, 3
SEA_T_5605	2, 3
SEA_T_5607	2, 3
SEA_T_5608	2
SEA_T_5609	2, 3
SEA_T_561	2, 3, 4
SEA_T_5610	2, 3
SEA_T_5611	2, 3
SEA_T_5612	2
SEA_T_5615	2
SEA_T_5616	2, 4
SEA_T_5617	2, 3
SEA_T_5618	2, 3
SEA_T_562	2, 4
SEA_T_5620	2
SEA_T_5621	2
SEA_T_5626	2, 3
SEA_T_5633	3
SEA_T_5634	2, 3
SEA_T_5635	2, 3
SEA_T_5636	2, 3
SEA_T_5637	1, 2, 3
SEA_T_5638	2, 3
SEA_T_5639	1, 2, 3
SEA_T_564	2, 3

ID	Factor met
SEA_T_5640	2, 3
SEA_T_5646	2, 3
SEA_T_5649	3
SEA_T_565	2, 3
SEA_T_5652	1
SEA_T_5653	1, 3
SEA_T_5654	3
SEA_T_5655	3
SEA_T_5656	3
SEA_T_5660	2, 4
SEA_T_5661	2
SEA_T_5665	2, 3, 4
SEA_T_5666	2
SEA_T_5667	2
SEA_T_5669	2, 3
SEA_T_567	4
SEA_T_5670	2, 3
SEA_T_5672	2
SEA_T_5674	2
SEA_T_5675	2, 3
SEA_T_5676	2, 3
SEA_T_5677	2, 3
SEA_T_5679	2
SEA_T_5680	2, 3
SEA_T_5683	2
SEA_T_5687	2
SEA_T_5688	2
SEA_T_5697	2
SEA_T_5698	2
SEA_T_570	3
SEA_T_5702	2
SEA_T_5703	2, 4
SEA_T_5704	2
SEA_T_5705	2, 4
SEA_T_5706	2, 4
SEA_T_5707	2
SEA_T_5708	2, 3
SEA_T_5709	3
SEA_T_5710	2, 3
SEA_T_5711	2, 3
SEA_T_5714	4
SEA_T_5715	2, 3, 4
SEA_T_5716	4

ID	Factor met
SEA_T_572	4
SEA_T_5720	2, 4
SEA_T_5721	2
SEA_T_5722	2, 4
SEA_T_5726	2, 4
SEA_T_5727	2, 4
SEA_T_5728	2, 4
SEA_T_5729	2, 4
SEA_T_5730	2, 4
SEA_T_5731	4
SEA_T_5733	3
SEA_T_5734	3
SEA_T_5735	4
SEA_T_5737	4
SEA_T_5739	3
SEA_T_5753	2
SEA_T_5763	2
SEA_T_5768	2, 3, 4
SEA_T_5769	2
SEA_T_5772	2
SEA_T_5774	2
SEA_T_5775	2
SEA_T_5776	2
SEA_T_578	4
SEA_T_5790	2, 3, 4
SEA_T_581	1, 2, 3
SEA_T_5813	1, 2, 3, 4
SEA_T_5814	1, 2, 3, 4
SEA_T_5815	2, 4
SEA_T_5816	3, 4
SEA_T_5817	1, 2, 4
SEA_T_5818	1, 2
SEA_T_5819	1, 2, 3, 4
SEA_T_5821	3, 4
SEA_T_5822	2
SEA_T_583	1, 2, 4, 5
SEA_T_5831	2
SEA_T_5832	2
SEA_T_5834	2, 3, 4
SEA_T_5835	2, 3, 4

ID	Factor met
SEA_T_5838	4
SEA_T_5839	3
SEA_T_5840	3
SEA_T_5842	3
SEA_T_5847	3, 4
SEA_T_5848	3, 4
SEA_T_5849	2
SEA_T_5850	2, 3
SEA_T_5854	4
SEA_T_5858	2, 3
SEA_T_5859	3
SEA_T_586	1, 2, 4
SEA_T_5861	4
SEA_T_5863	3
SEA_T_587	2, 3, 4
SEA_T_5872	3
SEA_T_5873	3
SEA_T_5874	3
SEA_T_5879	2
SEA_T_588	2, 3, 4
SEA_T_5881	2
SEA_T_5882	2
SEA_T_5883	2
SEA_T_5884	2
SEA_T_5887	2
SEA_T_5889	2
SEA_T_589	2, 3, 4
SEA_T_5892	2
SEA_T_5899	2, 3
SEA_T_59	3
SEA_T_590	2, 3
SEA_T_5901	2, 3
SEA_T_5902	2, 3
SEA_T_5903	3
SEA_T_5904	2, 3
SEA_T_5905	3
SEA_T_5906	2, 3
SEA_T_5907	2, 3
SEA_T_5909	2, 3
SEA_T_5910	2, 3
SEA_T_5911	2, 3
SEA_T_5915	2, 4
SEA_T_5916	4

ID	Factor met
SEA_T_592	1, 2, 3, 4
SEA_T_5922	2
SEA_T_5923	2
SEA_T_5924	2
SEA_T_5926	2, 3
SEA_T_5928	2, 3
SEA_T_5929	2, 3
SEA_T_593	1, 2, 3, 4
SEA_T_5930	2
SEA_T_5934	1, 2
SEA_T_594	2, 3
SEA_T_5940	1, 2
SEA_T_5941	3
SEA_T_5942	3
SEA_T_5943	3
SEA_T_5944	3
SEA_T_5945	3
SEA_T_5946	3
SEA_T_5947	3
SEA_T_595	2, 4
SEA_T_5950	2
SEA_T_5956	2, 3, 4
SEA_T_5958	2
SEA_T_5959	2
SEA_T_596	2, 4
SEA_T_5964	2, 3
SEA_T_5967	2
SEA_T_5968	2
SEA_T_5969	2
SEA_T_597	2, 4
SEA_T_5971	2
SEA_T_5974	2, 3
SEA_T_5975	2, 3
SEA_T_5976	2, 3
SEA_T_598	2, 3, 4
SEA_T_5982	2
SEA_T_5983	2, 3
SEA_T_5984	2, 3, 4
SEA_T_5985	2, 3, 4
SEA_T_599	2, 3, 4
SEA_T_5997	2, 3
SEA_T_5998	2, 3

ID	Factor met
SEA_T_600	4
SEA_T_6000	2, 3
SEA_T_6001	2
SEA_T_6002	4
SEA_T_6003	2, 3
SEA_T_6004	3
SEA_T_6008	2
SEA_T_6009	2, 4
SEA_T_6011	2
SEA_T_6016	5
SEA_T_6017	2
SEA_T_6020	2
SEA_T_6022A	4
SEA_T_6025	1, 2
SEA_T_6029	1, 2
SEA_T_6032	1, 2
SEA_T_6033	1, 2
SEA_T_6034	2
SEA_T_6037	1, 2
SEA_T_6041	1, 2
SEA_T_6045	2, 5
SEA_T_6055	2
SEA_T_6059	2, 4
SEA_T_6060	1, 2
SEA_T_6062	4
SEA_T_6063	2
SEA_T_6064	2
SEA_T_6065	1, 2, 4
SEA_T_6068	1, 2, 4
SEA_T_607	4
SEA_T_6074	4, 5
SEA_T_6088	3, 4
SEA_T_6089	3, 4
SEA_T_6096	2
SEA_T_6097	2
SEA_T_6098	2
SEA_T_6103	2
SEA_T_6104	4
SEA_T_6111	2
SEA_T_6113	2, 4
SEA_T_6114	1, 2
SEA_T_6116	1, 2
SEA_T_6117	1, 2

ID	Factor met
SEA_T_6117a	1, 2
SEA_T_6118	1, 2
SEA_T_6119	2, 4
SEA_T_612	2, 4
SEA_T_6120	1, 2
SEA_T_6121	1, 2, 4
SEA_T_6122	1, 2
SEA_T_6123	1, 2
SEA_T_6124	1, 2
SEA_T_6125	1, 2
SEA_T_6126	1, 2
SEA_T_6127	1, 2
SEA_T_6128	1, 2
SEA_T_6129	1, 2
SEA_T_613	2
SEA_T_6130	1, 2
SEA_T_6131	1, 2
SEA_T_6132	2, 4
SEA_T_6133	1, 2
SEA_T_6134	1, 2
SEA_T_6136	1, 2
SEA_T_6137	1, 2
SEA_T_6138	1, 2, 3
SEA_T_6146	1, 2, 3
SEA_T_6149	2, 3
SEA_T_6153	1, 2, 3
SEA_T_6155	1, 2, 3
SEA_T_6160	1, 2
SEA_T_6165	1, 2
SEA_T_6168	1, 2
SEA_T_6169	1, 2, 3, 4
SEA_T_6170	2
SEA_T_6171	1, 4
SEA_T_6171A	3
SEA_T_6172	4
SEA_T_6173	1, 2
SEA_T_6174	1, 2, 3
SEA_T_6175	4
SEA_T_6176	1, 2
SEA_T_6177	1, 2
SEA_T_6177a	1, 2, 4
SEA_T_6178	1, 2

ID	Factor met
SEA_T_6179	1, 2, 5
SEA_T_6180	1, 2
SEA_T_6181	1, 2, 4
SEA_T_6182	1, 2
SEA_T_6183	1, 2, 4
SEA_T_6184	2
SEA_T_6186	2, 3
SEA_T_6187	2
SEA_T_6188	1, 2
SEA_T_6189	1, 2, 3
SEA_T_6190	1, 2, 4
SEA_T_6191	2, 4
SEA_T_6193	2, 4
SEA_T_62	1, 2
SEA_T_6202	2, 3, 4
SEA_T_6205	1, 2
SEA_T_6206	1, 2, 4
SEA_T_6207	1, 2
SEA_T_6209	2, 3, 4
SEA_T_6211	3
SEA_T_6213	2
SEA_T_6214	1, 2
SEA_T_6215	1, 2
SEA_T_6216	1, 2
SEA_T_6218	1, 2
SEA_T_622	4
SEA_T_6221	1, 2
SEA_T_6228	2
SEA_T_6229	2
SEA_T_6234	1, 2
SEA_T_6235	1, 2
SEA_T_6236	1, 2
SEA_T_6237	1, 2, 4
SEA_T_6238	1, 2
SEA_T_6239	1, 2
SEA_T_6243	4
SEA_T_6244	2, 4
SEA_T_6244a	4
SEA_T_6246	2
SEA_T_6247	2
SEA_T_6249	2, 5
SEA_T_6257d	1, 3
SEA_T_626	2, 3, 4

ID	Factor met
SEA_T_6261	1, 3
SEA_T_6261b	1, 4
SEA_T_6263	2, 4
SEA_T_6264	2
SEA_T_6268	2
SEA_T_626a	2
SEA_T_626b	2
SEA_T_627	2, 4
SEA_T_6270	2
SEA_T_6272	2, 4
SEA_T_6274	4
SEA_T_6277A	3, 4
SEA_T_6277B	3, 4
SEA_T_6279	1, 2, 3
SEA_T_627a	2, 3, 4
SEA_T_627b	2, 4
SEA_T_627c	2, 4
SEA_T_628	1, 4
SEA_T_6282	1
SEA_T_6284	1
SEA_T_6285	1, 2
SEA_T_6289	1, 3
SEA_T_629	1, 2, 3
SEA_T_6290	2
SEA_T_6293	3
SEA_T_6298	1, 2, 4
SEA_T_63	2
SEA_T_6301	4
SEA_T_6303	1, 2, 3, 4
SEA_T_6304	3
SEA_T_631	3
SEA_T_6310	1, 2, 3
SEA_T_6310a	1
SEA_T_6311	1, 3
SEA_T_6319	3, 4
SEA_T_632	2, 3, 4
SEA_T_6320	4
SEA_T_6322	1, 4
SEA_T_6323	3
SEA_T_6324	4
SEA_T_6325	1
SEA_T_6327	1, 3

ID	Factor met
SEA_T_6328a	2, 3
SEA_T_6328d	2, 3
SEA_T_6329	1, 2
SEA_T_633	2, 3, 4
SEA_T_6334	2, 3
SEA_T_6336	3
SEA_T_6339	2, 3
SEA_T_634	3
SEA_T_6345	3
SEA_T_6346	2, 3
SEA_T_6349	4
SEA_T_635	2, 3
SEA_T_6353	3
SEA_T_6358	1, 2, 3
SEA_T_6359	3
SEA_T_636	1, 2
SEA_T_6360	1, 2
SEA_T_6361a	2, 4, 5
SEA_T_6363a	2, 3, 4, 5
SEA_T_6363B	2, 4
SEA_T_6364	1, 2, 3
SEA_T_6364a	2, 3, 4
SEA_T_6366a	2, 4
SEA_T_637	2, 3
SEA_T_6370	2
SEA_T_6370a	3
SEA_T_6370b	2, 4
SEA_T_6371	3, 4
SEA_T_6372	1, 2, 3
SEA_T_6373a	2, 4
SEA_T_6375	2, 4
SEA_T_6376	2, 3, 4
SEA_T_6377	2
SEA_T_6378	1, 2, 3
SEA_T_6379	1
SEA_T_638	1, 2, 3, 4
SEA_T_6380	2, 4
SEA_T_6380a	2, 3, 4, 5
SEA_T_6381	2
SEA_T_6382	2, 3, 4
SEA_T_6383	1, 2, 3,

ID	Factor met
	4
SEA_T_6384	2, 3
SEA_T_6384a	2
SEA_T_6385	4
SEA_T_6387	3, 4
SEA_T_6388	4
SEA_T_6388a	3, 4
SEA_T_6388c	4
SEA_T_6388e	2, 4
SEA_T_6389	1, 2, 3, 4
SEA_T_639	4
SEA_T_6390	4
SEA_T_6391	2, 3, 4
SEA_T_6392	4
SEA_T_6393	1, 2, 3, 4
SEA_T_6395	2, 4
SEA_T_6396C	2
SEA_T_6397	1
SEA_T_6398	2, 3, 4
SEA_T_6399	1, 2, 3, 4
SEA_T_6401	2, 4
SEA_T_6402	2, 3
SEA_T_6403	2
SEA_T_6404	3, 4
SEA_T_6405	4
SEA_T_6406	2, 4
SEA_T_6407	1, 3, 4
SEA_T_6409	1, 4
SEA_T_641	2, 3
SEA_T_6410	1, 3, 4
SEA_T_6411	3, 4
SEA_T_6412	1, 2, 4
SEA_T_6414	2, 3, 4
SEA_T_6416	1, 2, 3
SEA_T_6416a	4
SEA_T_6418	3, 4
SEA_T_6419	2, 3
SEA_T_6420	4
SEA_T_6420a	4
SEA_T_6421	4
SEA_T_6422	4

ID	Factor met
SEA_T_6423	4
SEA_T_6424	4
SEA_T_6425	2
SEA_T_6426	2, 4
SEA_T_6427	1, 3, 4
SEA_T_6429	1, 3
SEA_T_643	2
SEA_T_6431	1, 2, 3, 4, 5
SEA_T_6432	3, 4, 5
SEA_T_6435	2
SEA_T_6436	1, 2, 3, 4
SEA_T_6436a	2
SEA_T_6438	2, 3, 4
SEA_T_6439	1, 2, 4
SEA_T_6441	1, 2, 3, 4
SEA_T_6442	1, 4
SEA_T_6444	2, 4
SEA_T_6445	4
SEA_T_6446	2
SEA_T_6447	2, 3
SEA_T_6448	4
SEA_T_6449	2
SEA_T_6450	2, 3
SEA_T_6451	1, 2, 3, 4, 5
SEA_T_6452	1, 3
SEA_T_6453	1, 2, 3
SEA_T_6454	2, 3
SEA_T_6456	2, 3
SEA_T_6458	2, 5
SEA_T_6459	1, 2, 3, 4
SEA_T_6459b	2, 4
SEA_T_646	1, 2, 3
SEA_T_6461	2
SEA_T_6462	2, 3, 4
SEA_T_6463	2, 3, 4, 5
SEA_T_6464	2
SEA_T_6466	2, 4
SEA_T_6467	2, 4
SEA_T_6468	2, 3, 4

ID	Factor met
SEA_T_6469	2, 3, 4
SEA_T_6469a	2, 3, 4
SEA_T_647	4
SEA_T_6470	2, 3, 4
SEA_T_6471	2, 3, 4
SEA_T_6473	2, 3, 4
SEA_T_6474	1, 2, 4
SEA_T_6475	1, 2
SEA_T_6477	4
SEA_T_6479	3
SEA_T_648	1, 2
SEA_T_6480	2, 3
SEA_T_6481	4
SEA_T_6482	4
SEA_T_6483	4
SEA_T_6484	3
SEA_T_6486	2, 3, 4
SEA_T_6490	4
SEA_T_6491	1, 2, 4
SEA_T_6492	1, 3, 4
SEA_T_6493	2, 3
SEA_T_6494	1, 2, 4
SEA_T_6495	3
SEA_T_6496	2, 4
SEA_T_6498	1, 2
SEA_T_6499	1, 2, 3, 4
SEA_T_65	1, 2, 4
SEA_T_6500	2
SEA_T_6501	1, 2, 4
SEA_T_6502	4
SEA_T_6503	1, 2, 3
SEA_T_6504	1, 2, 3
SEA_T_6505	1, 2, 4
SEA_T_6507	1, 2
SEA_T_6508	1, 2, 4
SEA_T_6509	3
SEA_T_651	3
SEA_T_6510	1, 3
SEA_T_6511	1, 2
SEA_T_6512	1, 2
SEA_T_6513	1, 2, 3, 4
SEA_T_6514	1, 2, 3,

ID	Factor met
	4
SEA_T_6515	2, 3, 4
SEA_T_6517	3, 4
SEA_T_6517a	2, 3
SEA_T_6518	1, 2, 4
SEA_T_6519	1, 2, 3, 4
SEA_T_6520	1, 2
SEA_T_6521	1, 2, 3
SEA_T_6522	1, 2, 3, 4
SEA_T_6523	1, 2, 3, 4
SEA_T_6524	2, 3, 4
SEA_T_6525	2, 3, 4
SEA_T_6526	2, 3, 4
SEA_T_6527	1, 2, 3, 4
SEA_T_6528	2, 4
SEA_T_6529	1, 2, 3, 4
SEA_T_6530	2, 3, 4
SEA_T_6532	1, 2, 3
SEA_T_6533	1, 2, 3
SEA_T_6535	1, 2
SEA_T_6536	2
SEA_T_6537	1, 2, 3
SEA_T_6539	2, 4
SEA_T_6540	2, 4
SEA_T_6543	1, 2, 3
SEA_T_6544	2, 3, 4, 5
SEA_T_6545	2, 3, 4, 5
SEA_T_6551	1, 2
SEA_T_6552	1, 2, 3, 4
SEA_T_6553	1, 2, 4
SEA_T_6553a	1, 2
SEA_T_6555	1, 2, 3
SEA_T_6556	1, 2, 3
SEA_T_6557	1, 4
SEA_T_6558	1, 2, 3
SEA_T_6563	2, 3, 4
SEA_T_6564	2
SEA_T_6565	1, 2, 3

ID	Factor met
SEA_T_6567	1, 2, 3, 4
SEA_T_6568	4
SEA_T_6569	2, 3
SEA_T_6570	1, 2, 3
SEA_T_6571	2, 3, 4
SEA_T_6572	1, 2, 4
SEA_T_6573	1, 2
SEA_T_6574	1, 2, 3
SEA_T_6575	1, 2, 3, 4
SEA_T_6576	1, 2, 3, 4
SEA_T_6577	1, 2, 3
SEA_T_6578	1, 2, 3
SEA_T_6579	1, 2, 3
SEA_T_6582	2, 3, 4
SEA_T_6583	3, 4
SEA_T_6584	1, 2, 3
SEA_T_6585	1, 2
SEA_T_6586	1, 2
SEA_T_6587	1, 2, 4
SEA_T_6588	1, 2
SEA_T_6589	2, 3, 4
SEA_T_6592	4
SEA_T_6593	4
SEA_T_6594	3, 4, 5
SEA_T_6595	1, 2, 3, 4
SEA_T_6597	3, 4
SEA_T_6598	2, 3, 4
SEA_T_6599	2, 3
SEA_T_66	1, 2, 3
SEA_T_6600	1, 2, 3, 4
SEA_T_6601	1, 2, 3, 4
SEA_T_6602	1, 2, 3, 4
SEA_T_6603	1, 2, 3, 4
SEA_T_6605	2, 3
SEA_T_6606	2, 3, 4
SEA_T_6607	1, 2, 3
SEA_T_6608	1, 2, 3
SEA_T_6609	2, 3
SEA_T_661	1, 2, 5
SEA_T_6610	3
SEA_T_6612	1, 2, 3
SEA_T_6613	1, 2, 3
SEA_T_6614	3
SEA_T_6615A	4
SEA_T_6616	3
SEA_T_6617	4
SEA_T_6618	2, 4
SEA_T_6619a	4
SEA_T_662	1, 2
SEA_T_6620	4
SEA_T_6621	1, 3
SEA_T_6622	, 2, 3, 4, 5
SEA_T_6623	1, 2, 3, 4
SEA_T_6624	2
SEA_T_6625	2, 3, 4
SEA_T_6626	1, 2
SEA_T_6627	1, 2, 3
SEA_T_6628	4
SEA_T_6629	2, 4
SEA_T_6630	4
SEA_T_6631	1, 2, 3
SEA_T_6632	1, 2, 3, 4
SEA_T_6634	2, 4, 5
SEA_T_6635	2, 4, 5
SEA_T_6636	1, 2, 3, 4, 5
SEA_T_6637	2, 4
SEA_T_6638	1, 2
SEA_T_6639	1, 2, 3, 4
SEA_T_6641	2, 3, 4
SEA_T_6642	1, 2, 4
SEA_T_6643	1, 2, 4
SEA_T_6644	1, 2, 4
SEA_T_6646	2, 4
SEA_T_6647	1, 2, 3, 4
SEA_T_6648	2, 3, 4
SEA_T_6649	4
SEA_T_6650	1, 2
SEA_T_6651	1, 4
SEA_T_6652	1, 2, 3, 4
SEA_T_6652a	1, 2
SEA_T_6652B	2
SEA_T_6654	1, 2, 3, 4
SEA_T_6655	1, 2, 3, 4
SEA_T_6656	2, 3, 4
SEA_T_6660	3
SEA_T_6664	4
SEA_T_6669	1, 2, 3, 4
SEA_T_667	1, 3
SEA_T_6671	2, 3, 4
SEA_T_6672	2, 4
SEA_T_6673	3, 4
SEA_T_6674	2
SEA_T_6674a	2, 3, 4
SEA_T_6675	4
SEA_T_6676	1, 2, 4
SEA_T_6677	1, 2, 3
SEA_T_6678	1, 2, 3, 4
SEA_T_668	2, 3, 4
SEA_T_6680B	2, 4
SEA_T_6681	1, 2, 3
SEA_T_6682	1, 2, 3, 4
SEA_T_6683	2, 4
SEA_T_6684	1, 2, 3, 4, 5
SEA_T_6685	1, 2, 3
SEA_T_6687	4
SEA_T_6689	3
SEA_T_6690	2, 3, 4
SEA_T_6691	2, 4
SEA_T_6692	2
SEA_T_6693	1, 2, 3, 4
SEA_T_6694	1, 2, 3, 4
SEA_T_6695	1, 2, 3
SEA_T_6698	1, 2, 3
SEA_T_6699	1, 2

ID	Factor met
SEA_T_670	1
SEA_T_6700	1, 2, 3
SEA_T_6701	3
SEA_T_6703	2
SEA_T_6705	3
SEA_T_6706	2, 3, 4
SEA_T_6707	1, 2, 3, 4
SEA_T_6708	1, 2, 3
SEA_T_6709	1, 2
SEA_T_671	1
SEA_T_6710	3
SEA_T_6710a	3, 4
SEA_T_6712	1, 2
SEA_T_6713	3
SEA_T_6714	4
SEA_T_6715	1, 3
SEA_T_6716	2
SEA_T_6717	1
SEA_T_6718	1, 3
SEA_T_6719	4
SEA_T_672	2, 3
SEA_T_6723	3, 4
SEA_T_6724	3
SEA_T_6725	1, 2, 3, 4
SEA_T_6726	1, 2, 4
SEA_T_6727A	1, 2, 4
SEA_T_6727B	2
SEA_T_6728	2, 4
SEA_T_6729	2, 4
SEA_T_6729a	4
SEA_T_6729d	2, 4
SEA_T_672a	5
SEA_T_673	1, 2
SEA_T_6730	1, 2
SEA_T_6731	2, 4
SEA_T_6732	1, 2, 3, 4
SEA_T_6735	1, 2
SEA_T_6736	1, 2
SEA_T_6737	1, 2, 3, 4, 5
SEA_T_6738	1, 2, 3

ID	Factor met
SEA_T_6739	1, 3, 4
SEA_T_674	1, 2
SEA_T_6740	2, 3, 4
SEA_T_6741	3
SEA_T_6743	1, 2, 3, 4, 5
SEA_T_6743B	2, 3
SEA_T_6744	3
SEA_T_6745	2, 4
SEA_T_6746	1, 3, 4
SEA_T_6746a	4
SEA_T_6747	2
SEA_T_6747a	2, 4
SEA_T_6748	1, 2, 3, 4, 5
SEA_T_675	2, 4
SEA_T_6750	2, 4
SEA_T_6751	3, 4
SEA_T_6752	3
SEA_T_675A	2, 3
SEA_T_6760	2
SEA_T_6761	4
SEA_T_6761a	2
SEA_T_6761b	2
SEA_T_6763	1, 2, 3
SEA_T_6765	1, 3
SEA_T_6766	1, 2, 3, 4
SEA_T_6767	2
SEA_T_6767a	2, 3, 4
SEA_T_6768	1, 2, 3
SEA_T_6769	1, 2, 3
SEA_T_676a	1, 4
SEA_T_6770	2, 3
SEA_T_6771	4
SEA_T_6773	1, 2, 3
SEA_T_6774	1, 3
SEA_T_6775	1, 2, 3
SEA_T_6776	1, 2, 3
SEA_T_6778	1, 4
SEA_T_6779	2, 3
SEA_T_6780	4
SEA_T_6780a	2
SEA_T_6781	1, 2, 3

ID	Factor met
SEA_T_6781a	1
SEA_T_6782	2, 4
SEA_T_6783	2, 3
SEA_T_6784	1
SEA_T_6784B	2, 4
SEA_T_6788	2
SEA_T_678a	2, 3, 4
SEA_T_679	1, 2, 5
SEA_T_6791	4
SEA_T_6792	4
SEA_T_6793	4
SEA_T_679a	4
SEA_T_68	1, 2
SEA_T_6800	3, 4
SEA_T_6804	2
SEA_T_6808	3, 4
SEA_T_6813	3, 4
SEA_T_6821	4
SEA_T_6823	3, 4
SEA_T_6824	1, 3
SEA_T_6825	4
SEA_T_6826	1, 2
SEA_T_683	2, 3, 4
SEA_T_6830	4
SEA_T_6834	4
SEA_T_6835	3, 4
SEA_T_6836a	3, 4
SEA_T_6840	2, 4
SEA_T_6841	1, 2, 3
SEA_T_6846	4
SEA_T_685	1, 2
SEA_T_6850	3, 4
SEA_T_6851	1, 2, 3
SEA_T_6852	1, 2
SEA_T_6853	2
SEA_T_6854	2
SEA_T_6856	1, 2, 3
SEA_T_6857	1, 2
SEA_T_6858	1, 2, 4
SEA_T_6859	1, 2
SEA_T_685A	3
SEA_T_686	2, 3
SEA_T_6860	4

ID	Factor met
SEA_T_6862	2, 3
SEA_T_6863	2
SEA_T_6865	2
SEA_T_6866	1, 2, 3
SEA_T_6867	2, 3
SEA_T_6868	1, 2, 3
SEA_T_6869	4
SEA_T_686a	1, 2, 3, 4
SEA_T_687	1, 3, 4
SEA_T_6870	3, 4
SEA_T_6871	3, 4
SEA_T_6873	3, 4
SEA_T_6875	4
SEA_T_6876	2, 3, 4
SEA_T_688	1
SEA_T_6881	2, 3
SEA_T_6886	1, 2, 3
SEA_T_6888	3
SEA_T_688a	1, 2, 3
SEA_T_6890	1, 2, 4
SEA_T_6893	4
SEA_T_6894	3, 4
SEA_T_6895	3, 4
SEA_T_6896	2, 3, 4
SEA_T_6897	3, 4
SEA_T_6898	1, 2, 4, 5
SEA_T_6899	2, 3
SEA_T_69	2
SEA_T_690	1, 2, 3
SEA_T_6900	1, 2, 3
SEA_T_6901	1, 2, 4
SEA_T_6902	2, 4
SEA_T_6903	1, 2
SEA_T_6904	2
SEA_T_6905	1
SEA_T_6906	1, 2
SEA_T_6907	1, 2
SEA_T_690a	1, 2, 3
SEA_T_691	1, 2
SEA_T_6911	4
SEA_T_6912	3, 4
SEA_T_6913	1, 2, 4

ID	Factor met
SEA_T_6914	2, 3
SEA_T_6915	1, 2, 3, 5
SEA_T_6916	2, 3, 4, 5
SEA_T_6917	2, 3, 4
SEA_T_6918a	4
SEA_T_6918b	4
SEA_T_691a	2, 3, 4
SEA_T_691d	4
SEA_T_692	4
SEA_T_6920	2, 3, 4
SEA_T_6921	1, 3
SEA_T_6922	4
SEA_T_6923	3
SEA_T_6926	1, 3
SEA_T_6927	1, 2, 3, 4
SEA_T_6928	3
SEA_T_6929	1
SEA_T_693	3, 4
SEA_T_6930	4
SEA_T_6931	1, 3
SEA_T_6934	4
SEA_T_6936	2
SEA_T_6938	1, 2
SEA_T_6939	1, 2
SEA_T_693a	2, 3
SEA_T_6940	1, 2, 4
SEA_T_6942	1, 2, 3, 4
SEA_T_6943	2, 3
SEA_T_6945	2, 3, 4
SEA_T_6946	2, 3, 4
SEA_T_6947	3
SEA_T_6948	2, 3, 4
SEA_T_6949	2, 3
SEA_T_6951	2
SEA_T_6952	1, 2, 3
SEA_T_6953	3
SEA_T_6954	3
SEA_T_6955	3
SEA_T_695A	1, 3
SEA_T_696	1, 2

ID	Factor met
SEA_T_6961	2, 3, 4
SEA_T_6966	1, 2
SEA_T_6969	1, 2, 3
SEA_T_696a	1, 2, 3
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SEA_T_800	2

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SEA_T_8074	4
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SEA_T_8079	2, 4

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SEA_T_8178	1, 2

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SEA_T_8393	4

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SEA_T_910	1, 2, 3, 4
SEA_T_9101	2, 4
SEA_T_9102 (9043)	1, 2, 4
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SEA_T_927	2, 4
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SEA_T_990	2
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Appendix 9: Stream Valuation Plan

Boffa Miskell

Huia Water Treatment Replacement Plant

Stream Ecological Valuation Plan

Prepared for Watercare Services Limited

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CONTENTS

Appendices

1.0 Introduction

1.1 Background

The Huia water treatment plant (WTP), located at the corner of Woodlands Park Road and Manuka Road, is Auckland's third-largest water treatment plant. It treats water from the Upper and Lower Huia Dams and Upper and Lower Nihotupu Dams, comprising almost 20 percent of Auckland's water supply. The plant is nearing the end of its operational life and needs to be replaced.

In June 2017, the Watercare Board adopted the recommendation of management, of the Manuka Road site, Waima, as the preferred site for the replacement treatment plant. The proposed replacement of the water treatment plant requires the reclamation of approximately 53 m of stream intermittent stream within the headwaters of the Yorke Gully Catchment. This stream is referred to as Stream 'Yorke_Project_Intermittent', or the 'Impact' Site (Boffa Miskell 2019).

The purpose of this report is to present the proposed outcomes for effects on freshwater habitats as a result of the proposed Huia replacement WTP project. The value of freshwater habitats will be evaluated, including their current and potential stream ecological functions using the Auckland Council Stream Ecological Valuation (SEV) method. The calculation of an Environmental Compensation Ratio (ECR) will be undertaken to confirm that a 'no net loss of area weight ecological functions' occurs and is adequate for the impacts of the Huia replacement WTP project.

We note that while the SEV method uses the term "compensation" to calculate the quantum of works required to offset the loss of stream (i.e., Ecological Compensation Ratio or ECR), the stream diversion that Watercare proposes is within the impact site and is mitigation rather than compensation.

1.2 Site Location

The proposed Huia Replacement Water Treatment Plant site (the 'WTP Site') is located adjacent to the existing plant in Waima. The WTP Site is located within the Waitakere Ecological District, in the peri-urban foothills of the Waitakere Ranges.

The existing Huia WTP currently sits within the upper reaches of Armstrong Gully, while the proposed replacement WTP will primarily be located within the headwaters of the Yorke Gully (left branch). The Yorke Gully receiving environment is located within Waitakere Ranges Regional Parkland, commonly referred to as Clarks Bush. Both streams discharge into the Waituna Stream, before discharging into Little Muddy Creek (Figure 1).

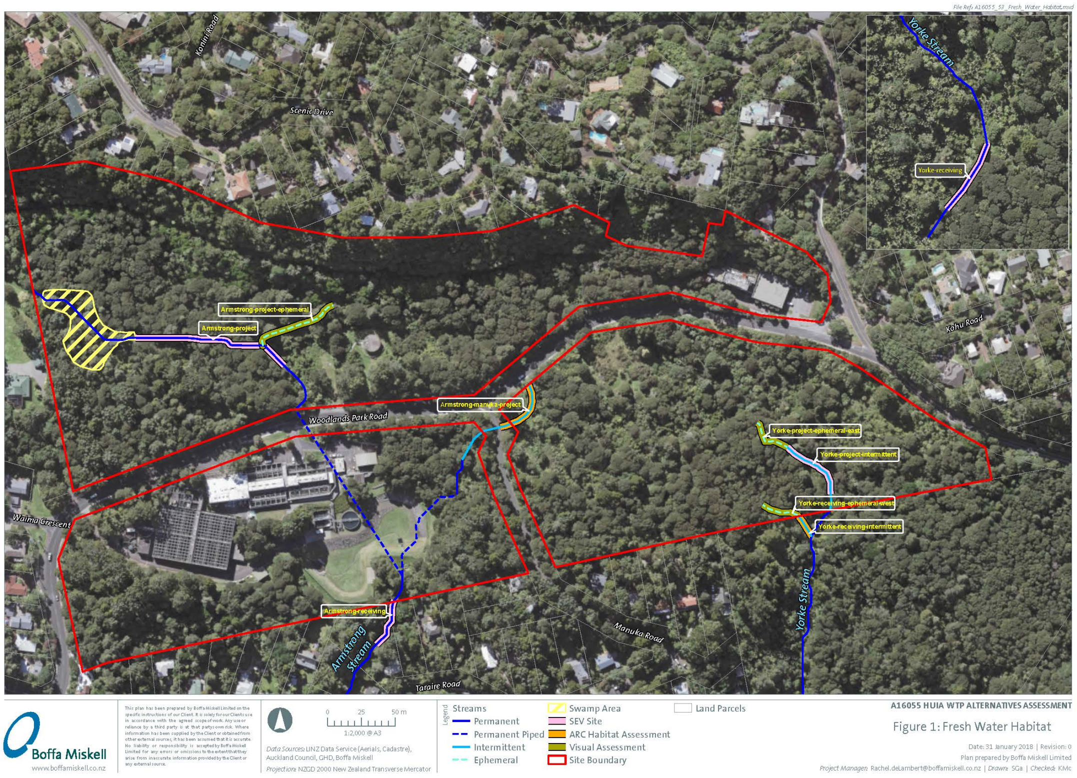

Figure 1. Watercourses at Waima, proposed Huia WTP upgrade

2.0 Survey Methods

2.1 Existing Ecology

2.1.1 Background

Prior to any field surveys being undertaken the location of the proposed footprint of works were assessed relative to freshwater habitats. The desktop review informed the type of freshwater habitats that may be encountered. A preliminary site visit was also undertaken at some locations by a qualified freshwater ecologist, prior to the formal freshwater survey fieldwork. The Auckland Council GIS platform, overland flow path layers, relevant New Zealand Freshwater Fish Database records, River Environment Classification stream orders and topographic maps were also utilised to inform the ecological value assessment.

2.1.2 Permanence Classification

Prior to any formal ecological assessment all watercourses within the proposed footprint of works were assessed for their permanence. This assessment was undertaken in the field by walking the length of all watercourses and was based on the definitions within the Auckland Unitary Plan – Operative in Part (Updated 14 December 2016), as outlined below. The permanence classification informed the survey site selection.

- Intermittent stream - Stream reaches that cease to flow for periods of the year because the bed is periodically above the water table. This category is defined by those stream reaches that do not meet the definition of permanent river or stream and meet at least three of the following criteria:

a) it has natural pools;
b) it has a well-defined channel, such that the bed and banks can be distinguished;
c) it contains surface water more than 48 hours after a rain event which results in stream flow;
d) rooted terrestrial vegetation is not established across the entire cross-sectional width of the channel;
e) organic debris resulting from flood can be seen on the floodplain; or
f) there is evidence of substrate sorting process, including scour and deposition.

- Ephemeral stream - Stream reaches with a bed above the water table at all times, with water only flowing during and shortly after rain events. This category is defined as those stream reaches that do not meet the definition of permanent river or stream or intermittent stream.

- Overland flow path - Low point in terrain, excluding a permanent watercourse or intermittent river or stream, where surface runoff will flow, with an upstream contributing catchment exceeding 4,000m²

g) Artificial watercourse - Constructed watercourses that contain no natural portions from their confluence with a river or stream to their headwaters. Includes; canals that supply water to electricity power generation plants; farm drainage canals; irrigation canals; and water supply races, but excludes naturally occurring watercourses.

2.1.3 Stream Ecological Valuation

The proposed activity is for a diversion of an intermittent stream of some 53 m in length. In order to verify the proposed diversion provides for an acceptable quantum of ecological function, we have applied the Stream Ecological Valuation (SEV) method.

The SEV is recommended by Auckland Council for providing an ecological valuation of stream functionality. The SEV uses a set of fourteen qualitative and quantitative variables to assess the integrity of stream ecological functions (Table 1; Auckland Council 2011). Field work consists of a comprehensive assessment of the in-stream and riparian environment. This includes a fish survey, aquatic macroinvertebrate sampling and cross-sections of the stream to measure width, depth and substrate, as well as using qualitative parameters for reach-scale attributes.

***Table 1**: Summary of 14 ecological functions used to calculate the SEV score (Auckland Council 2011).*

Hydraulic functions:	**Biogeochemical functions:**
Processes associated with water storage, movement and transport. Natural flow regime Floodplain effectiveness Connectivity for species migrations Natural connectivity to groundwater	Relates to the processing of minerals, particulates and water chemistry. Water temperature control Dissolved oxygen levels maintained Organic matter input In-stream particle retention Decontamination of pollutants
Habitat provision:	Biotic functions:
The types, amount and quality of habitats that the stream reach provides for flora and fauna. Fish spawning habitat Habitat for aquatic fauna	The occurrences of diverse populations of native plants and animals that would normally be associated with the stream reach. Fish fauna intact Invertebrate fauna intact Riparian vegetation intact

This data is analysed using a series of formulae in order to produce an SEV score of between 0-1, where a 0 is a stream with no ecological functionality and 1 is a pristine stream with maximum ecological function. Accepted interpretation of SEV scores is provided in Table 2.

***Table 2**: Interpretation of SEV scores (Adopted from Golder Associates, 2009).*

Score	Category
0 - 0.40	Poor
0.41 – 0.60	Moderate
0.61 – 0.80	Good
0.81+	Excellent

The application of the SEV methodology to intermittent streams has recently been tested through field trials, with the suitably of this method confirmed (Auckland Council 2016). The field assessment and variables assessed remains the same for intermittent reaches, with the only change being the reference data within the calculation spreadsheet (Auckland Council 2016). The recommended season for SEV assessments of intermittent streams is between July and October, following a minimum of two months of winter flows.

The field surveys were undertaken on 19 October 2018. The *impact* site (Site Yorke_project_intermittent) is an intermittent watercourse that contained almost no surface water at the time of surveying, with only three very shallow, isolated pools present. No flowing water was present. A partial SEV assessment was undertaken, with data collected on as many attributes as possible. However, these results may not be a true representation of ecological function of the stream, such as water depth, which predominantly resulted in zero depth at most survey transects.

Owing to the lack of surface water, the velocity, macroinvertebrate sample and fish surveys were unable to be undertaken. However, these attributes are excluded from the mitigation calculation (Section 2.2).

The SEV methodology also provides for the calculation of mitigation through the use of Environmental Compensation Ratio, which will inform the quantum of mitigation that is required.

2.2 Environmental Compensation Ratio

To help inform the quantum of mitigation to mitigate the impacts of stream reclamation an environmental compensation ratio (ECR) was calculated.

The environmental compensation ratio utilises the SEV score to calculate a ratio for the minimum area to be restored as mitigation for unavoidable stream loss. The ECR has the underlying principal of 'not net loss' and is based upon 'no net loss of area-weight stream function'. A minimum ratio of compensation of 1:1 is required, with the Auckland average for permanent urban streams of a 3:1 ratio. The formula for calculating the ECR is as below:

ECR = [(SEVi-P – SEVi-I)/(SEVm-P – SEVm-C)] x 1.5

- *SEVi-C & SEVi-P are the current and potential SEV values respectively for the site to be impacted.*
- *SEVm-C & SEVm-P are the current and potential SEV values respectively for the site where environmental compensation is to be applied.*
- *SEVi-I is the predicted SEV value of the stream to be impacted, after impact.*

The ECR calculation requires the prediction of a 'potential' and an 'impact' SEV score. The potential score for the impact site assumes that best practise enhancement works have been undertaken. The prediction of the impact scores assumes that the proposed streamworks have been undertaken.

The predicted potential and impact scores do not include biotic functions (invertebrate fauna intact and fish fauna intact) as they are too difficult to predict.

In order to get an SEVi-C score for the impact site, some attributes were predicted in the same manner they would be for 'potential' scores, assuming there was water within the channel. These predictions were based upon the site visit on 6 October 2017, where there was flowing water present within the channel.

3.0 Impact Site Existing Ecology

3.1 Freshwater Habitat

The proposed WTP Site is located to the south of Woodlands Park Road and east of Manuka Road, Titirangi. The location of the stream Yorke_Project_intermittent is to the south of the WTP Site and is located within the headwater catchment of the Yorke Gully (Figure 1; Table 3). The stream flows through the proposed WTP Site and into the open channel of the Yorke Gully Stream which intersects the adjoining Clarks Bush Reserve before discharging into Little Muddy Creek.

The stream Yorke_Project_intermittent is a small headwater intermittent stream, that was not flowing at the time of survey and contained very little surface water. The upper reach of the intermittent stream was determined by a small pool and cascade. Upstream of this location, the stream was classified as ephemeral.

The stream has an average bank to bank width (not wetted width) of 0.5 m (Table 3). The streambed is entirely silt/sand with moderate amounts of roots present across the stream channel, creating what would be small cascades during times of water flow. Three isolated pools of water were present with average water depth of 0.05 m. Shading along the stream channel is moderate, with nikau trees dominating the canopy. Ground cover is sparse, with some small areas of tradescantia present in the downstream end of the reach. The downstream section of the reach has steeper stream banks with some bryophyte patches.

The stream is naturally disconnected for fish passage from the downstream reach with excessive stream bank erosion and slumping outside of the WTP Site.

Table 3: *Images of Impact site.*

Stream banks were typically higher in the downstream section of the reach (0.3 m) than the upstream (0.15 m). There were small areas of undercut banks in the lower section of the reach. There was no active erosion present, but there was historical erosion evident around a small pool located at the upstream extent of the reach.

No macroinvertebrate or fish community surveys were undertaken.

3.2 Stream Ecological Valuation

Site Yorke_Project_Intermittent was classified as intermittent and at the time of the survey water within the reach was reduced to three small isolated pools (Table 4). As a consequence, a number of stream attributes were unable to be measured and a standard SEV score was unable to be calculated for this site. However, the results of those attributes that were able to be measured are discussed below (section 5.1).

The hydraulic function achieved the highest possible score (1.00), indicating a natural, stable stream channel with no external modification or inputs of stormwater and full access to the floodplain during storm events.

Biogeochemical function score includes measurements of stream water velocity, water depth and macrophyte abundance. While water depth was measured (with most depths 0.00), water velocity and macrophyte abundance were unable to be measured. Dissolved oxygen levels, and organic matter input both scored 1.00 showing high functionality. Functionality of pollutant decontamination and shade were both moderate, a result of patchy shade provided by overhead vegetation and the predominantly silt/sand substrate which provides limited surface area for biofilms.

Habitat provisions functions scored poorly, largely due to the unsuitability of fish spawning habitat, both for Galaxiidae and Gobiidae species.

Fish and macroinvertebrate communities were not surveyed as part of this SEV and are not included in the Biodiversity Provision functions score. Riparian condition and connection scored 0.80, demonstrating good functionality.

A predicted, current, SEV score for the Yorke_Project_Intermittent of 0.81 was calculated (Table 4). This predicted score is a high and is indicative of probable excellent ecological function.

4.0 Proposed Diversion Stream

4.1 Stream Design

The proposed diversion stream will be at least 70 m in length, with a minimum intermittent stream length of 70 m. The diversion watercourse will collect clean water from the upper catchment and bypass the WTP construction area (Figure 2). The watercourse will also collect treated stormwater from the WTP site via the outflow from a dry pond (Cook Costello 2019) (Figure 3). Water quality will be addressed through the construction of two proprietary devices on the WTP site. A stormfilter vault is proposed to provide treatment for the majority of WTP catchment (Cook Costello 2019).

The final diversion alignment will follow a similar alignment to the clean water diversion that is proposed to be used during the construction works. The diversion channel will mimic, where practical, the existing stream morphology and will replicate the natural steepness of the site. The design will take into account any energy dissipation to avoid scour within the realigned stream and minimise scour in the downstream receiving Yorke Gully. The final design will comprise a sequence of pools and cascades along its length and will meander across the contours to the boundary of the site, where it enters the mainstem of Yorke Gully.

The diversion channel will be designed to maintain and improve the existing SEV values, including enhancement to the riparian margins, and will provide improved overall aquatic ecological benefit, and we recommend that a condition of consent be prepared to ensure this occurs.

A 10 m average planted riparian zone on both sides of the diversion is recommended. However, it is anticipated that the banks of the diversion will likely to be more sinuous in width (i.e., a mix of wider and narrower margins) due to the nature and requirements of construction activities. It is recommended that a riparian planting plan be developed as part of the stream diversion design. In particular improvement to the vegetated lower stature ground cover close the stream will improve instream habitat.

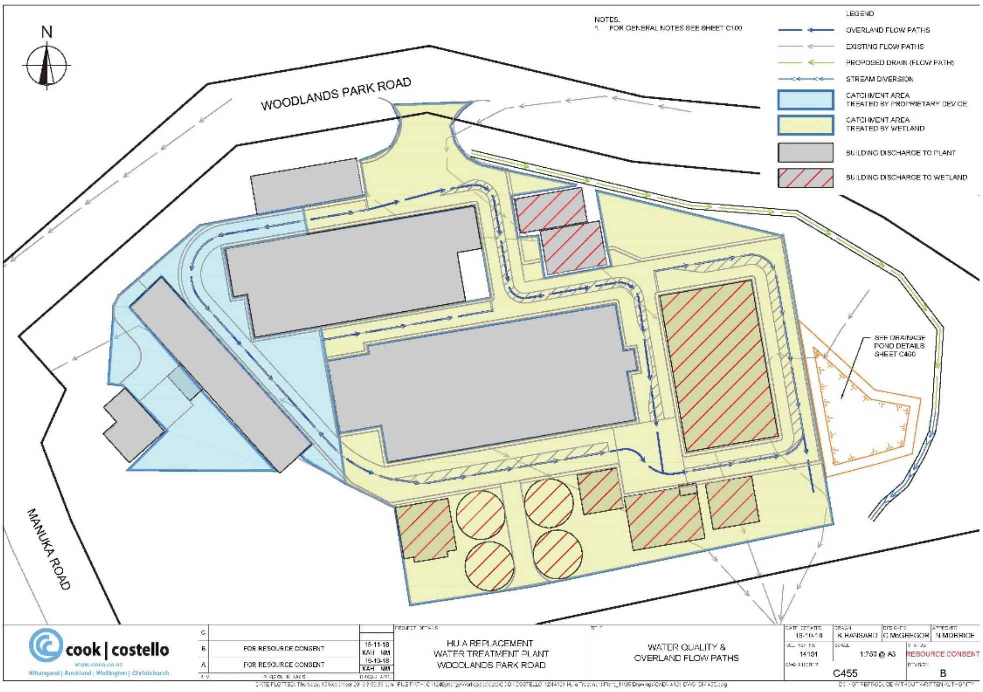

Figure 2: Water quality and overland flow paths with drainage pond and stream diversion (from Cook and Costello 2019).

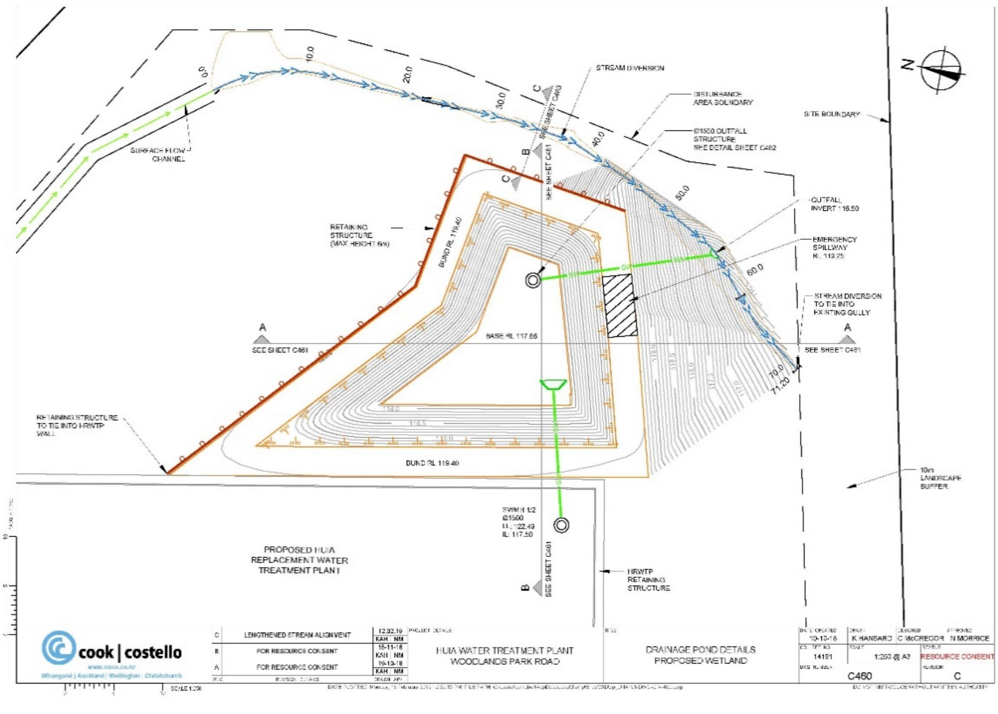

Figure 3: Proposed drainage pond and stream diversion at the replacement Huia WTP project (from Cook and Costello 2019).

5.0 Effects Management

5.1 Stream Diversion Channel

An accepted method for quantifying the amount of benefit required for unavoidable stream loss is the use of Stream Ecological Valuation (SEV) surveys and the environmental compensation ratio (ECR). The ECR utilises the SEV score to calculate a ratio to mitigate for stream loss. The ECR requires the calculation of the current value of the impact reach (SEVi-C) and the potential value (SEVi_P). The -C value is as surveyed, while the -P value is a predicted score that requires numerous assumptions to be made about the potential value of the reach based upon best practise enhancement being undertaken. The ECR also requires the calculation of the current ('SEVm-C') and potential ('SEVm-P') values of the compensation reach.

The SEV and ECR calculation will form the basis of the confirmation of ecological function of the diversion.

The current SEV had a number of attributes that were estimated as there was very little surface water at the time of the survey (See Appendix 1). This resulted in an SEVi-C (no FFI or IFI) score of 0.81 (Table 4). The predicted score after best practice mitigation for the impact site returned a SEVi-P score of 0.81.

The SEVm-P for the proposed diversion channel returned a score of .65. The predicted SEV score for the diversion channel is lower than that of the current channel to be reclaimed. The stream diversion design has yet to be finalised, and the attribute scores were conservatively estimated. The design of the diversion channel is to mimic the current channel to be reclaimed and this is reflected in the predicted scores. However, the lower SEVm-P is attributable to the prediction of an inflow from the stormwater device, the possibly of a weir-like device within the diversion to maintain water levels, a possible lack of connection between the channel and riparian zone in some sections and the increase in impervious surface within the catchment. While these factors result in a lower SEV score, it is not predicted that this will result in an actual reduction in ecological functionality.

Table 4: *Current and predicted SEV scores for use in ECR calculations.*

Function	**Yorke_Project** ***Intermittent***			**Proposed Diversion**	
	SEVi-C *Predicted current score owing to lack of water*	**SEVi-P** *Predicted potential from Restoration*	**SEVi-I** *Predicted after impact*	**SEVm-C** *Current value of mitigation site*	**SEVm-P** *Predicted value of mitigation site*
Natural Flow Regime	1.00	1.00	0	0	0.68
Floodplain Effectiveness	1.00	1.00	0	0	0.38
Connectivity for natural species migrations	1.00	1.00	0	0	1.00
Natural connectivity to groundwater	1.00	1.00	0	0	01.
Hydraulic Functions	**1.00**	**1.00**	**0.00**	**0.00**	**0.76**
Water temperature control	0.64	0.64	0	0	0.70
Dissolved oxygen levels	1.00	1.00	0	0	1.00
Organic matter input	1.00	1.00	0	0	0.75
Instream particle retention	1.00	1.00	0	0	0.96
Decontamination of pollutants	0.48	0.48	0	0	0.4
Biogeochemical Functions	**0.82**	**0.82**	**0.00**	**0.00**	**0.76**
Fish Spawning Habitat	0.05	0.05	0	0	0.10
Habitat for aquatic fauna	0.72	0.74	0	0	0.59
Habitat Provisions Functions	**0.39**	**0.40**	**0.00**	**0.00**	**0.34**
Fish Fauna Intact	-*	-*	-*	-*	-*
Invertebrate Fauna Intact	-*	-*	-*	-*	-*
Riparian Vegetation Intact	0.80	0.80	0.00	0.00	0.26
Biodiversity Provision Functions	**0.80**	**0.80**	**0.00**	**0.00**	**0.26**
SEV Score	**0.81**	**0.81**	**0.00**	**0.00**	**0.65**

* - not included in ECR SEV score.

Table 5: *SEV ECR calculations.*

Impact Site	Yorke_Project_Intermittent
Mitigation Sites	*Diversion Channel*
ECR	1.87
Length of impacted stream	53 m
Average width impacted stream	0.5 m
Area of compensation required	49.5 m^2
Length compensation available	70 m
Average width compensation site	0.5 m
Proportion of impact reach compensated for	71%
Comments	To mitigate for the reclamation of approximately 53 m of intermittent channel at site *Yorke_Project_intermittent* a stream diversion of at least 100 m in length is required. The proposed diversion channel is approximately 70 m in length. This satisfies the minimum requirement of a ratio of 1:1 but does not satisfy the minimum area calculated by the ECR. There is a shortfall of 30 m in length, or 15 m^2 of habitat.

The proposed mitigation of a 70 m stream diversion does not meet the quantum calculated by the ECR, accounting for some 71% of the stream loss. However, the proposed diversion channel is more than the minimum requirement of 1:1 replacement.

It is acknowledged that there is some uncertainty within the current and predicted SEV scores used in the ECR calculations, particularly with the diversion channel design yet to be finalised. The predicted score for the diversion channel was conservatively estimated, and the final design may result in a higher SEV that will result in a reduction of the amount of mitigation required.

5.2 Armstrong Headwater Stream Daylighting

The feasibility of daylighting piped sections of the Armstrong_Manuka watercourse are being investigated. The daylighting of this section of stream has the potential to offset the remaining 29% of required mitigation.

It is proposed to daylight two sections of piped stream, totalling approximately no less than 41 m in length. We understand that some 80 m of piped stream is available for daylighting. No SEV surveys have been undertaken on Armstrong_Manuka and consequently no formal ECR ratio has been calculated.

A predicted ECR calculation has be undertaken using the score from the adjacent headwater stream branch of Armstrong_impact, with the following scores applied:

- SEVi-P = 0.8
- SEVi-I = 0.0
- SEVm-C = 0.2
- SEVm-P = 0.7

Both impact scores are those utilised for the diversion ECR calculation and are based on the partial SEV and associated function score assumption undertaken on Yorke_Project_intermittent. The SEVm-C is the widely accepted SEV score that is applied to culverts. The SEV-mP is an adjusted (lowered) score taken from the SEV score of reach Armstrong_Manuka. This reach is located on an adjacent headwater branch of the Armstrong Stream. The daylighted channel is likely to be similar, or of higher ecological value, than this existing stream reach.

The reach Armstrong_impact had an average channel width of 0.47m. Therefore, it is predicted that a minimum of 41 meters of Armstrong_Manuka would need to be daylighted to offset the remaining 29% of impact.

Impact Site	Yorke_Project_Intermittent
Mitigation Sites	*Armstrong Stream_Manuka Tributary*
ECR	2.43
Length of impacted stream	53 m
Average width impacted stream	0.5 m
Area of compensation required	64.4 m^2
Length compensation available	41 m *(minimum required)*
Average width compensation site	0.47 m
Proportion of impact reach compensated for	29% *(required remaining compensation)*
Comments	To mitigate for the reclamation of approximately 53 m of intermittent channel at site *Yorke_Project_intermittent* a stream diversion of at least 100 m in length is required as outlined in Section 5.1.The proposed diversion channel has a shortfall of approximately 29% of the impact. The daylighting of the Armstrong_Manuka piped sections is able to fulfil the offset requirements if a minimum of 41 m of habitat is daylighted.

6.0 Summary

The proposed upgrade of the Huia WTP will result in the diversion of approximately 53 m of intermittent stream channel. The diversion of this stream channel will result in the development of an intermittent stream channel at least 70 m in length and the daylighting of at least 41 m of the Armstrong_Manuka tributary. Thus, the overall package encompasses both the creation of a stream diversion channel to mitigate on-site effects, and the daylighting of a currently piped channel (to provide additional benefit as a compensatory measure).

7.0 References

Auckland Council 2011. Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams. Auckland Council Technical Report 2011/009.

Auckland Council (2016). Stream Ecological Valuation: application to intermittent streams. Prepared by Golder Associates (NZ) Limited for Auckland Council. Auckland Council technical report, TR2016/023.

Boffa Miskell Limited 2019. Huia WTP Upgrade: Stream Environmental Compensation Plan. Report prepared by Boffa Miskell Limited for Watercare Services Limited.

Cook Costello 2019: Huia Replacement Water Treatment Plant, Woodlands Park Road: Civil Stormwater and Erosion and Sediment Control Report. Report prepared for Watercare Services Limited.

Appendix 1: SEV and ECR Assumption Tables

Yorke_impact	Yorke_Project_*Intermittent*			Proposed Diversion	
	SEVi-C *Predicted current score owing to lack of water*	SEVi-P *Predicted potential from Restoration*	SEVi-I *Predicted after impact*	SEVm-C *Current value of mitigation site*	SEVm-P *Predicted value of mitigation site*
Vchann	Measured	No change	*No stream*	*No stream*	Assume same as SEVi-C
Vlining	Measured	No change	*No stream*	*No stream*	Allowance has been made for 5% of the channel to be affected by instream structure such as ponding due to culvert or weir
Vpipe	Measured	No change	*No stream*	*No stream*	Assume same as SEVi-C
Vbank	Measured	No change	*No stream*	*No stream*	
Vrough	Measured	No change	*No stream*	*No stream*	Have assumed a single piped discharging
Vbarr	Measured	No change	*No stream*	*No stream*	Have assumed 50 % of channel has floodplain access, while the other 50% does not connect to the floodplain.
Vchanshape	Autopopulated	Autopopulated	Autopopulated	Autopopulated	Assume Regenerating indigenous vegetation in a late stage of succession.
Vshade	Measured	No change	*No stream*	*No stream*	Have assumed 20m on TLB and 10m on TRB.
Vdod	Measured	No change	*No stream*	*No stream*	Assume same as SEVi-C
Vveloc	*Not included*	*Not included*	*No stream*	*No stream*	Have not assumed any barriers above natural barriers already present within the channel.
Vdepth	Measured	No change	*No stream*	*No stream*	Autopopulated
Vripar	Measured	No change	*No stream*	*No stream*	Assume slight improvement from SEVi-C with increased high shading.
Vdecid	Measured	No change	*No stream*	*No stream*	Assume same as SEVi-C – optimal
Vmacro	Measured	No change	*No stream*	*No stream*	Not included
Vretain	Autopopulated	Autopopulated	Autopopulated	Autopopulated	Assume slight difference from SEVi-C with increased areas of depth
Vsurf	Measured	No change	*No stream*	*No stream*	Have assumed 20m on TLB and 10m on TRB.
Vripfilt	Measured	No change	*No stream*	*No stream*	Assume no deciduous species present
Vgalspwn	Measured	No change	*No stream*	*No stream*	Assume same as SEVi-C
Vgalqual	Measured	No change	*No stream*	*No stream*	Assume no macrophyte species present
Vgobspawn	Autopopulated	Autopopulated	Autopopulated	Autopopulated	Autopopulated
Vphyshab	Assume moderate habitat diversity and abundance of habitat and low hydrologic heterogeneity.	Assume small increase in habitat diversity and abundance.	*No stream*	*No stream*	Assume slight difference from SEVi-C with increased amounts of cobble and bedrock present, but still predominantly silt/sand.
Vwaterqual	Measured	No change	*No stream*	*No stream*	Assume 75% high filtering activity and 25% no filtering activity, to reflect the predicted riparian vegetation.

Vimperv	Measured	No change	*No stream*	*No stream*	Assume same as SEVi-C
Vfish	No change – excluded from model	No change – excluded from model	No change – excluded from model	No change – excluded from model	No fish passage up to reach (naturally obstructed downstream).
Vmci	No change – excluded from model	No change – excluded from model	No change – excluded from model	No change – excluded from model	Assume same as SEVi-C
Vept	No change – excluded from model	No change – excluded from model	No change – excluded from model	No change – excluded from model	No low stature vegetation, twigs or gravels.
Vinvert	No change – excluded from model	No change – excluded from model	No change – excluded from model	No change – excluded from model	Autopopulated
Vripcond	Autopopulated	Autopopulated	Autopopulated	Autopopulated	Assume moderate habitat diversity and abundance of habitat and low hydrologic heterogeneity based on current channel geomorphology and observations made on 6 October 2017 when flowing water was observed… Assume lower riparian vegetation integrity owing to 10m riparian margin on TRB.
Vripconn	Measured	Measured	*No stream*	*No stream*	Assume partial shading upstream.

About Boffa Miskell

Boffa Miskell is a leading New Zealand professional services consultancy with offices in Auckland, Hamilton, Tauranga, Wellington, Christchurch, Dunedin and Queenstown. We work with a wide range of local and international private and public sector clients in the areas of planning, urban design, landscape architecture, landscape planning, ecology, biosecurity, cultural heritage, graphics and mapping. Over the past four decades we have built a reputation for professionalism, innovation and excellence. During this time we have been associated with a significant number of projects that have shaped New Zealand's environment.

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