Proposed Sutton Block, Drury Quarry

E4:9 Residual Effects Analysis Report – Terrestrial Ecology

for: Stevenson Aggregates Limited

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P.O. Box 2027, Auckland 1140. New Zealand
www.Bioresearches.co.nz

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Author(s)	Chris Wedding, M.Sc. (Hons), MEIANZ, Ecology Manager, Lead Author – Terrestrial	
	Jennifer Shanks, M.Sc. (Hons), MEIANZ, Director, JS Ecology	
	Dr Michael Anderson, PhD, MEIANZ, Senior Ecologist	
Reviewer(s)	Jennifer Shanks, M.Sc. (Hons), MEIANZ, Director, JS Ecology	
	Chris Wedding, M.Sc. (Hons), MEIANZ, Ecology Manager, Lead Author – Terrestrial	

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Cover Illustration: Kanuka forest edge and identified location for biodiversity offset (May 2022).

EXECUTIVE SUMMARY

Stevenson Aggregates Limited (SAL) is proposing a new quarry pit and associated facilities ('the Project') to extend the life of its Drury (Auckland) Quarry operation. The Project area is largely zoned as a 'Special Purpose Zone: Quarry' (SPQZ) under the Auckland Unitary Plan – Operative in Part (AUP) and comprises some 108 ha of terrestrial environments that are predominantly grazing pasture, with fragments of indigenous and exotic vegetation. The terrestrial features within the Project (vegetation and habitats) have been described in the ecological impact assessment (EcIA) by Bioresearches and JS Ecology (December 2024). That assessment concluded that biodiversity offsetting and/or biodiversity compensation actions will be required to counterbalance significant residual adverse effects, following measures that would be undertaken to avoid and minimise those effects.

This Residual Effects Analysis Report - Terrestrial Ecology describes how 62.38 ha of restoration planting and 108 ha of forest enhancement actions would demonstrate net gain outcomes that counterbalance the loss of 16.78 ha of fragmented and degraded vegetation and habitat. Biodiversity Offset Accounting Models (BOAM) have been used to assess the quantum of offset actions required to demonstrate the net biodiversity gain with confidence.

Three different ecosystem types would be affected: Broadleaved podocarp forest (7.33 ha), Kanuka scrub/forest (8.8 ha) and Rock Forest (0.65 ha). These ecosystem types have been modelled separately and the quantum of biodiversity offset, and compensation actions required have been determined for each type. In addition, individual mature native trees that are scattered across the site have been included in the assessment and offset modelling.

The proposed biodiversity offset and compensation actions include a total of 62 ha of revegetation and 108 hectares native forest enhancement through mammalian predator and pest control. Loss of individual trees will be addressed through replacement planting to provide a net biodiversity gain. The offset and compensation sites selected are primarily *in situ*, in the immediate area surrounding the existing and proposed pits, on the Drury Quarry property. Five hectares of the revegetation planting will occur at the Drury Islands (Ngā Motu o Hingaia) site. Additional contingency planting and enhancement is available at the Tuakau site owned by SAL, should it be required. Offset and compensation actions are therefore very close to the impact site and within the same ecological district.

Details for ongoing monitoring are provided with specified targets and contingency plans for each of the offset and compensation actions to ensure the modelled biodiversity gains are achieved. A net gain in biodiversity values is anticipated following the completion of all offset and compensation actions.

DOCUMENT GUIDE

As part of the Sutton Block pit expansion, a full suite of ecology assessments, reports and plans have been developed (Table 1). A summary of each document, including its objectives and key findings are provided in this section. This table is provided at the start of each ecology document with the relevant document highlighted to improve navigation. This document is 4 of a series of 9 ecology documents (E4:9).

Table 1. Documents prepared as part of this project

Document name (abbreviated name)	Aspects covered
E1:9 Ecology Documents Guide and Summary	Summary of the whole project and guidance for navigating documents.
Ecological Impact and Management	
E2:9 Ecological Impact Assessment (EcIA)	Assessment of ecological values and impacts of the proposed Sutton Block on terrestrial and freshwater ecosystems, including regenerating and mature forest fragments, water courses and wetlands. Fauna values include common native invertebrates and birds, At Risk pipit, copper skinks, longfin eel and (potentially) threatened long-tailed bats. Recommendations are provided for avoiding, managing, offsetting and compensating for significant residual adverse effects.
E3:9 Ecological Management Plan (EMP)	Management of ecological impacts in accordance with the effects management hierarchy, prior to and during and following construction. Specific impacts and values addressed in this Plan include: a) Management of Vegetation Removal b) Avifauna Management Plan c) Long-Tailed Bats Management Plan d) Native Lizard Management Plan e) Edge Effects Management Plan f) Native Freshwater Fauna Management Plan g) Sutton Block Riparian Planting Plan
Residual Effects Analysis Reports (REAR)	
E4:9 REAR: Terrestrial Ecology (REAR-TE)	Residual effects on terrestrial ecosystems and fauna
E5:9 REAR: Stream and Wetland Loss (REAR-SW)	Residual effects on freshwater ecosystems
Net Gain Delivery Plans (NGDP)	
E6:9 NGDP: Planting Plan (NGDP:PP)	Terrestrial offset planting
E7:9 NGDP: Pest and Weed Control (NGDP:PWC)	Terrestrial offset pest and weed control
E8:9 NGDP: Wetland Planting (NGDP:WP)	Freshwater offset planting of wetlands.
E9:9 NGDP: Riparian Planting (NGDP:RP)	Freshwater offset planting of streams.

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation/Acronym	Explanation
AEE	Assessment of Ecological Effects
AUP	Auckland Unitary Plan
BBOP	Business and Biodiversity Offsets Programme
BCM	Biodiversity Compensation Model
BOAM	Biodiversity Offset Accounting Model
EcIA	Ecological Impact Assessment
ED	Ecological District
Ha	Hectares
NGDP:PP	Net Gain Delivery Plan: Planting Plan
NGDP:PWC	Net Gain Delivery Plan: Pest and Weed Control
NVS	National Vegetation Survey
REAR-TE	Residual Effects Analysis Report - Terrestrial Ecology
SEA	Significant Ecological Area
Spp	Species
SPQZ	Special Purpose Quarry Zone
VS2	Kānuka scrub/forest
VS5	Broadleaved species scrub/forest
WF9	Taraire, tawa, podocarp forest
WF11	Kauri, podocarp, broadleaved forest

1 INTRODUCTION

Stevenson Aggregates Limited (SAL) Drury Quarry is located in Drury, within the Auckland Region, and has been in operation for over 80 years. Drury Quarry is a greywacke hard rock quarry supplying concrete, asphalt and roading aggregate to the Auckland market. The Drury Quarry pit is located within the wider landholdings owned by SAL which encompasses an area of approximately 562 ha. This landholding includes quarry activities, a clean fill, farmland, and large swathes of native vegetation.

Stevenson Aggregates Limited (SAL) is proposing a new quarry pit and associated facilities ('the Project') to extend the life of its Drury (Auckland) Quarry operation. The new pit would be excavated within an area to the north-east of the existing pit, within an area known as the Sutton Block ('the Site'). The Sutton Block comprises approximately 108 ha of predominantly grazing pasture, with fragments of indigenous and exotic vegetation (Figure 1) as described in an EcIA of the proposed new pit and associated activities (Bioresearches and JS Ecology November 2024). Freshwater and wetland management and offsetting is addressed in a separate report (Bioresearches 2024).

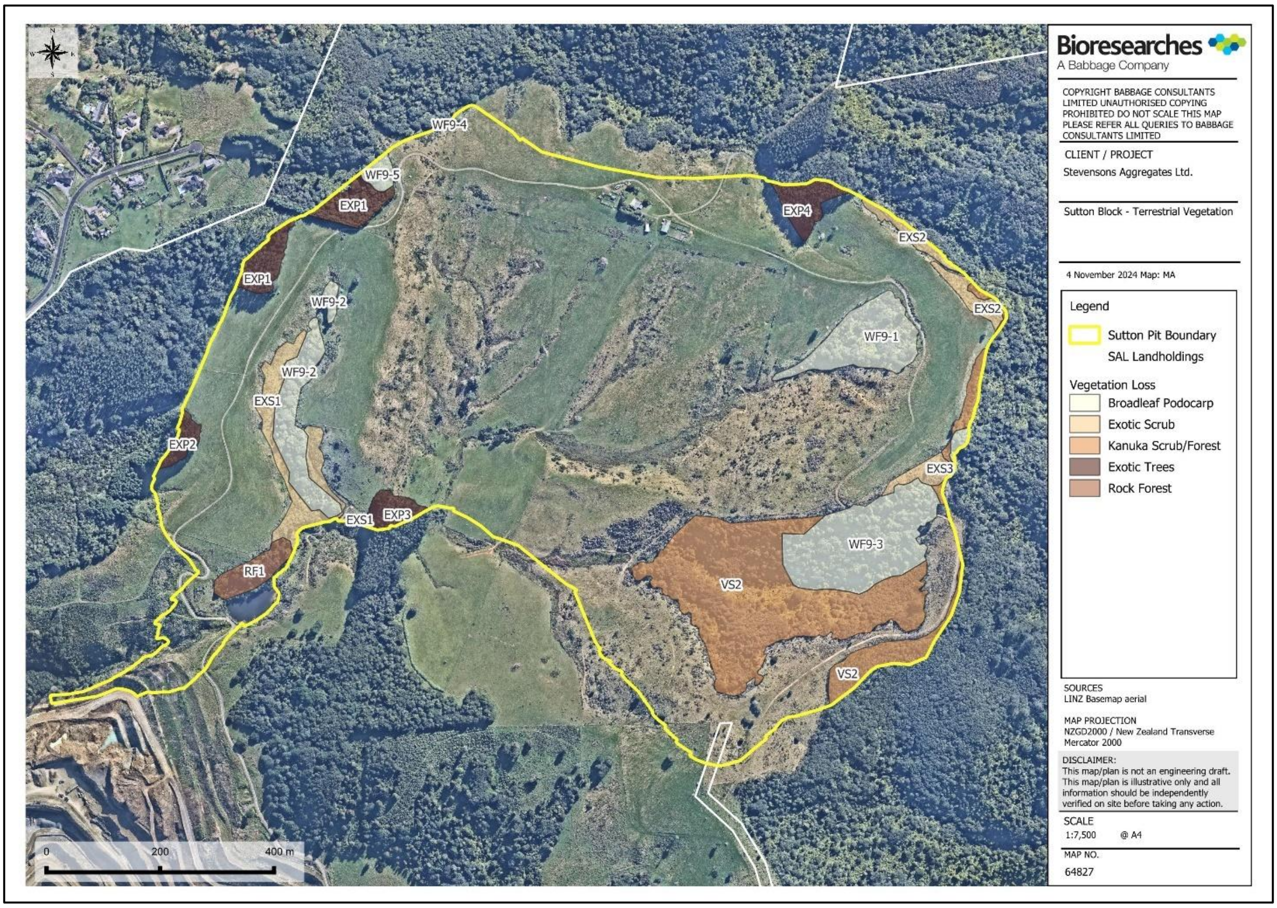

Figure 1. Areas of indigenous and exotic vegetation loss within the proposed Sutton Pit Project area.

In total, 16.78 ha of indigenous vegetation and fauna habitat would be removed to accommodate the new pit and associated infrastructure (Figure 1). Some of these features are considered significant under the Auckland Unitary Plan (SEA_T_1117 and SEA_T_5323), and one of these, SEA_T_1117, would be removed entirely.

1.1 Summary of terrestrial ecology effects

The Project will result in the removal of negligible to very high value vegetation and habitats, and this is expected to result in very low to high levels of residual adverse ecological effects (see E1:9 EcIA for details). This report addresses significant residual adverse effects on terrestrial ecology values only. Only those residual effects greater than 'Low' are considered to be significant, and therefore require further actions to offset or compensate. This report should be read in conjunction with other ecological plans (refer Table 1).

1.1.1 Direct effects

The loss of native vegetation from within Stages 1-5 of the proposed Sutton Block Pit would result in significant direct adverse effects. Direct effects on fauna (e.g. mortality, injury) would be minimised to low levels by way of pre-works surveys, timing of vegetation removal and targeted species management, and as detailed in other management plans within the EMP (E3:9). However, the permanent loss of this vegetation and habitat (0.65 ha rock forest, 7.33 ha broadleaved podocarp forest, 8.8 ha kanuka forest and a number of individual native trees) would represent a significant residual adverse effect, and this effect would be offset in accordance with this Plan.

1.2 Statutory Context and Application of Effects Management Hierarchy

1.2.1 Auckland Unitary Plan (AUP)

The Auckland Unitary Plan contains specific provisions in relation to the Drury Quarry SPQZ which set out the particular rules and matters of discretion that apply to the removal of vegetation within an SEA. These provisions are found in Chapters D9 and E15 of the AUP. Avoidance is not required within the actual rock extraction area under these provisions; however, minimisation and mitigation of significant adverse effects must be demonstrated (for details about how these requirements are met see section 1.2.2 below, and accompanying Assessment of Ecological Effects report).

1.2.2 National Policy Statement for Indigenous Biodiversity (NPSIB)

The National Policy Statement for Indigenous Biodiversity (New Zealand Government, 2023) requires that identified adverse effects within SNAs are avoided, except where provided for under Clause 3.11, which identifies significant national or regional benefit that cannot otherwise be achieved using resources within New Zealand (NPSIB, 3.11(1(aiii))). An explanation of the Project proposal with respect to this exception is provided with the application. However, where adverse effects are managed pursuant to subclause 3, the following is required to be demonstrated:

1. How each step of the effect's management hierarchy will be applied (refer section 1.2.1 below).

if biodiversity offsetting or biodiversity compensation is applied, how the proposal has complied with principles 1 to 6 in Appendix 3 and 4 and has had regard to the remaining principles in Appendix 3 and 4, as appropriate.

1.2.2.1 Effects Management Hierarchy (NPSIB, 2023)

The effects management hierarchy is an approach to managing the adverse effects of an activity on indigenous biodiversity that requires that:

adverse effects are avoided where practicable; then
where adverse effects cannot be avoided, they are minimised where practicable; then
where adverse effects cannot be minimised, they are remedied where practicable; then

a. where more than minor residual adverse effects cannot be avoided, minimised, or remedied, biodiversity offsetting is provided where possible; then
b. where biodiversity offsetting of more than minor residual adverse effects is not possible, biodiversity compensation is provided; then

if biodiversity compensation is not appropriate, the activity itself is avoided.

1.2.2.2 Drury Quarry Sutton Block Approach to the Effects Management Hierarchy

1.2.2.2.1 Adverse effects that are avoided, where practicable

Sutton Block has been specifically designed to avoid very high value rock forest at Kaarearea paa (SEA_T_5349) and an area of watercourse and wetland to the northeast of Kaarearea paa. Kaarearea paa is also of high cultural significance, and cultural values have shaped the final proposed pit design.

The proposed pit also largely occupies an open space with localised vegetation cover, generally avoiding a larger area of SEA (SEA_T_5323), which surrounds the Sutton Block Pit to the north and the east.

1.2.2.2.2 Adverse effects that are minimised, where practicable

Species-specific adverse effects (mortality) are minimised through specific methodology, as addressed in management plans such as capture-relocation, habitat enhancement and pre-vegetation removal surveys to avoid nesting birds and roosting bats. The following terrestrial management plans have been prepared separately to detail methods required to minimise these adverse effects in addition to the current report:

a. Native lizard management plan
b. Avifauna management plan
c. Long-tailed bat management plan
d. Edge- effects management plan

1.2.2.2.3 Adverse effects that are remediated, where practicable

No adverse effects are proposed to be remediated, as all vegetation and habitat values that are proposed to be removed, would be within the proposed quarry pit.

1.2.2.2.4 Residual adverse effects that are offset

The Project will offset the residual adverse effects on the following biodiversity types because they meet the principles for biodiversity offsetting as set out in Appendix 3 of the NPSIB and detailed in

Table 3.

- Very high-level effect resulting from the permanent loss of high value rock forest.

Moderate-level effect resulting from the permanent loss of Moderate value Taraire, tawa podocarp forest.

- Moderate-level effect resulting from the loss of Moderate value Kanuka forest.

1.2.2.2.5 Residual adverse effects that are compensated

No compensation actions are proposed for any residual effects..

1.2.2.2.6 Additional Conservation Actions

As per the EIANZ guidelines (Pg 98, Roper-Lindsay et al., 2018), additional conservation actions can be undertaken, in addition to Biodiversity Offsetting or Compensation, providing further additional biodiversity gains. Mature native trees have ecological value as sources of seed for regeneration in nearby forest habitats and as potential sources of food and nest/roost sites for mobile native fauna such as birds. Although their overall value to the Sutton site is assessed as Low and the level of effect due to their loss as Very low, replacement planting to offset their loss is considered appropriate. This will ensure the resources they provide are replaced and exceeded in the long term and their genetic provenance is maintained.

- Low level of effect resulting from loss of relict native trees amongst pasture

<u>Biodiversity offsetting</u>

Table 2 summarises the expected biodiversity losses, recommended mitigation measures, and biodiversity offset actions to be undertaken with respect to terrestrial values. This REAR-TE focuses on the offset component of the proposed biodiversity management for SAL's proposed Sutton Block Pit.

Table 2. Magnitude and level of effect of the proposed works to terrestrial habitats and fauna – prior to and after residual effects management measures.

Biodiversity component	Ecological value	Level of Effect (without minimisation)	Loss (ha)	Conservation management action	Level of effect after management action
Rock forest	High	Very High	0.65	Offset planting and enhancement	Net Gain
Taraire, tawa podocarp forest	Moderate	Moderate	7.33	Offset planting and enhancement	Net Gain
Kānuka forest	Moderate	Low	8.8	Offset planting and enhancement	Net Gain
Relict native trees	Low	Very Low	130 trees	Replacement planting	Net Gain
Exotic forest	Negligible	Very Low	2.79	Fauna Management Plans	Very Low
Exotic Scrub	Negligible	Very Low	2.47	Fauna Management Plans	Very Low
Exotic grassland	Low	Very Low	83.5	Fauna Management Plans	Very Low
Invertebrates	Low	Very Low			Very Low
Lizards	Moderate	Low	22.04	Lizard Management Plan	Low
Birds	Moderate	Low	22.04	Native Bird Management Plan	Low
Bats	Moderate	Moderate	Not recorded*	Bat Management Plan	Low
Edge effects	Low	Low		Edge Effects Management Plan	Very Low

*Surveys have not recorded bats within Sutton Block. Values precautionary.

1.3 Purpose of Report

The purpose of this report is to detail methods, explanations and outcomes of biodiversity offset accounting models (BOAM) to counterbalance the significant (Moderate and higher) residual adverse effects that would be expected as a result of the loss of the ecological values. The output of those modelled attributes for the current project are expected to result in an overall net gain.

Management measures, such as buffer planting and fauna management plans are presented separately and should be considered as part of the wider terrestrial ecological management package. This report should be read alongside the AEE, EcIA and in conjunction with the terrestrial, wetland and freshwater management and offset plans.

1.4 Biodiversity offsetting and the Auckland Unitary Plan

Appendix 8 of the AUP sets out a brief framework for the use of biodiversity offsets in the Auckland Region. As per the AUP framework, this Residual Effects Offset Plan follows good practice for biodiversity offsetting in New Zealand. The Department of Conservation (DOC, 2014) and Local Government New Zealand (Maseyk et al. 2018) provide guidance for offset design. These offset design guidelines recommend a demonstrable net environmental gain, and this is now a requirement of the NPS-IB. Appendices 3 and 4 of the NPS-IB set out specific principles that underpin Biodiversity

Offsetting. These principles are relevant to effects management at Drury Quarry's proposed Sutton Block Pit and are addressed in Table 3.

1.4.1 Suitability of ecological features within the Sutton Pit for biodiversity offset.

The terrestrial vegetation and habitats within the footprint of the proposed Sutton Block pit are suitable for using the Department of Conservation's (DOC) Biodiversity Offset Accounting Model (BOAM). Over preceding decades, the Sutton Block Pit area has been managed for pastoral farming and standard farm practices such as weed control and livestock grazing have severely impacted the ecological values of remnant indigenous forest and scrub communities. Community structure has become simplified and species diversity reduced, such that ecological values and biodiversity attributes are readily measured using standard protocols. The ecological features within the footprint and surrounding area have also been subject to repeat ecological surveys over the last decade (e.g. Bioresearches 2000, 2006, 2009, 2018; JS Ecology & Bioresearches 2021), and therefore there is a high level of confidence in the values that have been assessed.

Key biodiversity components of the affected ecological features have been selected to represent the overall biodiversity values being lost. These are:

- Vegetation structure.
- Diversity.

Fauna habitat.

These components are further divided into specific, measurable biodiversity attributes for which data has been collected.

The loss off mature forest communities is offset using two complimentary strategies, or modelled actions. These actions are revegetation of new, future ecosystems (long-term gains) and enhancement of existing, degraded ecosystems (shorter-term gains). Revegetation ensures the extent of specific biodiversity types is maintained and enhanced in the landscape over the longer term. Enhancement of existing, similar biodiversity types provides more immediate improvement in local ecological values to address the time lag between planting and the revegetation reaching maturity.

The terrestrial vegetation and habitats within the footprint of the proposed Sutton Block pit can be offset because the biodiversity attributes and ecological values of the vegetation being lost are well-documented and the offset methods are well-known techniques with good supporting scientific data. Long term monitoring and management ensures biodiversity targets are met at each stage and contingency tables address any instances where values may fall short of targets for any biodiversity attribute.

1.4.2 Principles of biodiversity offsetting

The NPSIB provides specific principles that underpin Biodiversity Offsetting. These principles are listed in

Table 3 and

, respectively, as well as an explanation of how the proposed offset for SAL will satisfy them. The DOC Guidance on Good Practice Biodiversity Offsetting in New Zealand (2014) states that:

> *"While an offset assessor should not insist on perfection in satisfying the Principles, Criteria and Indicators, major failures in any individual Principle or Criterion would disqualify a biodiversity offset from meeting the Standard and, consequently, it would not be consistent with the Guidance on Good Practice Biodiversity Offsetting in New Zealand".*

Table 3. Principles of biodiversity offsetting (NPSIB, Appendix 3) and how these are achieved for SAL Sutton Block expansion.

	Principles / Criteria of biodiversity offsetting	How these principles are complied with (1-6) or given regard to 7-11)
1	**Adherence to the mitigation hierarchy:** A biodiversity offset is a commitment to compensate for significant residual adverse impacts on biodiversity identified after appropriate avoidance, minimisation and on-site rehabilitation measures have been taken according to the mitigation hierarchy.	While avoidance is not practicable for all features of the proposed quarry, the proposed pit does avoid a significant ecological and cultural feature at Kaarearea paa SEA_T_5349. Management of effects by way of fauna management and edge buffer planting are recommended in the first instance, and the details of these are provided in separate Plans.
2	**When biodiversity offsetting is not appropriate**: Biodiversity offsets are not appropriate in situations where indigenous biodiversity values cannot be offset to achieve a net gain. Examples of an offset not being appropriate include where: (a) residual adverse effects cannot be offset because of the irreplaceability or vulnerability of the indigenous biodiversity affected: (b) effects on indigenous biodiversity are uncertain, unknown, or little understood, but potential effects are significantly adverse or irreversible: (c) there are no technically feasible options by which to secure gains within an acceptable timeframe.	Further detailed analysis is provided in section 1.5. It was found that all ecosystems that are to be lost could be offset with either relatively low standard of proof ('balance of probability') or with reasonable standard of proof ('clear and convincing evidence').
3	**Net gain:** This principle reflects a standard of acceptability for demonstrating, and then achieving, a net gain in indigenous biodiversity values. Net gain is demonstrated by a like-for-like quantitative loss/gain calculation of the following, and is achieved when the indigenous biodiversity values at the offset site are equivalent to or exceed those being lost at the impact site: (a) types of indigenous biodiversity, including when indigenous species depend on introduced species for their persistence; and (b) amount; and (c) condition (structure and quality).	Offset actions are quantified using the BOAM (Maseyk et al. 2015) to disaggregate key attributes, that appropriately describe / capture the overall biodiversity values of the ecosystem type (such as species diversity, structure, etc.), and compare those values with additional actions that would be undertaken to counterbalance expected losses. Those models demonstrate high confidence that that a Net Gain (>10%) would be achieved from proposed biodiversity conservation actions (revegetation, pest management and maintenance).
4	**Additionality:** A biodiversity offset achieves gains in indigenous biodiversity above and beyond gains that would have occurred in the absence of the offset, such as gains that are additional to any minimisation and remediation undertaken in relation to the adverse effects of the activity.	There are no current or future plans by any other parties to undertake any of the proposed revegetation or enhancement actions. While some areas are subject to land covenants (e.g. MacWhinney Reserve), these areas have no active management. The proposed revegetation planting would be undertaken in areas currently occupied by pasture. Revegetation areas will be protected where they currently have no protections.
5	**Leakage:** Biodiversity offset design and implementation avoids displacing harm to other indigenous biodiversity in the same or any other location.	The biodiversity offset actions (revegetation and enhancement) will not cause harm to other indigenous biodiversity at the site or other locations.

6	**Long-term outcomes:** A biodiversity offset is managed to secure outcomes of the activity that last at least as long as the impacts, and preferably in perpetuity. Consideration must be given to long-term issues around funding, location, management and monitoring.	All restoration actions will be legally protected in perpetuity by way of covenant and monitored for a minimum 30 years to ensure offset targets are achieved.
7	**Landscape context:** Biodiversity offsetting is undertaken where this will result in the best ecological outcome, preferably close to the impact site or within the same ecological district. The action considers the landscape context of both the impact site and the offset site, considering interactions between species, habitats and ecosystems, spatial connections, and ecosystem function.	The biodiversity offset actions will be undertaken predominantly *in situ*, within the SAL Drury Quarry Project Area and on SAL property, where biodiversity management actions would have positive outcomes for the same species and communities. Two offsite locations have been selected for a small subset of offset actions, both of which are near the Drury Quarry site.
8	**Time lags:** The delay between loss of, or effects on, indigenous biodiversity values at the impact site and the gain or maturity of indigenous biodiversity at the offset site is minimised so that the calculated gains are achieved within the consent period or, as appropriate, a longer period (but not more than 35 years).	Enhancement, by way of pest animal control, will be implemented in advance of losses in adjacent environments, to minimise effects of time lag. In addition, 67% of revegetation planting will occur at least 10 years in advance of vegetation loss.
9	**Science and mātauranga Māori:** The design and implementation of a biodiversity offset is a documented process informed by science and mātauranga Māori.	The design of the biodiversity offset is based on established and best practice methods for revegetation and restoration. Published scientific data and studies, such as the National Vegetation Survey database, local recce plot data, studies of nesting success in relation to predator control, and regional ecosystem diversity and values have informed modelled benchmarks and expected outcomes. These are supported by vegetation RECCE plot data and fauna habitat parameters collected from impact and offset sites at Drury Quarry, established native plantings and other mature ecosystems. Annual and five-yearly monitoring is provided to measure and document the offset outcomes against modelled and indicative targets. Adaptive management options are provided to respond to any outcomes that may fall sort of modelled values. Where targets are not met, contingency actions are provided to ensure offset success is not compromised and a final Net Gain is achieved. Traditional knowledge and values have been incorporated through consultation with local iwi. For example, components of the offset include revegetation which will enhance the ecological integrity of rock forest at Kaarearea paa, a significant cultural feature.
10	**Tangata whenua and stakeholder participation:** Opportunity for the effective and early participation of tangata whenua and stakeholders is demonstrated when planning biodiversity offsets, including their evaluation, selection, design, implementation, and monitoring.	SAL engages in ongoing consultation with iwi and the local community. Consultation with local government occurs at the resource consent application stage and thereafter via monitoring and reporting of resource consent conditions. SAL is active in the local community and has well established, long-term relationships that are built on dialogue and collaboration. SAL has engaged local communities and iwi to collaborate regarding the offset planting and other ecological restoration projects. SAL have consulted stakeholders and tangata whenua throughout the evolution of this proposal and have provided community open days and site walk-throughs for local iwi groups. Their input led to the expansion of the Kaarearea paa protected area. The offset will further enhance the ecological integrity of this significant cultural feature.
11	**Transparency:** The design and implementation of a biodiversity offset, and communication of its results to the public, is undertaken in a transparent and timely manner.	Drury Quarry will deliver the biodiversity offset and document its key targets and outcomes through provision of regular monitoring reports and compliance meetings in liaison with Auckland Council and where appropriate, other stakeholders.

1.5 Suitability for Biodiversity Offsetting and Burden of Proof Framework

The NPSIB outlines principles for Biodiversity Offsetting (Appendix 3). One of the key principles is for determining the offsetability of biodiversity. We provide an analysis here of this concept, using guidance from the (Department of Conservation 2014) and the NPSIB (2023) to assess the vulnerability, irreplaceability and likelihood of success of offset for the Drury Quarry proposal. These concepts interact to determine an overall burden of proof framework, which combines biodiversity value with likelihood of offset (Department of Conservation 2014). In this section, we demonstrate that the overall burden of proof for Drury Quarry Sutton Block offset is relatively low or medium depending on ecosystem type and scale of analysis, meaning that the biodiversity is offsetable with either a relatively low or reasonable standard of proof, respectively.

1.5.1 Burden of proof framework for 'offsetability'

Vulnerability is defined in the NPSIB as:

> *"…an estimate of the degree of threat of destruction or degradation that indigenous biodiversity faces from change, use or development. It is the degree to which an ecosystem, habitat or species is likely to be affected by, is susceptible to or able to adapt to harmful impacts or changes. It interacts with the irreplaceability, complexity and rarity to indicate the biodiversity value and level of risk for a given area."*

Irreplaceability is defined in the NPSIB as:

> *"…a measure of the uniqueness, replaceability and conservation value of biodiversity and the degree to which the biodiversity value of a given area adds to the value of an overall network of areas. It interacts with vulnerability, complexity and rarity to indicate the biodiversity value and level of risk for a given area".*

We applied a methodology presented by Pilgrim et al. (2013), and acknowledged by the Department of Conservation (2014) and Maseyk et al. (2018) to:

determine how the vulnerability and irreplaceability interact to inform the 'conservation concern;

1. assess likelihood of offset success;

determine offset-ability and burden of proof required for offsetting.

This process simplifies to:

i) Irreplaceability x Vulnerability = Conservation Concern

ii) Residual Impact Magnitude X Offset Opportunity X Offset Feasibility = Likelihood of Success

Conservation Concern X Likelihood of Success = Burden of Proof required for offsetting

1.5.1.1 Vulnerability and Irreplaceability of Taraire, tawa podocarp forest (WF9) and Podocarp Forest (WF7).

Pilgrim *et al.* (2013) set out a system for categorising biodiversity conservation concern, based on irreplaceability and vulnerability rankings. This system defines irreplaceability as the percentage of the global range or population of a biodiversity feature sustained by the area of analysis. Vulnerability is assessed by reference to identified categories in a table, with those categories referring to relative risk of extinction in the wild. We now apply this system to our assessment.

Starting with vulnerability, terrestrial ecosystems in New Zealand have not been assigned a threat status, however Auckland Council has assessed WF7 as 'Critically Endangered' and WF9 as 'Endangered' on a regional basis (Singers *et al*. 2017). The categories in the Pilgrim *et al*. 2013 table for determining conservation concern (

Table 6) includes categories for that match these threat statuses, and we therefore apply these values to this analysis.

Turning to irreplaceability, ideally a measure of the total area nationwide of each ecosystem type could be assessed. Both ecosystem types are predominantly in the upper parts of the North Island. Total areas of WF7 and WF9 ecosystems are available for Northland and Auckland regions, but not the Waikato, so these two regions are relied on, acknowledging that this is an underestimate of the total ecosystem area.

WF9 forest occupies 8,249 ha within the Auckland Region (Table 7 in Griffiths et al. 2021[1]) and 69,157 ha for Auckland and Northland Regions combined (including Northland Regional Council online maps; Table 4). Therefore the 7.33 ha of WF9 forest that would be lost from Drury Quarry Sutton Block expansion equates to an irreplaceability ranking of ≥ 0.1% for the Auckland Region and <0.1% nationally, using Pilgrim et al. (2013) categories for determining irreplaceability – refer Table 4. When vulnerability and irreplaceability findings are combined for WF9 forest (using Table 1 within Pilgrim et al. (2013)), a biodiversity conservation concern of medium (regional) or low (Nationally) is derived (reproduced here as

[1] Griffiths, Georgianne J. K., Jade Khin, Todd J. Landers, Grant Lawrence, Miriam R. Ludbrook and Craig D. Bishop (2021). Ecological integrity of forests in Tāmaki Makaurau / Auckland 2009-2019. State of environment reporting. Auckland Council technical report, TR2021/01

Table 6). It is acknowledged that we have not accounted for all WF9 forest nationally, so, the score derived based on only Auckland and Northland would be the highest possible potential loss.

Table 4. The current and potential extent of Taraire, Tawa, Podocarp Forest (WF9), and the potential proportion that would be removed for the Drury Quarry Sutton Block expansion. Values were determined by Auckland and Northland Regional Council GIS databases.

Region	Current Extent (ha)	Potential Extent (ha)	% remaining	Loss of 7.33 ha (%)
Northland	60,835	108,601	56%	0.018%
Auckland	8249	49,400	16.7%	0.13%
Other regions*	unknown	unknown	unknown	
Total	69,084	158,001	43.7%	0.02%

*WF9 vegetation occurs outside these regions, but the total current and potential extent could not be determined.

For WF7 forest, the current and potential extent in Auckland and Northland is summarised in Table 5. Based on the current extent of WF7 in Auckland and Northland alone, the loss of 0.65 ha from Drury Quarry Sutton Block expansion equates to an irreplaceability ranking of >0.1% regionally (0.29%) and <0.1% nationally (0.003%), using Pilgrim et al. (2013) categories for determining irreplaceability. When vulnerability and irreplaceability findings are combined for WF7 forest (using Table 1 within Pilgrim et al. (2013), a biodiversity conservation concern of high (Regionally) and medium (Nationally) is derived (reproduced here as

Table 6).

However, it should be noted that for this analysis, all WF7 subtypes (WF7.1, WF7.2 and WF7.3) have been grouped together, as not all records were classified into one of the three subtypes by the regional council GIS databases. The ecosystem type at Drury Quarry is WF7.2

Table 5. The current and potential extent of Puriri Forest (WF7), and the potential proportion that would be removed for the Drury Quarry Sutton Block expansion. Values were determined by Auckland and Northland Regional Council GIS databases.

Region	Current Extent (ha)	Potential Extent (ha)	% remaining	Loss of 0.65 ha (%)
Northland	24,549	106,279	23.1%	0.003%
Auckland	223	91,356	0.27%	0.29%
Other regions*	Unknown	Unknown	Unknown	Unknown
Total	24,772	197,365	12.55%	0.003%

*WF7 vegetation occurs outside these regions, but the total current and potential extent could not be determined.

Table 6. A system for categorising biodiversity conservation concern, based on irreplaceability and vulnerability rankings (reproduced from Pilgrim et al. 2013, Table 1).

Irreplaceability of area of analysis	Vulnerability of biodiversity feature: Critically Endangered	Endangered	Vulnerable	Near Threatened/ Least Concern	Data Deficient/ Not Evaluated
≥95%	Extremely High	Extremely High	Very High	High	Assign to a threat level or apply precautionary approach
≥10%	Extremely High	Very High	High	Medium	
≥1%	Very High	High	Medium	Low	
≥0.1%	High	Medium	Low	Low	
<0.1%	Medium	Low	Low	Low	

Note: Irreplaceability is the percentage of the global range or population of a biodiversity feature sustained by the area of analysis. Vulnerability categories refer to relative risk of extinction in the wild.

1.5.1.2 Likelihood of offset success for Taraire, tawa podocarp forest (WF9) and Podocarp Forest (WF7).

Criteria for offset success are presented by Pilgrim *et al.* (2013) and adopted by the New Zealand Government[2] (Section 4.2.2: Assessing the likelihood of success of an offset), which considers three key factors:

the residual impact magnitude,

1. offset opportunity and
2. the offset feasibility.

Each of these issues can be broken down further into sub issues and scored. We have undertaken this analysis, evaluating each of the sub issues or criteria with a class score from 1 (worst) to 4 (best), and summarised in Table 7. Overall, the project scored highly, with 10 of the 15 criteria scoring a 4, one criterion scored a 3, three criteria scored a 2 and one criterion scored a 1. This gave an overall score of 50 out of a possible 60, or a mean class score of 3.3 for likelihood of success.

[2] New Zealand Government. (2014). Guidance on Good Practice Biodiversity Offsetting in New Zealand

Table 7. Likelihood that project impacts can be successfully offset (based on Pilgrim et al 2013 Table 2) for Drury Quarry Sutton Block pit expansion. Class score represents a scale of 1 (worst) to 4 (best).

Issue	Sub issue	Criterion	Project Details	Class (1-4)	Class score	Notes
Residual Impact magnitude	Severity	Declines of each biodiversity feature at a set scale		4	Very limited (but still significant)	
	Extent	Proportion of range/population of each biodiversity feature impacted		4	Very small (but still significant)	
	Duration	Length of impacts, relative to viability of affected biodiversity		1	Permanent	See table 9, EIANZ guidelines
Offset opportunity		Potential for restoring affected biodiversity functions elsewhere	Revegetation and enhancement actions	3	Possible	
		Offset opportunities within natural range	Revegetation and enhancement actions	4	Excellent	
		For restoration offsets, condition to which offset can be restored compared to impacted feature	Revegetation and enhancement actions	2	Lower complexity and diversity for revegetation	
		For averted loss offsets, landscape-level condition of affected biodiversity	Enhancement of onsite vegetation	2	Good; decreasing	
Offset Feasibility	Technical	Availability of proven relevant methods for restoration protection		4	Many proven methods	
		Adequacy of long-term offset implementation plans		4	Credible plan exits	
		Adequacy of long-term offset implementation		4	Excellent	
	Financial	Funding for long-term offset implementation		4	Fully pre-impacts	
		Funding for long-term offset monitoring		4	Includes funding for independent input	
	Temporal	Time after impacts until offset gains replace affected	Replacing modelled attributes	2	Medium-term	
	Capacity	Capacity of offset implementer for relevant methods at necessary scale	SAL has extensive experience at successfully implementing, managing and monitoring offsets (>40 ha over > 10 years)	4	High	
		Capacity of developer to keep residual impacts within predicted magnitudes	Long experience in quarrying at the site. Detailed quarry engineering plans	4	High	
Mean score				3.33 (50/60)		

The scores for biodiversity conservation concern and likelihood of success can then be used to determine the overall burden of proof framework[3] (Figure 2).

We determine that burden of proof for this project, as mapped on to this framework, as being:

WF7 puriri forest:

National scale- (Point A, Figure 2): Offsetable with relatively low standard of proof ('balance of probability')

- Regional scale- (Point C, Figure 2): Offsetable with reasonable standard of proof ('clear and convincing evidence')

WF9 taraire forest:

National scale- (Point A, Figure 2): Offsetable with relatively low standard of proof ('balance of probability')
Regional scale- (Point B, Figure 2): Offsetable with relatively low standard of proof ('balance of probability')
Under either circumstance, we provide strong confidence in our models, and detailed evidence for high likelihood of success as per the BOAMs presented in Section 2.

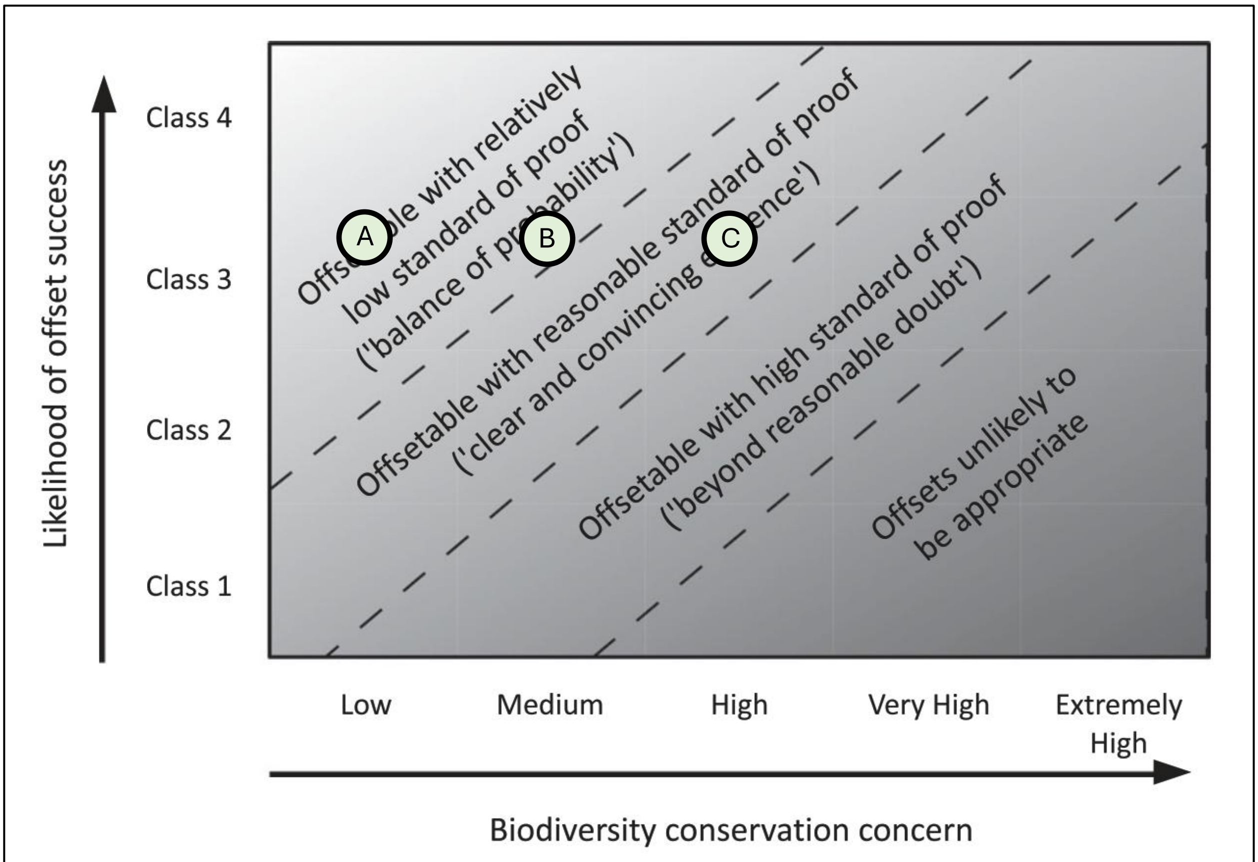

Figure 2. Burden of proof framework, combining biodiversity conservation concern and likelihood of offset success (after Pilgrim et al. 2013 and NZ Government 2014). Point A represents the project when the biodiversity conservation concern is considered low (WF7 national extent, WF9 national extent), point B is for medium (WF9 Regional extent) and point C is for high (WF7, regional extent).

[3] Determined as per Figure 3 of the Department of Conservation (2014).

1.5.1.3 Effects on indigenous biodiversity are uncertain (Principle 2b)

Principle 2b states that Biodiversity Offsetting is not appropriate when:

> *(b) effects on indigenous biodiversity are uncertain, unknown, or little understood, but potential effects are significantly adverse or irreversible:*

This is addressed through the BOAMs that have been conducted for each of the affected ecosystems. The effects are well understood (empirical field measurements taken of a variety of flora and fauna attributes).

1.5.1.4 Effects on indigenous biodiversity are uncertain (Principle 2c)

Principle 2c states that Biodiversity Offsetting is not appropriate when:

> *(c) there are no technically feasible options by which to secure gains within an acceptable timeframe.*

The longest timeframe that we have used for net gains to be achieved as modelled using the BOAMs is 30 years. This provides for a 5-year buffer, should there be any delays in achieving targets within the specified timeframes. Well understood technical methods exist, with documented success for revegetation and management reducing the risk that these targets will not be achieved within an acceptable time frame (e.g. Auckland Council, 2023[4]). These potential lags will be detected through regular monitoring and should be corrected sufficiently before this endpoint.

[4]Auckland Council (2023). Te Haumanu Taiao: Restoring the natural environment in Tāmaki Makaurau.

2 RESIDUAL EFFECTS ANALYSIS REPORT - TERRESTRIAL ECOLOGY: REVEGETATION AND ENHANCEMENT

2.1 Summary of biodiversity offset actions and timing

This BOCP details how the Project will counterbalance the expected significant, residual adverse effects resulting from the permanent loss of vegetation and habitats. The actions modelled here would be independent of other actions, detailed in separate management plans, that would be undertaken in adherence to the effects management hierarchy (such as fauna management, buffer planting).

A summary of the losses and modelled offset outputs (like for like revegetation and enhancement of existing adjacent ecosystems) are tabulated in Table 8 and mapped in Figure 11. An explanation of these actions (revegetation and enhancement) is provided below, along with the details of the BOAMs, including specific biodiversity components, attributes and justifications.

Table 8. Summary of losses and modelled outputs and timing to achieve Net Gain

Ecosystem type	Loss (ha)	Timing of removal	BOAM Actions		Time of offset Planting	
			Revegetation	Enhancement ALL areas from Year 1	Phase 1	Phase 2
Rock Forest	0.65	0-5	8.32 ha	5.35 ha	Years 2 & 3	Years 5-9
Taraire, tawa podocarp Forest model 1 (WF9 2 and 5)	1.89	0-5	12 ha	23 ha	Years 1-5	Years 4 -8
Taraire, tawa podocarp Forest model 2 (WF9 1,3,4)	5.44	>30	20 ha	40 ha	Years 6-9	Years 9-13
Kanuka Forest (VS2)	8.8	>30	22 ha	40 ha	10-16 years	None
Relict native trees amongst pasture	130 trees	1-50	887 trees	-	1 – 10 years	none
Total	**16.78**		**62.32**	**108.35**		

2.2 Description of revegetation and enhancement actions

The proposed ecological restoration planting will provide much enhanced ecological connectivity across the ecologically fragmented landscape within SAL land holdings, including buffering and reconnecting the very high value Kaarearea paa rock forest with significant ecological areas to the east (SEA_T_5323) through a series of existing forest fragments and areas of existing and proposed restoration planting.

Biodiversity offset actions within land adjacent to MacWhinney Reserve will remove a biodiversity threat posed by pest plants and fulfil community aspirations for the restoration of this area. It will also connect to existing restoration planting and forest on the western side of the Sutton Pit, strengthening ecological connections to the south and to SEA_T_5323 on the northern side of the pit.

2.2.1 Revegetation

Revegetation aims to replace what is lost. These values will, however, take decades to achieve similar maturity to those lost, and are therefore long-term benefits. The Biodiversity Offset Accounting Model (BOAM) accounts for this lag, and therefore larger areas are planted and protected to achieve an overall Net Gain modelled biodiversity outcome within a 30-year timeframe.

The biodiversity attributes that would be offset through revegetation include canopy cover, canopy height, basal area and fauna habitat resources (avifauna winter food resources, leaf litter and woody debris) for all biodiversity types. Revegetation of rock forest and kanuka forest would also address species richness and percent cover targets for lower forest tiers.
Revegetation will occur primarily with SAL holdings at Drury Quarry. Approximately 4.4 ha of Kanuka forest (VS5) revegetation will occur at Hingaia Island 2, one of Ngaa Motu a Hingaia group located in the Drury Estuary, and some of the replacement relict trees will be planted at Tuakau site.

2.2.1.1 Revegetation locations

2.2.1.1.1 Drury Quarry revegetation

Revegetation targets the immediate landscape where biodiversity benefits would include:

- Buffering and connection of isolated rock forest fragments and areas of podocarp broad-leaved forest;

Restoration of weed dominant components of SAL land adjacent to MacWhinney Reserve;
Conversion of a pine plantation on land adjacent to MacWhinney Reserve to native forest;
Planting around Kaarearea paa to buffer and reconnect this high value tract of forest; and

- Edge planting along the southern edge of SEA_T_5323 north of the Sutton Pit (refer to Figure 3 below).

All areas of revegetation would also be subject to pest animal and weed control. Restoration planting to compensate for loss of rock forest will occur on the northwestern side of Kaarearea paa adjacent to existing protected rock forest and on the eastern side of the site adjacent to small, grazed remnants of rock forest. The substrate in both areas contain surface rocks and boulders, to which further boulders can be added to recreate the rocky substrate being lost. These locations will buffer and extend areas of existing rock forest resulting in improved ecological connectivity.

Restoration planting to compensate for loss of Taraire, tawa podocarp forest will be undertaken on land adjacent to MacWhinney Reserve on the western side of the Sutton Pit and on the eastern side of the site in gaps between existing areas of Taraire, tawa podocarp forest. These revegetation planting sites will improve ecological connectivity between the western and eastern sides of the site and also provide connectivity to isolated forest fragment towards the southeastern corner of the site. Control of dense infestations of pest plants (privet and woolly nightshade) will remove a significant biodiversity threat to existing and proposed areas of restoration planting that surround MacWhinney Reserve.

Restoration planting to offset loses of kanuka forest will be undertaken to the east of Kaarearea paa to increase the extent of this forest tract. It will also occur to the southeastern side of the site adjacent to existing native vegetation and other restoration planting for rock forest and podocarp broadleaved forest.

All areas of in-situ offset planting will have soils, exposure, rainfall, and other climatic conditions that are very similar to those that affect the impacted areas of vegetation. Soil fertility is moderate with low vulnerability to drought; annual rainfall is moderate at 1200 – 1300mm per annum. The growing conditions for restoration planting are well understood as extensive planting has been undertaken as part of earlier resource consent conditions.

The restoration planting approach is a two-phase process involving the initial establishment of a pioneer plant community composed manuka/kanuka and broadleaved shrubs and small trees. Once the pioneer community reaches 5 years old, infill planting with canopy species can take place. Biodiversity gains for revegetation are modelled over 30 years for vegetation loss occurring during stages 1 and 2 (Taraire, tawa podocarp and rock forest biodiversity types) and over 20 years for vegetation loss occurring during stages 4 and 5 (Taraire, tawa podocarp (WF9) and kanuka forest (VS2). This is due to planting in advance of later vegetation loss, which will occur at least 10 years prior to loss. Refer to Figure 9 , Figure 10 and Figure 11 for location and staging of restoration planting.

Detailed restoration planting plans are provided separately to this report for each biodiversity type within the NGDP:PP.

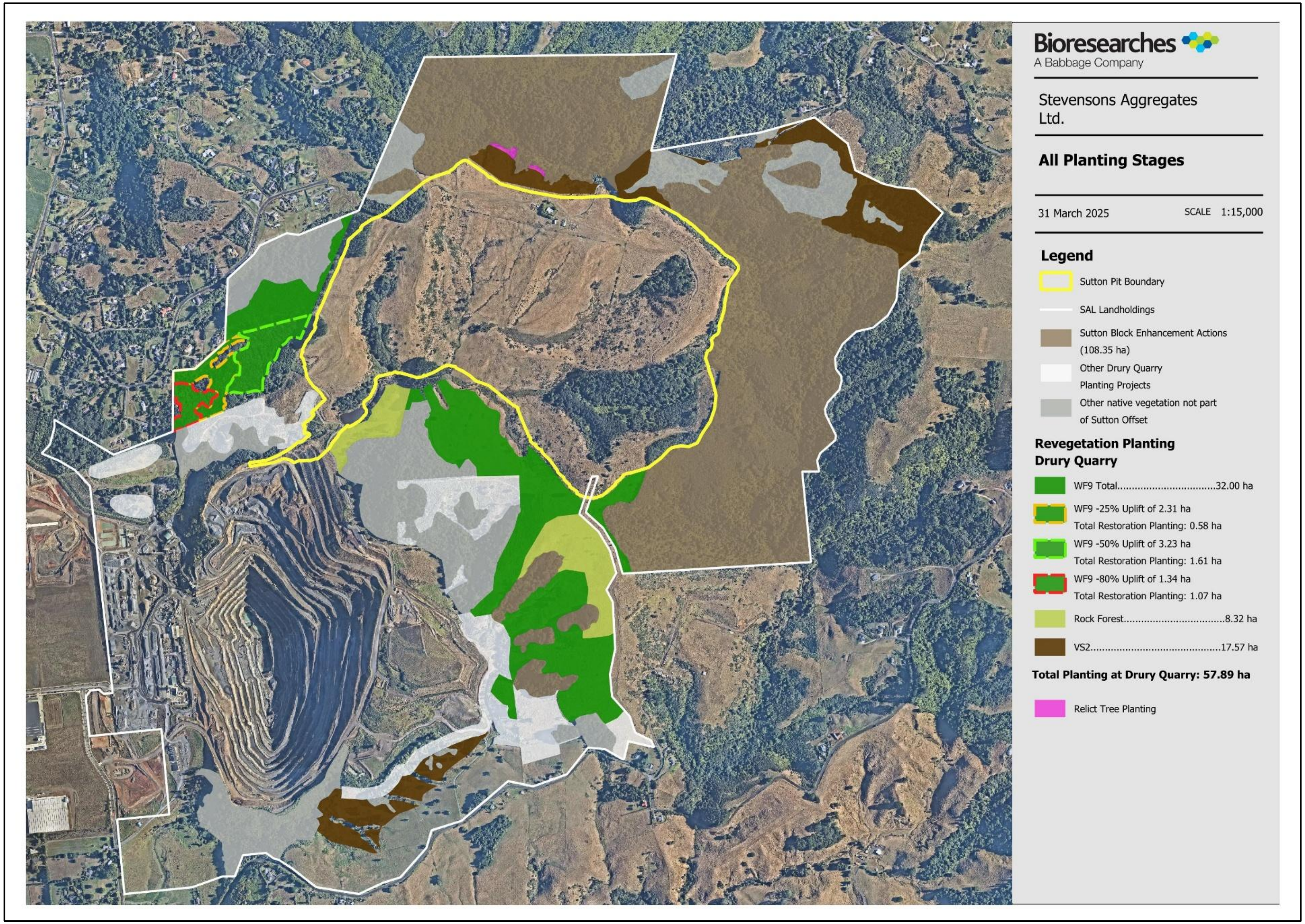

Figure 3. Offset restoration actions for Drury Quarry.

2.2.1.1.2 Hingaia Island

Hingaia Island is located in the South-eastern margin of the Manukau Harbour, approximately 6.5 km northwest of Drury Quarry. Planting of 4.4 ha of Kanuka Scrub/Forest (VS2) and specimen Totara trees will take place on the Island (see Figure 4, Table 10). Further details regarding the planting plans are provided within Chapter 9 of the NGDP:PP.
Consultation identified a Ngāti Te Ata Waiohua aspiration to see Ngā Motu o Hingaia fully restored to indigenous vegetation. In response, SAL has agreed to locate 4.4 ha of kanuka scrub/forest (VS2) on Island 2 where suitable terrestrial habitat exists. Replacement planting of totara will also be undertaken in groups to provide "seed islands" on Island 2. A landowner agreement is currently in place for the revegetation and monitoring as part of this biodiversity offset.

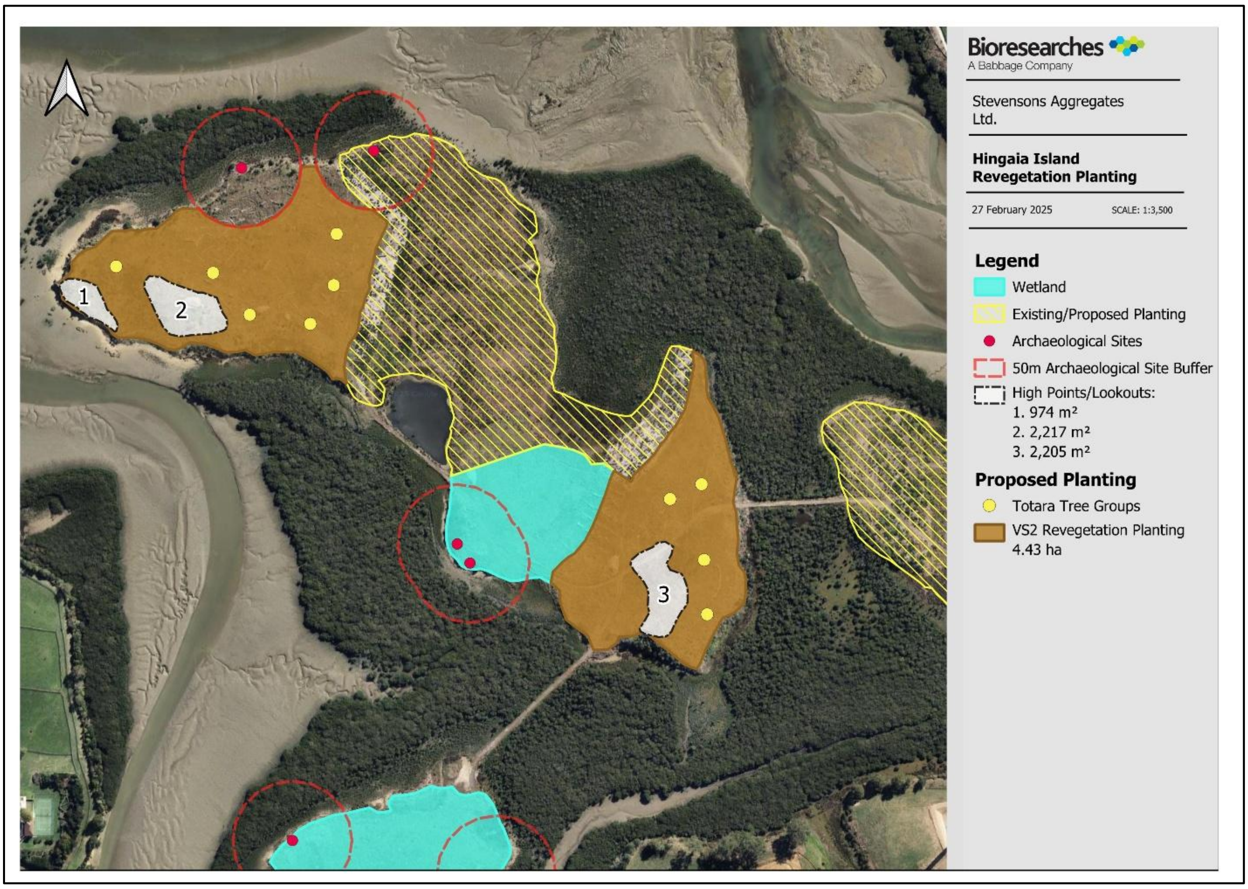

Figure 4. Hingaia Island with proposed planting areas indicated.

2.2.1.1.3 Tuakau site

As part of SAL holdings, the company has a sandmining operation near Tuakau, Auckland (Figure 5), approximate 17 km South of Drury Quarry. This site has extensive areas available for revegetation, as well as remnant vegetation, some of which has been covenanted. Most of the remnant vegetation is composed of Kahikatea Forest (MF4), due to the site being low lying and adjacent to the Waikato River. As some of the species of relict trees that will be lost, are less suitable for the primary ecosystem types (RF, WF9, VS2) that are undergoing revegetation, the Tuakau site is more suitable. In particular, the replacement tree plantings for rimu (*Dacrydium cupressinum*), kahikatea (*Dacrycarpus dacrydioides*) and pukatea (*Laurelia novae-zelandiaeare*) are better suited to be located at a lowland flood plain site like the Tuakau site.

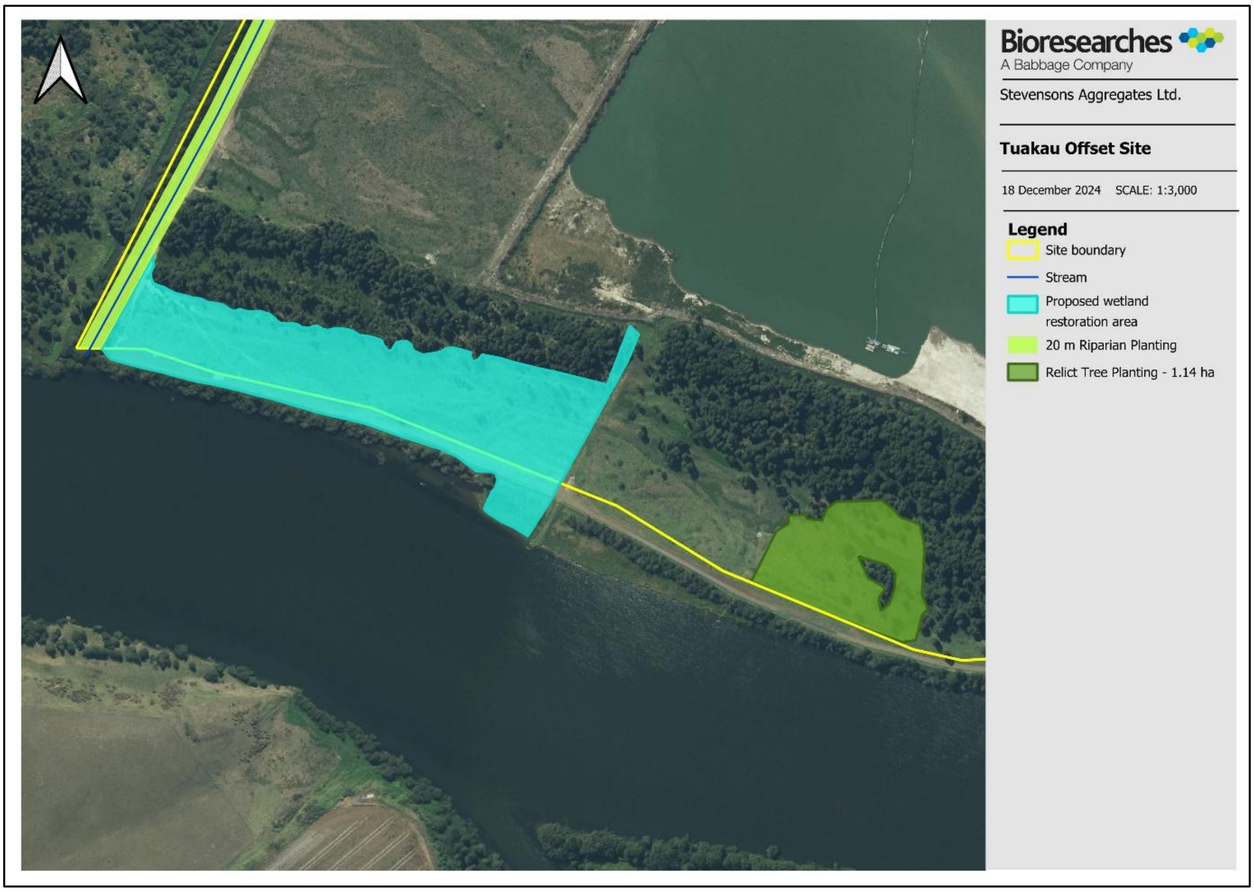

Figure 5. Tuakau Site with proposed planting areas indicated.

2.2.1.2 Relict trees

Revegetation planting is proposed to account for small stands and individual relict mature native trees amongst pasture within the Sutton Block. The number of trees required is calculated using tools available on the Tane's Trees Trust website (Tanes Trees Growth and Yield calculator) and the BOAM. A total of 130 individual trees will be lost with a total basal area of 20.43.m^2 (Table 9). Revegetation of 2ha of planting at 444 stems per hectare is proposed across three sites (Drury Quarry, Hingaia Island and Tuakau) to provide a biodiversity gain within 25 years (Table 10).

Table 9. Relict native trees amongst pasture

Tree species	Number of individuals lost	Average dbh/cm	Total basal area/m^2	Average height/m	Replacement planting	Plus 10% biodiversity gain
Kahikatea	94	29	9.78	17 - 18	514	565
Pukatea	12	31.6	1.99	14	53	58
Tōtara	14	37	2.058	12	103	113
Rewarewa	1	25	0.049	12	2	3
Rimu	1	35.2	0.097	15	4	5
Puriri	5	1784	5.46	16	103	113
Taraire	3	65.1	1.00	16	27	30
Total	**130**		**20.43**		**806**	**887**

Table 10. Relict trees replacement planting

Species	Loss / count	Timing of removal / year	Replanting / count	Time of Planting	Location
Puriri	5	1 - 5	113	Year 1 - 5	SAL Drury
Taraire	3	1 - 5	30	Year 1 - 5	SAL Drury
Rewarewa	1	1	3	Year 1 - 5	SAL Drury
Rimu	1	>30	5	Year 20	Tuakau site
Totara	14	>30	113	Year 10 - 16	Hingaia Island
Kahikatea	94	>30	565	Year 20	Tuakau site
Pukatea	12	>30	58	Year 20	Tuakau site
Total	**130**		**887**		

2.2.2 Enhancement

Enhancement achieves modelled improvements to existing ecological values, thereby enabling existing like-for-like values in the immediate landscape to be maintained and enhanced. Biodiversity benefits can generally be achieved within a shorter timeframe and include:

1. Removal of pest predators and browsers;
2. Recovery of fauna through improved breeding success;

Increased floral species diversity;
Restoration of forest structural tiers impacted by pest browsers; and

3. Removal of pest plants that threaten forest ecological integrity.

Current threats to forest ecosystem integrity within SAL property include deer, goats, possums and hares that are browsing forest tiers, particularly the understorey and groundcover, pest plants, and predators on native forest fauna.

The biodiversity attributes that would be offset through enhancement actions include seedling and sapling regeneration and native groundcover for Taraire, tawa podocarp forest and avifauna breeding success for all biodiversity types.

Enhancement actions would be provided through implementation of a comprehensive pest plant and pest animal control programme targeting pest plants and pest predators (rodents, mustelids and possums) and browsers (possums deer, goats and hares). Control would be implemented over approximately 108 ha of forested area within SAL Drury property.

The proposed enhancement area is the remaining extent of SEA_T_5323 within SAL property. It contains a mosaic of forest types, mostly podocarp broadleaved forest (mapped by Auckland Council as WF13 but it is not this forest type and more similar to WF9) and kanuka forest (VS2). Additional enhancement of rock forest fragments (5.35 ha) within SAL property will also be enhanced.

Biodiversity offset gains for enhancement are modelled over 25 years for Taraire, tawa podocarp (WF9, loss during stage 1 and 2) and rock forest (WF7.2) biodiversity types as the biodiversity attributes being enhanced include vegetation parameters that take several decades to show measurable improvements. For kanuka forest (VS2) and Taraire, tawa podocarp (WF9, loss during stages 4 and 5) biodiversity offset gains are modelled over 20 years since the enhancement will start in advance. For the bird breeding success enhancement attribute, the gains are modelled for 1 year, as the positive effects of predator control are evident after one breeding season for bird breeding success.

Refer to Figure 11 for location and staging of enhancement areas. A detailed ecological enhancement plan for this area is provided separately to this report in the NGDP:PWC.

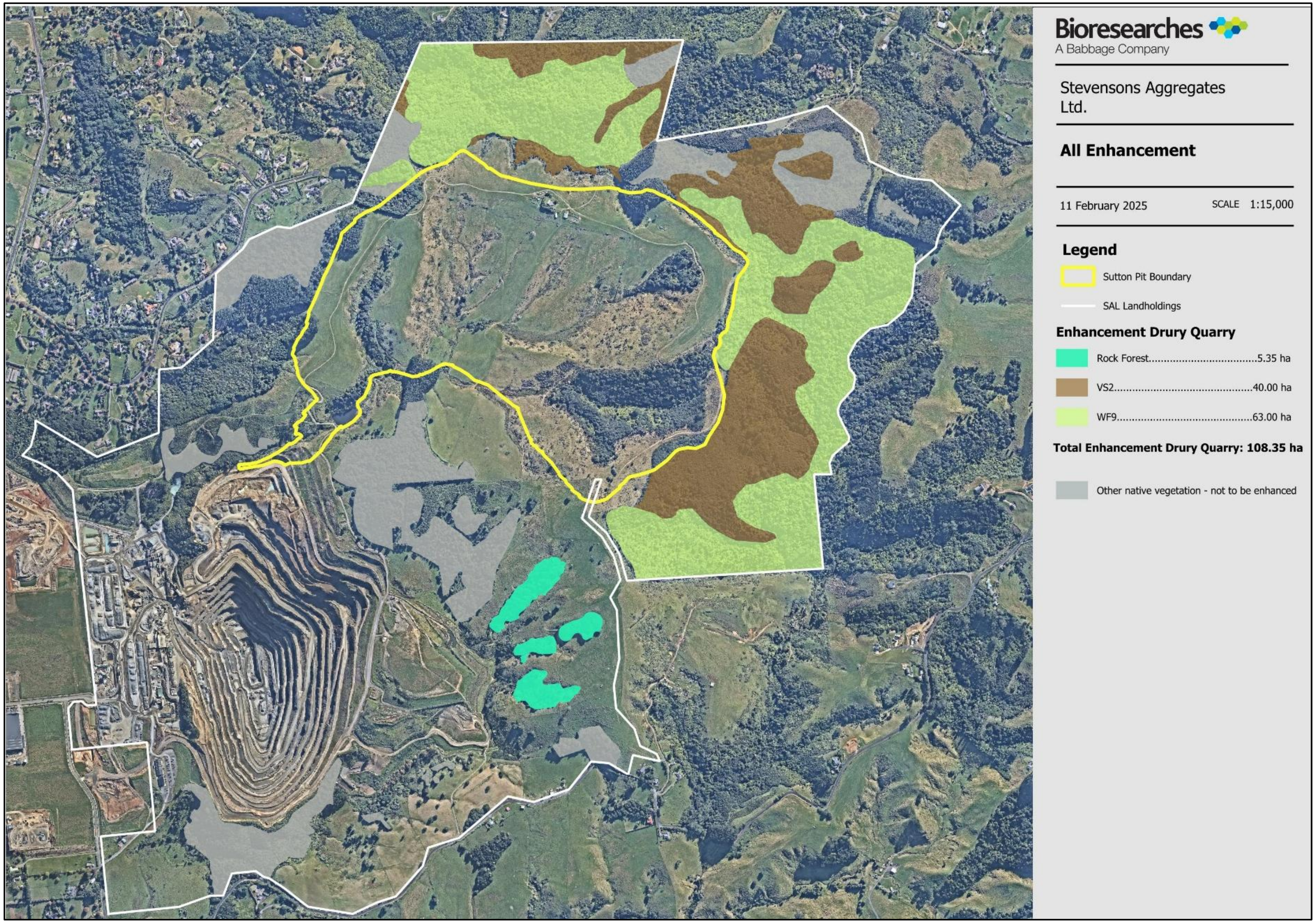

Figure 6. Locations of offset enhancement actions.

Table 11. Summary of terrestrial vegetation and habitat loss, values and effects within the Quarry Pit extent.

Vegetation type	Ecological Value	Level of effect (without mitigation)	Estimated area of removal (ha)	Recommended Management (refer separate management plans)	Recommended offset of residual adverse effects	Level of Effect (with management and offset
Rock Forest (RF)	High	High	0.65	1. Timing of vegetation removal to avoid the main bird breeding season (or preclearance nesting surveys). 2. Implementation of a lizard management plan. 3. Adoption of bat tree-felling protocol.	1. Biodiversity offset planting on / with appropriate rock substrate with like-for-like rock forest vegetation, in accordance with a biodiversity offset model that demonstrates at least a 10% gain for flora and fauna habitat values. 2. Enhancement of an appropriate quantum of existing rock forest as determined by a Biodiversity offset Model that demonstrates a net gain for flora and fauna habitat values.	**Offset: Net gain** 8.32 ha revegetation 5.35 ha pest control
Taraire, tawa podocarp Forest (WF9)	Moderate	Moderate	7.33	1. Timing of vegetation removal to avoid the main bird breeding season (or preclearance nesting surveys). 2. Implementation of a lizard management plan. 3. Adoption of bat tree-felling protocol. 4. Buffer planting of newly created SEA edge (SEA_T_5323).	1. Offset planting of like-for like WF9 forest vegetation, in accordance with a biodiversity offset model that demonstrates at least a 10% gain for flora and fauna habitat values. Planting will be implemented 10 years in advance of loss. 2. Enhancement of an appropriate quantum of existing WF9 forest as determined by a Biodiversity offset Model that demonstrates at least a 10% gain for flora and fauna habitat values. Enhancement will be implemented >20 years ahead of loss.	**Offset: Net Gain** 32 ha revegetation 63 ha pest control
Kānuka Forest (VS2)	Moderate	Moderate	8.8	1. Timing of vegetation removal to avoid the main bird breeding season (or preclearance nesting surveys). 2. Implementation of a lizard management plan. 3. Adoption of bat tree-felling protocol. 4. Buffer planting of newly created SEA edge (SEA_T_5323).	1. Offset planting of like-for like VS2 forest vegetation, in accordance with a biodiversity offset model that demonstrates at least a 10% gain for flora and fauna habitat values. 2. Enhancement of an appropriate quantum of existing VS2 forest as determined by a Biodiversity offset Model that demonstrates at least a no-net-loss for flora and fauna habitat values.	**Offset: Net Gain** 22 ha revegetation 47 ha pest control

Relict Native trees amongst pasture	Low	Very Low	0.17	1. Timing of vegetation removal to avoid the main bird breeding season (or preclearance nesting surveys). 2. Implementation of a lizard management plan. 3. Adoption of bat tree-felling protocol	Replacement planting of like-for like specimen trees, in accordance with a. biodiversity offset model that demonstrates at least a 10% gain for flora and fauna habitat values. Proposed to plant 887 specimen trees with infill restoration planting between.	**Offset: Net gain** Tree biomass 0.13
Exotic Trees	Negligible	Very Low	2.78	1. Timing of vegetation removal to avoid the main bird breeding season (or preclearance nesting surveys). 2. Implementation of a lizard management plan. 3. Adoption of bat tree-felling protocol.	Not required	**Very Low**
Exotic Scrub	Negligible	Very Low	2.47	1. Timing of vegetation removal to avoid the main bird breeding season (or preclearance nesting surveys). 2. Implementation of a lizard management plan.	Not required	**Very Low**
Total			**Native:** 16.78 ha (14.25 ha within SEA) **Exotic:** 5.25 ha			

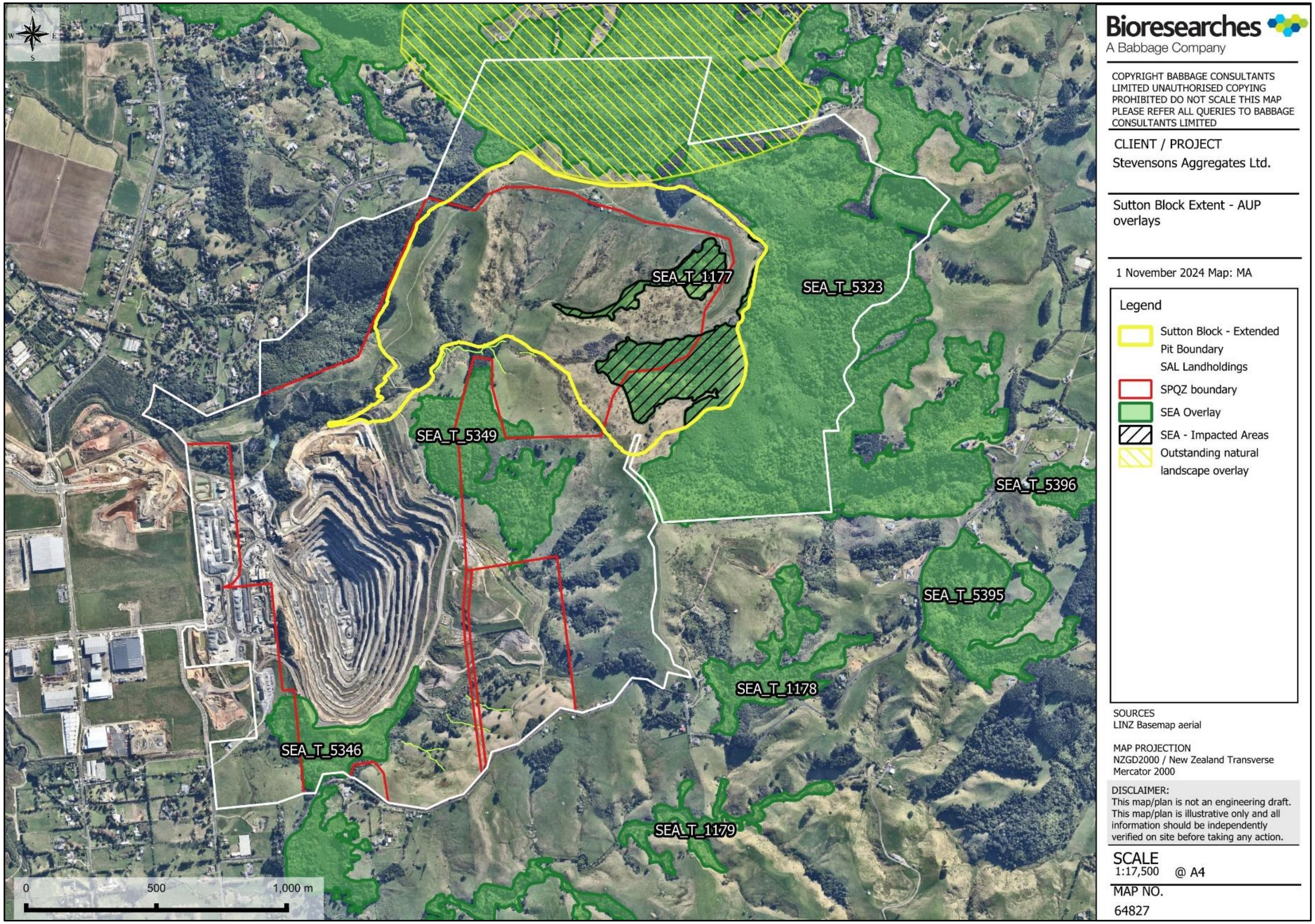

Figure 7. AUP overlays: SEAs, SPQZ and ONL within and around the proposed Sutton Pit Project area.

2.2.3 Timing

The modelled actions would be undertaken over five stages to either coincide with, or in advance of expected losses. See the EcIA for more information regarding quarry activity within each of the five stages.

2.2.3.1 Stage 1 - Infrastructure establishment (three-year plan)

The initial stage of work (Years 1 -3) involves the construction of the roading infrastructure required to access the site, draining of the existing farm dam to establish a sediment retention pond, associated stream diversion, initial offset planting, commencement of overburden removal, stockpiles (including bunding), and establishment of the conveyor system. Refer to Figure 8.

At Stage 2, enhancement of the entire 108.35 ha of podocarp broadleaved forest and kanuka forest will begin, providing biodiversity offsetting 20 – 30 years in advance for WF9 1, 3 and 4 and Kanuka forest. This will ensure the expected biodiversity gains are evident well before the loss of these impacted areas of vegetation.

2.2.3.2 Stage 2 - Operating Quarry (15 year plan)

The second stage of work is the 15- year plan which involves the commencement of quarrying within the interim pit boundary. Whether the interim pit commences within the west or east of the pit boundary will be determined by market demand for blue or brown rock. Regardless, expansion of the pit will be incremental, deepening and widening as resource is extracted. Internal pit roads will be constructed as the pit expands. Offset planting and weed and pest control will continue (Refer to Figure 9 and Table 12).

LOSSES DURING STAGES 1 AND 2:

- 0.65 ha of rock forest.
- 1.89 ha of Taraire, tawa podocarp forest (WF9-2 and WF9-5[5]).
- 10 Relict trees.

GAINS:

- 59.32 ha of offset revegetation.

108.35 ha offset enhancement, (all enhancement required for life of quarry, including some in advance of future losses.

Revegetation would initially focus on establishing all 8.32ha of the rock forest offset planting and some of the Taraire, tawa podocarp Forest (WF9) offset planting to buffer and support it. Rock forest revegetation would occur onto rocky substrate, where it occurs contiguously with the northwestern side of Kaarearea paa and contiguously with other rock forest fragments. The proposed offset planting will surround and buffer five hectares of rock forest across four small fragments which would be enhanced via pest animal control and fencing as necessary (Figure 8).

Further offset planting for WF9 would target privet and pine dominant vegetation on SAL-owned land adjacent to MacWhinney Reserve as a priority following response to stakeholder engagement. Buffer

[5] Note that not all of WF9-5 falls within the stage 2 pit boundary, but as only a small fraction will remain that will be heavily modified, all of the area has been included at this stage.

planting along the northeastern edge of Kaarearea paa (SEA_T_5349) will also be undertaken (Figure 9).

Later in Stage 2 19ha of kanuka forest revegetation will also be established at the Drury Quarry and Hingaia Islands (Figure 9).

At Stage 1, enhancement of the entire 108.35 ha of podocarp broadleaved forest and kanuka forest will begin, providing biodiversity offsetting 30- 50 years in advance for WF9 1, 3 and 4 and Kanuka forest. This will ensure the expected biodiversity gains are evident well before the loss of these impacted areas of vegetation.

By the end of Stage 2 (Year 15) all offset planting and enhancement will have been completed except for 3ha of VS2 planting to be completed in Year 16 (Stage 3).

Table 12. Stage 2 Biodiversity offset for Years 1 – 15 of LOQ Plan

Table Ref	Vegetation type	Loss (ha)	Revegetation (ha)	Location	Enhancement (ha)	Location
1	Rock Forest	0.65	8.32	SE of Sutton SPQZ and against Kaarearea paa	5.35	S of Sutton SPQZ
2	Taraire, tawa podocarp Forest (WF9 1 and 5)	1.88	12	MacWhinney Reserve & E of Kaarearea paa	23	Within SEA_T_5323
3	Taraire, tawa podocarp Forest (WF9 2, 3 & 4)	0	20	-	40	Within SEA_T_5323
4	Kanuka forest (VS2)	0	19	-	40	Within SEA_T_5323
TOTALS		2.63	59.32		108.35	

2.2.3.3 Stage 3 – Operating Quarry (30 year plan)

The third stage of works is further expansion of the interim pit boundary.

Refer to Figure 10, and Table 8.

LOSSES

- 13 Relict trees.

GAINS

- 3 ha of Kanuka Forest (VS2). All gains carried out in advance of losses.

Stage 3 will involve advance planting of 3 ha of VS2 which will complete the biodiversity offset planting for the entire life of the quarry. The development of the new areas of offset reforestation should be apparent by the time the impacted VS2 and WF9 2 & 3 areas are lost.

2.2.3.4 Stage 4 – Life of Quarry Plan (40 year plan)

The fourth stage of works is a further expansion of the interim pit boundary. Refer to Table 8, Table 13, and Figure 11.

LOSSES

- 2.66 ha Taraire, tawa podocarp forest.
- 5.06 kanuka forest.
- 107 relict native trees amongst pasture.

GAINS

All gains carried out in advance of losses.

Taraire, tawa podocarp forest offset planting will be at least 10 years old. Kanuka forest offset planting (12.05 ha) will be undertaken to the east of Kaarearea paa and adjacent to existing WF9 and rock forest revegetation on the southeastern side of the Sutton Pit.

Table 13. Stage 4 Biodiversity offsets (Years 30-40)

Table Ref	Vegetation type	Loss (ha)	Revegetation (ha)	Location	Enhancement (ha)	Location
1	Kanuka forest (VS2)	5.06	0	(planting in advance)	0	-
2	Taraire, tawa podocarp Forest (WF9 2, 3 & 4)	2.66	0	(planting in advance)	0	
2	Relict native trees amongst pasture	130 Individuals	1ha (887stems)	S edge of SEA_T_5323, N of bund	0	-

2.2.3.5 Stage 5 – Life of Quarry Plan (50 year plan)

The fifth stage reflects the full extent of the quarry pit over an approximate 50-year period. Refer to Table 8, Table 14, and Figure 11.

LOSSES

- 5.45 ha Taraire, tawa podocarp forest.
- 3.74 kanuka forest.

GAINS

- All gains carried out in advance of losses.

Taraire, tawa podocarp forest offset planting will be at least 20 years old.

Table 14. Stage 5 Biodiversity offsets (Years 40-50)

Table Ref	Vegetation type	Loss (ha)	Revegetation (ha)	Location	Enhancement (ha)	Location
1	Kanuka forest (VS2)	3.74	0	(planting in advance)	0	-
2	Taraire, tawa podocarp Forest (WF9 1, 3 & 4)	5.45	0	(planting in advance)	0	
2	Relict native trees amongst pasture	115 individuals	1ha (750 stems)	S edge of SEA_T_5323, N of bund	0	-

2.2.3.6 Stages 1-5: Summary.

Revegetation will start from year 1 and continue until year 16, with the forest fragments impacted first being replaced from years 1-5. Enrichment planting (phase 1) will occur 3 years after the initial pioneer planting (phase 1). All WF9 planting will be completed by year 13 and all VS2 planting will be completed by year 16, allowing for a minimum of 19 years of monitoring to occur within the 35 year biodiversity offset timeframe.

Table 15. Summary of planting extent by year for each of the ecosystem types. Preparation of Rock Forest planting substrate will occur in year 1 (i.e. moving boulders into planting areas). Phase 2 (enrichment) plantings are indicated by green shaded cells and will occur from 3 years after initial planting.

Year	WF9 (Lost Stages 1 & 2)	WF9 (Lost Stages 4 & 5)	RF (Lost Stage 1)	VS2 (Lost stages 4 & 5)	Total ha/year	Running Total
1	3				3	3
2	2		3		5	8
3			5.32		5.32	13.32
4	5				5	18.32
5	2				2	20.32
6		5			5	25.32
7		5			5	30.32
8		5			5	35.32
9		5			5	40.32
10				4	4	44.32
11				3	3	47.32
12				3	3	50.32
13				3	3	53.32
14				3	3	56.32
15				3	3	59.32
16				3	3	62.32
Total	**12**	**20**	**8.32**	**22**	**62.32**	

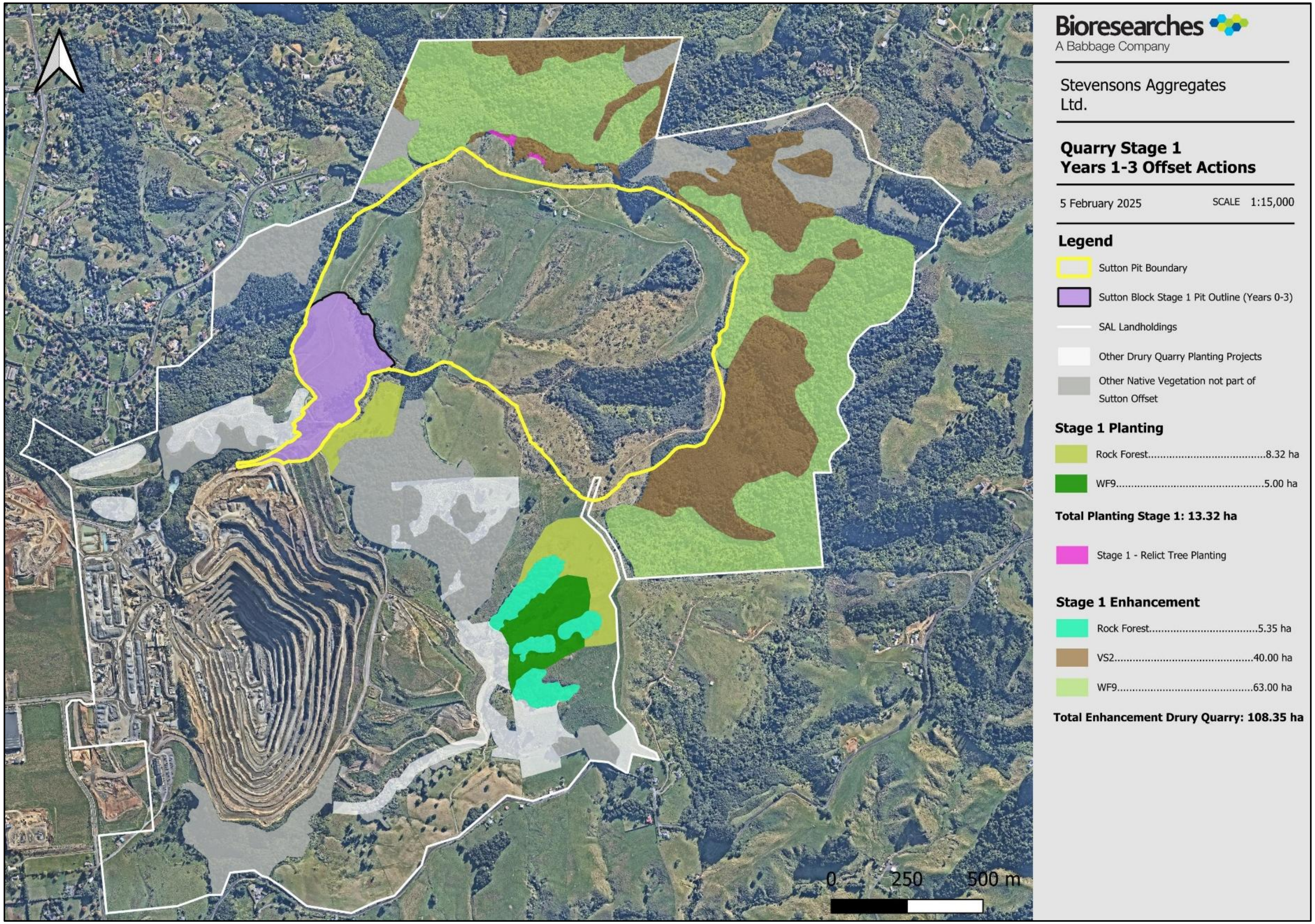

Figure 8. Stage 1 offset revegetation and enhancement actions.

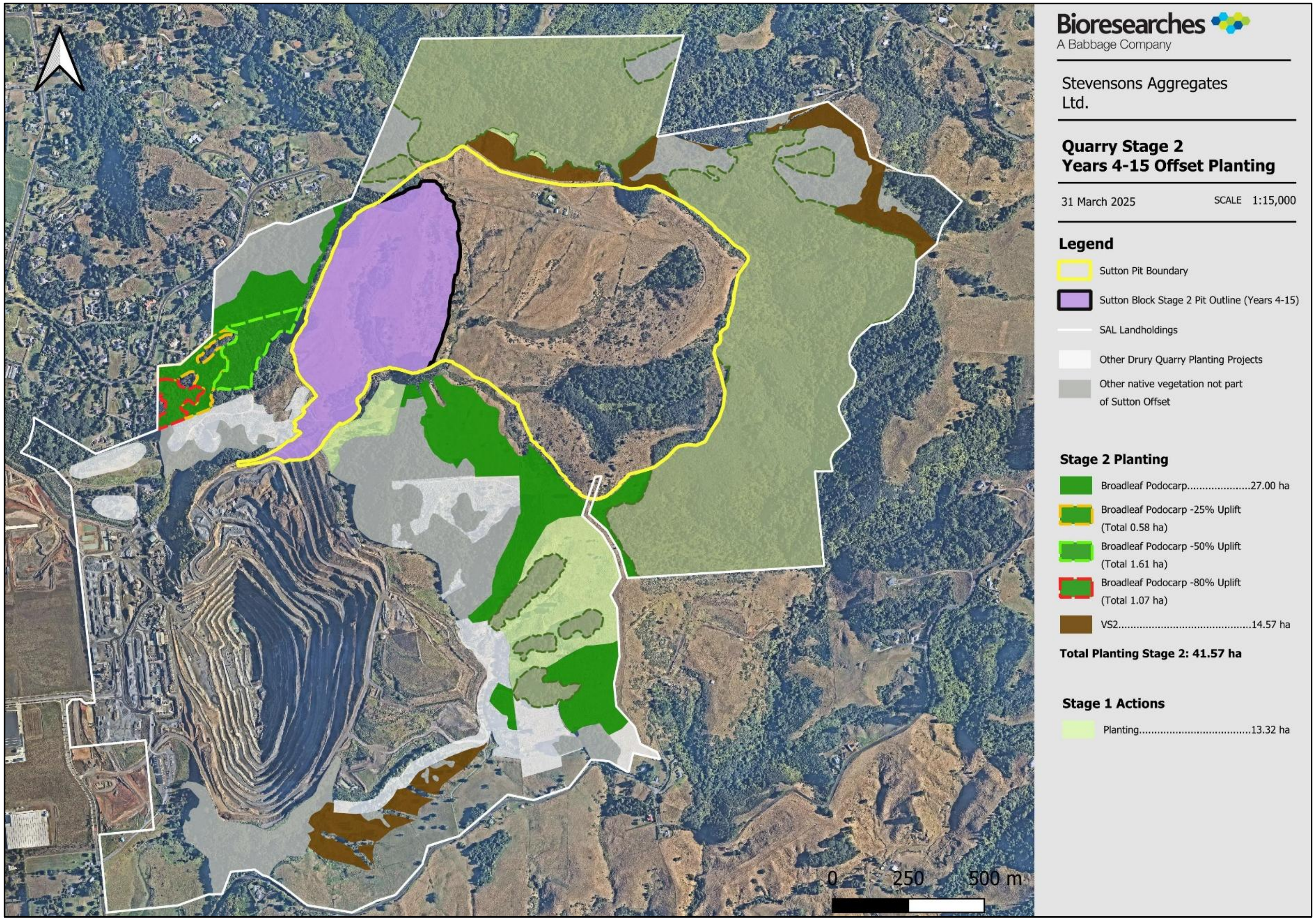

Figure 9. Stage 2 offset revegetation and enhancement actions.

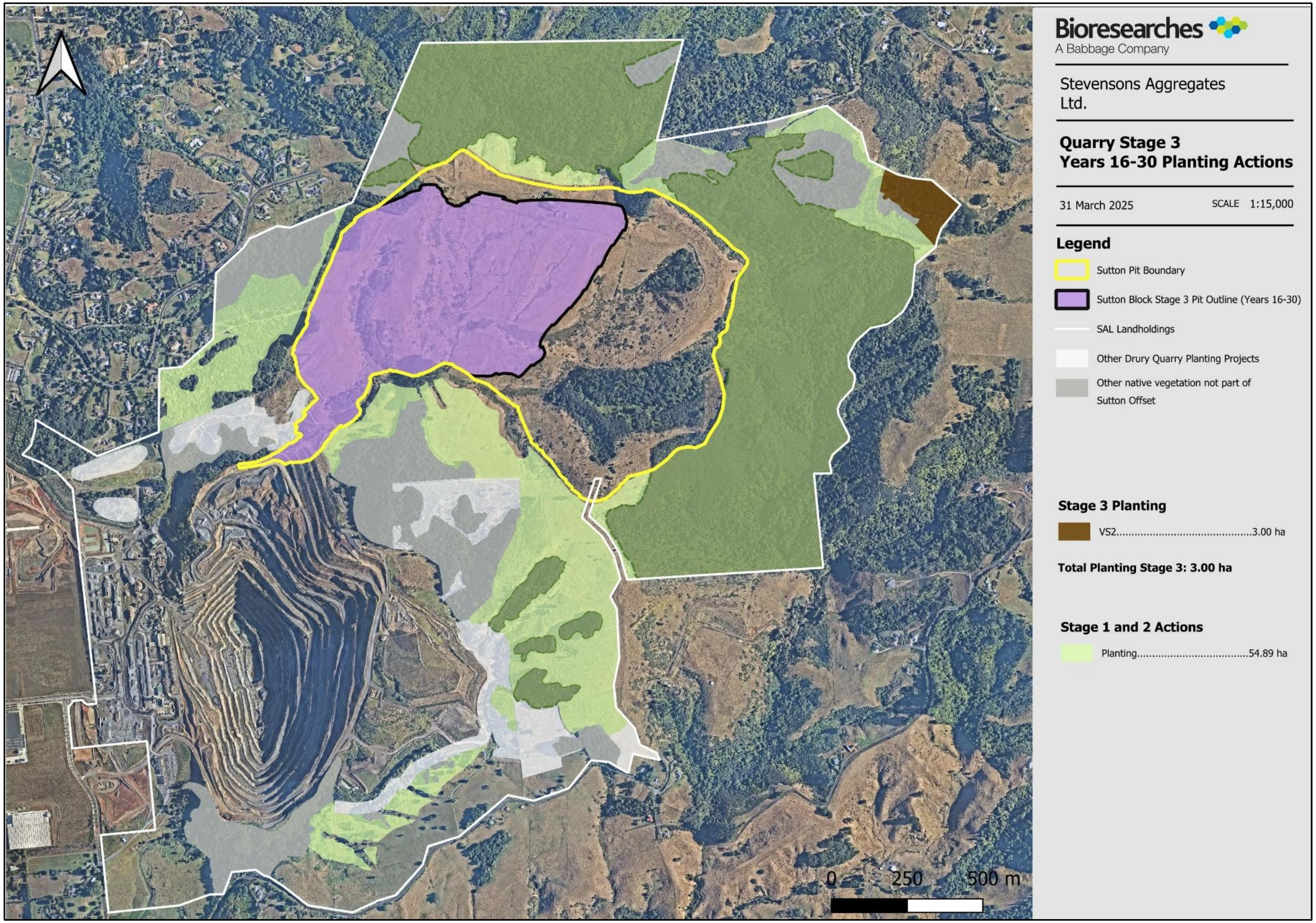

Figure 10. Stage 3 offset revegetation and enhancement actions.

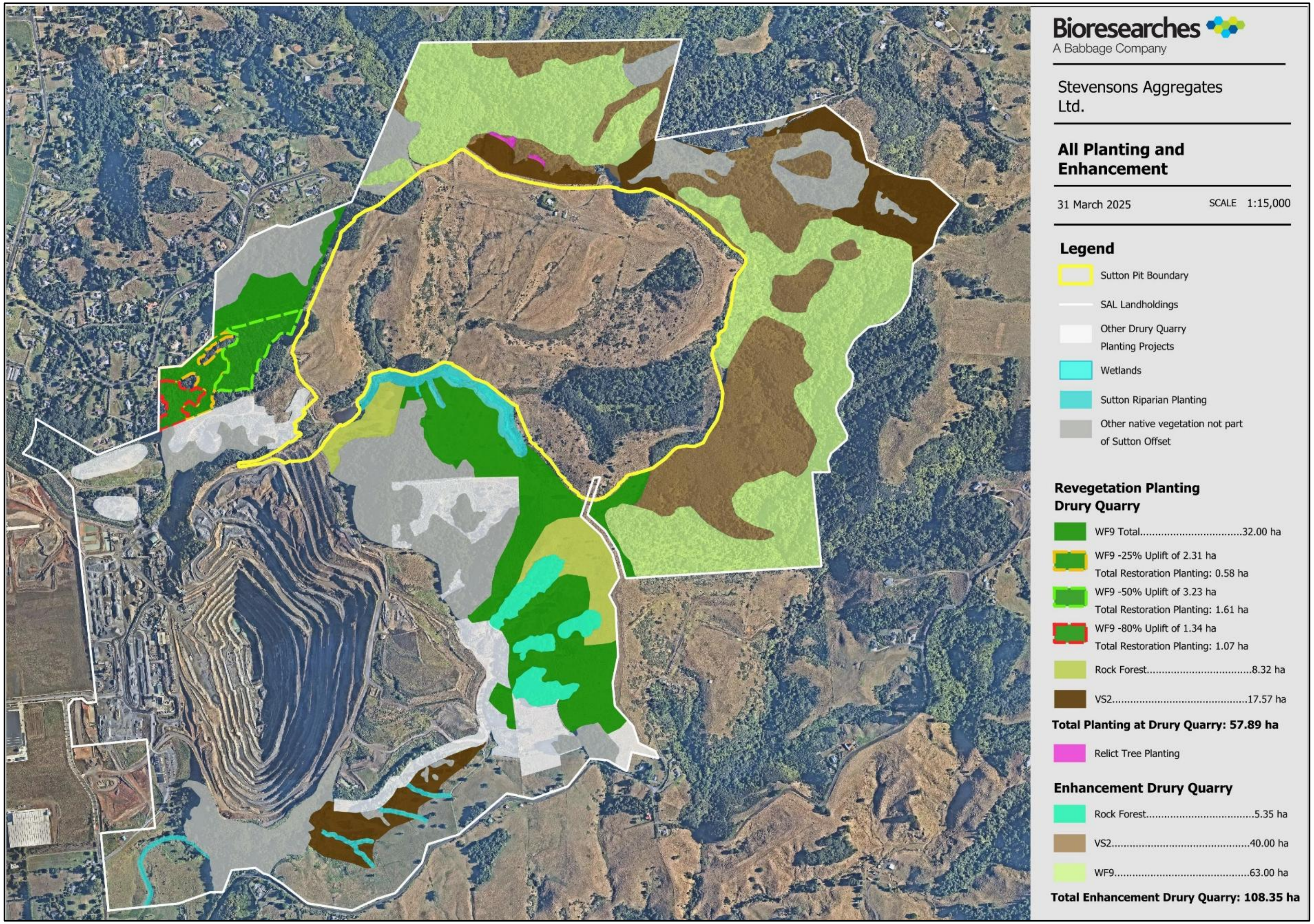

Figure 11. Total offset revegetation and enhancement actions. All stages.

2.3 Explanation of BOAM: Accounting Model Features

This section provides brief explanations of the BOAM parameters for offsetting loss of Rock Forest, Taraire, tawa podocarp forest (WF9), and kānuka forest ecosystem (VS2) as modelled.

2.3.1 Biodiversity Components

The biodiversity components are identified in the BOAM as aggregated features that collectively describe a set of similar attributes such as vegetation structure, diversity or fauna habitat resources. Biodiversity attributes are disaggregated into separate components to ensure that modelled outcomes for some attributes do not skew outcomes for other attributes that represent different components of the ecosystem.

Biodiversity components of ecological features within the proposed Sutton Block are aggregated into four biodiversity components: vegetation structure, vegetation diversity and volume, fauna habitat values and forest enhancement. These core components collectively describe the attributes against which each biodiversity type (Rock Forest, Taraire, tawa podocarp forest and kānuka forest) were measured.

Vegetation structure attributes quantify the three-dimensional structure of the vegetation and its distribution in height tiers.

Vegetation diversity and volume quantifies biomass and species diversity.

Fauna habitat values quantify food and habitat resources for fauna.

Forest enhancement quantifies key forest attributes that are currently impacted by pests, are measurable, and that are expected to respond most markedly to integrated pest control over existing degraded forest.

Kanuka forest was not assessed for some structural components such as sub canopy and basal area because it is a regenerating forest type with a simpler structure than mature forest types.

2.3.2 Biodiversity Attributes

Biodiversity attributes are the particular values that are measured and assessed in the BOAM. Attributes used in biodiversity offset modelling are chosen for their ability to capture the key biodiversity values that are representative of and collectively describe the biodiversity type. The attributes selected for the SAL Sutton Pit biodiversity offset models provide a balance of measurable vegetation and fauna values that are representative of rock forest, Taraire, tawa podocarp forest and kanuka scrub/forest. Key attributes for the proposed Sutton Pit BOAM are identified in

Table 16.

Table 16. Biodiversity components and attributes chosen for the SAL Sutton Pit biodiversity offset models.

Biodiversity Component	Biodiversity attributes
Vegetation Structure	Indigenous Canopy % cover
	Indigenous Subcanopy % cover
	Indigenous Understorey % cover
	Indigenous Groundcover % cover
Vegetation diversity and volume	Total vascular species richness
	Groundcover species richness
	Canopy species basal area
	Mean canopy height
Fauna habitat resources	Log fall
	Leaf litter depth
	Winter fruit diversity (trees and shrubs)
	Winter nectar-bearing flower diversity (trees and shrubs).
Forest Enhancement (pest management over existing forest)	Bird breeding success
	Sapling abundance
	Sapling species richness
	Seedling abundance
	Groundcover % cover

2.3.3 Benchmarks

The BOAM compares the biodiversity values for each biodiversity type at the impact and offset sites with the biodiversity values of a 'benchmark'. The benchmark provides a reference point for a similar biodiversity type in a very high-quality condition (e.g. primary forest, pest free if possible), against which to evaluate the biodiversity losses and gains. While it is often not possible to identify such 'pristine' benchmarks (acknowledging irreversible historic biodiversity losses), this study collected data from recce plots within 'best example' sites within the Hunua Ecological District.

2.3.4 BOAM Offset Justification

The following justification tables correspond with the three forest ecosystems and the relict tree BOAMs and their respective biodiversity attributes. The tables provide references or data that underpins and justifies the values inputted to each model. The output values are provided as red (Net Loss) or black (Net gain).

Table 17. Offset model explanation. Biodiversity Type: Rock Forest (Stage 1, 0.65 ha loss)

Biodiversity attribute	Benchmark and justification	Impact value	Action and confidence	Biodiversity value after 30 years	Justification for confidence (References / data)	Attribute Net Biodiversity Value
Indigenous Canopy cover (%)	**57** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control for 15 years	**60** Measured from 20m x 20m Recce plot within rock forest vegetation within Sutton footprint. Best available measure.	**Revegetation 8.32 ha** Confidence 75-90%	**50** Conservative 30-year value allowing for potentially slower growth on boulder substrate.	Well-established approach to revegetation with known success over numerous projects. Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook. Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry.	**1.83**
Subcanopy cover %	**15** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**8** Measured from 20m x 20m Recce plot within rock forest vegetation within Sutton footprint. Best available measure.	**Revegetation 8.32 ha** Confidence 75-90%	**15** 30 years long enough for forest tiers to begin to develop	Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry	**1.16**
Indigenous ground cover %	**8** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**0.1** Measured from 20m x 20m Recce plot within broadleaf rock forest vegetation within Sutton footprint. Best available measure.	**Revegetation 8.32 ha** Confidence 75-90%	**5** 30 years long enough for forest tiers to begin to develop	Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry. Understorey species will be specifically planted in Phase 2 of forest establishment.	**0.62**
Total species richness	**21** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**17** Measured from 20m x 20m Recce plot within rock forest vegetation within Sutton footprint. Best available measure.	**Revegetation 8.32 ha** Confidence 75-90%	**5** 30 years long enough for forest tiers to begin to develop	The required range of species will be specifically planted.	**1.90**
Ground cover indigenous species richness	**11** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**3** Measured from 20m x 20m Recce plot within rock forest vegetation within Sutton footprint. Best available measure.	**Revegetation 8.32 ha** Confidence 75-90%	**7** Additional rock forest species can be introduced at 15-20 years if necessary.	Conservative value based on well-known revegetation techniques but allowing for slower establishment of species on rocky substrate and more specific habitat type. Groundcover species can be specifically planted if natural colonisation not sufficient.	**1.62**
Canopy tree basal area (>10cm diameter)	**46.67** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**32.49** Measured from 20m x 20m Recce plot within rock forest vegetation within Sutton footprint.	**Revegetation 8.32 ha** Confidence 75-90%	**14** https://toolkit.tanestrees.org.nz/). Expected basal area/ha after 30 years allowing for slower growth rates than normal. DBH expected to be > 70% of normal rates. Stocking rate of canopy trees 550 stems/ha (4.2m spacing).	Expected mean height targets are based on the Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/	**0.40**

Mean canopy height	**18** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**16** Measured from 20m x 20m Recce plot within rock forest vegetation within Sutton footprint.	**Revegetation 8.32 ha** Confidence 75-90%	**8** Expected height after 30 years allowing for slower establishment than normal on boulder substrate.	Expected mean height targets are based on the Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/	**0.68**
Log fall (m^3/ha)	**235** Richardson et al. (2009) for deadwood in forest plots from a broadleaved forest with a diameter > 10 cm.	**15.98** Measured from 20m x 20m Recce plot within rock forest vegetation within Sutton footprint.	**Revegetation 8.32 ha** Confidence 75-90%	**20 m^3/ha**	Value would be met at 30 yrs- based on measurements within 13-year-old planted vegetation at Waingaro Quarry: 0.08 m^3 / ha	**0.20**
Leaf litter depth (mm)	**53** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**17** Measured from 20m x 20m Recce plot within rock forest vegetation within Sutton footprint.	**Revegetation 8.32 ha** Confidence 75-90%	**12 mm**	Value would be met at 20 yrs based on 13-year-old manuka-dominant planting at Waingaro Quarry (14 mm).	**0.43**
Winter fruit diversity (trees & shrubs)	**8** *Alectryon excelsus* *Alseuosmia macrophylla* *Beilschmiedia tarairi* *Hedycarya aborea* *Piper excelsum* *Podocarpus totara* *Rhopalostylis sapida* *Vitex lucens*	**5** Measured from vegetation plot or identified from surrounds.	**Revegetation 8.32 ha** Confidence 75-90%	**8** All benchmark species	Revegetation is a well-established approach to restoration with known success over numerous projects. All benchmark species commonly included in planting schedules in Auckland Region or can be included.	**3.39**
Winter flower diversity (trees & shrubs)	**5** *Kunzea robusta* *Sophora microphylla* *Vitex lucens* *Metrosideros fulgens* *Dysoxylem*	**2** Measured from vegetation plot or identified from surrounds.	**Revegetation 8.32 ha** Confidence 75-90%	**5** All benchmark species	Revegetation is a well-established approach to restoration with known success over numerous projects. All benchmark species commonly included in planting schedules in Auckland Region or can be included.	**3.54**
Seedling count ≥ 15cm/20x20m plot	**600** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**0** Measured from 20 x 20 m plot in rock forest within Sutton Block footprint. Subject to grazing/browsing.	**Enhancement / pest control of rock forest 5.35 ha** Confidence >90%	**600** Conservative 30-year value since reference plot fenced for 15 year and pest controlled <15 years.	Conservative figure based on benchmark plot with 15 years browser exclusion and pest control.	**2.10**
Saplings count	**280** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**0.5** Measured from 20 x 20 m plot in rock forest within Sutton Block footprint. Subject to grazing/browsing.	**Enhancement / pest control of rock forest 5.35 ha** Confidence >90%	**280** Conservative 30-year value since reference plot fenced for 15 year and pest controlled <15 years.	Conservative figure based on benchmark plot with 15 years browser exclusion and pest control.	**2.10**
Sapling diversity	**6** Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	**0.5** Measured from 20 x 20 m plot in rock forest within Sutton Block footprint. Subject to grazing/browsing.	**Enhancement / pest control of rock forest 5.35 ha** Confidence >90%	**6** Conservative 30-year value since reference plot fenced for 15 year and pest controlled <15 years.	Conservative figure based on benchmark plot with 15 years browser exclusion and pest control.	**2.10**
Ground cover (%)	**8**	**0.1**	**Enhancement / pest control of rock forest 5.35 ha** Confidence >90%	**8**	Conservative figure based on benchmark plot with 15 years browser exclusion and pest control.	**2.08**

	Kaarearea paa 20m x 20m Recce plot within deer exclusion fence with pest control	Measured from 20 x 20 m plot in rock forest within Sutton Block footprint. Subject to grazing/browsing.		Conservative 30-year value since reference plot fenced for 15 year and pest controlled <15 years.		
Forest bird breeding success (%)	**70%** Innes et al. 2015 (81-88% success at pest-manged forest fragments) But also 63% success reported from pest free location (Pierce & Graham 1995).	**50%** Wide range of values: -65-73% success at unmanaged forest fragments (Innes et al. 2015) but typically much lower elsewhere (0 -31% success reported by Innes et al. 2004; 22% success (Clout et al. 1995); 19% success (Pierce & Graham 1995)	**Enhancement / pest control of rock forest 5.35 ha** Confidence >90%	**65%** (Increase by 15%)	Large volume of data demonstrates value of pest control to indigenous biodiversity. Note confidence reduced from >90% due to large variation in published success rates for managed and unmanaged sites)	**0.45**

Table 18. Offset model explanation. Biodiversity Type: Taraire, tawa podocarp forest (WF9) (Stage 1 and 2: 1.98 ha loss)

Biodiversity attribute	Benchmark and justification	Impact value	Action and confidence	Biodiversity value after 30 years	Justification for confidence (References / data)	Attribute Net Biodiversity Value
Indigenous Canopy cover (%)	**65** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**75** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint. Stage 1 &2.	**Revegetation 12 ha** Confidence 75 - 90%	**75**	Well-established approach to revegetation with known success over numerous projects. Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook. Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry.	**2.10**
Indigenous subcanopy cover %	**20** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**12** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint. Stage 1 &2.	**Revegetation 12 ha** Confidence 75 - 90%	**10**	Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook. Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry. Conservative estimate, likely to be exceeded.	**0.85**
Indigenous understorey cover %	**45** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**5** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint. Stage 1 &2.	**Revegetation 12 ha** Confidence 75 - 90%	**15**	Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry. Understorey species will be specifically planted in Phase 2 of forest establishment.	**1.14**
Indigenous ground cover %	**2** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within the Hunua Ranges. Best available measure.	**3** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint. Stage 1 &2.	**Revegetation 12 ha** Confidence 75 - 90%	**10**	Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry. Understorey species will be specifically planted in Phase 2 of forest establishment.	**2.10**
Total species richness	**40** Mean value for 10 standard NVS plots of WF9 in Hunua ranges. Best available measure.	**26** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stage 1 &2.	**Revegetation 12 ha** Confidence > 90%	**28**	The required range of species will be specifically planted.	**2.02**
Ground cover indigenous species richness	**24** Mean value for 10 standard NVS plots of WF9 in Hunua ranges. Best available measure.	**14** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stage 1 &2.	**Revegetation 12 ha** Confidence > 90%	**16**	Groundcover species can be specifically planted if natural colonisation not sufficient.	**1.99**

Canopy tree basal area (>10cm diameter)	**52.97** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**46.65** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stage 1 &2.	**Revegetation 12 ha** Confidence > 90%	**21**	Expected mean height targets are based on the Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/	**0.13**
Mean canopy height	**18** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**18** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stage 1 &2.	**Revegetation 12 ha** Confidence > 90%	**8.5**	Expected mean height targets are based on the Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/	**0.25**
Log fall (m^3/ha)	**235** Richardson et al. (2009) for deadwood in forest plots from a broadleaved forest with a diameter > 10 cm	**19.05** Measured from 20 x 20 m plots of WF9 vegetation within Sutton footprint Stage 1 &2.	**Revegetation 12 ha** Confidence > 90%	**35 m^3/ha**	Value would be met at 30 yrs- based on measurements within 13-year-old planted vegetation at Waingaro Quarry: 0.08 m^3 / ha	**0.54**
Leaf litter depth (mm)	**53** Plots within WF9 within Hunua Ranges	**38** Measured from 20 x 20 m plots of WF9 vegetation within Sutton footprint Stage 1 &2.	**Revegetation 12 ha** Confidence > 90%	**15 mm**	Value would be met at 30 yrs based on 13-year-old manuka-dominant planting at Waingaro Quarry (14 mm).	**-0.08**
Winter fruit diversity (trees & shrubs)	**7** *Alseuosmia macrophylla* *Beilschmiedia tarairi* *Hedycarya aborea* *Piper excelsum* *Podocarpus totara* *Rhopalostylis sapida* *Vitex lucens* Common species found in standard NVS plots of WF9 in the Hunua ranges.	**5** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stage 1 &2.	**Revegetation 12 ha** Confidence > 90%	**7** All benchmark species	Revegetation is a well-established approach to restoration with known success over numerous projects. All benchmark species commonly included in planting schedules in Auckland Region or can be included.	**3.31**
Winter flower diversity (trees & shrubs)	**5** *Kunzea robusta* *Sophora microphylla* *Vitex lucens* *Metrosideros fulgens* *Didymocheton spectabilis* Common species found in standard NVS plots of WF9 in the Hunua ranges.	**3** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stage 1 &2.	**Revegetation 12 ha** Confidence > 90%	**5** All benchmark species	Revegetation is a well-established approach to restoration with known success over numerous projects. All benchmark species commonly included in planting schedules in Auckland Region can be included	**2.59**
Seedling count	**711** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**89** Average value from WF9 plots within Stage 4 & 5	**Enhancement / pest control of WF9 forest 23 ha** Confidence >90%	**700** Conservative 30 year value	Reasonable to expect 30 years of pest control will result in strong recovery of the seedling layer.	**4.02**

Saplings count	**48** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**0.5** Average value from WF9 plots within Stage 4 & 5	**Enhancement / pest control of WF9 forest 23 ha** Confidence >90%	**40** Conservative 30 year value	Reasonable to expect 30 years of pest control will result in strong recovery of the sapling class.	**8.18**
Sapling diversity	**4** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**0.5** Average value from WF9 plots within Stage 4 & 5	**Enhancement / pest control of WF9 forest 23 ha** Confidence >90%	**4** Conservative 30 year value	Reasonable to expect 30 years of pest control will result in palatable species being able to reach the sapling class.	**6.31**
Ground cover (%)	**2** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**1.5** Average value from WF9 plots within Stage 4 & 5	**Enhancement / pest control of WF9 forest 23 ha** Confidence >90%	**2** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	Conservative value, taking into account typical WF9 structure.	**1.14**
Forest bird breeding success (%)	**70%** Innes et al. 2015 (81-88% success at pest-manged forest fragments) But also 63% success reported from pest free location (Pierce & Graham 1995).	**50%** Wide range of values: -65-73% success at unmanaged forest fragments (Innes et al. 2015) but typically much lower elsewhere (0 -31% success reported by Innes et al. 2004; 22% success (Clout et al. 1995); 19% success (Pierce & Graham 1995)	**Enhancement / pest control of WF9 forest 23 ha** Confidence >90%	**65%** (Increase by 15%)	Large volume of data demonstrates value of pest control to indigenous biodiversity. Note confidence reduced from >90% due to large variation in published success rates for managed and unmanaged sites)	**1.22**

Table 19. Offset model explanation. Biodiversity Type: Taraire, tawa podocarp forest (WF9) (Stage 4 and 5: 5.42 ha loss). Will be planted at least 10 years in advance of loss.

Biodiversity attribute	Benchmark and justification	Impact value	Action and confidence	Biodiversity value after 30 years	Justification for confidence (References / data)	Attribute Net Biodiversity Value
Indigenous Canopy cover (%)	**65** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**60** Measured from 20m x 20m Recce plot within WF9 vegetation within Sutton footprint. Stage 4 & 5.	**Revegetation 20 ha** Confidence 75 - 90%	**75**	Well-established approach to revegetation with known success over numerous projects. Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook. Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry.	**5.57**
Subcanopy cover %	**20** Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**13** Measured from 20m x 20m Recce plot within WF9 vegetation within Sutton footprint. Stage 4 & 5.	**Revegetation 20 ha** Confidence 75 - 90%	**10**	Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook. Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry. Conservative estimate, likely to be exceeded.	**1.04**
Indigenous understorey cover %	**45** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**4.5** Measured from 20m x 20m Recce plot within WF9 vegetation within Sutton footprint. Stage 4 & 5.	**Revegetation 20 ha** Confidence 75 - 90%	**15**	Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry	**2.50**
Indigenous ground cover %	**2** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within the Hunua Ranges. Best available measure.	**0.1** Measured from 20m x 20m Recce plot within WF9 vegetation within Sutton footprint. Stage 4 & 5.	**Revegetation 20 ha** Confidence 75 - 90%	**10**	Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry.	**8.86**
Total species richness	**40** Mean value for 10 representative NVS plots from WF9 in the Hunua Ecological District	**29** Measured from 20m x 20m Recce plot within WF9 vegetation within Sutton footprint. Stage 4 & 5.	**Revegetation 20 ha** Confidence > 90%	**28**	The required range of species will be specifically planted.	**3.47**
Ground cover indigenous species richness	**24** Mean value for 10 representative NVS plots from WF9 in the Hunua Ecological District	**18**	**Revegetation 20 ha** Confidence > 90%	**16**	Groundcover species can be specifically planted if natural colonisation not sufficient.	**2.99**

		Measured from 20m x 20m Recce plot within WF9 vegetation within Sutton footprint. Stage 4 & 5.				
Canopy tree basal area (>10cm diameter)	**52.97** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**46.15** Measured from 20m x 20m Recce plot within WF9 vegetation within Sutton footprint. Stage 4 & 5.	**Revegetation 20 ha** Confidence 75- 90%	**21**	Expected mean height targets are based on the Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/	**-1.10**
Mean canopy height	**18** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control.	**15** Measured from 20m x 20m Recce plot within WF9 vegetation within Sutton footprint. Stage 4 & 5.	**Revegetation 20 ha** Confidence 75- 90%	**8.5**	Expected mean height targets are based on the Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/	**-0.20**
Log fall (m^3/ha)	**235** Richardson et al. (2009) for deadwood in forest plots from a broadleaved forest with a diameter >10 cm.	**20.01** Measured from 20 x 20 m plots of WF9 vegetation within Sutton footprint Stage 4 &5.	**Revegetation 20 ha** Confidence 75- 90%	**20 m^3/ha**	Value would be met at 20 yrs- based on measurements within 13-year-old planted vegetation at Waingaro Quarry: 0.08 m^3 / ha	**0.32**
Leaf litter depth (mm)	**53** Plots within WF9 within Hunua Ranges	**20** Measured from 20 x 20 m plots of WF9 vegetation within Sutton footprint Stage 4 &5.	**Revegetation 20 ha** Confidence 75- 90%	**12 mm**	Value would be met at 20 yrs based on 13-year-old manuka-dominant planting at Waingaro Quarry (14 mm).	**0.02**
Winter fruit diversity (trees & shrubs)	**7** *Alectryon excelsus* *Beilschmiedia tarairi* *Hedycarya aborea* *Piper excelsum* *Podocarpus totara* *Rhopalostylis sapida* *Vitex lucens*	**5** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stage 4 & 5.	**Revegetation 20 ha** Confidence > 90%	**7** All benchmark species	Revegetation is a well-established approach to restoration with known success over numerous projects. All benchmark species commonly included in planting schedules in Auckland Region.	**6.70**
Winter flower diversity (trees & shrubs)	**5** *Vitex lucens* *Kunzea robusta* *Metrosideros fulgens* *Dysoxylem spectabile* *Sophora microphylla*	**3** Measured from vegetation plot or identified from surrounds	**Revegetation 20 ha** Confidence > 90%	**4** All benchmark species	Revegetation is a well-established approach to restoration with known success over numerous projects. All benchmark species commonly included in planting schedules in Auckland Region	**5.21**
Seedling count	**711** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**89**	**Enhancement / pest control of WF9 forest 40 ha** Confidence >90%	**700**	Reasonable to expect 30 years of pest control will result in strong recovery of the seedling layer.	**7.92**

		Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stages 4 & 5.				
Saplings count	**48** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**0.5** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stages 4 & 5.	**Enhancement / pest control of WF9 forest 40 ha** Confidence >90%	**40**	Reasonable to expect 30 years of pest control will result in strong recovery of the sapling class.	**16.47**
Sapling diversity	**4** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**0.5** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stages 4 & 5.	**Enhancement / pest control of WF9 forest 40 ha** Confidence >90%	**4**	Reasonable to expect 30 years of pest control will result in palatable species being able to reach the sapling class.	**12.54**
Ground cover (%)	**2** Measured from 20m x 20m Recce plot within WF9 dominant vegetation within protected reserve with pest control. Best available measure.	**1.5** Measured from 20m x 20m Recce plot within broadleaf podocarp dominant vegetation within Sutton footprint Stages 4 & 5.	**Enhancement / pest control of WF9 forest 40 ha** Confidence >90%	**2**	Conservative value, taking into account typical WF9 structure.	**5.02**
Forest bird breeding success (%)	**70%** Innes et al. 2015 (81-88% success at pest-manged forest fragments) But also 63% success reported from pest free location (Pierce & Graham 1995).	**50%** Wide range of values: -65-73% success at unmanaged forest fragments (Innes et al. 2015) but typically much lower elsewhere (0 -31% success reported by Innes et al. 2004; 22% success (Clout et al. 1995); 19% success (Pierce & Graham 1995)	**Enhancement / pest control of WF9 forest 40 ha** Confidence >90%	**65%** (Increase by 15%)	Large volume of data demonstrates value of pest control to indigenous biodiversity. Note confidence reduced from >90% due to large variation in published success rates for managed and unmanaged sites)	**1.43**

Table 20. Offset model explanation. Biodiversity Type: Kanuka Forest (8.79 ha loss)

Biodiversity attribute	Benchmark and justification	Impact value	Action and confidence	Biodiversity value after 20 years	Justification for confidence (References / data)	Attribute Net Biodiversity Value
Indigenous Canopy cover (%)	**55** Measured from 20m x 20m Recce plot within kanuka dominant vegetation within mature kanuka forest within the Hunua Ranges. Best available measure.	**50** Measured from 20m x 20m Recce plot within kanuka dominant vegetation within Sutton footprint. Stage 4.	**Revegetation 22 ha** Confidence 75 - 90%	**55**	Well-established approach to revegetation with known success over numerous projects. Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook. Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry.	**2.05**
Mean canopy height (m)	**12** Measured from 20m x 20m Recce plot within mature kanuka forest within the Hunua Ranges.	**9** Measured from 20m x 20m Recce plot within kanuka dominant vegetation within Sutton footprint. Stage 4.	**Revegetation 22 ha** Confidence 75 - 90%	**7**	Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook. Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry. Conservative estimate, likely to be exceeded.	**-0.74**
Indigenous understorey cover %	**27** Measured from 20m x 20m Recce plot within mature kanuka forest within the Hunua Ranges. Best available measure. .	**10** Measured from 20m x 20m Recce plot within kanuka dominant vegetation within Sutton footprint. Stage 4.	**Revegetation 22 ha** Confidence 75 - 90%	**10**	Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry	**0.46**
Indigenous ground cover %	**10** Measured from 20m x 20m Recce plot within mature kanuka forest within the Hunua Ranges. Best available measure.	**0.01** Measured from 20m x 20m Recce plot within kanuka dominant vegetation within Sutton footprint. Stage 4.	**Revegetation 22 ha** Confidence 75 - 90%	**5**	Recce data obtained from 10m x 10m plot amongst 13-year-old planted vegetation at Waingaro Quarry.	**5.02**
Diversity # of native vascular species	**28** Measured from 20m x 20m Recce plot within mature kanuka forest within the Hunua Ranges.	**21** Measured from 20m x 20m Recce plot within kanuka dominant vegetation within Sutton footprint. Stage 4.	**Revegetation 22 ha** Confidence 75 - 90%	**21**	Data obtained from 13-year-old planted vegetation at Waingaro Quarry.	**0.94**
Log fall (m^3/ha)	**23.71** Plots from onsite (outside quarry footprint). Note that VS2 plots at Hunua Ranges were lower: 16.6 m^3/ha, therefore used adjacent to Project as benchmark.	**5.89** Measured from 20 x 20 m plots of VS2 vegetation	**Revegetation 22 ha** Confidence 75 -90%	**0.1 m^3/ha**	Value would be met at 20 yrs- based on measurements within 13-year-old planted vegetation at Waingaro Quarry: 0.08 m^3 / ha	**-2.14**
Leaf litter depth (mm)	**18.4** Plots within VS2 at Hunua Ranges	**14**	**Revegetation 22 ha** Confidence 75 -90%	**12 mm**	Value would be met at 20 yrs based on 13-year-old manuka-dominant planting at Waingaro Quarry (14 mm).	**-0.14**

Winter fruit diversity (trees & shrubs)	**4** *Hedycarya arborea* *Piper excelsum* *Podocarpus totara* *Rhopalostylis sapida*	**1** *Podocarpus totara*	**Revegetation 22 ha** Confidence >90%	**4** All benchmark species	Revegetation is a well-established approach to restoration with known success over numerous projects. All benchmark species commonly included in planting schedules in Auckland Region.	**9.43**
Winter flower diversity (trees & shrubs)	**3** *Leptospermum scoparium* *Kunzea robusta* *Sophora microphylla*	**1** *Leptospermum scoparium*	**Revegetation 22 ha** Confidence >90%	**3** All benchmark species	Revegetation is a well-established approach to restoration with known success over numerous projects. All benchmark species commonly included in planting schedules in Auckland Region	**8.70**
Seedling count >15 cm/plot	**578**	**200**	**Enhancement / pest control of kanuka forest 40 ha** Confidence >90%	**500**	Reasonable to expect 30 years of pest control will result in strong recovery of the seedling layer.	**7.93**
Saplings count	**138**	**1**	**Enhancement / pest control of kanuka forest 40ha** Confidence >90%	**100**	Reasonable to expect 30 years of pest control will result in strong recovery of the sapling class.	**15.11**
Sapling diversity	**8**	**1**	**Enhancement / pest control of kanuka forest 40ha** Confidence >90%	**5**	Reasonable to expect 30 years of pest control will result in palatable species being able to reach the sapling class.	**9.48**
Ground cover (%)	**10**	**0.01**	**Enhancement / pest control of kanuka forest 40ha** Confidence >90%	**10**	Conservative value, taking into account typical VS2 structure.	**21.12**
Forest bird breeding success (%)	**70%** Innes et al. 2015 (81-88% success at pest-manged forest fragments) But also 63% success reported from pest free location (Pierce & Graham 1995).	**50** Wide range of values: -65-73% success at unmanaged forest fragments (Innes et al. 2015) but typically much lower elsewhere (0 -31% success reported by Innes et al. 2004; 22% success (Clout et al. 1995); 19% success (Pierce & Graham 1995)	**Enhancement / pest control of kanuka forest 40ha** Confidence >90%	**65%** (Increase by 10%)	Large volume of data demonstrates value of pest control to indigenous biodiversity. Note confidence reduced from >90% due to large variation in published success rates for managed and unmanaged sites)	**1.03**

Table 21. Offset model explanation. Biodiversity Type: Relict trees in pasture (130 trees loss)

Biodiversity attribute	Benchmark and justification	Impact value	Action and confidence	Biodiversity value after 25 years	Justification for confidence (References / data)	Attribute Net Biodiversity Value
Basal Area (m^2)	**48** Tanes trees growth and yield calculator	**20.43** Measured from relict trees within Sutton footprint	**Revegetation 2 ha** Confidence > 90%	**29**	Well-established approach to revegetation with known success over numerous projects. Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook.	**0.30**
Mean canopy height (m)	**20** Tanes trees growth and yield calculator	**15** Measured from relict trees within Sutton footprint	**Revegetation 2 ha** Confidence > 90%	**10**	Well-established approach to revegetation with known success over numerous projects. Data on shrub & small tree growth rates taken from Tanes Trees Technical handbook.	**0.01**

2.4 BOAM Models

2.4.1 Rock Forest (Stage 1, 0.65 ha loss) BOAM output

Table 22. BOAM Output for loss of 0.65 ha rock forest: vegetation structure. Model indicates a net biodiversity gain (1.34).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component		Biodiversity Attribute	Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Vegetation structure	3.1a	Indigenous canopy cover	% cover	57	Restoration planting	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	50	30	2.48	-0.65	1.83	1.34
	3.1b	Indigenous subcanopy cover	% cover	15	Restoration planting	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	8	30	1.51	-0.35	1.16	
	3.1c	Indigenous understorey cover	% cover	57	Restoration planting	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	15	30	0.74	-0.13	0.62	
	3.1d	Indigenous ground cover	% cover	8	Restoration planting	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	5	30	1.77	-0.01	1.76	

Table 23. BOAM Output for loss of 0.65 ha rock forest: diversity and volume. Model indicates a net biodiversity gain (1.15).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component		Biodiversity Attribute	Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Diversity and volume	3.2a	Diversity of native vascular	count	21	Restoration planting	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	18	30	2.42	-0.53	1.90	1.15
	3.2b	Diversity of native ground cover	count	11	Restoration planting	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	7	30	1.80	-0.18	1.62	
	3.2c	Basal area >10cm dbh	m2/ha	46.67	Restoration planting	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	14	30	0.85	-0.45	0.40	
	3.2d	Mean canopy height	m	18	Restoration planting	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	8	30	1.26	-0.58	0.68	

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Table 24. BOAM Output for loss of 0.65 ha rock forest: fauna habitat. Model indicates a net biodiversity gain (1.89).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Fauna habitat	3.3a	Log fall	volume, m3/ha	235	Revegetation/ stock fencing	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	20	30	0.24	-0.04	0.20	1.89
	3.3b	Leaf litter depth	mm	53	Revegetation/ stock fencing	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	12	30	0.64	-0.21	0.43	
	3.3c	Winter fruit diversity (trees &	(%)	8	Revegetation/ stock fencing	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	8	20	3.80	-0.41	3.39	
	3.3d	Winter flower diversity	count	5	Revegetation/ stock fencing	8.32	Confident 75-90%	Finite end point	Continue to Column M	0	5	20	3.80	-0.26	3.54	

Table 25. BOAM Output for loss of 0.65 ha rock forest: ecosystem enhancement. Model indicates a net biodiversity gain (1.77).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Enhancement - Vegetation	3.4a	# Seedlings > 15cm per plot	count	600	Integrated pest control of existing habitats	5.35	Very confident >90%	Finite end point	Continue to Column M	0	600	30	2.10	0.00	2.10	1.77
	3.4b	# Saplings per plot	count	280	Integrated pest control of existing habitats	5.35	Very confident >90%	Finite end point	Continue to Column M	0	280	30	2.10	0.00	2.10	
	3.4c	Sapling diversity per plot	count	6	Integrated pest control of existing habitats	5.35	Very confident >90%	Finite end point	Continue to Column M	0	6	30	2.10	0.00	2.10	
	3.4d	Groundcover %	% cover	8	Integrated pest control of existing habitats	5.35	Very confident >90%	Finite end point	Continue to Column M	0.1	8	30	2.08	0.00	2.08	
		Breeding success Avifauna	count	70	Integrated pest control of existing habitats	5.35	Very confident >90%	Finite end point	Continue to Column M	50	65	30	0.45	0.00	0.45	

2.4.2 Taraire, tawa podocarp forest (Stages 1 and 2: 1.98 ha loss) BOAM output

Table 26. BOAM Output for loss of 1.98 ha of Taraire, tawa podocarp forest: vegetation structure and diversity. Model indicates a net biodiversity gain (1.55).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component		**Biodiversity Attribute**	**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodiversity Value**	**Component Net Present Biodiversity Value**
Vegetation structure	1.1a	Indigenous canopy cover	%	65	Revegetation	12	Confident 75-90%	Finite end point	Continue to Column M	0	75	30	4.08	-1.98	2.10	1.55
	1.1b	Indigenous subcanopy cover	%	20	Revegetation	12	Confident 75-90%	Finite end point	Continue to Column M	0	10	30	2.04	-1.19	0.85	
	1.1c	Indigenous understorey cover	%	45	Revegetation	12	Confident 75-90%	Finite end point	Continue to Column M	0	15	30	1.36	-0.22	1.14	
	1.1d	Indigenous ground cover	%	2	Revegetation	12	Confident 75-90%	Finite end point	Continue to Column M	0	10	30	4.08	-1.98	2.10	

Table 27. BOAM Output for loss of 1.98 ha of Taraire, tawa podocarp forest: diversity and volume. Model indicates a net biodiversity gain (1.10).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component		**Biodiversity Attribute**	**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodiversity Value**	**Component Net Present Biodiversity Value**
Diversity and volume	1.2a	Diversity # native vascular species	count	40	Revegetation	12	Very confident >90%	Finite end point	Continue to Column M	0	28	30	3.30	-1.29	2.02	1.10
	1.2b	Ground cover indigenous species richness	count	24	Revegetation	12	Very confident >90%	Finite end point	Continue to Column M	0	16	30	3.15	-1.16	1.99	
	1.2c	Canopy tree basal area >10cm	m2/ha	52.97	Revegetation	12	Very confident	Finite end point	Continue to Column M	0	21	30	1.87	-1.74	0.13	
	1.2d	Mean canopy height	m	18	Revegetation	12	Very confident >90%	Finite end point	Continue to Column M	0	8.5	30	2.23	-1.98	0.25	

Table 28. BOAM Output for loss of 1.98 ha of Taraire, tawa podocarp forest: fauna habitat. Model indicates a net biodiversity gain (2.12).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Fauna habitat incl rock forest	1.3a	Log fall	volume, m3/ha	235	Revegetation/ stock fencing	12	Very confident >90%	Finite end point	Continue to Column M	0	35	30	0.70	-0.16	0.54	2.12
	1.3b	Leaf litter depth	mm	53	Revegetation/ stock fencing	12	Very confident >90%	Finite end point	Continue to Column M	0	15	30	1.34	-1.42	-0.08	
	1.3c	Winter fruit diversity (trees & shrubs)	count	7	Revegetation/ stock fencing	12	Very confident >90%	Finite end point	Continue to Column M	0	7	30	4.72	-1.41	3.31	
	1.3d	Winter flower diversity (trees & shrubs)	count	5	Revegetation/ stock fencing	12	Very confident >90%	Finite end point	Continue to Column M	0	4	30	3.78	-1.19	2.59	

Table 29. BOAM Output for loss of 1.98 ha of Taraire, tawa podocarp forest: ecosystem enhancement. Model indicates a net biodiversity gain (4.17).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Ecosystem enhancement	1.4a	# Seedlings >15cm per plot	count	711	Integrated pest control	23	Very confident	Finite end point	Continue to Column M	411	700	25	4.26	-0.25	4.02	4.17
	1.4b	# Saplings per plot	Count	48	Integrated pest control	23	Very confident >90%	Finite end point	Continue to Column M	2.5	40	25	8.20	-0.02	8.18	
	1.4c	Sapling diversity per plot	count	4	Integrated pest control	23	Very confident	Finite end point	Continue to Column M	1.5	4	25	6.56	-0.25	6.31	
	1.4d	Groundcover %	%	2	Integrated pest control	23	Very confident	Finite end point	Continue to Column M	1.5	2	25	2.62	-1.49	1.14	
		Breeding success Avifauna Species	count	70	Integrated pest control	23	Confident 75-90%	Finite end point	Continue to Column M	55	65	1	2.63	-1.41	1.22	

2.4.3 Taraire, tawa podocarp forest (Stages 4 and 5: 5.42 ha loss) BOAM output

Table 30. BOAM Output for loss of 5.42 ha of Taraire, tawa podocarp forest: vegetation structure and diversity. Model indicates a net biodiversity gain (4.50).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component		**Biodiversity Attribute**	**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodiversity Value**	**Component Net Present Biodiversity Value**
Vegetation structure	1.1a	Indigenous canopy cover	%	65	Revegetation	20	Very confident >90%	Finite end point	Continue to Column M	0	75	20	10.58	-5.00	5.57	4.50
	1.1b	Indigenous subcanopy cover	%	20	Revegetation	20	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	4.57	-3.52	1.04	
	1.1c	Indigenous understorey cover	%	45	Revegetation	20	Confident 75-90%	Finite end point	Continue to Column M	0	15	20	3.05	-0.54	2.50	
	1.1d	Indigenous ground cover	%	2	Revegetation	20	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	9.14	-0.27	8.86	

Table 31. BOAM Output for loss of 5.42 ha of Taraire, tawa podocarp forest: diversity and volume. Model indicates a net biodiversity gain (1.29).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component		**Biodiversity Attribute**	**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodiversity Value**	**Component Net Present Biodiversity Value**
Diversity and volume	1.2a	Diversity # native vascular species	count	40	Revegetation	20	Very confident >90%	Finite end point	Continue to Column M	0	28	20	7.40	-3.93	3.47	1.29
	1.2b	Ground cover indigenous species richness	count	24	Revegetation	20	Very confident >90%	Finite end point	Continue to Column M	0	16	20	7.05	-4.07	2.99	
	1.2c	Canopy species basal area >10cm diameter	m2/ha	52.97	Revegetation	20	Confident 75-90%	Finite end point	Continue to Column M	0	21	20	3.62	-4.72	-1.10	
	1.2d	Mean canopy height	m	18	Revegetation	20	Confident 75-90%	Finite end point	Continue to Column M	0	8.5	20	4.31	-4.52	-0.20	

Table 32. BOAM Output for loss of 5.42 ha of Taraire, tawa podocarp forest: fauna habitat. Model indicates a net biodiversity gain (4.08).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component		**Biodiversity Attribute**	**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodiversity Value**	**Component Net Present Biodiversity Value**
Fauna habitat incl rock forest	1.3a	Log fall	volume, m3/ha	235	Revegetation/ stock fencing	20	Confident 75-90%	Finite end point	Continue to Column M	0	20	20	0.78	-0.46	0.32	4.08
	1.3b	Leaf litter depth	mm	53	Revegetation/ stock fencing	20	Confident 75-90%	Finite end point	Continue to Column M	0	12	20	2.07	-2.05	0.02	
	1.3c	Winter fruit diversity (trees & shrubs)	count	7	Revegetation/ stock fencing	20	Very confident >90%	Finite end point	Continue to Column M	0	7	20	10.58	-3.87	6.70	
	1.3d	Winter flower diversity (trees & shrubs)	count	5	Revegetation/ stock fencing	20	Very confident >90%	Finite end point	Continue to Column M	0	4	20	8.46	-3.25	5.21	

Table 33. BOAM Output for loss of 5.42 ha of Taraire, tawa podocarp forest: ecosystem enhancement. Model indicates a net biodiversity gain (8.67).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component		**Biodiversity Attribute**	**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodiversity Value**	**Component Net Present Biodiversity Value**
Ecosystem enhancement	1.4a	# Seedlings per plot	count	711	Fencing, pest control of WF9 forest	40	Very confident	Finite end point	Continue to Column M	411	700	20	8.60	-0.68	7.92	8.67
	1.4b	# Saplings per plot	Count	48	Fencing, pest control of WF9 forest	40	Very confident >90%	Finite end point	Continue to Column M	2.5	40	20	16.52	-0.06	16.47	
	1.4c	Sapling diversity per plot	count	4	Fencing, pest control of WF9 forest	40	Very confident	Finite end point	Continue to Column M	1.5	4	20	13.22	-0.68	12.54	
	1.4d	Groundcover %	%	2	Fencing, pest control of WF9 forest	40	Very confident	Finite end point	Continue to Column M	1.5	2	20	5.29	-0.27	5.02	
		Breeding success Avifauna Species	count	70	Fencing, pest control of WF9 forest	40	Very confident >90%	Finite end point	Continue to Column M	55	65	1	5.30	-3.87	1.43	

2.4.4 Kānuka forest area (Stages 4 and 5: 8.79 ha loss) BOAM output

Table 34. BOAM Output for loss of 8.79 ha of kānuka forest: vegetation structure and diversity. Model indicates a net biodiversity gain (1.55).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Vegetation structure & diversity	3.1a	Indigenous canopy cover	% cover	55	Revegetation	22	Confident 75-90%	Finite end point	Continue to Column M	0	55	20	10.05	-8.00	2.05	1.55
	3.1b	Height of canopy	m	12	Revegetation	22	Confident 75-90%	Finite end point	Continue to Column M	0	7	20	5.86	-6.60	-0.74	
	3.1c	Indigenous understorey cover	% cover	27	Revegetation	22	Confident 75-90%	Finite end point	Continue to Column M	0	10	20	3.72	-3.26	0.46	
	3.1d	Indigenous ground cover	% cover	10	Revegetation	22	Confident 75-90%	Finite end point	Continue to Column M	0	5	20	5.02	-0.01	5.02	
	3.1e	Diversity # native vascular	count	28	Revegetation	22	Confident 75-90%	Finite end point	Continue to Column M	0	21	20	7.54	-6.60	0.94	

Table 35. BOAM Output for loss of 8.79 ha of kanuka forest: fauna habitat. Model indicates a net biodiversity gain (3.96).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Fauna habitat	3.2a	Log fall	volume, m3/ha	23.71	Revegetation	22	Confident 75-90%	Finite end point	Continue to Column M	0	0.1	20	0.04	-2.19	-2.14	3.96
	3.2b	Leaf litter depth	mm	18.4	Revegetation	22	Confident 75-90%	Finite end point	Continue to Column M	0	12	20	6.55	-6.70	-0.14	
	3.2c	Winter fruit diversity (trees &	count	4	Revegetation	22	Very confident >90%	Finite end point	Continue to Column M	0	4	20	11.63	-2.20	9.43	
	3.2d	Winter flower diversity	count	3	Revegetation	22	Very confident >90%	Finite end point	Continue to Column M	0	3	20	11.63	-2.93	8.70	

Table 36. BOAM Output for loss of 8.79 ha of kanuka forest: fauna habitat. Model indicates a net biodiversity gain (3.96).

This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
Biodiversity Component	Biodiversity Attribute		Measurement Unit	Benchmark	Proposed Offset Actions	Offset area (ha)	Confidence in Offset Actions			Measure prior to Offset	Measure after Offset	Time till endpoint (years)	Biodiversity Value at Offset Site	Biodiversity Value at Impact Site	Attribute Net Present Biodiversity Value	Component Net Present Biodiversity Value
Ecosystem enhancement	3.3a	# Seedlings > 15cm per plot	count	578	Integrated pest control	40	Very confident >90%	Finite end point	Continue to Column M	200	500	20	10.98	-3.04	7.93	10.93
	3.3b	# Saplings per plot	Count	138	Integrated pest control	40	Very confident >90%	Finite end point	Continue to Column M	1	100	20	15.17	-0.06	15.11	
	3.3c	Sapling diversity per plot	count	8	Integrated pest control	40	Very confident >90%	Finite end point	Continue to Column M	1	5	20	10.58	-1.10	9.48	
	3.3d	Groundcover %	%	10	Integrated pest control	40	Very confident >90%	Finite end point	Continue to Column M	0.01	10	20	21.13	-0.01	21.12	
		Breeding success Avifauna	count	70	Integrated pest control	40	Very confident >90%	Finite end point	Continue to Column M	50	65	1	7.95	-6.91	1.03	

2.4.5 Relict trees in pasture (All stages: 130 trees loss) BOAM output

Table 37. BOAM Output for loss of 130 trees: tree biomass. Model indicates a net biodiversity gain (0.15).

	This section captures which elements of biodiversity are to be accounted for, and the benchmark value for the Attribute. The information matches that in the Impact Model					These cells provide information about the proposed Offset Actions			Calculations can be made for a finite end point, or at five yearly time-steps over 35 years. Indicate preference in Column K and Follow the instructions in Column L		This section is where the marginal change in the measure of Biodiversity Attribute due to the Offset Action is quantified. Inputs are derived from direct measure, existing data or models where available, or expert estimated predictions. Attribute Biodiversity Value at the Offset Site is compared to the Attribute Biodiversity Value at the Impact Site to calculate the Net Present Biodiversity Value for each Attribute						This is the average Net Present Biodiversity Value for the Biodiversity Component
	Biodiversity Component	**Biodiversity Attribute**		**Measurement Unit**	**Benchmark**	**Proposed Offset Actions**	**Offset area (ha)**	**Confidence in Offset Actions**			**Measure prior to Offset**	**Measure after Offset**	**Time till endpoint (years)**	**Biodiversity Value at Offset Site**	**Biodiversity Value at Impact Site**	**Attribute Net Present Biodiversity Value**	**Component Net Present Biodiversity Value**
3.1	Tree biomass	**3.1a**	basal area	m2	48	replanting	2	Very confident >90%	Finite end point	Continue to Column M	0	29	25	0.55	-0.25	0.30	0.15
		3.1b	height	m	20	replanting	2	Very confident >90%	Finite end point	Continue to Column M	0	10	25	0.46	-0.45	0.01	

3 OFFSET MONITORING

Monitoring biodiversity offset actions is critical to determining overall offset success, and ultimately, whether a Net Environmental Gain is achieved. Should offset outcomes fall short of expected outcomes at any point in the monitoring process, then contingency actions are provided here to counterbalance those shortfalls.

Offset outcomes would be measured at least every five years at each of the offset sites. The purpose of the monitoring is to:

Track the progress of identified biodiversity attributes;
Provide feedback with recommendations for any additional management required to ensure the offset performs to targets;
Identify any requirements for contingency actions early, where any shortfalls could affect offset outcomes;
Provide a monitoring report, following each monitoring occasion, to demonstrate that the offset is developing as expected and is being appropriately managed and maintained.

3.1 Monitoring Targets and Contingencies

Monitoring targets are provided in Table 38 to Table 44. These are based on the modelled outcomes. While ultimate success will be determined at 20-30 years, the targets provide an indication of expected values for attributes at each 5-yearly interval with the gradual development and maturation of the offset vegetation. Failure to meet biodiversity attribute targets prior to 20-30 year endpoints for each modelled offset may not necessarily result in failure of the offset, however monitoring outcomes that result in values that are short of the targets would inform adaptive management actions, such as additional planting, watering, provision of fertilisers, or wind protection.

This section addresses monitoring targets and contingencies as modelled for each BOAM.

Table 38. Monitoring targets for 0.65 ha Rock Forest revegetation offset – Note: Offset success measured at 20 or 30 years, depending on attribute. Targets prior to offset outcome are indicative only and should prompt management response.

Biodiversity attribute	5 years	10 years	15 years	20 years	25 years	30 years
Indigenous Canopy cover (%)	10	15	20	25	30	50%
Indigenous subcanopy cover (%)	0	0	0	3	5	8%
Indigenous understorey cover (%)	0	0	1	5	10	15%
Indigenous ground cover (%)	0	0	1	2	3	5%
Diversity of native vascular plant species	12	18	18	18	18	18
Ground cover indigenous species richness	0	4	6	7	7	7
Basal area >10 cm diameter (m^2 /ha)	3	5	7	10	12	14 m^2 / ha
Mean canopy height	1	1.5	3	5	6.5	8
Log fall (m^3 / ha)	0	0	5	10	15	20
Leaf litter depth (mm)	0	2	5	8	10	12
Native winter fruit diversity (count)	8	8	8	8		
Native winter flower diversity (count)	5	5	5	5		

Table 39. Monitoring targets for 0.65 ha Rock Forest enhancement offset – Note: Offset success measured at 20 or 30 years, depending on attribute. Targets prior to offset outcome are indicative only and should prompt management response.

Biodiversity attribute	5 years	10 years	15 years	20 years	25 years	30 years
Seedling count/20x20m plot	100	200	300	400	500	600
Sapling count/20x20m plot	5	20	50	100	200	280
Sapling diversity/20x20m plot	1	2	3	4	5	6
Groundcover (%)	0.1	1	2	4	6	8

Table 40. Contingency table for Rock Forest values at offset (all attributes managed through revegetation)

Biodiversity attribute	Required biodiversity value by 30 years	Contingency if not met at 20 years	Rationale for Contingency
Indigenous Canopy cover (%)	50	Adaptively manage. If expected 15-year target is not met investigate causes of slow canopy establishment and seek to remedy through manipulation of environmental factors such as improved plant nutrition, watering, or wind protection. Plant additional specimens of appropriate species if particular species found not to be thriving. If 20-year target subsequently not met recalculate the model using known data and increase overall area of rock forest planting accordingly.	The establishment of canopy cover is crucial to the creation of suitable sheltered habitats for understorey and groundcover species. The manipulation of environmental factors or additional planting of hardy species may be necessary to creation of these habitats. Mature pioneer species are expected to contribute to the provision of adequate canopy % cover in conjunction with young canopy trees. If the timescale for the development of more sheltered habitats is found to be longer than expected, additional revegetation area is required to offset this greater than expected time lag.
Indigenous subcanopy cover (%)	8	Adaptively manage. If future subcanopy species are not present at 15 years proactively plant these species and ensure they are appropriately cared for to ensure their survival. If at 20 years, the target has not been met undertake further planting of subcanopy species and continue management until target is met.	Sub-canopy species will be planted as part of Phase 1 and 2. They will thrive once a canopy is established.
Indigenous understorey cover (%)	15	Adaptively manage. If shade-tolerant understorey species are not present at 15 years proactively plant these species and ensure they are appropriately cared for to ensure their survival. If at 20 years, the target has not been met undertake further planting of understory species and continue management until target is met.	Appropriate shade-tolerant understorey species can only thrive in the shelter of an established canopy. Understory species will be planted during Phase 2 and further species such as ferns should naturally colonise once conditions are suitable.
Indigenous ground cover (%)	5	Adaptively manage. If shade-tolerant groundcover species are not present at 15 years proactively plant these species and ensure they are appropriately cared for to ensure their survival. If at 20 years, the target has not been met undertake further planting of groundcover species and continue management until target is met	Ground cover will be slow to develop on rocky substrate. Good shading and protection from taller forest tiers is required for groundcover species to survive.
Diversity of native vascular plant species	18	At least 8 hardy pioneer species should be planted at Year 1 and at least a further 13 future canopy, subcanopy, understorey and groundcover species will be planted during phase 2 enrichment planting as more sheltered habitats develop. Continue planting additional species in subsequent years as necessary until a full palette of suitable species has become established. If at 20 years the target of 18 species has not been met recalculate the model using known data and increase overall area of rock forest planting accordingly.	Timescales for the establishment of mature rock forest vegetation are poorly understood. If these timescales prove to be longer than anticipated, then additional revegetation area is required to offset this greater than expected time lag.
Native ground cover species richness	7	Adaptively manage. If sufficient groundcover species are not present at 15 years proactively plant these species and ensure they are appropriately cared for to ensure their survival. Continue planting additional species in subsequent years until a full palette of suitable species has become established.	Good shading and protection from taller forest tiers is required for a range of native groundcover species to survive. If the timescales for the development of these tiers prove to be longer than anticipated, sustained efforts will need to be made to introduce ground cover species at the appropriate time which may need to occur beyond 20 years.

Basal area (m^2)	14	Adaptively manage. If future canopy species have not established and put on sufficient growth by 15 years proactively plant more canopy trees and intensively manage all canopy species through the addition of suitable nutrients, mulch and wind protection.	Unless the planting fails it is highly unlikely that the conservatively established basal area targets will not be met.
Mean canopy height (m)	8	Adaptively manage. If mean canopy height has not reached the 20-year target of 5m, intensively manage all canopy species through the addition of suitable nutrients, mulch and wind protection until the 30-year height target is met.	Height targets have been conservatively set for rock forest according to existing data and taking account of the expected slower growth rates on rocky substrate. If factors such as climate change/drought result in poorer than expected height gain or greater than expected losses of plants (requiring replacement planting) the revegetation may require ongoing management for longer than 30 years.
Log fall (m^3 / ha)	20 m^3/ha	Maintain pest control until attribute achieved. Note that offset model (fauna habitat) delivers Net Gain at 0 value for this attribute.	Attribute is a measure of habitat quality. Pest control is a suitable, reliable proxy.
Leaf litter depth (mm)	12 mm	Maintain pest control until attribute achieved. Note that offset model (fauna habitat) delivers Net Gain at 0 value for this attribute.	Attribute is a measure of habitat quality. Pest control is a suitable, reliable proxy.
Native winter fruit diversity	8 spp. *Alectryon excelsus* *Alseuosmia macrophylla* *Beilschmiedia tarairi* *Hedycarya aborea* *Piper excelsum* *Podocarpus totara* *Rhopalostylis sapida* *Vitex lucens*	Plant these species as appropriate habitats become available for them. Introduce shade tolerant understorey species between Years 5 and 10 and manage more sensitive species intensively if necessary. If at Year 15 there are insufficient species, undertake further planting in subsequent years until all species have established. Offset model (fauna habitat) delivers Net Gain at 0 count for this attribute.	Good shading and protection from taller forest tiers is required for some of these species to establish. If the timescales for the development of these tiers prove to be longer than anticipated, sustained efforts will need to be made to introduce them at the appropriate time which may need to occur beyond 20 years.
Native winter flower diversity	5 spp. *Vitex lucens* *Kunzea robusta* *Metrosideros fulgens* *Dysoxylem spectabile* *Sophora microphylla*	Plant these species as appropriate habitats become available for them. Introduce shade tolerant understorey species between Years 5 and 10 and manage more sensitive species intensively if necessary. If at Year 15 there are insufficient species, undertake further planting in subsequent years until all species have established Plant species in. Offset model (fauna habitat) delivers Net Gain at 0 count for this attribute.	Good shading and protection from taller forest tiers is required for some of these species to establish. If the timescales for the development of these tiers prove to be longer than anticipated, sustained efforts will need to be made to introduce them at the appropriate time which may need to occur beyond 20 years.
Seedling count ≥ 15cm/20x20m plot	600	Manage through enhancement of existing rock forest. Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of seedlings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.

Saplings count/20x20m plot	280	Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of saplings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.
Sapling diversity/20x20m plot	6	Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of saplings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.
Ground cover (%)	8	If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot. Intensify control of browsers if this seems to be the likely cause of insufficient groundcover development.	Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.

Table 41. Monitoring targets for Taraire, tawa podocarp Forest- Area– Offset success measured at 25-30 years, depending on attribute. Targets prior to offset outcome are indicative only and may require management response.

Biodiversity attribute	5 years	10 years	15 years	20 years	25 years	30 years
Indigenous Canopy cover (%)	30	40	50	60	70	75
Indigenous subcanopy cover (%)	0	0	2	5	7	10
Indigenous understorey cover (%)	0	2	5	7	10	15
Indigenous ground cover (%)	0	2	3	5	7	10
Diversity of native vascular plant species	18	28	28	28	28	28
Native ground cover species richness	3	4	6	7	9	16
Basal area (m^2)	0	1.65	4.96	9.24	14.17	21
Mean canopy height (m)	1	3.5	6	7.5	8.5	8.5
Log fall (m^3 / ha)	0	0	5	10	20	35
Leaf litter depth (mm)	0	2	5	8	12	15
Native winter fruit diversity (count)	7	7	7	7	7	7
Native winter flower diversity (count)	4	4	4	4	4	4

Table 42. Monitoring targets for Taraire, tawa podocarp Forest- Area. Targets prior to offset outcome are indicative only and may require management response.

Biodiversity attribute	5 years	10 years	15 years	20 years	25 years	30 years
Seedling count/20x20m plot	500	550	600	650	700	
Sapling count/20x20m plot	5	10	20	30	40	
Sapling diversity/20x20m plot	2	2	3	3	4	
Groundcover (%)	1.5	2	2	2	2	

Table 43. Contingency table for Taraire, tawa podocarp Forest values at offset.

Biodiversity attribute	Required biodiversity value by 30 years	Contingency if not met at 20 years	Rationale for Contingency
Indigenous Canopy cover (%)	75	Adaptively manage. If expected 15-year target is not met investigate causes of slow canopy establishment and seek to remedy through manipulation of environmental factors such as improved plant nutrition, watering, or wind protection. Plant additional specimens of appropriate species if particular species found not to be thriving. If 20-year target subsequently not met recalculate the model using known data and increase overall area of WF9 forest planting accordingly.	The establishment of canopy cover is crucial to the creation of suitable sheltered habitats for understorey and groundcover species. Mature pioneer species are expected to contribute to the provision of adequate canopy % cover in conjunction with young canopy trees. The manipulation of environmental factors or additional planting of hardy species may be necessary to creation of these habitats. If the timescale for the development of more sheltered habitats is found to be longer than expected, additional revegetation area is required to offset this greater than expected time lag.
Indigenous subcanopy cover %	10	Adaptively manage. If future subcanopy species are not present at 15 years proactively plant these species and ensure they are appropriately cared for to ensure their survival. If at 20 years, the target has not been met undertake further planting of subcanopy species and continue management until target is met.	The subcanopy may take some time to recover from browsing but should easily meet the target by 25 years.
Indigenous understorey cover (%)	15	Adaptively manage. If shade-tolerant understorey species are not present at 15 years proactively plant these species and ensure they are appropriately cared for to ensure their survival. If at 20 years, the target has not been met undertake further planting of understory species and continue management until target is met.	The understorey may take some time to recover from browsing but should easily meet the target by 25 years.
Indigenous ground cover (%)	10	Adaptively manage. If shade-tolerant groundcover species are not present at 15 years proactively plant these species and ensure they are appropriately cared for to ensure their survival. If at 20 years, the target has not been met undertake further planting of groundcover species and continue management until target is met	The groundcover may take some time to recover from browsing but should easily meet the target by 25 years.
Total species richness	28	The planting schedules for this ecosystem type list 19 pioneer (Phase 1) species 21 Phase 2 enrichment and understorey species. At least 28 of the total 39 species to be planted can be expected to persist in reasonable abundance	At least 28 species are likely to persist from the plant schedules in the NGDP:PP. In addition, colonisation by common ferns and fern allies is expected
Ground cover indigenous species richness	16	It is expected that common ground ferns and native sedges will colonise the habitat and that seedlings of canopy and understorey species will also contribute to this layer.	Natural increase in species richness is dependent on local seed sources and appropriate seed dispersers being present. By 20 years, many of the planted species will be producing fruit and seeds.
Canopy tree basal area	21	This biodiversity attribute will be managed through enrichment planting with canopy tree species. Adaptively manage. If future canopy species have not established and put on sufficient growth by 15 years to reach the target values proactively plant more canopy trees and intensively manage all canopy species through the addition of suitable nutrients, mulch, and wind protection.	Expected basal area targets are based on 550 young canopy trees/ha and Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/

Mean canopy height (m)	8.5	This biodiversity attribute will be managed through revegetation. Adaptively manage. If mean canopy height has not reached the 20-year target of 7.5m, intensively manage all canopy species through the addition of suitable nutrients, mulch and wind protection until the 30-year height target is met.	Expected mean height targets are based on the Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/
Log fall (m^3 / ha)	35 m^3/ha	Maintain pest control until attribute achieved. Note that offset model (fauna habitat) delivers Net Gain at 0 value for this attribute.	Attribute is a measure of habitat quality. Pest control is a suitable, reliable proxy.
Leaf litter depth (mm)	15 mm	Maintain pest control until attribute achieved. Note that offset model (fauna habitat) delivers Net Gain at 0 value for this attribute.	Attribute is a measure of habitat quality. Pest control is a suitable, reliable proxy.
Winter fruit diversity (trees & shrubs)	7spp. *Hedycarya aborea* *Piper excelsum* *Podocarpus totara* *Rhopalostylis sapida* *Vitex lucens*	This biodiversity attribute will be managed through revegetation. Plant these species as appropriate habitats become available for them. Introduce shade tolerant understorey species between Years 5 and 10 and manage more sensitive species intensively if necessary. If at Year 15 there are insufficient species, undertake further planting in subsequent years until all species have established. Offset model (fauna habitat) delivers Net Gain at 0 count for this attribute.	Good shading and protection from taller forest tiers is required for some of these species to establish. If the timescales for the development of these tiers prove to be longer than anticipated, sustained efforts will need to be made to introduce them at the appropriate time which may need to occur beyond 20 years.
Winter flower diversity (trees & shrubs)	5 spp. *Vitex lucens* *Kunzea robusta* *Metrosideros fulgens* *Leptospermum scoparium* *Sophora microphylla*	This biodiversity attribute will be managed through revegetation. Plant these species as appropriate habitats become available for them. Introduce shade tolerant understorey species between Years 5 and 10 and manage more sensitive species intensively if necessary. If at Year 15 there are insufficient species, undertake further planting in subsequent years until all species have established Plant species in. Offset model (fauna habitat) delivers Net Gain at 0 count for this attribute.	Good shading and protection from taller forest tiers is required for some of these species to establish. If the timescales for the development of these tiers prove to be longer than anticipated, sustained efforts will need to be made to introduce them at the appropriate time which may need to occur beyond 20 years.
Seedling count	**700**	Managed through enhancement of existing WF9 forest. Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of seedlings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.
Saplings count	**40**	Managed through enhancement of existing WF9 forest. Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of saplings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.

Sapling diversity	**4**	Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of saplings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.
Ground cover (%)	**2**	If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot. Intensify control of browsers if this seems to be the likely cause of insufficient groundcover. Consider whether there is sufficient local seed source and disperser presence (birds).	Lack of seedlings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.

Table 44. Monitoring targets for kanuka forest offset– Offset success measured at 20 years. Targets prior to offset outcome are indicative only and may require management response (all attributes managed through revegetation).

Biodiversity attribute	5 years	10 years	15 years	20 years
Indigenous Canopy cover (%)	30	40	45	55
Mean canopy Height (m)	1	3.5	5	7
Indigenous understorey cover (%)	0	1	5	10
Indigenous ground cover (%)	0	0	3	5
Diversity of native vascular plant species	18	18	18	21
Log fall (m^3 / ha)	0	0	0	0.1
Leaf litter depth (mm)	0	4	8	12
Native winter fruit diversity	4	4	4	4
Native winter flower diversity	3	3	3	3

Table 45. Monitoring targets for kanuka forest offset– Offset success measured at 20 years. Targets prior to offset outcome are indicative only and may require management response (all attributes managed through enhancement).

Biodiversity attribute	5 years	10 years	15 years	20 years
Seedling count/20x20m plot	200	300	400	500
Saplings count/20x20m plot	2	20	50	100
Sapling diversity/20x20m plot	1	2	4	5
Ground cover (%)	<1	3	6	10

Table 46. Contingency table for Kanuka Forest values at offset.

Biodiversity attribute	Required biodiversity value by 20 years	Contingency if not met at 20 years	Rationale for Contingency
Indigenous Canopy cover (%)	55	Adaptively manage. If expected 10-year target is not met investigate causes of slow canopy establishment and seek to remedy through manipulation of environmental factors such as improved plant nutrition, watering, or wind protection. Plant additional specimens of appropriate species if particular species found not to be thriving. If 20-year target subsequently not met recalculate the model using known data and increase overall area of WF9 forest planting accordingly.	Targets have been conservatively set and canopy closure of pioneer species is expected to occur prior to Year 10. Subsequent to closure of the pioneer canopy, maturation will cause this to thin out allowing planted climax canopy species to emerge. Risk of not achieving the target is low
Mean canopy height	7	This biodiversity attribute will be managed through revegetation. Adaptively manage. If mean canopy height has not reached the 20-year target of 7.5m, intensively manage all canopy species through the addition of suitable nutrients, mulch and wind protection until the 30-year height target is met.	Expected mean height targets are based on the height of planted native shrubs and represent conservative calculations using established multi-species data.
Indigenous understorey cover (%)	10	Adaptively manage. Additional understorey species can be planted between 5 and 10 years as the canopy lifts. If an understorey has not developed to target levels by 15 years, consider proactively planting further subcanopy species or broadcast seed to introduce them. If at 20 years, the target has not been met undertake further planting of understory species and continue management until target is met.	Good management will reduce the risks to low levels. Risk of non-achievement is low.
Indigenous ground cover (%)	5	Adaptively manage. If groundcover has not developed to target levels by 15 years, consider proactively planting additional groundcover species or broadcast seed to introduce them. If at 20 years, the target has not been met undertake further planting of groundcover species and continue management until target is met.	Groundcover should largely self-establish as the planting matures.
Diversity of native vascular plant species	21	Adaptively manage. The model assumes at least 18 planted species and 3 self-introduced species. If total species richness is not trending up after 15 years, identify which species are missing and add these as plants or seed.	Natural increase in species richness is dependent on local seed sources. Common native ferns are expected to readily self-establish as the habitat develops for them. Missing species can be planted if necessary.
Log fall (m^3 / ha)	0.1	Maintain pest control until attribute achieved. Note that offset model (fauna habitat) delivers Net Gain at 0 value for this attribute.	Attribute is a measure of habitat quality. Pest control is a suitable, reliable proxy.
Leaf litter depth (mm)	12	Maintain pest control until attribute achieved. Note that offset model (fauna habitat) delivers Net Gain at 0 value for this attribute.	Attribute is a measure of habitat quality. Pest control is a suitable, reliable proxy.
Native winter fruit diversity	4 *Coprosma robusta* *Coprosma lucida* *Hedycarya arborea* *Podocarpus totara*	. Plant these species as appropriate habitats become available for them. Introduce shade tolerant understorey species between Years 5 and 10 and manage more sensitive species intensively if necessary. If at Year 15 there are insufficient species, undertake further planting in subsequent years until all species have established. Offset model (fauna habitat) delivers Net Gain at 0 count for this attribute.	Good canopy shading and protection is required for some of these species to establish. If the timescales for the establishment of these species prove to be longer than anticipated, sustained efforts will need to be made to introduce them at the appropriate time which may need to occur beyond 20 years.

Native winter flower diversity	3 *Kunzea robusta* *Leptospermum scoparium* *Sophora microphylla* *Coprosma robusta*	This biodiversity attribute will be managed through revegetation. Plant these species as appropriate habitats become available for them. Introduce shade tolerant understorey species between Years 5 and 10 and manage more sensitive species intensively if necessary. If at Year 15 there are insufficient species, undertake further planting in subsequent years until all species have established Plant species in. Offset model (fauna habitat) delivers Net Gain at 0 count for this attribute.	Good canopy shading and protection is required for some of these species to establish. If the timescales for the establishment of these species prove to be longer than anticipated, sustained efforts will need to be made to introduce them at the appropriate time which may need to occur beyond 20 years.
Seedling count	700	Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of seedlings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.
Saplings count	40	Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of saplings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.
Sapling diversity	4	Examine possible reasons for lack of sufficient seedlings e.g. insufficient control of browsing ungulates possums or rats. Intensify control of browsers if this is the reason. Consider whether there is sufficient local seed source and disperser presence (birds). If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot	Lack of saplings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.
Ground cover (%)	2	If the monitoring targets are not being met, undertake more plots to ascertain whether it is a widespread problem or the result of an atypical plot. Intensify control of browsers if this seems to be the likely cause of insufficient groundcover development. Consider whether there is sufficient local seed source and disperser presence (birds).	Lack of seedlings is most often the result of browsing pressure or lack of seed and avian dispersers. Forest lower tiers are often patchy. If monitoring targets are consistently falling short over multiple plots and vegetation enhancement parameters, additional enhancement area may be required.

Table 47. Monitoring targets for relict trees offset area success measured at 25 years. Targets prior to offset outcome are indicative only and may require management response.

Biodiversity attribute	5 years	10 years	15 years	20 years	25 years
Total basal area (m^2)	0	2.2	7.2	14	21.9
Mean canopy height	1.7	3.8	6	7.8	10

Table 48. Contingency table for relict native tree values at offset.

Biodiversity attribute	Required biodiversity value by 30 years	Contingency if not met at 20 years	Rationale for Contingency
Total basal area (m^2)	21.9	This biodiversity attribute will be managed through revegetation. Adaptively manage. If future canopy species have not established and put on sufficient growth by 15 years to reach the target values proactively plant more canopy trees if necessary or remodel to ensure 10% biodiversity gain at 25 years. Intensively manage all canopy species through the addition of suitable nutrients, mulch, and wind protection.	Expected basal area targets are based on 550 young canopy trees/ha and Tanes Trees Trust Growth and Yield Calculator using appropriate multi-species data. https://toolkit.tanestrees.org.nz/. Based on extensive data pool across multiple environments. Risk of non-achievement is low providing planting sies are carefully selected to suit species requirements.
Mean canopy height	10.68	This biodiversity attribute will be managed through revegetation. Adaptively manage. If mean canopy height has not reached the 20-year target of 7.81m, intensively manage all canopy species through the addition of suitable nutrients, mulch and wind protection until the 30-year height target is met. If necessary, plant more canopy trees or remodel to ensure 10% biodiversity gain at 30 years	Expected mean height targets are based on the Tanes Trees Trust Growth and Yield Calculator using established multi-species data. https://toolkit.tanestrees.org.nz/. Based on appropriate data pool across multiple environments. Risk of non-achievement is low providing planting sies are carefully selected to suit species requirements.

3.2 Monitoring Methods

Monitoring will be undertaken annually for the first five years, followed by long term monitoring thereafter in Years 7, 10, 15, 20 & 30, at which time a detailed report will be prepared assessing the progress of the revegetation planting against the biodiversity offset targets and BOAMs. These reports must identify any major contingencies that need to be implemented such as remodelling of any biodiversity attributes in response to actual results or adjustment of timescales and adaptive management.

3.2.1 Monitoring of establishment phase: Years 1 –5

3.2.1.1 Revegetation

3.2.1.1.1 Planting completion

At the completion of the Phase 1 pioneer planting in each identified planting area a planting completion report should be prepared by a suitably qualified person verifying that planting has been completed in accordance with the detailed restoration planting plan for the area. This completion report will form part of annual monitoring.

3.2.1.1.2 Annual monitoring

Annual monitoring in the first 5 years for each planting area should include the following assessment parameters at a minimum:

- Description of planting (species, numbers, grade & spacing), pest and weed management undertaken in the preceding 12 months;
  - Canopy closure;
  - Identification of any replacement planting or additional planting required;
  - Identification of any additional weed or pest management required;
  - Recommendations on any changes required to the EOPP.

The reviewer should also note:

  - any species or specific areas that are performing poorly;
  - Plant diversity.

Monitoring reports should identify any adaptive management required in the coming year to ensure each planting area develops in line with the BOAM and the detailed restoration planting plan for that biodiversity type.

3.2.1.1.3 Five-year planting establishment report

At the end of Year 5, 20 x 20m permanent plots and photo points must be established in each biodiversity type revegetation area and measurement of the parameters set out in Table 49 undertaken. An Establishment Report is to be prepared setting out the results of the plot measurements at year 5 and assessing whether the revegetation area has the appropriate species diversity and structural characteristics to enable it to meet the modelled targets and adhere to the detailed restoration planting plan. Any major adaptive management actions, contingencies or adjustments to the model should be identified at this time and appropriate action taken.

- Indigenous Canopy cover (%).
- Indigenous ground cover (%).
- Total native vascular plant species richness.

- Native ground cover species richness.
- Mean canopy height.
- Leaf litter depth (mm).

3.2.1.2 Forest Enhancement

Pest control will be undertaken within the retained vegetation at Drury Quarry (Figure 11). Pest animal control methods would follow current industry best practice, and Auckland Council's "*Pest animal control guidelines for the Auckland region*"[6] provides a suitable guidance document. The details for the quantity, frequency and methodology of pest control are described in a separate Net Gain Delivery Plan: Pest and Weed Control (E7:9 NGDP:PWC) which contains specific proposed monitoring targets and a contingency table for pest indices.

Permanent Recce plots will be used to monitor forest enhancement vegetation parameters (seedlings, saplings, sapling diversity and groundcover % cover). Monitoring of rats, possums and stoats will be undertaken by the contractors twice per year using tracking tunnels and wax tag chew cards.

3.2.2 Revegetation progress Monitoring: Years 7, 10, 15, 20 &30

Following the issue of the Planting Establishment Report progress monitoring will be undertaken by a suitably qualified and experienced person (SQEP). All parts of the offset planting areas will be walked through, and the following qualitative information recorded:

Description of the survival and growth rate of planted specimens, average canopy closure, average height and plant diversity;

a. Evidence of natural regeneration and colonisation by native flora and fauna species.
b. Evidence of development of forest community structure.
c. Fauna habitat values and native bird abundance.
d. Description of pest and weed management undertaken and its effectiveness.
e. Description of any replacement planting, or other remedial actions or adaptive management undertaken since the last monitoring report.
f. Identification of any replacement planting or adaptive management or other remedial actions required before the next monitoring report.
g. Identification of any additional weed or pest management required.
h. Health of planted threatened species (Carmine rata).
i. Recommendations on any changes required to the EOPP.

The purpose of the progress report is to identify actions that need to be taken in the coming years to ensure each planting area develops in line with the modelled targets and the detailed restoration planting plan for that biodiversity type (contained in this report, the E6:9 NGDP:PP).

This report is to accompany the long-term monitoring review, undertaken 7, 10, 15, 20 & 30 so that both qualitative and quantitative data is collected.

[6] https://www.tiakitamakimakaurau.nz/media/v1wpc30z/pag-2-0-for-web-july-22.pdf

3.2.2.1 Revegetation Long term monitoring review Years 7, 10, 15, 20 & 30

A full review of for each planting site shall be conducted by a SQEP at Years 7, 10, 15, 20 and 30 following completion of the implementation of planting.

The purpose of each review is to gather quantitative data in order to determine whether the biodiversity offset strategies used to address the ecological effects of the project are achieving the modelled 7, 10-, 15-, 20- and 30-year monitoring targets contained in the REAR-TE and associated management plans for each area.

Permanently marked Recce plots and photo points (as established at Year 5) are to be used within each biodiversity planting type (Rock Forest, VS2, WF9) to collect data on the following biodiversity attributes for comparison with modelled targets as shown in Table 49:

In addition to the collection of the data as set out in Section 3.2.2.1.1 and 3.2.2.1.2, permanent photo points must be established at each plot to provide a visual record of progress. These should be taken from each corner of the plot, facing towards the centre of the plot and the GPS coordinates recorded.

The review reports at Years 7, 10, 15, 20 & 30 must detail whether the modelled targets of the BOAMs have been reached and where targets have not been reached, whether further biodiversity offset actions are required to ensure the success of the model.

3.2.2.1.1 Data collection sites

- Plot locations should be representative of the average condition of the total area of revegetation and should aim to provide wide spatial coverage where offset monitoring requires multiple plots.
- Plot locations should be permanently marked, and data collection repeated at the same locations in every monitoring year.
- Four 10 x 10 m Recce plot should be used in place of one 20 x 20 Recce plot if better representation of the vegetation can be achieved.

Plots will be established at a rate of one 20m x20m plot per 5 hectares of planting.

Monitoring data will be collected from revegetation sites from standard 20 x 20 m Recce plots within each vegetation type at the following general locations:

1. Drury Quarry
    a. 2 plots in Rock Forest
    b. 6 plots in Taraire, Tawa Podocarp Forest (WF9)
    4 plots in Kānuka Scrub/Forest (VS2)
2. Hingaia Islands
    1 plot in Kānuka Scrub/Forest (VS2)

3.2.2.1.2 Data Collection

Table 49. Measurement of biodiversity attributes for revegetation areas: Rock Forest, VS2, WF9 Years 5 – 30.

Biodiversity attribute	Plot Collection method
Indigenous Canopy cover (%)	Standard Recce method
Indigenous subcanopy cover (%)	Standard Recce method
Indigenous understorey cover (%)	Standard Recce method
Indigenous ground cover (%)	Standard Recce method
Total native vascular plant species richness	Standard Recce method
Native ground cover species richness	Standard Recce method
Basal area (m^2 /ha)	Standard Recce method
Mean canopy height	Standard Recce method
Log fall (m^3 / ha)	Within each plot, measure diameter x length of all woody objects >2cm diameter. Calculate total volume and convert to m^3 / ha. Monitoring value is mean of all plots for that biodiversity component.
Leaf litter depth (mm)	Within each plot, take five measurements of leaf litter depth: four corners and one in plot centre. Monitoring value is mean of all plots for that biodiversity component.
Native avifauna diversity	Standard 5 minute bird counts, spaced 200 metres apart

3.2.2.2 Forest enhancement monitoring Years 1, 5, 10, 15, 20 & 25

Monitoring data will also be collected from permanently established, representative 20 x 20 m Recce plots within the Drury Quarry Forest enhancement areas at Years 1, 5, 10, 15, 20 and 25. Year 1 monitoring will provide baseline data on forest condition and inform any remodelling that may be required.

3.2.2.2.1 Data collection sites

- Plot locations should be representative of the average condition of the total area of revegetation and should aim to provide wide spatial coverage where offset monitoring requires multiple plots.
- Plot locations should be permanently marked, and data collection repeated at the same locations in every monitoring year.

Forest enhancement monitoring plots will be established at a rate of one 20m x20m plot per 10 hectares of forest enhancement.

- Each plot must have permanently marked photo points to provide qualitative data.

One permanently marked 20 X 20 Recce plot will be established per 10 ha of forest (on average) as follows:

1. Drury Quarry Vegetation (3 plots)
    a. 1 plot in Rock Forest
    b. 6 plots in Taraire, Tawa Podocarp Forest (WF9)

4 plots in Kānuka Scrub/Forest (VS2)

Table 50. Measurement of biodiversity attributes for forest enhancement areas: VS2, WF9, WF11 Years 1, 5, 10, 15, 20 & 25

Biodiversity attribute	Plot Collection method
Sapling species richness	Standard Recce method
Sapling density	Standard Recce method
Seedling density	Standard Recce method
Indigenous ground cover (%)	Standard Recce method

Pest control outcomes across the total enhancement area will be monitored twice yearly as part of the overall predator management plan for the area.

3.2.3 Adaptive Management

Based on the complexities of this ecological offset, a tier system will be provided based on remodelling of attribute values as necessary:

If net present biodiversity component values are below modelled values, but within 10 %, then only notification is required at time of reporting and proposed remediation.
If net present biodiversity component values are below modelled values, and greater than 10 %, then additional modelled actions must be presented for certification by Auckland Council Biodiversity Team or their nominated agents.

Table 51. Monitoring programme for planting and enhancement areas.

Loss (ha)	Biodiversity type	Planting (ha)	Planting year (s) Phase 1 (pioneer)	Phase 2 (enrichment)	Annual monitoring years	5 Year establishment report	5 yearly monitoring years	10 yearly reports	Enhancement (all established Year 1)	Enhancement monitoring
0.65	Rock forest	8.32ha	2-3	5-9	2,3,4,5,6	6	11,16,21,31	12,22,32	5.32 ha	1,5,10,15,20,25
1.87	WF9 2 &5	12	1-5	4-8	1,2,3,4,5	5	10,15,20,30	10,20,30	23 ha	1,5,10,15,20,25
5.46	WF9 1, 3 & 4	20	6-9	9-13	7,8,9,10,11	11	16,21,26,36	20,30	40 ha	1,5,10,15,20,25
8.8	VS2	22	10-16	None	11,12,13,14,15	15	21,26,36	30	40 ha	1,5,10,15,20,25
130 trees	Relict trees	887 trees	1-20	None	1,2,3,4,5	5	7,10,15,20,30	30	0	-

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APPLICABILITY AND LIMITATIONS

Restrictions of Intended Purpose

This report has been prepared solely for the benefit of Stevenson Aggregates Limited as our client with respect to the brief. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such party's sole risk.

Legal Interpretation

Opinions and judgements expressed herein are based on our understanding and interpretation of current regulatory standards and should not be construed as legal opinions. Where opinions or judgements are to be relied on, they should be independently verified with appropriate legal advice.

Maps and Images

All maps, plans, and figures included in this report are indicative only and are not to be used or interpreted as engineering drafts. Do not scale any of the maps, plans or figures in this report. Any information shown here on maps, plans and figures should be independently verified on site before taking any action. Sources for map and plan compositions include LINZ Data and Map Services and local council GIS services. For further details regarding any maps, plans or figures in this report, please contact Bioresearches.

Appendix A Recce Plots and Results

Four 20m x20m Recce plots were laid out in each of the four key areas of indigenous vegetation within the Sutton Pit extent (Figure 12). These areas are:

1. Taraire, tawa podocarp forest (WF9- 1) within SEA_T_1117
2. Gully forest (WF9-2)
3. Taraire, tawa podocarp forest (WF9-3) within SEA_T_ 5323

Kānuka scrub/forest (VS2 SEA_T_5323)

4. Rock forest (RF)

One reference plot was established within SEA_T_5349 amongst rock forest at Ballard's Cone that has been deer-fenced for 15 years to compare understorey recovery, seedling and sapling regeneration with grazed areas. Two further reference plots, one for WF9 and one for VS2 were established in Kirks' Bush, Papakura and in the Hunua Ranges within representative vegetation types with no grazing and with a basic level of pest control.

Four further plots were established within areas of representative vegetation where offset enhancement of degrades areas of rock forest, WF9 and VS2 forest are planned.

In each plot key ecological measures of forest structure were recorded as follows:

- Average top height
- Per cent cover within standard RECCE tier heights 1 -7, including canopy, subcanopy, understorey, groundcover and epiphytes.
- Species present in each tier and their per cent cover
- Total species richness
- Groundcover species richness
- Basal area of all trees >10 cm dbh[7]
- Seedlings <15cm in height (ephemeral).
- Seedlings > 15cm in height (established)
- Sapling (>135cm height, <2.5cm dbh) count
- Sapling species richness

Parameters such as canopy height, % cover in forest tiers, basal area and species richness provide a snapshot of the forest structure, biomass and diversity and hence the ecological values of the vegetation.

Seedling and sapling data provide insight into the intensity of browse pressure and seed predation by pests such as possums, ungulate browsers and rats. Small seedlings < 15cm in height are considered "ephemeral", easily succumbing to periods of drought and failing to recruit into the understorey or eventually the canopy. Larger seedlings are considered "established" and more likely to persist to become saplings and eventually reach the canopy (although % survival is often naturally low). A lack of larger seedlings and saplings indicates browsing pressure where the young plants are being eaten, or the fruit, flowers and seeds of mature plants are being eaten by possums and rats, resulting in

[7] Diameter at breast height

recruitment failure and disruption of other key ecological processes such as pollination and dispersal. This in turn negatively affects habitat values for native fauna.

Table 52. RECCE plot locations.

Plot number (refer Figure 22)	Plot	NZTM/Lat, long
Impact plots		
1	Taraire, tawa podocarp forest (WF9-1) within SEA_T_1117	E1777991 N5890275
3	Non-SEA Gully forest (WF9-2)	E1776967 N5890244
6	Taraire, tawa podocarp forest (WF9-3) within SEA_T_5323	E1777934 N5889899
2	Kānuka scrub/forest (VS2) within SEA_T_5323	E177601 N5908360
4	Non-SEA Rock forest (RF)	E1776904 N5889859
Reference plots		
5	Kaarearea Paa rock forest within SEA_T_5349	E1776925 N5889560
11	WF9 Reference Kirk's Bush SEA	S37^{0}04.404' E 174^{0}50.475
12	VS2 reference Mangatawhiri Dam	S37^{0}05.767' E175^{0}09.035'
Offset plots		
7	Taraire, tawa podocarp forest (WF9 offset 1) within SEA_T_5323	S37^{0}65.785' E175^{0}02.434'
10	Taraire, tawa podocarp forest (WF9 offset 2) within SEA_T_5323	E1777774 N5889396
8	Non-SEA Rock forest	S37^{0}07.665' E175^{0}00.016'
9	Kānuka scrub/forest (VS2) within SEA_T_5323	E1778102 N5889695

<u>Summary of results</u>

RECCE plot measurements are summarized in Table 53 below. All plots within the Sutton Pit Project area are grazed and native ground cover is very sparse. The understorey tier includes species present from 0.3 - 5 m height and cover were generally made up of tree ferns and those small trees in the 2 - 5 m height range that were above the browse height of cattle. Very little cover is present in the 0.3 – 2m height range.

For the WF9 forest, tree density, basal area and species richness were all within a typical range for this forest type. WF9-1 has a broken canopy, reflected in a lower canopy % cover. Kānuka scrub/forest had typically high density of trees and lower canopy height.

Canopy percent cover ranged between 50 and 75 percent for all plots and the sparse subcanopy was generally composed of nīkau and tree ferns. Groundcover species richness was moderate for some plots; however, the abundance of these species was very low. All WF9 and RF plots retained a range of epiphytic ferns and species of climbing rātā, however only WF9-1 and WF9-3 contained large epiphytic asteliads.

The rock forest impact plot had a lower plot basal area than WF9 plots or the RF reference plot, however the number of trees in each WF9 or RF plot was not markedly different, ranging from 12 - 17. Overall species richness was lower for rock forest plots than for the taraire plots and this was particularly so for the grazed rock forest. This observation is consistent with the harsher environmental conditions in the rock forest and difficulty for plants to establish amongst the boulders. The effects of fencing to exclude livestock, deer and goats were very clear for the Ballard's Cone reference plot where the understorey and ground tiers have recovered and there are many more larger seedlings and saplings. The seedling/sapling population is heavily dominated by two species (kawakawa and karaka) at present and this is possibly due to the lower palatability of these two species.

Grazed plots within the Sutton Pit Project area supported very few saplings (Table 54). Seedling numbers were moderate for the taraire plots when extrapolated, however virtually all seedlings seen in the plot were <5 cm high. Kānuka plot seedlings were also very small (<15 cm) and any larger seedling were less palatable species (tōtara and twiggy coprosma). Compared to the reference plots, all plots within the Sutton Pit footprint are depauperate in saplings and larger seedlings (>15 cm).

Plots outside the Sutton footprint within SEA-T_5323 are subject to some browsing by pest browsers but not to livestock grazing. There is a deer shooting programme in place for the wider landscape but the frequency of control is not known. Recce plot data was comparable to the impact plots except that the understorey layer was generally thicker. There were many more larger seedlings per plot however and a modest number of saplings, reflecting periodic browsing pressure from feral ungulates. Seedling and sapling counts within the reference plots were significantly higher than for the enhancement plots.
The RF offset enhancement area is not fenced and is grazed by livestock. It is dominated by a few large puriri and taraire and has a large basal area. Species richness is low and there are no larger seedlings or any saplings, with only a few small seedlings <15cm.

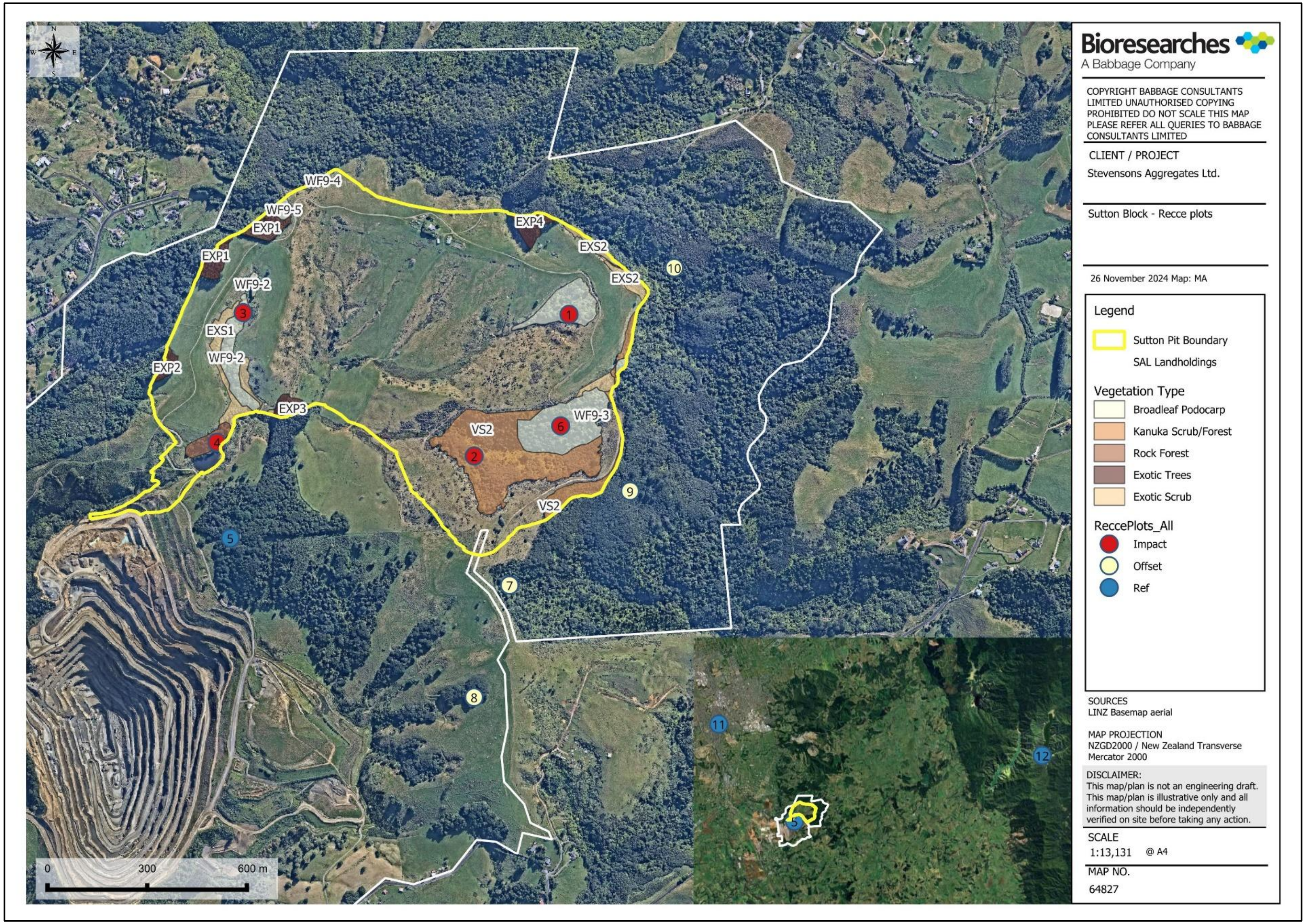

Figure 12. RECCE plot locations within the proposed Sutton (Impact), benchmark sites (Ref) and proposed enhancement areas (Offset).

Table 53. RECCE plot summary of data for Sutton pit

Biodiversity type	Plot number (refer Figure 12)	Mean top height/m	% canopy cover	Canopy tree count/ plot	Canopy species richness	Total canopy tree basal area/m²ha⁻¹ (trees > 10cm dbh)	Total species richness/ count	Groundcover species richness/ count	Sub canopy % cover 5 -12m	Understorey % cover 0.3 – 5m	Ground cover % cover <0.3m	Aspect
Impact plots												
Taraire, tawa podocarp forest (WF9-1)	1	16m	50	13	6	53.29	30	17	20	3	<1	W
Gully Forest (WF9-2)	3	18m	75	14	4	46.65	26	14	12	5	3	WSW
Taraire, tawa podocarp (WF9-3)	6	14	70	12	2	39.0	28	19	6	6	<1	S
Kānuka scrub/forest (VS2)	2	9	50	45	1	n/a	21	16	n/a	10	<1	NW
Rock forest (RF)	4	16	60	4	2	32.49	17	3	8	11	<1	ESE
Reference Plots												
Rock forest reference (Ballard's cone SEA)	5	18	57	4	2	46.67	21	11	15	57	8	NE
Taraire, tawa podocarp forest (WF9) Kirk's Bush Reserve.	WF9 REF	18-20	65	16	3	52.97	22	17	20	45	2	flat
Kānuka scrub/forest (VS2) Hunua Ranges	VS2-REF	12	55	46	4	34.18	28	20	n/a	27	10	E

Table 54. Summary of seedling and sapling data for enhancement vegetation outside the Sutton pit.

Biodiversity type	Plot number	Saplings /plot	Number/hectare	Sapling diversity	Seedlings ≤15cm /plot	Number/hectare	Seedlings>15cm /plot	Number/hectare
Enhancement plots								
Broadleaved podocarp forest	10	1	25	1	2,800	70,000	467	11,666
Broadleaved podocarp forest	7	4	100	2	1600	40,000	356	8,889
Kānuka scrub/forest	9	1	25	1	1311	32,775	200	5000
Rock forest	8	0	0		111	2778	0	0

Appendix B. Indicative Planting Schedules

Table 55. Phase 1: Pioneer planting Year 1

Common name	Botanical name
Akeake	*Dodonea viscosa*
Akepiro	*Olearia furfuracea*
Whauwhaupaku	*Pseudopanax arboreus*
Houhere	*Hoheria populnea*
Kanuka	*Kunzea robusta*
Karamu	*Coprosma robusta*
Kohuhu	*Pittosporum tenuifolium*
Koromiko	*Veronica stricta*
Manuka	*Leptospermum scoparium*
Mapou	*Myrsine australis*
Tarata	*Pittosporum eugenioides*
Totara	*Podocarpus totara*
Makomako	*Aristotelia serrata*

Pioneer planting should consist of approximately 50% kanuka/manuka and 50% broadleaved species.

Table 56. Phase 2 Enrichment planting with future canopy species Years 5 -10

Common name	Botanical name
Podocarps	
Tanekaha	*Phyllocladus trichomanoides*
Rimu	*Dacrydium cupressinum*
Kahikatea	*Fuscospora truncata*
Totara	*Podocarpus totara*
Miro	*Pectinopitys ferruginea*
Broadleaved trees	
Taraire	*Beilschmiedia tarairi*
Tawa	*Beilschmiedia tawa*
Rewarewa	*Knightia excelsa*
Hinau	*Elaeocarpus dentatus*
Kohekohe	*Dysoxylem spectabile*
Puriri	*Vitex lucens*
Hard Beech	*Fuscospora truncata*
Pukatea	*Laurelia novaezelandiae*
Karaka	*Corynocarpus laevigatus*
Kowhai	*Sophora microphylla*
Titoki	*Alectryon excelsus*

Enrichment planting must introduce at least 550 stems/ha of future canopy trees in order to meet modelled basal area targets at Year 30.

Table 57. Phase 3 planting with shade-tolerant understorey, groundcover and subcanopy species Year 5 - 10

Common name	Botanical name
Porokaiwhiri	*Hedycarya arborea*
Horoeka	*Pseudopanax crassifolius*
Hangehange	*Geniostoma ligustrifolium*
Nikau	*Rhopalostylis sapida*
Kawakawa	*Piper excelsum*
Thin-leaved coprosma	*Coprosma areolata*
Twiggy coprosma	*Coprosma rhamnoides*
Hook sedge	*Carex uncinata*
Forest sedge	*Carex dissita*
Toropapa	*Alseuosmia macrophylla*
Scarlet rata	*Metrosideros fulgens*

Table 58. Indicative Pioneer and Enrichment plant schedules for Ngā Motu o Hingaia Island 2

Common name	Botanical name
PHASE 1: Pioneer Planting	
Akeake	*Dodonaea viscosa*
Harakeke	*Phormium tenax*
Houpara/ Coastal five finger	*Pseudopanax lessonii*
Kānuka	*Kunzea robusta*
Karamuramu & Karamu	*Coprosma macrocarpa* *Coprosma robusta* *Coprosma lucida*
Karo	*Pittosporum crassifolium*
Koromiko	*Hebe stricta* var. *stricta*
Mānuka	*Leptospermum scoparium*
Mingimingi	*Coprosma propinqua*
PHASE 2: enrichment species	
Horoeka/Lancewood	*Pesuedopanax crassifolium*
Houhere	*Hoheria populnea*
Kohuhu	*Pittosporum tenuifolium*
Mahoe	*Melicytus ramiflorus*
Porokaiwhiri	*Hedycarya arborea*
Rewarewa	*Knightia excelsa*
Tanekaha	*Phyllocladus trichomanoides*
Totara	*Podocarpus totara*
Whau	*Entelea arborescens*
Whauwhaupaku	*Pseudopanax arboreus*

Table 59. Indicative Pioneer and Enrichment plant schedules for Kahikatea/pukatea/rimu relict tree replacement planting(1.14ha)

Common name	Botanical name
Phase 1 Pioneer planting	
Harakeke	*Phormium tenax*
Mānatu/ribbonwood	*Plagianthus regius*
Mānuka	*Leptospermum scoparium*
Putaputaweta	*Carpodetus serratus*
Tī kōuka/cabbage tree	*Cordyline australis*
Phase 2 Enrichment planting	
Kahikatea	*Dacrycarpus dacrydioides*
Pukatea	*Laurelia novae-zelandiae*
Rimu	*Dacrydium cupressinum*

It is expected that common tree ferns, ground ferns and epiphytes will self-introduce as suitable habitats become available.

Auckland

Address | Level 4, 68 Beach Road, Auckland 1010
Post | PO Box 2027, Shortland Street, Auckland 1140, New Zealand
Ph | 64 9 379 9980
Fax | +64 9 377 1170
Email | contact-us@babbage.co.nz

Hamilton

Address | Unit 1, 85 Church Road, Pukete, Hamilton 3200
Post | PO Box 20068, Te Rapa, Hamilton 3241, New Zealand
Ph | +64 7 850 7010
Fax | +64 9 377 1170
Email | contact-us@babbage.co.nz

Christchurch

Address | 128 Montreal Street, Sydenham, Christchurch 8023
Post | PO Box 2373, Christchurch 8140, New Zealand
Ph | +64 3 379 2734
Fax | +64 3 379 1642
Email | solutions@babbage.co.nz

Babbage Consultants Australia Pty Ltd – Australia

Address | Suite 4, Level 2, 1 Yarra Street, Geelong, Victoria 3220, Australia
Ph | +61 3 8539 4805
Email | contact-us@babbage.co.nz

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