Kings Quarry Stage 2

Terrestrial Ecology Residual Effects Analysis Report

for: Kings Quarry Limited

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EXECUTIVE SUMMARY

Kings Quarry Limited is proposing to expand its existing Kings Quarry operation with a Stage 2 pit and fill development. This will require the removal of 28.97 ha of indigenous vegetation. The Stage 2 area (Project area) is zoned 'Special Purpose Zone: Quarry' (SPQZ) under the Auckland Unitary Plan – Operative in Part (AUP) and the vegetation is identified as a significant ecological area (SEA) under the AUP (SEA_T_6454). An Ecological Impact Assessment (EcIA; Bioresearches 2025a) identified the vegetation composition as consistent with kānuka scrub/forest (VS2) and broadleaved species scrub/forest (VS5), both of which are classed as IUCN regional threat status of least concern (Singers et al. 2017). A small area of young kauri, podocarp forest (WF11) will also be impacted on the north-east pit margin. The WF11 ecosystem type has an IUCN regional threat status of 'endangered' (Singers *et al*., 2017). The EcIA identified that the removal of indigenous vegetation would constitute a 'moderate' level of residual effect, following onsite ecological management (e.g. native revegetation remediation, buffer planting, and weed and pest control, Bioresearches, 2025).

This report sets out the type and quantum of habitat restoration and enhancement measures required to achieve net biodiversity gains[12], as modelled using biodiversity offset (BOAM, Maseyk *et al.,* 2015; 2018) and compensation (BCM, Baber et al. 2021) models as follows:

- **BOAM**s are used in this report to address quantifiable gains in disaggregated biodiversity values, through provision of **61.8 ha of revegetation** in the first instance.
- **A BCM** is used to inform the general uplift to indigenous forest biodiversity that would be expected to be result from the proposed overarching effects management following enhancement of **88.28 ha of regenerating indigenous vegetation** of variable quality, age and composition. Enhancement would be achieved over 88.28 ha and would incorporate multiple management approaches, including pest elimination within a 60 ha predator proof fence as follows:

[1] The term net gain is used generically to refer to expected outcomes from the offsetting/compensation package. However, we note that technically net gain relates to biodiversity offsetting while net positive is the appropriate term for biodiversity compensation and aligns with criteria 3 of the Biodiversity Compensation Principles that are set out in Appendix 4 of the NPSIB

- **Inside Pest proof fence:** 60 ha habitat restoration and enhancement actions including:
    a. 28.42 ha of revegetation
    b. Enhancement and enrichment planting of 30.76 ha of existing vegetation, including 23.28 ha of VS2 and 7.48 ha of VS5.
    c. Elimination of mammalian pests
    d. Weed control
- **Outside Pest proof fence:** 90.86 ha habitat restoration actions including:
    a. 33.34 ha of revegetation
    b. Enhancement and enrichment planting 57.52 ha of revegetation, including 40.04 ha of VS2, 16.6 ha of VS5 and 0.88 ha of WF11 revegetation.

Details for ongoing monitoring are provided with specified targets and contingency plans for each of the offset/compensation Project areas. It is anticipated that a net gain in biodiversity values should occur following the completion of all compensation actions.

Overall, outcomes of the residual effects analysis and implementation of the resulting planting, pest predator elimination, browser control and habitat enhancement actions would result in significant restoration outcomes across a 150.86 ha area of pasture and existing, degraded mixed indigenous vegetation to the immediate north of Dome Valley, an area of high ecological value.

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List of Acronyms and Abbreviations

Abbreviation/Acronym	Explanation
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
NPSIB	National Policy Statement for Indigenous Biodiversity
NVS	National Vegetation Survey
REAR	Residual Effects Analysis Report
REMP	Residual Effects Management Plan
SEA	Significant Ecological Area
Spp	Species
SPQZ	Special Purpose Quarry Zone
VS2	Kānuka scrub/forest
VS5	Broadleaved species scrub/forest
WF11	Kauri, podocarp, broadleaved forest

Glossary of terms

Term	Definition
Biodiversity Compensation	Actions (excluding biodiversity offsets) to compensate for residual adverse biodiversity effects arising from activities after all appropriate avoidance, minimisation, remediation, and biodiversity offset measures have been applied. Gains generated by compensation actions must be additional to those that would have occurred anyway in the absence of those actions[3].
Biodiversity Offsetting	A measurable outcome resulting from actions designed to compensate for residual adverse biodiversity effects arising from activities after appropriate avoidance, minimisation, and remediation measures have been subsequently applied and that achieves No Net Loss or preferably a Net Gain[3].
Management	Management includes all action under the RMA Management Hierarchy, including avoidance, minimisation, remediation, offsetting and compensation.
Residual Effects Analysis Report	Report that addresses any remaining residual effects, following management actions. Both a terrestrial ecology (REAR-TE) and freshwater ecology (REAR-FW) reports are provided. Residual Effects Management Plan

[3] Baber, M., Quinn, J., Craig, J., Bramley, G., Lowe, M., Webb, C., Ussher, G., Whiteley, C., Kessels, G., Davies, F., Markham, J., Miller, D., van Winkel, D., Wedding, C., Chapman, S. (2025). The Biodiversity Compensation Model: a framework to facilitate better ecological outcomes. *New Zealand Journal of Ecology*, *49*(1), 3591.

1 INTRODUCTION

Kings Quarry Limited is proposing to expand Kings Quarry at Wainui, north Auckland, to develop a stage 2 pit and associated fill and access areas. Collectively, the stage 2 pit and associated footprints are hereafter referred to as the 'Project area'. The expansion will require removal of 28.97 ha of indigenous vegetation, comprising regenerating broadleaved (VS5) and kanuka (VS2) forest ecosystem types (Figure 1). The Project area is within a 'Special Purpose Zone: Quarry' (SPQZ) and most of the vegetation is within a Significant Ecological Area overlay (SEA; SEA_T_6454), as mapped under the Auckland Unitary Plan – Operative in Part (AUP).

An Ecological Impact Assessment (EcIA, Bioresearches 2025) determined that the regenerating broadleaved and kanuka ecosystems within in Project area are of high value, and moderate levels of residual effects are expected following ecological management in accordance with the effect's management hierarchy, including avoidance, minimisation including fauna management, buffer enhancement and ongoing remediation.

This report (TEREAR) should be read in conjunction with the following ecological reports, which form the ecological Effects assessments and ecological management approach:

1. Ecological Impact Assessment (Bioresearches 2025a)
2. Ecological Management Plan (Bioresearches 2025b)
3. Remediation Planting Plan (Barker & Associates 2025)

Following the outcome of this TEREAR, a Residual Effects Management Plan (REMP) has been prepared to detail the actions required to implement and monitor the modelled outcomes.

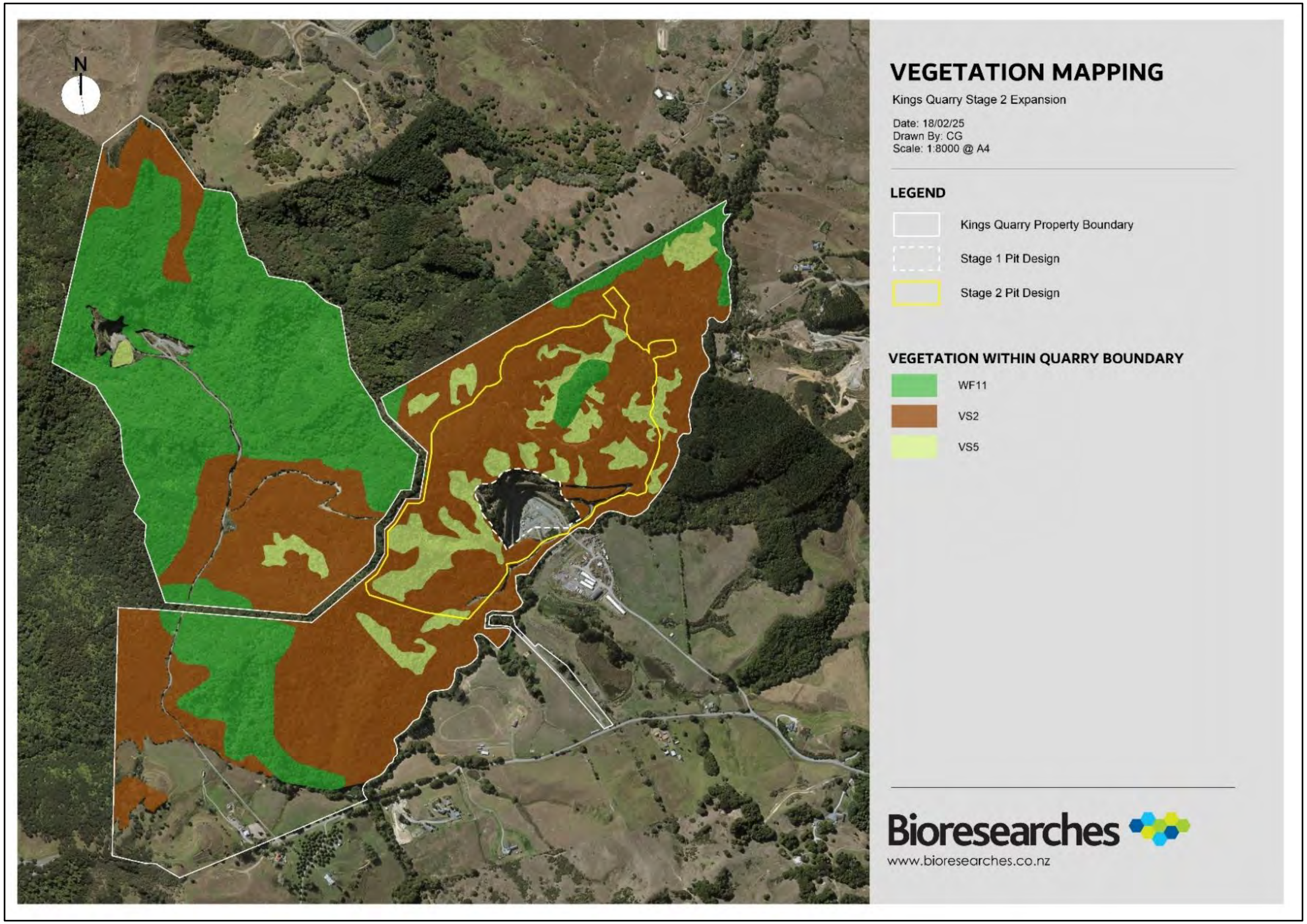

Figure 1. Proposed Project area at Kings Quarry, including vegetation cover within the Project area.

1.1 Purpose of Report

The purpose of this report is to determine the quantum of conservation actions (revegetation of new habitats and enhancement of existing habitats) required to counterbalance losses expected from the removal of vegetation and habitats from the Project area. Those actions are quantified and measured against losses and modelled, using the Biodiversity Offset Accounting Model (BOAM, developed by Maseyk and others (Maseyk *et al.,* 2015; 2018)) where possible. We also employed the Biodiversity Compensation Models (BCM; Baber *et al.*, 2021a, 2021b, 2021c) to determine residual effects management requirements. BCM models are used when insufficient information is available, or principles of Biodiversity offsetting cannot be achieved. Biodiversity Offset Accounting Model (BOAM), developed by Maseyk and others (Maseyk *et al.,* 2015; 2018), are preferable to determine if an overall net biodiversity gain is achieved. The BCM models overall change to the habitat or ecosystem, whereas the BOAM models individual measurable biodiversity components. As such, we have used BOAM models to model available components to determine the quantity of actions required. These were then used to inform the inputs to the BCM, improving the accuracy of the BCM models.

Biodiversity Offsetting and Biodiversity Compensation are recognised tools for counterbalancing significant residual effects on ecological values in New Zealand, as long as it aligns with the Effects Management Hierarchy (National Policy Statement for Indigenous Biodiversity (NPSIB, 2023)). A summary of the Project's application of the Effects Management Hierarchy is provided in section 1.3.2.2. This Residual Effects Plan should therefore be read in conjunction with other reports and management plans that detail measures that will be taken to avoid, minimise, and remedy effects prior to offsetting and compensating. Management measures such as revegetation planting and fauna management plans are presented separately and should be considered as part of the wider terrestrial ecological management package.

1.2 Summary of Adverse Effects on Terrestrial Ecology Values

The Project will result in removal of 28.97 ha of high value indigenous vegetation, comprising of predominantly kānuka scrub/forest (VS2) and broadleaved species scrub/forest (VS5) ecosystem types, with a smaller amount of kauri, podocarp, broadleaved forest (WF11) (Figure 1). The residual effect on vegetation values, following ecological management, is assessed as being moderate. The residual levels of effect on indigenous fauna and flora (including those Threatened and At Risk (TAR) species (Table 1), are assessed as being low or very low, following ecological management (Bioresearches 2025a).. Only those residual effects greater than 'Low' are considered to be significant and therefore require further actions to offset or compensate. In this case, this report addresses the significant residual effect of the loss of VS2, VS5 and WF11 vegetation.

Table 1. Threatened and At-Risk species detected from surveys within and around the Project area.

Type	Species	National status	Regional Status
Flora	**Kauri, *Agathis australis***	At Risk	At Risk
	Toetoe, *Austroderia fulviada*	Not Threatened	Threatened
	Euchiton audax	Not Threatened	At Risk
	Forest sedge, *Carex ochrosaccus*	Not Threatened	At Risk
	Kūmarahou, *Pomaderris kumeraho*	Not Threatened	At Risk
	Tanglefern, *Gleichenia microphylla*	Not Threatened	At Risk
	Large leaved māhoe, *Melicytus macrophyllus*	Not Threatened	At RIsk
	Swamp māhoe, *Melicytus micranthus*	Not Threatened	Threatened
	Small white rātā, *Metrosideros perforata*	Not Threatened	At Risk
	Kaikomako, *Pennantia corymbosa*	Not Threatened	At Risk
	Short hair plume grass *Pentapogon inaequiglumis*	At Risk	At Risk
Fauna (bat)	**Long tailed bat, *Chalinolobus tuberculatus****	Threatened	Threatened
Fauna (lizard)	**Copper skink, *Oligosoma aeneum***	At Risk	At Risk
	Forest gecko, *Mokopirirakau granulatus*	At Risk	At Risk
	Elegant gecko*, *Naultinus elegans**	At Risk	At Risk

Note. Species recorded from contiguous vegetation outside the Project area.

Table 2. Summary of adverse effects, values, management actions and levels of effects before and after management.

Adverse Effect	Ecological value	Level of effect before management	Management action(s)
Loss of VS2 vegetation (19.75 ha)	High	Moderate	• Remediation of Pit • Buffer planting • Pest and weed control.
Loss of VS5 vegetation (8.03 ha)	High	Moderate	• Remediation of Pit • Buffer planting • Pest and weed control.
Loss of WF11 vegetation (1.19 ha)	High	Moderate	• Remediation of Pit • Buffer planting • Pest and weed control.
Habitat fragmentation / increased edge effect	High	Low	• Implementation of Edge Effects and Buffer Management Plan • Buffer planting and pest animal control. • Sequential remediation of Pit
Loss of TAR plants and habitats	High	Low	• Provision of TAR plant species in remediation. • Planting schedules and pest management at planting locations
Mortality to Invertebrates and loss of habitats	Low	Low (temporary – medium term, 5-15 years)	• Implementation of Lizard and Invertebrate Management Plan, relocate invertebrates • Remediation of Pit • Buffer planting • Pest and weed control.
Mortality to lizards and loss of habitats	High	Low (temporary – medium term, 5-15 years)	• Lizard and Invertebrate Management Plan to capture / relocate lizards • Remediation of Pit
Mortality to birds and loss of habitats	Moderate	Low (temporary – medium term, 5-15 years)	• Implementation of Avifauna Management Plan • Pre-clearance nesting surveys to minimise mortality to nesting birds
Mortality to bats and loss of habitats	Very High	Low	• Bat Management Plan to provide for preclearance bat surveys, adoption of tree felling protocols and provision of artificial bat roost boxes in accordance with DOC advice note where a bat roost is discovered.

1.3 Statutory Context and the Effects Management Hierarchy

1.3.1 Auckland Unitary Plan

The AUP contains specific provisions in relation to special purpose- Quarry Zones (SPQZ), which provide for significant mineral extraction to be undertaken in a manner that minimises and manages adverse effects. Avoidance of adverse effects is not required within the actual rock extraction area under these provisions, however, minimisation, management offset or compensation of significant adverse effects must be demonstrated.

1.3.2 National Policy Statement for Indigenous Biodiversity (NPSIB)

The NPSIB requires that identified adverse effects within SNAs (SEAs under the AUP) are avoided, except where provided for under Clause 3.11 (NPSIB), which includes aggregate extraction that provides significant national or regional public benefits that could not otherwise be achieved using resources within New Zealand (NPSIB, clause 3.11(1(aiii))). An explanation of the Project with respect to this exception is provided with the application, however where adverse effects are managed pursuant to subclause 3 of the NPSIB, the following is required to be demonstrated (NPSIB, clause 3.10(4)):

1. How each step of the effect's management hierarchy will be applied, and
2. 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.

1.3.2.1 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 (NPSIB, clause 1.6):

a. adverse effects are avoided where practicable; then
b. where adverse effects cannot be avoided, they are minimised where practicable; then
c. where adverse effects cannot be minimised, they are remedied where practicable; then
d. where more than minor residual adverse effects cannot be avoided, minimised, or remedied, biodiversity offsetting is provided where possible; then
e. where biodiversity offsetting of more than minor residual adverse effects is not possible, biodiversity compensation is provided; then
f. if biodiversity compensation is not appropriate, the activity itself is avoided.

1.3.2.2 Kings Quarry Approach to the Effects Management Hierarchy

Adverse effects that are avoided, where practicable

The quarry pit location and shape for Kings Quarry Stage 2 was redesigned at an early stage to avoid very high value kauri podocarp forest (WF11 - Regionally endangered ecosystem, c.f. 'least concern' VS2 and VS5 within the Project area), where possible, within the SPQZ. Some WF11 (1.19 ha) was found to occur within the Project area, but this was not identified as WF11 until the later stages of the project.

Further, earlier design optioneering identified a proposed fill area further north of the Project area. Preliminary ecological assessments identified that this option would completely bisect

SEA_T_6454 and significantly increase fragmentation effects. The current proposal avoids this outcome and contains the quarry pit and fill in a single footprint, set back 50-150 m from the northern edge of the forest, at its northern-most extent.

Adverse effects that are minimised, where practicable

Separate management plans have been prepared to detail actions required to minimise adverse effects on high value flora (threatened plants) and fauna (lizards, birds, long-tailed bats), such as pre-clearance surveys to avoid nesting native birds and roosting bats; and capture, relocation, and habitat enhancement for native lizards. This report should be read in conjunction with those management plans, specifically:

Ecological Management plan:

- Vegetation removal Management Plan
- Lizard and Invertebrate Management Plan
- Avifauna Management Plan
- Bat Management Plan
- Freshwater Fish Management Plan
- Threatened Plant Management Plan
- Kauri dieback Management Plan
- Edge Effects and Buffer Planting Plan (
- Mammalian Pest Control Plan

Adverse effects that are remedied, where practicable

Kings Quarry Stage 2 will provide remediation of the proposed fill and pit area. Remediation will consist of restoration plantings of 22 ha within the fill and pit area and will be staged as the fill becomes available for reinstatement.

Table 3. Summary of areas of vegetation proposed to be removed, as used within the BCM model.

Vegetation clearance by ecosystem type			
	VS2 (ha)	**VS5 (ha)**	**WF11 (ha)**
Total	19.75	8.03	1.19
Combined total	28.97		

Figure 2: Areas of vegetation clearance within the proposed stage 2 pit areas (left) and proposed replanting areas to be reinstated (images courtesy of Aggretech).

Adverse effects that are offset

We were not able to offset all residual effects, due to variability of the two regenerating ecosystem types (VS2 and VS5), and it was not possible to collect sufficient data to make the results meaningful and accurate across the entire Project. BOAM models are, however, used to quantify the amount of revegetation required, by modelling DBH and bird abundance and diversity. The output of the BOAM models is also used to verify data input into compensation models where possible. Where BOAM models are used to offset residual adverse effects, it was ensured that they meet the principles for biodiversity offsetting as set out in Appendix 3 of the NPSIB. The following effects are offset through revegetation:

High-level effect resulting from the loss of High value Kauri, Podocarp, Broadleaved Forest (WF11).

- High-level effect resulting from the loss of High value regenerating broadleaved species vegetation and habitats relating to avifauna (VS5).
- High-level effect resulting from the loss of High value Kanuka scrub/forest and habitats relating to avifauna (VS2).

Adverse effects that are compensated

We provide Biodiversity Compensation Models (BCM) to demonstrate confidence in quantified compensation actions, as well as net gain from a range of enhancement outcomes over various vegetation types and condition within adjacent vegetation and contiguous with the compensation Project area at Dome Valley (Oldfield Road).

- High-level effect resulting from the loss of High value Kauri, Podocarp, Broadleaved Forest (WF11).

- High-level effect resulting from the loss of High value regenerating broadleaved species vegetation and habitats relating to avifauna (VS5).
- High-level effect resulting from the loss of High value Kanuka scrub/forest and habitats relating to avifauna (VS2).

Table 4. Summary of terrestrial vegetation, values, effects and effects management for proposed Stage 2 expansion of Kings Quarry.

Vegetation type	Ecological Value	Level of effect (without management management actions)	Estimated area of removal (ha)	Actions required to minimise adverse effects (refer separate ecological management plans)	Actions required to offset or compensate residual effects.	Level of residual effects after management	Predicted ecological outcome
Broadleaved Scrub (VS5)	High	High	8.03 ha	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. Revegetation of like-for-like Broadleaved Scrub Forest vegetation, in accordance with a biodiversity offset model that demonstrates at least a no-net-loss for flora and fauna habitat values. 2. Installation of a predator-proof fence at the offset/compensation Project area (Oldfields Road property) and removal of all pest animal species within the fence. Additionally, pest plant species will be controlled and enrichment planting within existing vegetation. 3. Weed and mammalian browser control of the remaining property outside the fence (~150 ha, of which 57.52 is existing vegetation).	Moderate	Net Positive
Kanuka scrub/forest (VS2)	High	High	19.75 ha	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. Revegetation of like-for-like kanuka Forest vegetation, in accordance with a biodiversity offset model that demonstrates at least a no-net-loss for flora and fauna habitat values. 2. Installation of a predator-proof fence at the offset/compensation Project area (Oldfields Road property) and removal of all pest animal species within the fence. Additionally, pest plant species will be controlled and enrichment planting within existing vegetation. 3. Weed and mammalian browser control of the remaining property outside the fence (~150 ha, of which 57.52 is existing vegetation).	Moderate	Net Positive
Kauri, podocarp, broadleaved forest (WF11)	High	High	1.19 ha	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. Revegetation of like-for-like Kauri, podocarp, broadleaved Forest vegetation, in accordance with a biodiversity offset model that demonstrates at least a no-net-loss for flora and fauna habitat values. 2. Installation of a predator-proof fence at the offset/compensation Project area (Oldfields Road property) and removal of all pest animal species within the fence. Additionally, pest plant species will be controlled and enrichment planting within existing vegetation. 3. Weed and mammalian browser control of the remaining property outside the fence (~150 ha, of which 57.52 is existing vegetation).	Moderate	Net Positive

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 NPSIB, the Department of Conservation (DOC, 2014) and Local Government New Zealand (Maseyk *et al.,* 2018) provide guidance for offset design. These offset design guidelines represent best current practice for achieving a net environmental gain, as is the intention in this case (rather than 'no net loss'). No specific guidance is provided by the AUP for biodiversity compensation. However, each of the key points from the guidance for offset design are addressed below, in relation the compensation actions for the Project. The listed important aspects of offset design include:

1. *Restoration, enhancement, and protection actions undertaken as a biodiversity offset are demonstrably additional to what will otherwise occur, including that they are additional to any avoidance, remediation or mitigation undertaken in relation to the adverse effects of the activity.*

Terrestrial mitigation and management are detailed in management plans separate to this document.

2. *Offset actions should be undertaken close to the location of loss, where this will result in the best ecological outcome.*

Compensation actions are proposed to be undertaken within the same ecological district (Rodney). It was not possible to do all offset/compensation actions in the immediate landscape.

3. *The values to be lost through the activity to which the offset applies are counterbalanced by the proposed offsetting activity, which is at least commensurate with the adverse effects on indigenous biodiversity. Where possible the overall result should be no net loss, and preferably a net gain in ecological values.*

The proposed compensation activities, including revegetation, installation of a pest-proof fence and pest eradication, enrichment planting of existing vegetation, browser control outside the fence, and weed control, are expected to achieve an overall net gain in terrestrial ecological values.

4. *The offset is applied so that the ecological values being achieved through the offset are the same or similar to those being lost ('like for like').*

The compensation actions proposed target components of those biodiversity values in the same ecosystem types, so that fauna and flora communities that will benefit from the proposed actions are as similar as possible to those that are impacted. Regenerating forest (VS2 and VS5) and Kauri, podocarp broadleaf forest (WF11) are compensated with like for like restoration and enhancement actions.

5. *The offset is legally protected in perpetuity, such as via a conservation covenant. Covenanted areas are required to have stock exclusion fences.*

For this Project, all offset restoration and enhancement actions would be protected in perpetuity by way of legal covenant and the predator-proof fence and/or stock or deer exclusion fencing.

1.4.1 Suitability of ecological features within Kings Quarry Stage 2 for biodiversity offset.

Using a biodiversity offsetting approach proved to not be feasible for all aspects, so a biodiversity compensation approach has also been used. The original forest in Project area is likely to have been Taraire, tawa, podocarp forest (WF9) and Kauri, podocarp-broadleaved beech forest (WF12) as mapped on the

Auckland Council Geomaps biodiversity layer for the potential extent of ecosystems. Currently, the composition of the vegetation varies considerably across the Project area according to its maturity and site-specific factors such as aspect and topography. It forms a mosaic of forest types that is indicative of multiple past disturbances. The community structure has become simplified and species diversity reduced. However, accurate measures for specific biodiversity attributes, as required for Biodiversity Offset modelling proved challenging, due to the variability across the Project area. This is a feature of regenerating ecosystems, due to different stages of regeneration, which affects features such as vegetation structure and diversity. However, the ecological features within the footprint and surrounding area have also been subject to repeat ecological surveys (e.g. Bioresearches, 1998, 2008, 2009, 2021), and therefore there is a high level of confidence in the values that have been assessed.

1.4.2 Suitability of ecological features within Kings Quarry Stage 2 for biodiversity compensation.

The loss off the three forest communities is compensated using three complimentary strategies, or modelled actions. These actions are grouped by broadly different habitats that will receive compensation actions:

- Existing vegetation within the predator proof fence (VS2 and VS5): pest eradication, enrichment planting, and weed control.

Existing vegetation outside the predator proof fence (VS2, VS5 and WF11): pest browser control, enrichment planting, and weed control

Revegetation of new, future ecosystems (long-term gains) both inside and outside the predator-proof fence.

Restoration and replanting of existing wetlands (WL19: Raupo Wetland) outside the predator-proof fence (See REAR-FW for details).

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 predator proof fence provides both short-term and longer-term gains. Further explanation of these actions is provided in Section 2.3.

The terrestrial vegetation and habitats within the Project area can be successfully compensated because the biodiversity attributes and ecological values of the vegetation being lost are well-documented and the compensation methods are well-known techniques with good supporting scientific data. Long-term monitoring and management ensure biodiversity targets are met at each stage and contingency tables address any instances where values may fall short of targets for any biodiversity attribute.

1.4.3 Principles of biodiversity offsetting and compensation

The National Policy Statement on Indigenous Biodiversity (2023) (NPSIB) provides specific principles that underpin Biodiversity Offsetting and Biodiversity Compensation. The principles for biodiversity compensation are listed in Table 6, as well as an explanation of how the proposed compensation for

Kings Quarry stage 2 will satisfy them. The NPSIB requires that a biodiversity offset or biodiversity compensation must comply with principles 1 to 6 and has regard to the remaining principles.

The effects management hierarchy requires that Biodiversity Offsetting is carried out where possible, and Biodiversity Compensation is only used in circumstances where the principles of Biodiversity offsetting are not met. Here, we follow this hierarchy, and compensation is only used due to such circumstances. Further discussion regarding the use of offsetting (BOAM) versus compensation (BCM) models is provided in section 3.

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Table 5. Principles of biodiversity offsetting (NPSIB, Appendix 3) and how these are achieved for regenerating kanuka forest and regenerating broadleaved species ecosystems at Kings Quarry Stage 2 expansion.

	Principles / Criteria of biodiversity offsetting	How these principles are achieved
1	**Adherence to effects management hierarchy:** A biodiversity offset is a commitment to redress more than minor residual adverse effects and should be contemplated only after steps to avoid, minimise, and remedy adverse effects are demonstrated to have been sequentially exhausted.	Full details of the adherence to the effects management hierarchy are provided in section 1.2. Avoid: Kings Quarry Stage 2 was redesigned at an early stage to avoid very high value kauri podocarp forest, where it occurs within the SPQZ. Notably, the protection and enhancement of parts of this threatened ecosystem is incorporated into the modelled conservation actions. Further, earlier design optioneering identified a proposed fill area further north of the current proposal. Preliminary ecological assessments identified that this option would completely bisect SEA_T_6454 and significantly increase fragmentation effects. The current proposal avoids this outcome, although acknowledges that the footprint retains substantial edge effects. Minimise: Species specific effects are minimised through specific methodology, as addressed in separate management plans. Remedy: Kings Quarry Stage 2 will provide remediation of the proposed fill area. Remediation will consist of restoration plantings of 22 ha within the fill and pit area and will be staged as the fill and pit areas becomes available for reinstatement.
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.	The biodiversity is classed as 'least concern' VS2 and VS5 forest and 'regionally endangered' WF11 (Singers et al., 2017) and the effects have high certainty. Offsetting models (BOAMs) are therefore used for these three ecosystem types to determine offsetting actions more accurately. The BOAMs model measurable biodiversity attributes. It is acknowledged that some values cannot be replaced or offset, such as the habitat capacity provided by mature tree cavities or epiphytic vegetation (noting the affected vegetation is largely regenerating). Therefore, while these attributes are not modelled, they are addressed where possible, and such values are captured through management measures provided in other management plans, such as lizard management (transfer of epiphytes), revegetation restoration (includes direct transfer of vegetation and soil) and where triggered, artificial bat roost provision.
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).	An offsetting model (BOAM; Maseyk et al, 2016) approach is used for the three ecosystem types to ensure net gain of like-for-like biodiversity types. These models include disaggregation of biodiversity components to ensure net gain across components, include species diversity, flora, fauna, and condition. All revegetation aims to buffer or connect existing fragmented ecosystems that support VS2, VS5 or WF11 ecosystem types. The actions are modelled to achieve an overall net gain in biodiversity at 20 years.
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 to undertake any of the proposed revegetation or enhancement actions at the identified Project areas. The proposed revegetation planting would be undertaken in areas currently occupied by pasture or former exotic forestry. Revegetation areas will be protected in perpetuity 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) will not cause harm to other indigenous biodiversity at the Project area or other locations. All actions are well established methods for improving indigenous biodiversity.

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 20 years to ensure offset targets are achieved. Annual and five-yearly monitoring is provided to measure 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
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.	Offset actions will comprise revegetation and enhancement that is contiguous with existing native vegetation within SEAs and with other areas of restoration planting. Revegetation and enhancement offset actions aim to protect, enhance, and connect native habitats within the immediate landscape where they benefit like-for-like biodiversity values, and similar / same species assemblages and communities. Sites contiguous with Kings Quarry form part of the offset actions, however, constraints to site availability have required an additional Project areaat Oldfield Road, Wellsford (same Ecological District) which is situated at the northern end of Dome Valley and supports the same species assemblages, particularly lizards, birds and bats).
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).	The BOAM models account for time lags between loss of biodiversity values at the impact site and gains at the offset sites. Enhancement actions (pest control) will produce net gains quickly (< 1 year). Longer timeframes have been used for revegetation (20 years).
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, 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 Kings Quarry, established native plantings and other mature ecosystems.
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.	Tangata Whenua engagement and consultation continues to form part of this offset package, which will evolve with new considerations. Tangata Whenua will be provided opportunities for participation in all aspects of ecological management and monitoring.
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.	Refer Section 3. Kings 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, the Department of Conservation. Contingency reports are part of this plan to ensure that if biodiversity offset objectives are not met in keeping with the BOAM parameters, further ecological enhancement/offset activities are set out for Kings Quarry to meet their BOAM targets.

Table 6. Principles of biodiversity compensation (NPSIB, Appendix 4) and how these are achieved for Kings Quarry Stage 2 expansion (A BCM is used because of the difficulty in quantifying uplift from enhancement of seral forest fragments with a wide range of states of degradation and age.

	Principles / Criteria of biodiversity offsetting	How these principles are achieved
1	**Adherence to effects management hierarchy:** A biodiversity offset is a commitment to redress more than minor residual adverse effects and should be contemplated only after steps to avoid, minimise, and remedy adverse effects are demonstrated to have been sequentially exhausted.	Details about the adherence to the effects management hierarchy are provided in section 1.2. Avoid: Kings Quarry Stage 2 was redesigned at an early stage to avoid very high value kauri podocarp forest, where it occurs within the SPQZ. Notably, this threatened ecosystem is further proposed to be protected and enhanced as part of the modelled conservation actions. Further, earlier design optioneering identified a proposed fill area further north of the current proposal. Preliminary ecological assessments identified that this option would completely bisect SEA_T_6454 and significantly increase fragmentation effects. The current proposal avoids this outcome, although acknowledges that the footprint retains some edge effects. Minimise: Species specific effects are minimised through specific methodology, as addressed in management plans. Remedy: Kings Quarry Stage 2 will provide remediation of the proposed fill area. Remediation will consist of restoration plantings of 22 ha within the fill and pit area and will be staged as the fill and pit areas becomes available for reinstatement.
2	**When biodiversity compensation is not appropriate:** Biodiversity compensation is not appropriate where indigenous biodiversity values are not able to be compensated for. Examples of biodiversity compensation not being appropriate include where: (a) the indigenous biodiversity affected is irreplaceable or vulnerable; (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 a proposed net gain within acceptable timeframes.	The biodiversity is classed as 'least concern' VS2 and VS5 forest and 'regionally endangered' WF11, and the effects are well understood. Acceptable gains are considered to be confidently achieved within an acceptable timeframe.
3	**Scale of biodiversity compensation:** The indigenous biodiversity values lost through the activity to which the biodiversity compensation applies are addressed by positive effects to indigenous biodiversity (including when indigenous species depend on introduced species for their persistence), that outweigh the adverse effects.	A compensation approach is used and modelled using a BCM to both 'sense check' the ecological package and ensure that that the complexities of quantifying uplift from enhancement actions of forest fragments that have a wide range of ages and condition / states of degradation are still accounted for. The overall positive effects of specific biodiversity components are also calculated in a BOAM, adding additional assurance that the BCM calculations provide sufficient biodiversity gains.
4	**Additionality**: Biodiversity compensation achieves gains in indigenous biodiversity above and beyond gains that would have occurred in the absence of the compensation, such as gains that are additional to any minimisation and remediation or offsetting undertaken in relation to the adverse effects of the activity.	There are no current or future plans to undertake any of the proposed enhancement actions. The proposed enhancement would be undertaken over vegetation of various ages and states of degradation from recent land use.
5	**Leakage:** Biodiversity compensation design and implementation avoids displacing harm to other indigenous biodiversity in the same or any other location.	The biodiversity compensation actions (pest eradication, revegetation and forest enhancement) will not cause harm to indigenous biodiversity at the site or other locations. All actions are well established methods for making net gains in biodiversity.

6	**Long-term outcomes:** Biodiversity compensation is managed to secure outcomes of the activity that last as 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 compensation actions will be legally protected in perpetuity by way of covenant and monitored for a minimum 20 years to ensure offset targets are achieved. Annual and five-yearly monitoring is provided to measure 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.
7	**Landscape context:** Biodiversity compensation 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 Project area and the compensation site, taking into account interactions between species, habitats and ecosystems, spatial connections, and ecosystem function.	The Project areaused for compensations actions, Oldfield Road, Wellsford (same Ecological District), supports the same ecosystem types and species assemblages (particularly lizards, birds and bats), being at the northern end of Dome Valley, an area of high ecological value and fauna habitat.
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 compensation 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).	The BCM models account for time lags between loss of biodiversity values at the impact site and gains at the offset Project ares. Enhancement actions (Pest control) will produce net gains relatively quickly (largely 2-10 years) as seral ecosystems are generally comprised of fast growing, pioneer species.
9	**Trading up**: When trading up forms part of biodiversity compensation, the proposal demonstrates that the indigenous biodiversity gains are demonstrably greater or higher than those lost. The proposal also shows the values lost are not to Threatened or At Risk (declining) species or to species considered vulnerable or irreplaceable.	Like-for-like compensation actions have been selected. This is due in part to natural environments typically representing a mosaic of different communities and ecosystems, as well as VS2 and VS5 representing regenerating systems that would ultimately mature to WF11 forest type.
10	**Financial contributions:** A financial contribution is only considered if: (a) there is no effective option available for delivering biodiversity gains on the ground; and (b) it directly funds an intended biodiversity gain or benefit that complies with the rest of these principles.	No separate financial contribution is being provided. The proposed compensation actions are being funded directly.
11	**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 compensation (pest control over a range of vegetation ages and condition) is based on established and best practice methods for restoration. Published scientific data and studies, such as the National Vegetation Survey database, studies of nesting success in relation to predator control, and regional ecosystem diversity and values have informed modelled benchmarks and expected outcomes.
12	**Tangata whenua and stakeholder participation:** Opportunity for the effective and early participation of tangata whenua and stakeholders is demonstrated when planning for biodiversity compensation, including its evaluation, selection, design, implementation, and monitoring.	Tangata Whenua engagement and consultation continues to form part of this offset package, which will evolve with new considerations. Tangata Whenua will be provided opportunities for participation in all aspects of ecological management and monitoring.

13	**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.	Refer Section 4. Kings Quarry will deliver the biodiversity offset and compensation actions and then document its key targets and outcomes through provision of regular monitoring reports and compliance meetings in liaison with Auckland Council and where appropriate, the Department of Conservation. Contingency reports are part of this plan to ensure that if biodiversity offset objectives are not met in keeping with the BOAM parameters, further ecological enhancement/offset activities are set out for Kings Quarry to meet their BOAM targets.

2 BIODIVERSITY OFFSET AND COMPENSATION PLAN

2.1 BCM versus BOAM models

Two biodiversity models are commonly used by terrestrial ecologists in New Zealand to guide habitat restoration and enhancement activities for offsetting and compensation. The Biodiversity Offset Accounting Model (BOAM) is used to assess the adequacy of an offset proposal. More recently, a Biodiversity Compensation Model (BCM) has been developed for when compensation is required. Overall, the BCM is a simpler model than the BOAM models and does not include the disaggregation of biodiversity components found within BOAM models. This feature of BOAM models ensures that there will not be no net biodiversity loss for individual ecosystem components and therefore provides a more detailed analysis and ensures the overall biodiversity gains are not at the cost of other specific components. However, the BOAM is not always considered appropriate (New Zealand Government, 2014; Pilgrim et al., 2013) and in such cases the BCM is used as well, to ensure that the proposed offset actions also provide sufficient biodiversity gain within the BCM model. A BCM can be used instead of a biodiversity offset model when insufficient quantitative data is available or if it lacks the necessary precision to determine if adverse effects can be demonstrably offset (Baber et al. 2021a, 2021b, 2021c). A recent review provided clarification around the appropriate application of the BOAM vs the BCM models to ensure that they are used appropriately (Baber et al., 2025).

Here, an overall compensation approach is used. However, BOAM models are used first to provide more informed estimates of the quantity of conservation actions required. The outcomes of the BOAM models are then used to provide values for the BCM. This approach has been used as initial attempts at developing BOAM models based on field data collected on site led to results that were unreliable, due to high levels of variability in biodiversity attributes within the Project are. This is a feature of regenerating ecosystems. Instead, an overall BCM for the project has been developed, as this applies overall qualitative measures, using the EIANZ guidelines.

Further detail about the BOAM and BCM models and their use are provided in Sections 3 and 4.

2.2 Locations for offset and compensation actions.

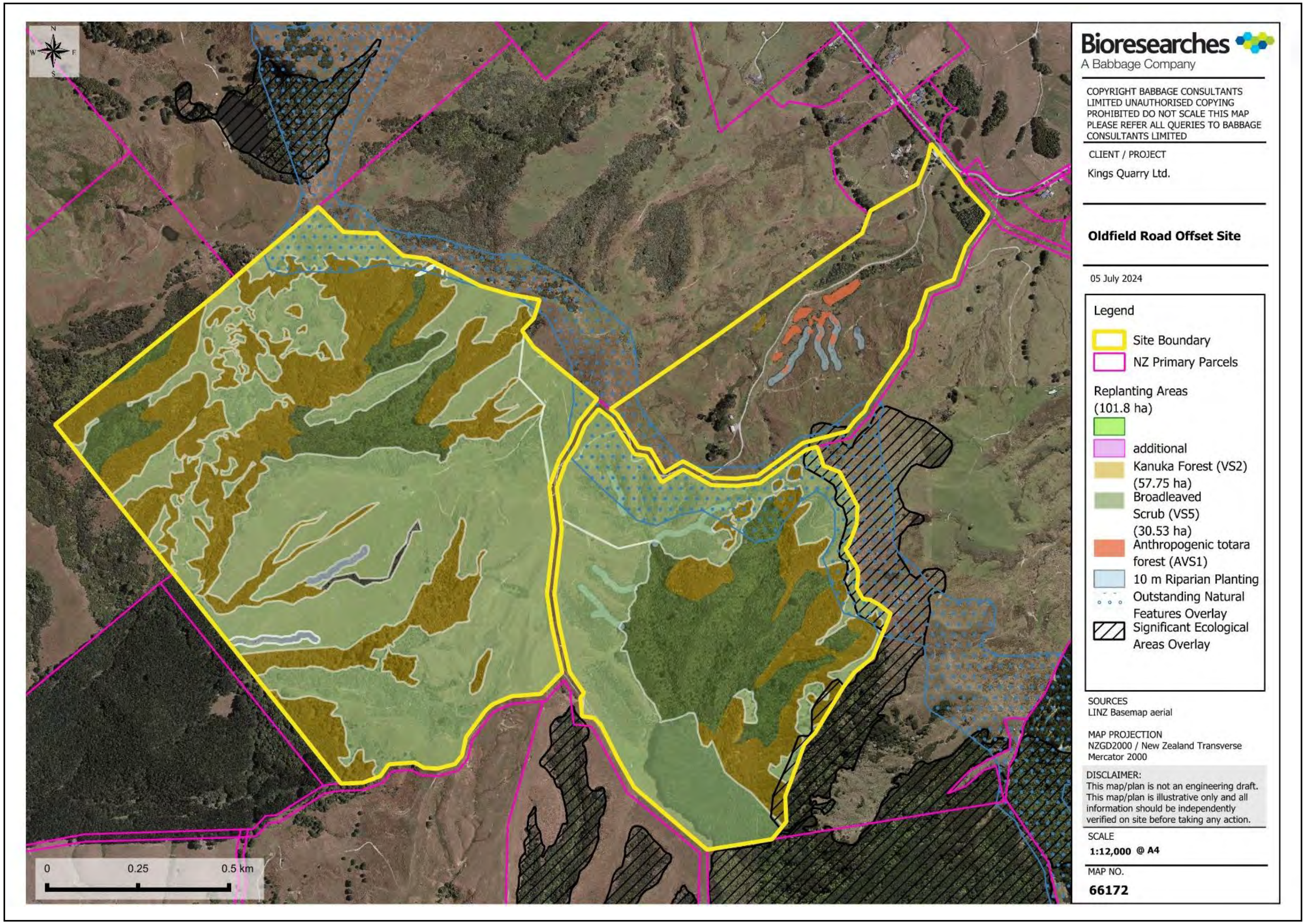
The location for offsetting/compensation actions will be an existing farm Project area at Oldfield Road, Wellsford (Rodney ED). All actions will be undertaken at this site, including the pest-proof fence, revegetation and enhancement actions as detailed below.

Considerations for selection of the offset/compensation location included like-for-like ecosystem types, connectivity to existing established ecosystems, and proximity to impacted ecosystems. It was not always possible to meet all these criteria, so the Project area selected that most closely resembled those criteria.

2.2.1 Project area description: Oldfield Road, Wellsford (Rodney ED)

The Oldfield Road Project area (Rodney ED) is located approximately 26 km North of Kings Quarry (Figure 3). The Oldfields Road property supports some 149.9 ha of revegetation opportunities and 88.28 ha of existing vegetation (63.32 ha of VS2; 24.08 ha of VS5; and 0.88 ha of WF11). It was previously mostly pine forest that has been retired and will be replaced with native revegetation plantings, where they will reconnect existing fragments of indigenous mature and regenerating forest fragments.

The Project area is within the Forest Bridge Trusts ‘area of interest’, which incorporates identified habitat corridors between Mataia Restoration Project and Tāwharanui Regional Park, both which support kiwi populations. The Forest Bridge Trust is a community group who work with landowners to reconnect and enhance ecological values throughout the landscape. The Project area is located approximately 4 km west of Sunnybrook Scenic Reserve and ~8 km West of the Dome Forest Conservation Area, both administered by the Department of Conservation (Figure 5). The southern and eastern margins of the property also border on three existing SEAs (SEA_T_635, SEA_T_6675, SEA_T_943) (Figure 4). SEA_T_635, directly to the east of the property, is included for SEA factors 2 and 3 (“Threat Status and Rarity” and “Diversity”), whereas the other two SEAs are designated due to factor 4 (“Stepping-stones, migration pathways and buffers”). By planting close to established reserves, it will help to facilitate colonisation of plant and fauna species, as the revegetation sites mature, and eventually become contextually very important as an ecological stepping stone within the surrounding landscape.


Bioresearches
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CLIENT / PROJECT
Kings Quarry Ltd.
Oldfield Road Offset Site
05 July 2024
Legend
Site Boundary
NZ Primary Parcels
Replanting Areas (101.8 ha)
additional
Kanuka Forest (VS2) (57.75 ha)
Broadleaved Scrub (VS5) (30.53 ha)
Anthropogenic totara forest (AVS1)
10 m Riparian Planting
Outstanding Natural Features Overlay
Significant Ecological Areas Overlay
SOURCES
LINZ Basemap aerial
MAP PROJECTION
NZGD2000 / New Zealand Transverse Mercator 2000
DISCLAIMER:
This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.
SCALE
1:12,000 @ A4
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66172
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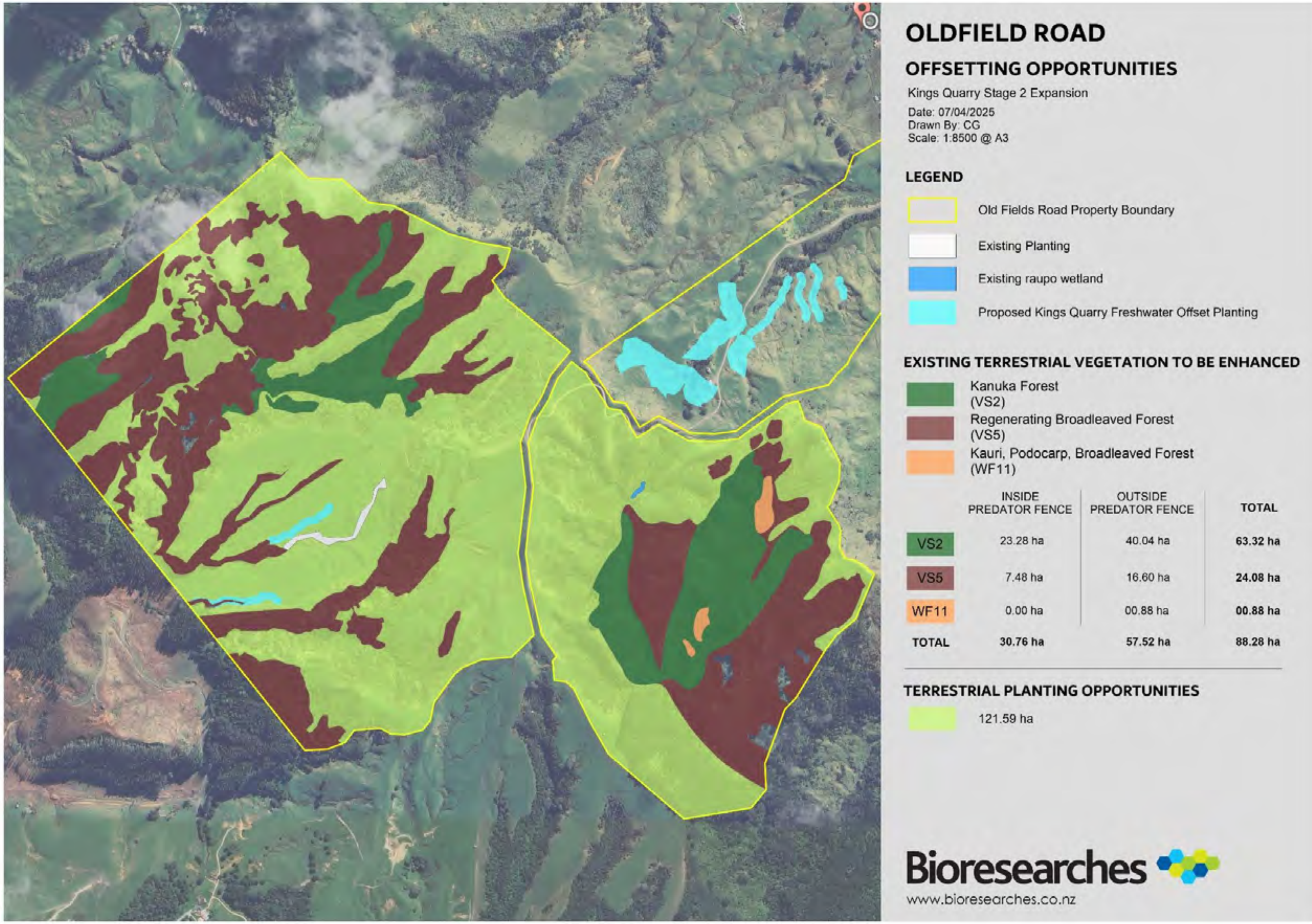


Figure 3: Oldfield Road (Rodney ED) and opportunities for offset revegetation and enhancement.

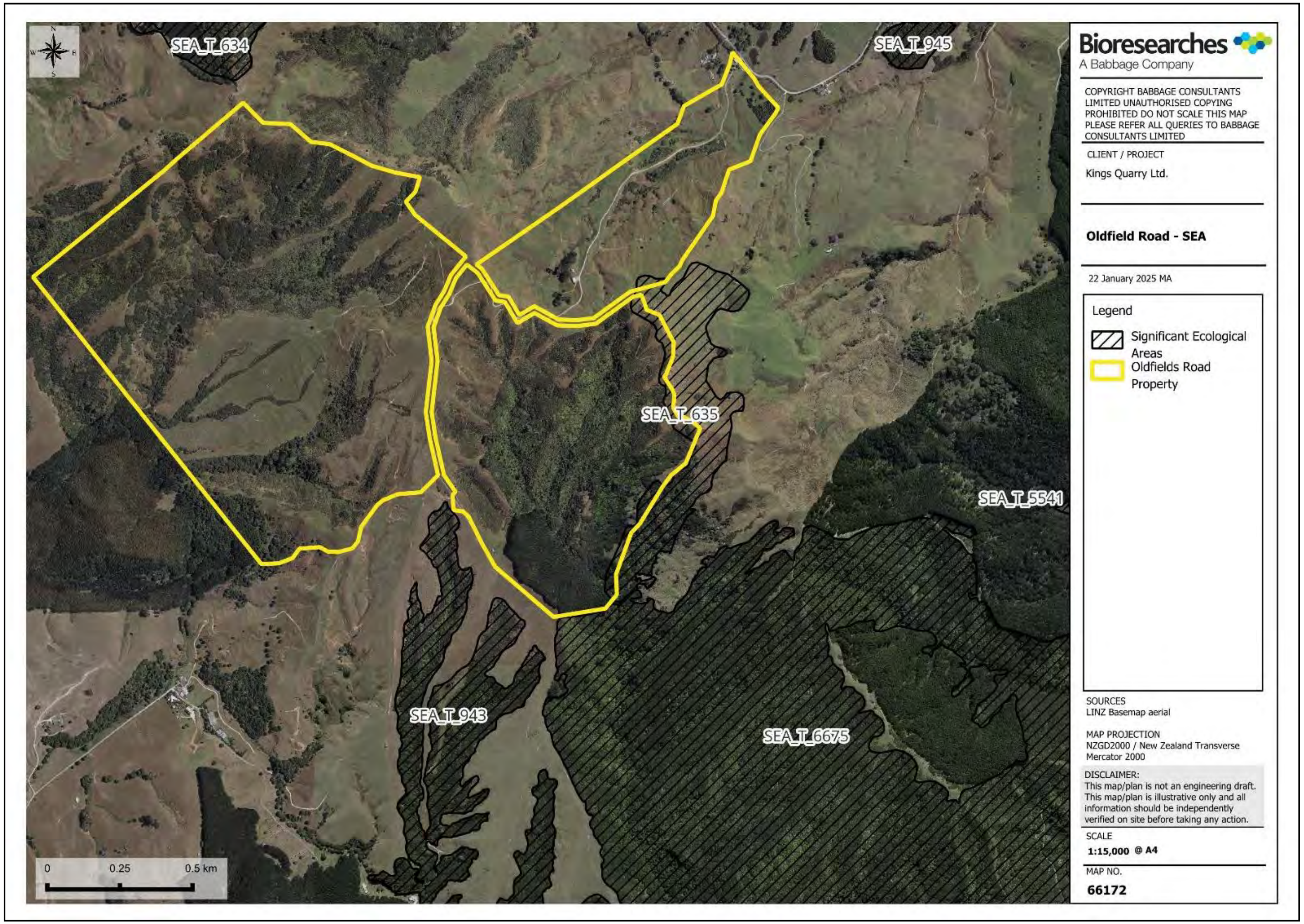


Figure 4. Significant Ecological Areas adjoining the Oldfields Road Property.

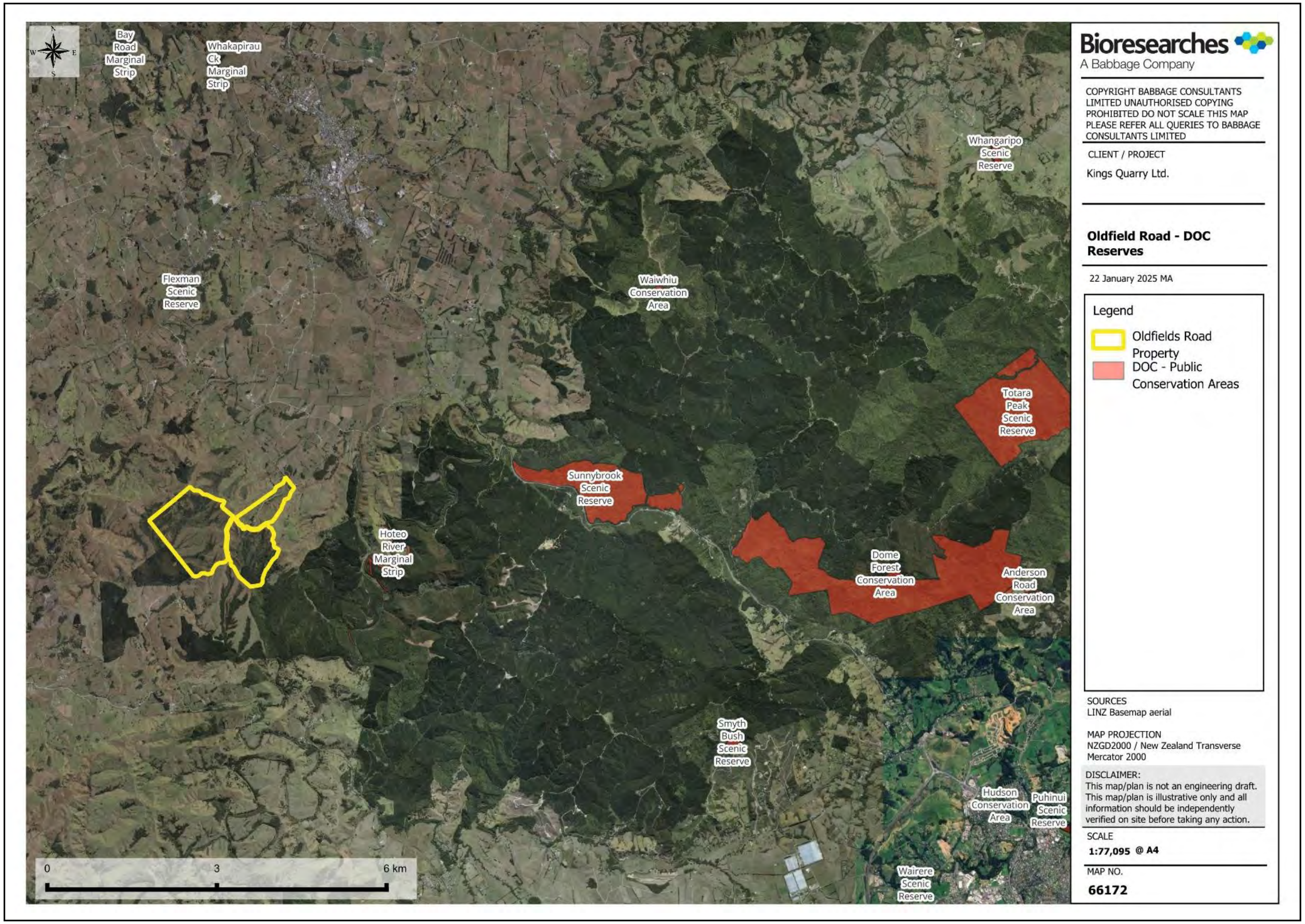


Figure 5. The Oldfields Road property and nearby Department of Conservation public conservation areas.

2.3 Proposed Restoration Activities: Revegetation and Enhancement

This REAR-TE 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 minimisation aspect of the effects management hierarchy (such as flora and fauna management).

It is proposed to carry out a comprehensive restoration package at the Oldfield Road Project area, including 61 ha of revegetation, and 88.28 ha of habitat enhancement via mammalian pest and weed management coupled with native enrichment planting. The offset/compensation package includes the establishment of a 60 ha predator-proof fence.

Specifically, the following actions will be undertaken:

- **Inside Pest proof fence:** Habitat restoration and enhancement measures within the 60 ha predator-proof fence including:
    - 28.42 ha of revegetation
    - Enhancement and enrichment planting of 30.76 ha of existing vegetation, including 23.28 ha of VS2 and 7.48 ha of VS5.
    - Elimination of mammalian pests
    - Weed control
- **Outside Pest proof fence:** Habitat restoration outside the fence which includes:
    - 33.34 ha of revegetation
    - Enhancement and enrichment planting 57.52 ha of revegetation, including 40.04 ha of VS2, 16.6 ha of VS5 and 0.88 ha of WF11 revegetation.

Pest suppression across the remaining property (152 ha), including 57.52 ha of existing vegetation.

Weed control across the entire Project area

A summary of the losses and modelled gains (revegetation and enhancement of existing adjacent ecosystems) are tabulated in Table 7 and mapped in Figure 6. An explanation of these gains is provided in 2.3.1 to 2.3.3.

Table 7. Summary of losses and modelled outputs to achieve Net Gain.

Ecosystem type	Loss (ha)	OFFSET/COMPENSATION ACTIONS			
		Revegetation (ha)	Pest-proof fence (ha)	Enrichment planting (ha)	Weed/pest control (ha)
Kānuka scrub/forest (VS2)	19.75	46	60	88.28	57.52
Broadleaved species scrub/forest (VS5)	8.03	8			
Kauri, Podocarp Forest (WF11)	1.19	7			
Avifauna habitat	28.97	61			
Total	**28.97**	**61**	**60**	**88.28**	**57.52**

2.3.1 Predator-proof fence

It is proposed to construct a predator-proof fence within the Oldfield Road (Wellsford) property. The fence would encompass an area of 60 hectares within the property. Currently the proposed Project area contains a mixture of VS2 and VS5 vegetation and some pasture areas. Following construction of the fence, pest mammalian species would be eradicated, providing a high-quality habitat for indigenous fauna species. The existing vegetation would be improved through weed control and enrichment planting, and any areas of pasture would be revegetated. Regular monitoring of pest animals and plants would be required, as well as fence maintenance. This would also allow for the potential of future indigenous species reintroductions that would further enhance the restored habitats and provide protection for Threatened and At Risk species.

2.3.2 Revegetation

Revegetation aims to replace, at least, the diversity and areal extent of values that would be lost. These values will, however, take decades to achieve similar maturity to those lost, and are therefore long-term benefits.

A total of 61 ha of revegetation is required, as modelled, and this action would be undertaken at a large Project area at Oldfield Road, Wellsford (same Ecological District), that provides for both planting and enhancement. This property contains existing areas regenerating fragments of kanuka (VS2) and broad-leaved (VS5) that would benefit greatly from enhancement and provide opportunities for reconnecting these areas through revegetation. The proposed revegetation prioritises available locations within the predator-proof fence, with any additional requirements used to create a buffer planting area outside the fence and on the margins of other existing vegetation on the property (Figure 6).

The revegetation areas will use eco-sourced seedlings and further benefit from seed source from adjacent forest fragments at Dome Valley, and area contiguous with the Oldfield Road Project area and of very high ecological value. These details are provided in a separate revegetation, enhancement, and restoration plan (Bioresearches 2025).

All areas of revegetation will be subject to pest animal and weed control and provided stock proof fencing, where appropriate.

2.3.3 Enhancement of Existing Values

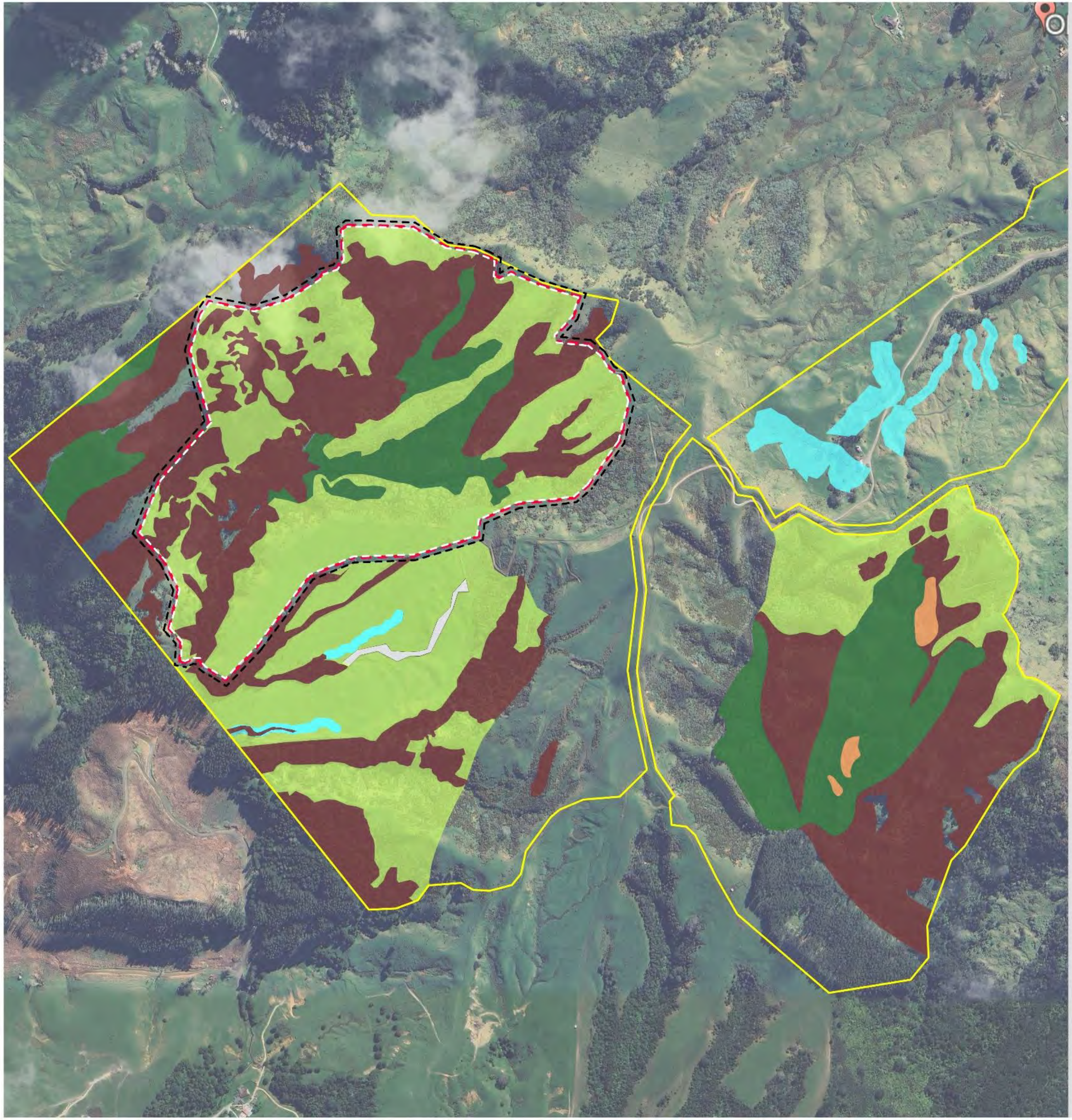
Enhancement actions target existing values where immediate (e.g. fauna breeding success) to mid-term (e.g. recovery of flora tiers) gains can be achieved.

Biodiversity benefits can generally be achieved within a shorter timeframe than revegetation and include:

- Removal of pest predators and browsers from within the predator-proof fence area;
- Weed removal across all existing VS2, VS5 and WF11 vegetation on the property (within and outside the predator-proof fence);
- Recovery of fauna through improved breeding success following pest predator species;
- Increased flora species diversity and;
- Restoration of forest structural tiers through enrichment planting and browser control of all VS2 and VS5 vegetation on the property.

Current threats to forest ecosystem integrity include goats and possums that are browsing forest tiers, particularly the understorey and groundcover, and predators on native forest fauna. These forest ecosystems will be enhanced through provision of long-term pest control (pest predators and browsers) as detailed in in a separate Residual Effects Management Plan (REMP; Bioresearches and Alliance Ecology, 2025c). In short, all pest predators and browsers will be eradicated from within the pest-proof fence, whereas all existing forest habitat outside the pest proof fence on the property will have pest browsers only removed.

Figure 6 (following page). Proposed conservation actions at the Oldfields Road property.



OLDFIELD ROAD

PROPOSED PLANTING AND ENHANCEMENT

Kings Quarry Stage 2 Expansion

Date: 07/04/2025
Drawn By: CG
Scale: 1:8500 @ A3

LEGEND

- Old Fields Road Property Boundary
- Proposed Kings Quarry Riparian/Wetland Planting
- Existing Planting
- Proposed Predator Elimination Fencing(PEF)
- PEF - 3m internal maintenance buffer
- PEF - 10m external maintenance buffer

EXISTING VEGETATION TO BE ENHANCED

- Kanuka Forest (VS2)
- Regenerating Broadleaved Forest (VS5)
- Kauri, Podocarp, Broadleaved Forest (WF11)

	INSIDE PREDATOR FENCE	OUTSIDE PREDATOR FENCE	TOTAL
VS2	23.28 ha	40.04 ha	**63.32 ha**
VS5	7.48 ha	16.60 ha	**24.08 ha**
WF11	0.00 ha	00.88 ha	**00.88 ha**
TOTAL	**30.76 ha**	**57.52 ha**	**88.28 ha**

PROPOSED TERRESTRIAL OFFSET PLANTING

Inside Predator Fence..............................28.42 ha
Outside Predator Fence............................33.14 ha

TOTAL PLANTING **61.56 ha**

Bioresearches
www.bioresearches.co.nz

3 BIODIVERSITY OFFSET MODELS

3.1 Biodiversity Offsetting

Following the management hierarchy, biodiversity offsetting should be undertaken where possible, before resorting to biodiversity compensation. Offsetting was feasible for the revegetation actions, but not for enhancement actions. Too much variability occurred at the Oldfields Road restoration Project area, which meant that providing meaningful offset modelling for enhancement (pest/weed control) was not feasible. As such, BOAM models have been developed to determine the quantity of revegetation required for each of the three ecosystem types (VS2, VS5 and WF11).

3.2 Explanation of BOAM: Accounting Model Features

This section provides brief explanations of the BOAM parameters as modelled. The outputs of the BOAM models are used to determine the quantity of revegetation required, while also providing precision for the BCM models, and ensuring modelled outcomes of the BCMs are sufficient for the biodiversity loss. The BOAMs provide increased certainty of an overall net gain.

3.2.1 Biodiversity Components

The biodiversity components are identified in the BOAM as aggregated features that collectively describe a set of similar attributes such as basal area, bird diversity, or bird abundance. These components comprise separate Biodiversity attributes (Section 3.2.2) that are selected to separately describe the key and measurable values of those components, as they relate the ecological feature. The components are modelled separately to ensure that modelled outcomes for some attributes do not skew outcomes for other attributes that represent different components of the ecosystem (e.g. fauna values vs. flora values) (Maseyk *et al.*, 2016).

Ecological values for Kings Quarry BOAM are disaggregated into three biodiversity components: 1) basal area, 2) bird diversity, and 3) bird abundance. These core components collectively describe the attributes against which each biodiversity type (Broadleaved Species Scrub Forest, Kanuka Forest and Kauri, Podocarp Broadleaved Forest) was measured.

3.2.2 Biodiversity Attributes

Biodiversity attributes are values that are measured and collectively describe the core components (described above). 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, and are measurable. Note that limitations to offsetting acknowledge that some attributes cannot be reasonably measured, such as interstitial spaces, such as cracks or cavities that may provide fauna habitats. The attributes selected for the Kings Quarry biodiversity offset models provide a balance of measurable vegetation and fauna values that are representative of Broadleaved Species Scrub Forest, Kanuka Forest and Kauri, Podocarp Broadleaved Forest. Key attributes for the proposed Kings Quarry Stage 2 Pit BOAM are identified in Table 8.

Table 8. Biodiversity components and attributes chosen for the Kings Quarry biodiversity offset models.

Biodiversity Component	Biodiversity attributes
Basal Area (DBH)	Kanuka Forest (VS2) basal area
	Broadleaved Species Scrub Forest (VS5) basal area
	Kauri, Podocarp Broadleaved Forest (WF11) basal area
Bird Diversity	Number of bird species
Avian abundance	Tui abundance
	Kereru abundance
	Breeding Success

3.2.3 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 sourced published data or plots from 'best example' Project areas within the Rodney Ecological District. For seral vegetation types, some attributes within the site were used as benchmarks, due to the dynamic nature of seral communities and the high variability of their biodiversity values.

If the biodiversity value for a particular attribute at any impact Project area was the best available, then that value was used as the benchmark value. Shakespear Regional Park (VS2 and VS5), a predator managed mainland sanctuary at Whangaparaoa, was assessed as a benchmark for some attributes, while Alice Eaves Scenic Reserve was used as a regenerating kauri podocarp forest (WF11) benchmark for some attributes (enhancement actions). However, subsequent modelling resulted in unexpectedly high values at the Kings Quarry enhancement site, and therefore the higher of these two values was used as a benchmark, depending on the attribute.

3.2.4 BOAM Offset Justification

The following two tables correspond with two BOAMs and their respective biodiversity attributes. The tables provide references or data that underpins and justifies the values inputted to each model. For raw BOAM outputs, please refer to Appendix C.

.

Table 9: Offset model explanation.

Biodiversity attribute	Benchmark and justification	Impact value	Action and confidence	Biodiversity value after conservation action	Justification for confidence (References / data)
VS5 Basal Area (m^2/ha)	**41.72** Highest measured value from benchmark site (SRP)	**12.39** Basal area as measured from Recce Plots within VS5 vegetation in Stage 2	**Revegetation 8 ha** Confidence 75 – 90%	**71.45** (20 years)	Basal area values after 20 years are based on growth rates for typical VS5 species, as measured by Tanes Tree Trust (https://www.tanestrees.org.nz/). Only trees exceeding 10 cm dbh at 20 years included in final value. See Appendix E for further information.
VS2 Basal Area (m^2/ha)	**54.6** Highest measured value from within Stage 2 area, which exceeded the benchmark site (SRP)	**54.6** Basal area as measured from Recce Plots within VS2 vegetation in Stage 2	**Revegetation 46 ha** Confidence 75 – 90%	**155.65** (20 years)	Basal area values after 20 years are based on growth rates for typical VS2 species, as measured by Tanes Tree Trust (https://www.tanestrees.org.nz/). Only trees exceeding 10 cm dbh at 20 years included in final value. See Appendix E for further information.
WF11 Basal Area (m^2/ha)	**177** Highest value from the literature for Kauri Forest (Ahmed & Ogden, 1987)	**33.24** Basal area as measured from Recce Plots within WF11 vegetation in Stage 2	**Revegetation 7 ha** Confidence 75 – 90%	**71.2** (20 years)	Basal area values after 20 years are based on growth rates for typical WF11 species, as measured by Tanes Tree Trust (https://www.tanestrees.org.nz/). Only trees exceeding 10 cm dbh at 20 years included in final value. See Appendix E for further information.
Indigenous Forest Bird Diversity	**14** Maximum forest bird diversity within the Auckland Region (excluding islands). Value is from the Kokako Management Area (KMA) in the Hunua Ranges, as recorded by Auckland Council monitoring (raw data supplied).	**0** Based on 5 minute bird counts within revegetation sites (pasture), prior to revegetation.	**Revegetation 61 ha** Confidence 75 – 90%	**9** (12 years)	Anticipated bird diversity based on local avifauna data (5 minute bird counts, ebird.com and inaturalist.com). Value is conservative, as uncommon local species (e.g. bellbird, tomtit) are not included
Tui abundance (mean/ count)	**3.69**	**1.66** Values from 5-minute bird counts within kanuka dominant vegetation within Stage 2.	**Revegetation 61 ha** Confidence 75 – 90%	**2.4**	Values from the Auckland wide average for Tui (2.4) during five-minute bird counts in Forest areas (Landers et al., 2021; p12). Tui are known to increase in abundance in response to pest control (Baber *et al*, 2009; Innes *et al.*, 2004).

	Maximum recorded Tui abundance within the Auckland Region (excluding islands). Value is from the Kokako Management Area (KMA) in the Hunua Ranges, as recorded by Auckland Council monitoring (raw data supplied).				
Kereru abundance (mean/count)	**2.5** Values from 5-minute bird counts within Stage 2 used, as values from counts within benchmark site (SRP) were lower.	**2.5** Values from 5-minute bird counts from vegetation within Stage 2.	**Revegetation 61 ha** Confidence 75 – 90%	**2.5**	Values from 5-minute bird counts from vegetation within Stage 2. Kereru are known to increase in abundance in response to pest control (Baber *et al*, 2009; Innes *et al.*, 2004).

*SRP = Shakespear Regional Park

3.3 BOAM Outputs

The overall attribute and component net present biodiversity value (NPBV) are presented in Table 10. The complete BOAM outputs are provided in Appendix C. Overall, a net gain was demonstrated for all attributes and components.

Table 10. Biodiversity components and attributes chosen for the Kings Quarry biodiversity offset models.

Biodiversity Component	Component Net Present Biodiversity Value	Biodiversity attributes	Attribute Net Present Biodiversity Value
Basal Area (DBH)	1.20	Kanuka Forest (VS2) basal area	1.27
		Broadleaved Species Scrub Forest (VS5) basal area	1.26
		Kauri, Podocarp Broadleaved Forest (WF11) basal area	1.07
Bird Diversity	4.08	Number of bird species	4.08
Avian abundance	7.77	Tui abundance	7.31
		Kereru abundance	4.44
		Breeding Success	11.55

4 THE BIODIVERSITY COMPENSATION MODELLING (BCM) APPROACH

4.1 Overview

A Biodiversity Compensation Model (BCM) is used instead of a biodiversity offset model when insufficient quantitative data is available or if it lacks the necessary precision to determine if adverse effects can be demonstrably offset (Baber *et al.,* 2021a, 2021b, 2021c). This situation frequently occurs when data is based on predictions of future outcomes, rather than modelling based on ongoing monitoring after the project has commenced and offset actions have been undertaken.

A BCM includes the determination of a biodiversity "value score" for habitats and/or species, both before and after impacts ("losses) and before and after implementation of proposed compensation actions ("gains"). These values are determined from the assessment of ecological value (prior to impacts) and magnitude of effect based on the Ecological Impact Assessment (EcIA, Bioresearches, 2025a). Therefore, the value scores are based on both the site-specific field assessments, desktop assessments (literature and online databases), and the professional judgement of the project ecologists. Further details are provided regarding the BCM methods within the User Guide (Baber *et al.*, 2021c)

The outputs of the BOAM model also help to demonstrate confidence in the proposed quantum of enhancement actions (revegetation and pest control). While initial attempts to input data to a BOAM were made, offsetting was ultimately ruled out as the principal approach, due to limitations with obtaining or interpreting meaningful site-specific data or predicted future states. In this instance, a more simplistic model, with appropriate supporting data and assumptions, is considered more appropriate to provide confidence in a quantum of residual effects management relating to forest enhancement.

The model used here adheres to the compensation principles (Table 6), and the inputs for the model are explained further within Appendix D(Table 20).

5 TERRESTRIAL BCM

The BCM input parameters are detailed in Appendix D (Table 20, Appendix D). Table 11 shows that the BCM predicts a net compensation score of 28.45 and a 'net gain outcome' of 20.8% in biodiversity values. This score provides confidence that the proposed actions (predator-proof fence, forest enhancement and revegetation) will sufficiently counterbalance the significant residual adverse effects of the proposed vegetation loss associated with the Kings Quarry Stage 2 expansion.

5.1 Whole project BCM model (with pest control / forest enhancement actions)

Table 11. BCM Output for loss of 28.97 ha of vegetation (all ecosystem types combined). The model predicts a net gain outcome of 20.8%.

Model Inputs			
Input descriptors	**Input data**		
Project/reference name	Kings Quarry Stage 2		
Biodiversity type	Regenerating vegetation		
Technical expert(s) input	Chris Wedding, Michael Anderson		
Benchmark	5		
How many habitat types OR sites are impacted	3		
Number of proposed compensation actions	3		
Net gain target	10%		
Habitat/Site Impact(s)	**Regen kanuka / VS2**	**regen broadleaf / VS5**	**Kauri podocarp / WF11**
Impact risk contingency:	3	3	3
Impact uncertainty contingency:	2	2	2
Areal extent of impact (ha):	19.753	8.0253	1.1859
Value score prior to impact:	3.5	3	3.5
Value score after impact:	0.001	0.001	0.001
Compensation Action(s)	**VS2/VS5 within Pest exclusion fence (pest eradication/enrichment/ weeds)**	**Enhancement of VS2/VS5 outside fence (Browser and weed control, enrichment planting)**	**Revegetation**
Discount rate:	3.0%	3.0%	3.0%
Finite end point (years):	12	12	20
Compensation confidence contingency:	2	3	2
Areal extent (ha) of compensation type:	30.76	57.52	61
Value score prior to compensation:	2	2	0.01
Value score after compensation:	4	3.5	2.48

Model outputs				
	Total impact score	**Regen kanuka / VS2**	**regen broadleaf / VS5**	**Kauri podocarp / WF11**
Impact score	**-23.55461**	-16.72601	-5.82443	-1.00417
	Total compensation score	**VS2/VS5 within Pest exclu**	**Enhancement of VS2/VS5**	**Revegetation**
Compensation score	**28.44863**	7.11957	7.56438	13.76468
Net gain outcome	**20.8%**			

This Biodiversity Compensation Model (BCM) and the accompanying User Guide has been developed by:
M. Baber, J. Dickson, J. Quinn, J. Markham, G. Ussher, S. Jackson and S. Heggie-Gracie

Table 12. Weighted terrestrial habitat scores before and after pest eradication/enrichment planting/weed control of existing VS2 and VS5 vegetation within the predator-proof fence.

Habitat type	Area (ha)	Value before pest eradication	Weighted area (ha)	Weighted value before pest eradication	Value after pest eradications	Weighted value after pest eradication
VS2	26.81	2.00	0.75	1.50	4.00	3.00
VS5	8.91	2.00	0.25	0.50	4.00	1.00
Total	**35.72**		1.00	2.00		4.00

Table 13. Weighted terrestrial habitat scores before and after pest control and revegetation (outside fence) at the Oldfields Road offset Project area.

Habitat type	Area (ha)	Value before pest eradication	Weighted area (ha)	Weighted value before pest eradication	Value after weed/mammal control/revegetation	Weighted value after pest eradication
VS2	40.04	2.00	0.70	1.39	3.50	2.44
VS5	16.60	2.00	0.29	0.58	3.50	1.01
WF11	0.88	2.00	0.02	0.03	3.50	0.05
Total	**57.52**		**1.00**	**2.00**		**3.50**

Table 14. Weighted terrestrial habitat scores before and after revegetation (outside fence) at the Oldfields Road offset Project area.

Habitat type	Area (ha)	Value before pest eradication	Weighted area (ha)	Weighted value before pest eradication	Value after weed/mammal control/revegetation	Weighted value after pest eradication
Pasture (inside fence)	28.42	0.01	0.47	0.01	2.00	0.93
Pasture (outside fence)	33.34	0.01	0.53	0.01	3.00	1.60
Total	**61.00**		1.00	0.01		2.53

6 OFFSET/COMPENSATION MONITORING

Monitoring biodiversity offset and compensation 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 and compensation outcomes will be measured at year 5, following establishment of pioneer and enrichment planting establishment, and continue five-yearly for the life of the offset / compensation. The purpose of the monitoring is to:

Track and verify that the stated outcomes are met for identified biodiversity attributes.

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

Specific details for the offset/compensation monitoring are provided in the Residual Effects Management Plan (Bioresearches and Alliance Ecology, 2025c), with only a brief summary provided here.

6.1 Monitoring Targets and Contingencies

While ultimate success for within the pest-proof fence will be determined at 10 years (after fence completion) for fauna values and at 20 years after planting for revegetation, the targets provide an indication of expected values for attributes at each 5-yearly intervals with the gradual development and maturation of the offset vegetation. Failure to meet biodiversity attribute targets prior to 10 or 20 years 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, provision of fertilisers, or wind protection.

For revegetation, monitoring targets are for total basal area (m^2/ha) for each ecosystem type (VS2, VS5, and WF11) that is replanted. Specific targets have been developed for each 5-year interval, based on BOAM modelling.

For the success of fauna values, three specific biodiversity attributes will be measured: bird diversity, Tui abundance and Kereru abundance. These targets have been set at five yearly intervals, starting at year 5 until year 10 after predator-proof fence completion.

Pest control targets have been set at 5-year intervals for outside the fence, as determined by residual trap catch and tracking tunnel indices. Inside the fence, regular monitoring will be undertaken, but with the target of zero detections.

Full monitoring targets and contingencies are provided in the Residual Effects Management Plan (Bioresearches and Alliance Ecology, 2025c).

6.2 Monitoring methods

Establishment monitoring will be undertaken annually for the first five years for revegetation only, followed by five-yearly monitoring thereafter. A detailed quarterly report will be prepared at Years 5, 10, 15, & 20, 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.

Full monitoring methods are provided in the Residual Effects Management Plan (Bioresearches and Alliance Ecology, 2025c).

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APPLICABILITY AND LIMITATIONS

Restrictions of Intended Purpose

This report has been prepared solely for the benefit of Kings Quarry 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

A total of four 20 x 20m RECCE plots were laid out within the Kings Quarry property. These were selected at sites within each vegetation type (VS2, VS5 and WF11) and both within and outside of the Project area (6 plots). In addition, 3 RECCE plots were carried out at benchmark sites with the same vegetation type (VS2, VS5 and WF11) at locations within the Rodney Ecological District. These required sites with mature vegetation that have been actively managed for pests, in particular browsing species that may affect undergrowth cover and species diversity.

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

- Average canopy 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 percent cover.
- Total species richness
- Ground cover species richness
- Basal area of all trees >10 cm dbh
- Fallen log volume (length x area; all logs > 2.5cm diameter)
- Leaf litter depth (5 measures, 1 per plot quarter, and one in the centre)

Summary of results

RECCE plot measurements are summarized in Table 15 below. In general, it appears that the Kings Quarry Project areas have been affected by affected by stock browsing, which was reflected by lower percentage cover in the understorey. See the AEE for further details and commentary about the plant values within the Project area.

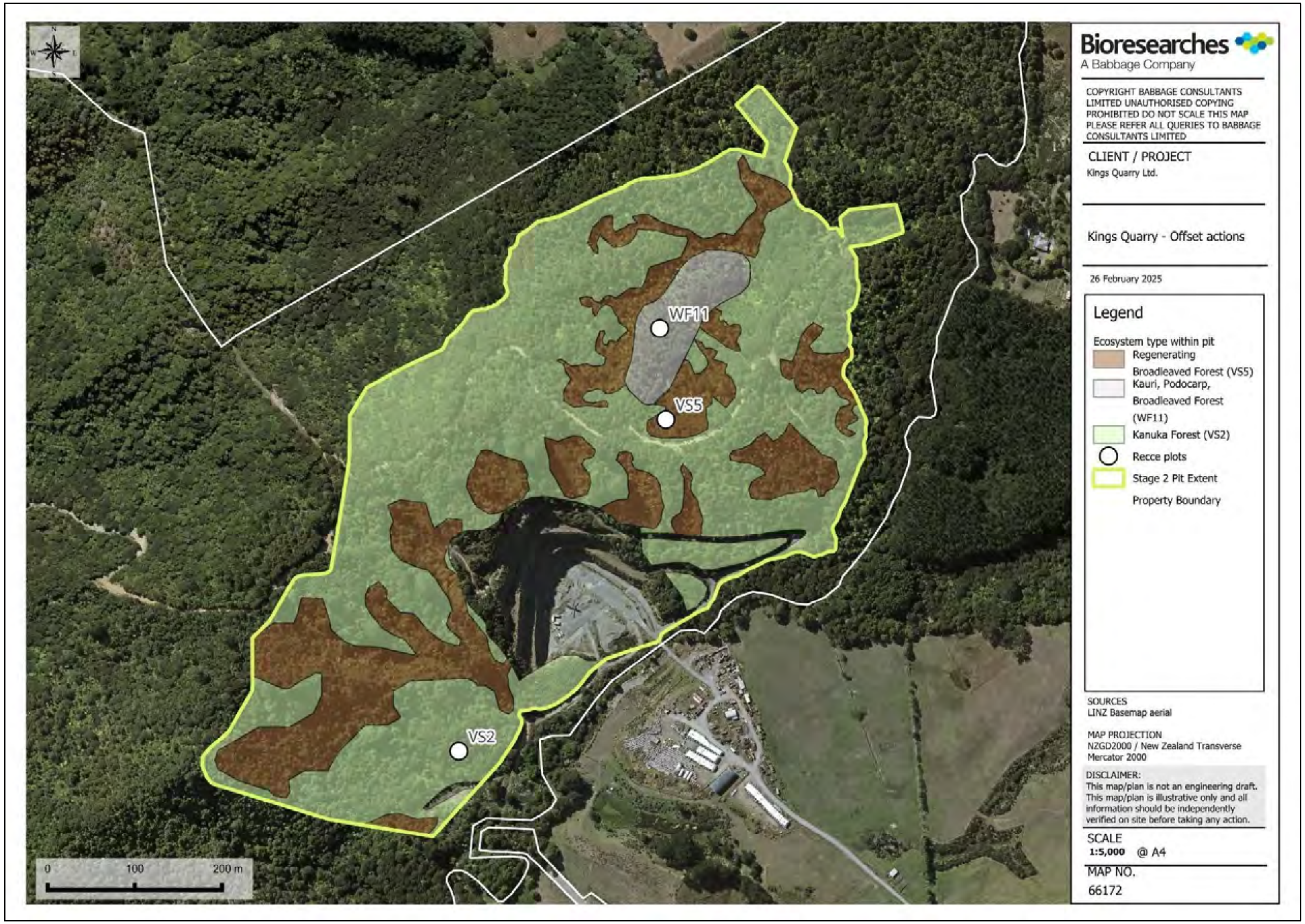

Figure 7. RECCE plot locations within the SPQZ.

Figure 8. RECCE plot locations within Shakespear Regional Park (benchmark site).

Figure 9. RECCE plot locations within Shakespear Regional Park (benchmark site).

Table 15. RECCE plots summary of data

Category	Impact	Impact	Impact	Benchmark	Benchmark	Benchmark	Offset	Offset
Biodiversity type	VS5	VS2	WF11	WF11	VS5	VS2	VS5	VS2
Plot Name	Kings Plot C	Kings 23	Kings WF11	Alice Eaves	Shakespear 2	Shakespear 1	Oldfield	Oldfield
Biodiversity Component								
Mean top height/m	13.00	11.00		14.50	10.00	4.00	4.00	6.00
% canopy cover	25.00	70.00	30.00	65.00	0.00	65.00	90.00	60.00
Canopy tree count/ plot	50.00	54.00	61.00	57.00	59.00	27.00	111.00	65.00
Canopy species richness	2.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00
Total canopy tree basal area/m2ha-1 (trees > 10cm dbh)	12.39	54.60	33.24	54.59	41.72	9.84	51.16	79.83
Log fall	10.19	22.23	4.08	12.60	7.96	9.77		
Leaf litter depth	18.20	9.60	5.75	10.00	9.80	2.80		
Total species richness/ count	25.00	20.00	39.00	42.00	30.00	37.00	20.00	15.00
Groundcover species richness/ count	15.00	17.00	21.00	30.00	18.00	35.00	16.00	17.00
Sub canopy % cover (5-12m)	15.00	15.00	30.00	38.00	38.00	0.00	15.50	63.00
Understorey % cover (0.3-5m)	15.00	15.00	37.50	33.00	65.00	38.00	63.00	38.00
Ground cover % cover (<0.3 m)	2.50	2.50	5.00	3.00	2.50	18.00	15.50	38.00
Epiphyte species richness	1.00	1.00	3.00	1.00	4.00	3.00	10.00	2.00
Aspect	20.00	135.00	90.00	270.00	0.00	180.00	0.00	0.00

Appendix B Five-minute bird count data.

A total of 19 five-minute bird counts were conducted within Kings Quarry, across the Project area, with count stations placed both within and outside the proposed pit area and within each of the three key vegetation types (VS2, VS5 and WF13). Only those counts that were done within the proposed pit area (counts 14-19; see Figure 10) were used to calculate key measures for birds (see below), so they reflect habitat values within the proposed pit area.

In addition, benchmark sites were selected that were of the same ecosystem type, in the same ecological district, are protected and of similar age, as well as receiving ongoing pest control. This would remove any impacts nest predation, or predation of adults on key measures of species abundance, providing realistic and achievable targets for sites that are to receive enhancement actions. These sites were Alice Eaves Reserve in Orewa, which is WF11, and Shakespear Regional Park, which has VS2 and VS5 ecosystem types.

A further 22 five-minute bird counts were conducted at the offset Project area at Oldfield Road. Counts were divided between each VS2 (8 counts) and VS5 (5 counts) forest types and pasture areas (9 counts). The number of counts varied depending on ecosystem type availability.

In each five-minute bird count station, all species seen and heard within a 100m radius, were recorded, and counted. All count stations were determined prior, by randomising points within the Project area, either randomly by area or randomly along existing tracks, with stations being no closer than 200 m increase independence of counts as recommended by DOC bird count SOP (DOC, 2012).

Three key measures were used from the five-minute bird counts:

- Mean species abundance (average number of birds recorded per count) for Tui and Kereru.
- Indigenous species diversity.

The two key species used were selected, as they are common native species found on the mainland, both with and without pest control. These species also have previously been shown to increase in abundance in response to pest control (Baber et al., 2009, Innes et al., 2004). Additionally, these species have different feeding guilds, meaning that their abundance responds to different components of food abundance within an ecosystem, i.e. Kereru are folivores and frugivores (leaves and fruit) and Tui are nectivores (nectar).

<u>Summary of results</u>

The five-minute bird counts are summarized in Table 16 below. In general, it appears that the Kings Quarry Project areas have high levels of bird abundance, sometimes exceeding benchmark sites and are higher than the average abundance for each of the key species within the Auckland area for forested areas (Landers et al., 2021). See the AEE for further details and commentary about the bird values within the project area.

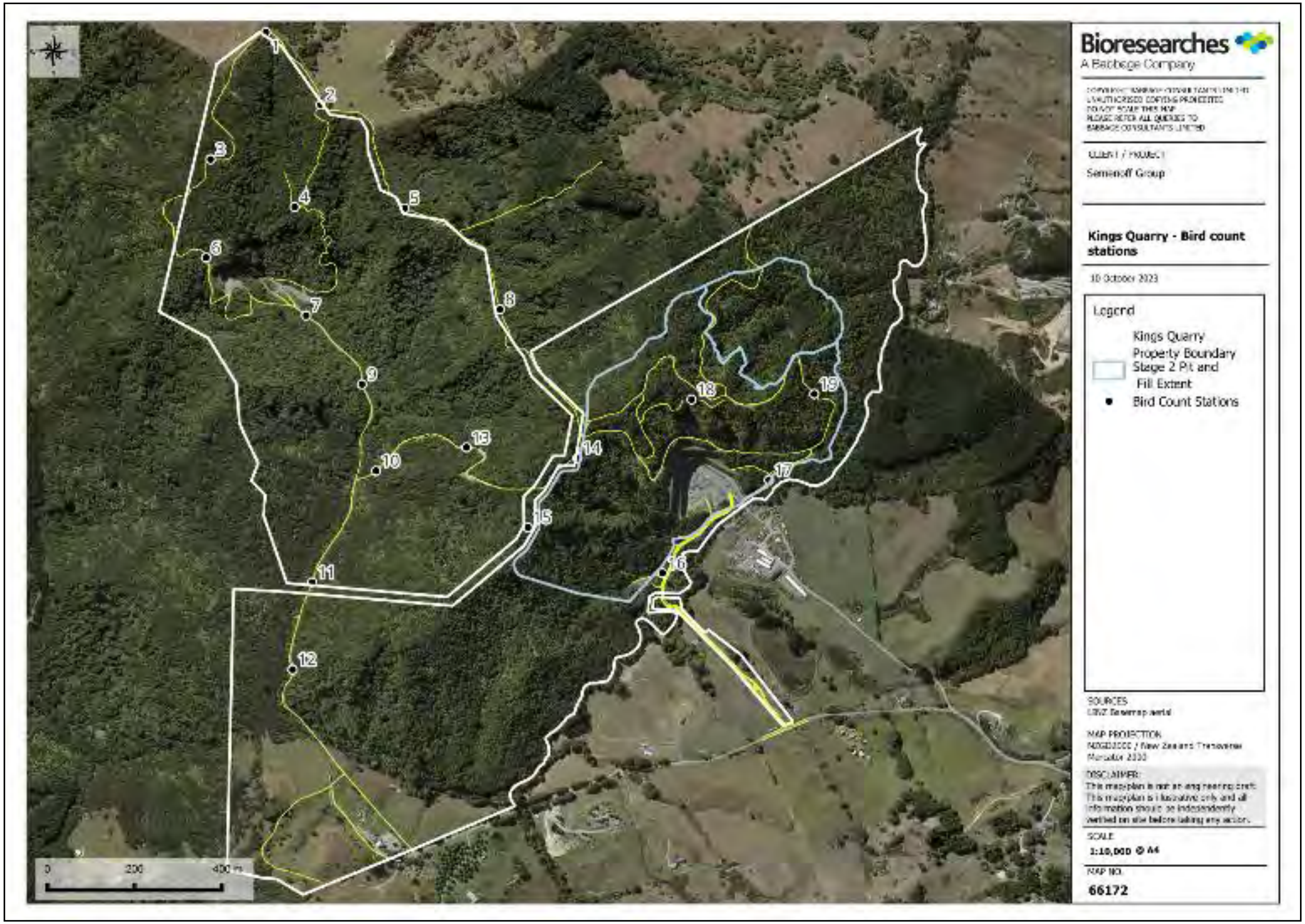

Figure 10. Bird count locations at Kings Quarry.

Figure 11. Bird count locations at Alice Eaves reserve (benchmark site).

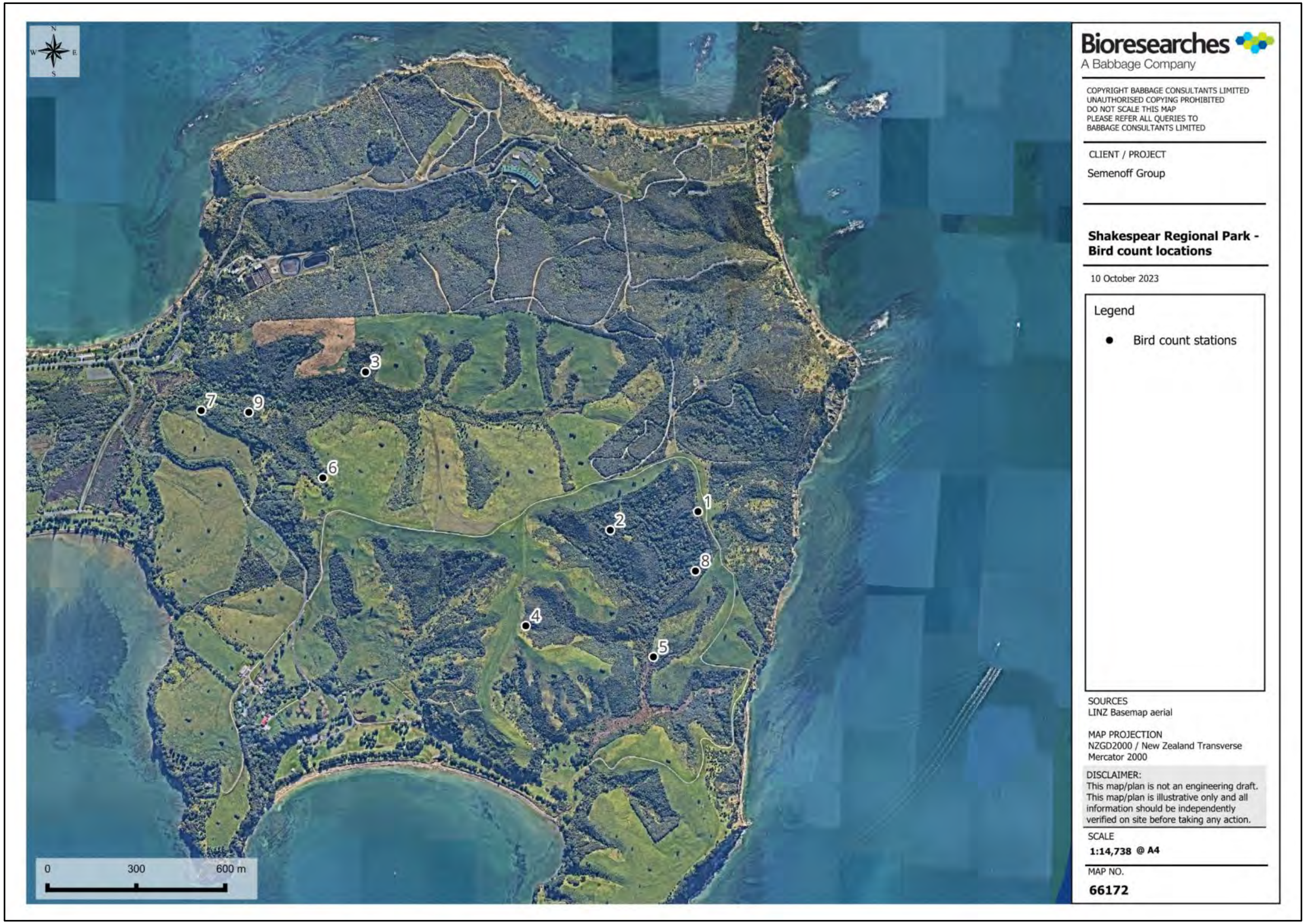

Figure 12. Bird count locations at Shakespear Regional Park (benchmark site).

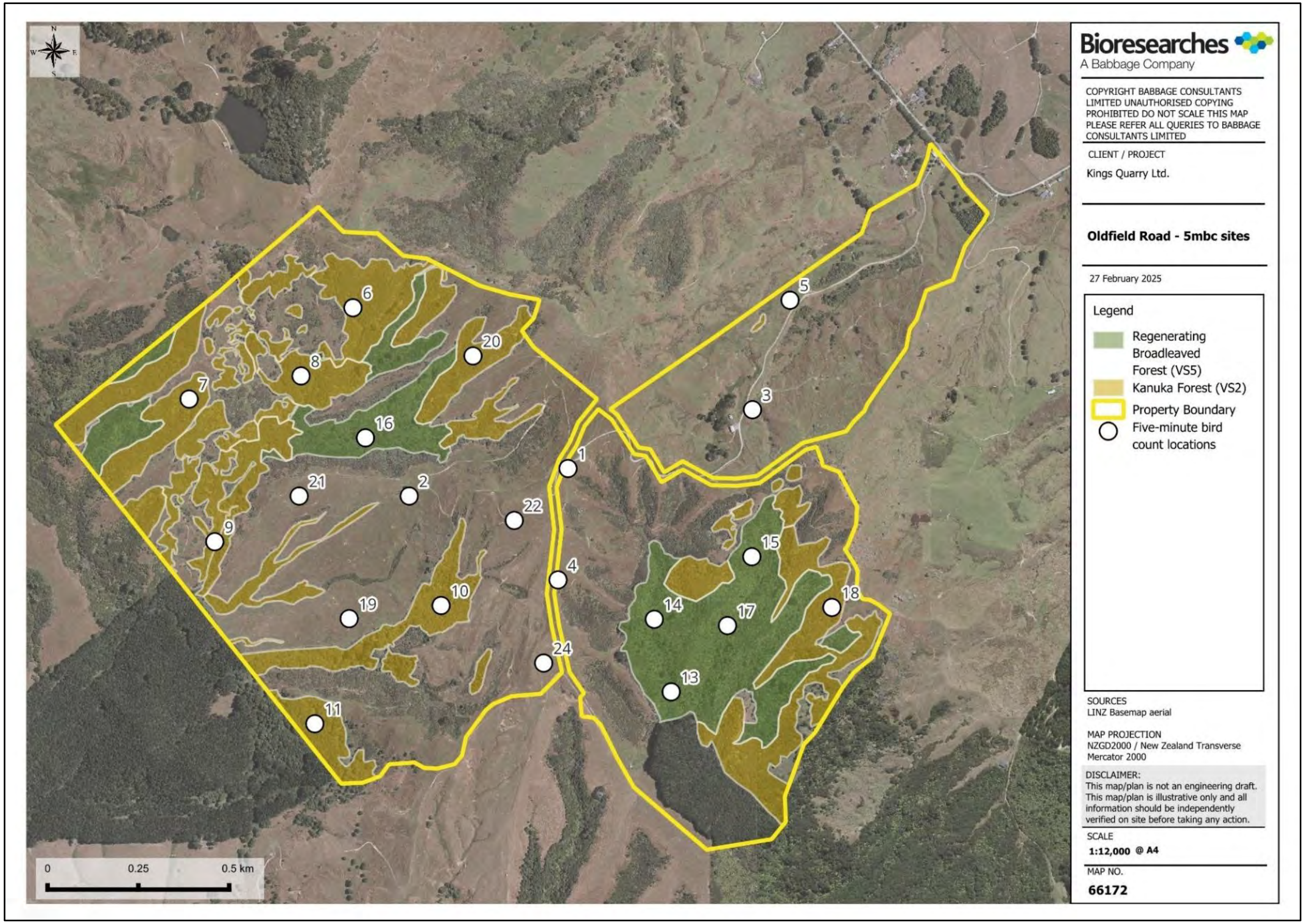

Figure 13. Bird count locations at the offset Project area (Oldfield Road Property).

Table 16: Summary of the five-minute bird count data for each site and ecosystem type. Values are the average number of each species recorded within each bird count (mean +/- standard error). Key species and variables are highlighted in bold.

Category			Impact	Benchmark			Offset		
Site			Kings Quarry	Shakespear Regional Park		Alice Eaves Reserve	Oldfield Road		
Ecosystem type			VS2 and VS5 (Within pit)	VS2	VS5	WF11	EG	VS2	VS5
Species	Native/Introduced								
Bellbird, (mainland)	Native		0.00 ± 0.00	1.00 ± 0.58	0.40 ± 0.24	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Fantail, Nth Is	Native		2.00 ± 1.06	0.33 ± 0.33	0.80 ± 0.49	1.75 ± 0.63	0.00 ± 0.00	0.38 ± 0.74	0.20 ± 0.45
Harrier, Australasian	Native		0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.13 ± 0.35	0.00 ± 0.00	0.00 ± 0.00
Kingfisher, NZ	Native		0.00 ± 0.00	0.33 ± 0.33	0.60 ± 0.40	0.75 ± 0.48	0.13 ± 0.35	0.25 ± 0.46	0.20 ± 0.45
Pigeon, NZ/Kereru/Kupapa	**Native**		**2.00 ± 0.58**	**0.67 ± 0.33**	**0.40 ± 0.24**	**0.25 ± 0.25**	**0.00 ± 0.00**	**0.00 ± 0.00**	**0.40 ± 0.55**
Plover, Spur-winged	Native		0.00 ± 0.00	0.00 ± 0.00	0.40 ± 0.24	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Pukeko	Native		0.00 ± 0.00	0.67 ± 0.33	1.00 ± 0.55	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Robin, Nth Is	Native		0.00 ± 0.00	0.33 ± 0.33	0.40 ± 0.24	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Shelduck, Paradise	Native		0.00 ± 0.00	0.00 ± 0.00	0.80 ± 0.49	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Silvereye	Native		4.17 ± 0.60	1.33 ± 0.88	0.40 ± 0.24	2.00 ± 0.91	0.50 ± 1.07	1.00 ± 1.60	2.40 ± 2.30
Swallow, Welcome	Native		0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.38 ± 0.52	0.00 ± 0.00	0.00 ± 0.00
Tomtit, Nth Is	Native		0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Tui	**Native**		**3.83 ± 0.31**	**2.33 ± 0.33**	**3.00 ± 0.32**	**3.25 ± 0.25**	**0.00 ± 0.00**	**0.50 ± 1.07**	**0.20 ± 0.45**
Warbler, Grey	Native		2.33 ± 0.33	1.67 ± 0.33	2.60 ± 0.24	1.25 ± 0.75	0.50 ± 0.76	1.38 ± 1.06	2.00 ± 0.71
Whitehead	Native		0.00 ± 0.00	2.33 ± 0.33	2.00 ± 0.45	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Blackbird	Introduced		1.67 ± 0.42	0.00 ± 0.00	0.00 ± 0.00	1.50 ± 0.65	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Chaffinch	Introduced		0.50 ± 0.34	0.00 ± 0.00	0.00 ± 0.00	0.25 ± 0.25	0.88 ± 1.13	0.13 ± 0.35	0.80 ± 0.84
Dove, Barbary	Introduced		0.00 ± 0.00	0.00 ± 0.00	0.20 ± 0.20	0.50 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Goose, Canada	Introduced		0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Magpie, Australian (magpie sp.)	Introduced		0.00 ± 0.00	0.33 ± 0.33	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.75 ± 0.71	0.20 ± 0.45
Myna, Indian	Introduced		0.00 ± 0.00	1.00 ± 1.00	0.40 ± 0.24	1.25 ± 0.48	1.00 ± 1.07	0.38 ± 1.06	0.20 ± 0.45
Pheasant	Introduced		0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.13 ± 0.35	0.00 ± 0.00	0.00 ± 0.00
Pigeon, Feral	Introduced		0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Quail, California	Introduced		0.33 ± 0.21	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Rosella, Eastern	Introduced		0.00 ± 0.00	0.67 ± 0.67	1.00 ± 0.63	0.25 ± 0.25	0.25 ± 0.71	0.13 ± 0.35	0.20 ± 0.45

Skylark	Introduced		0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	2.63 ± 2.07	0.13 ± 0.35	0.20 ± 0.45
Sparrow, House	Introduced		0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.25 ± 0.63	0.75 ± 1.49	0.13 ± 0.35	0.00 ± 0.00
% Native Individuals)			**73.809524**	**84.62**	**88.89**	**64.91**	**22.41**	**63.63636**	**77.14286**
No. native species			**9**	**10**	**12**	**6**	**5**	**5**	**6**

Appendix C BOAM Outputs

Table 17. BOAM Output for loss of 28.97 ha of basal area from VS2, VS5 and WF11 Forest. Model indicates a net biodiversity gain (1.2).

	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
1.1	Basal Area	1.1a	VS5 Basal Area	m²/ha	41.72	Revegetation	8	Confident 75-90%	Finite end point	Continue to Column M	0	60.7305	20	3.65	-2.38	1.27	1.20
		1.1b	VS2 Basal Area	m²/ha	54.6	Revegetation	46	Confident 75-90%	Finite end point	Continue to Column M	0	155.65	20	21.01	-19.75	1.26	
		1.1c	WF11 Basal Area	m²/ha	177	Revegetation	7	Confident 75-90%	Finite end point	Continue to Column M	0	71.3	20	1.29	-0.22	1.07	

Table 18. BOAM Output for loss of bird diversity due to removal of 28.97 ha of bird habitat (VS2, VS5 and WF11 Forest). 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
1.2	Fauna	1.2a	Bird Diversity	species number	14	Revegetation	61	Confident 75-90%	Finite end point	Continue to Column M	0	9	12	22.69	-18.62	4.08	4.08

Table 19. BOAM Output for loss of bird abundance due to removal 28.97 ha of bird habitat (VS2, VS5 and WF11 Forest). Model indicates a net biodiversity gain (7.77).

	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**
1.3	Bird Abundance	1.3a	Tui	Average abundance (Mean/count)	3.69	Pest exclusion fence	60	Confident 75-90%	Finite end point	Continue to Column M	0.238	2.4	12	20.34	-13.03	7.31	7.77
		1.3b	Kereru	Average abundance (Mean/count)	2.5	Pest exclusion fence	60	Confident 75-90%	Finite end point	Continue to Column M	0.095	2.5	12	33.40	-28.96	4.44	
		1.3c	Breeding success	count	70	Pest exclusion fence	60	Confident 75-90%	Finite end point	Continue to Column M	0	65	12	32.24	-20.68	11.55	

Appendix D BCM Model Inputs and Justifications

Table 20. BCM Model inputs and justification for all revegetation and pest control combined.

Model inputs	Explanation
Biodiversity type	**Kings Quarry revegetation and forest enhancement**
Technical expert inputs(s)	**Chris Wedding, Dr. Michael Anderson**
Benchmark	**Benchmark- always 5** A benchmark of 5 would be established, pest-free vegetation, supporting a mosaic of terrestrial vegetation including kanuka and broadleaved forest types
How many habitat types OR sites are impacted	3 regenerating / seral ecosystems: kanuka (VS2) and broadleaved species (VS5). Kauri, podocarp, broadleaved forest (WF11)
Number of proposed compensation measures	3 1) VS2/VS5 within Pest exclusion fence (pest eradication/enrichment/weed control) 2) Enhancement of VS2/VS5 outside fence (Browser and weed control, enrichment planting) 3) All Revegetation
Net Gain target	**10%**
Impact model inputs and descriptions	
Habitat/site impacted	Terrestrial vegetation, including regenerating kanuka and broadleaved species
Impact contingency risk (uncertainty)	**3: High risk/high value** (calculated impact score is multiplied by 1.1 (+10%)) VS2 and VS5 are seral ecosystem types, rated 'least concern' and WF11 is rated as 'Endangered' by Auckland Council (Singers et al. 2017). These environments support a range of high value 'At Risk' flora and fauna, as well as threatened long-tailed bats.
Areal extent of impact (ha)	28.97 ha (19.753 ha (VS2); 8.0253 ha (VS5); 1.1859 ha (WF11))
Value score prior to impact	**Kanuka (VS2): 3.5 High / Very High value** Good diversity of high value species (2-4 lizards, regionally rare plants) naturally occurring in indigenous vegetation. However, habitats are not pest controlled, and species abundance not apparently high. **Broadleaved spp (VS5): 3 High value** Similar to VS2, however some aspects have lower diversity (some areas tree fern dominant) and less typical habitats for gecko species. **Kauri Podocarp, Broadleaved Forest (WF11): 3.5 High /Very High Value** Good diversity of high value species (2-4 lizards, regionally rare plants) naturally occurring in indigenous vegetation. However, habitats are not pest controlled, species abundance not apparently high, and non-mature for forest type.
Value score after impact	**0.001** There will be a permanent and complete loss of habitat within the footprint (noting that the formula cannot work with 0).
Compensation model inputs	
Compensation type 1	**VS2 & VS5 forest enhancement (pest eradication within fence)**
Discount rate	+3 % (the default discount score as per Maseyk et al. (2015); Baber et al. (2021a). The discount rate addresses the temporal time lag between the impact occurring and the biodiversity gains being generated by the conservation action(s).

Finite end-point	**12 years**. Two years allowed for completion of fence construction; gains expected within the 10 years afterwards. Some aspects such as native forest-bird breeding success is conservatively expected to achieve at least a 10% improvement each year from first year of implementation (year 2). However other forest recovery measures, such as seedling and sapling diversity, indigenous ground cover, may take several years to respond to weed control, enrichment planting and removal of browsers (such as goats, possums and rats). We consider ten years to be conservative for a seral system, comprised predominantly of pioneer flora.
Compensation contingency (confidence)	**2** High confidence: pest pressure well understood (goats are a major browse pressure, with possums and rodents generally uncontrolled as well).
Areal extent (ha) of compensation type	**30.76 ha**
Value score <u>prior to</u> compensation measure (relative to benchmark)	**2** As per value score prior to impact- vegetation values considered moderate
Value score <u>after</u> compensation measure (relative to benchmark)	**4** Not benchmark, but a very high values expected with respect to vegetation and habitat values after ten years management in a high value seral ecosystem.
Compensation model inputs	
Compensation type 2	**Enhancement of VS2/VS5 outside fence (Browser and weed control, enrichment planting)**
Discount rate	+3 % (the default discount score as per Maseyk et al. (2015); Baber et al. (2021a). The discount rate addresses the temporal time lag between the impact occurring and the biodiversity gains being generated by the conservation action(s).
Finite end-point	**12 years**. Two years allowed for project establishment; gains expected within the 10 years afterwards. Forest improvement through weed control, enrichment planting and removal of browsers (such as goats, possums and rats). Gains are expected through forest recovery (e.g. seedling and sapling diversity, indigenous ground cover) that may take several years to respond t. We consider ten years to be conservative for a seral system, comprised predominantly of pioneer flora.
Compensation contingency (confidence)	**3** Moderate confidence: Pest pressure well understood (goats are a major browse pressure, with possums and rodents generally uncontrolled as well). However, confidence reduced from similar enhancement actions adjacent to Kings Quarry because vegetation composition (VS2 and VS5) at Oldfields has higher variability in quality / degradation and age.
Areal extent (ha) of compensation type	**57.52 ha**
Value score <u>prior to</u> compensation measure (relative to benchmark)	**2** As per value score prior to impact- vegetation values considered moderate
Value score <u>after</u> compensation measure (relative to benchmark)	**3.5** A 30% improvement is expected, based on rapid growth rates of seral ecosystems with large components being relatively younger, but expected to additionally benefit from diverse restoration plantings adjacent to enhancement areas.
Compensation model inputs	
Compensation type 1	**All revegetation**

Discount rate	**+3 % (the default discount score as per Maseyk et al. (2015); Baber et al. (2021a).** The discount rate addresses the temporal time lag between the impact occurring and the biodiversity gains being generated by the conservation action(s).
Finite end-point	**20 years**. Establishment and maturation of seral vegetation (VS2 and VS5) expected within 20 years, with components of future mature forest (WF11) featuring within understory.
Compensation contingency (confidence)	**2** **High confidence:** Revegetation is a well proven method for ecosystem restoration, with flora growth rates and flora and fauna colonisation well understood.
Areal extent (ha) of compensation type	**61 ha** as modelled using a biodiversity offset accounting model (BOAM) using total basal area for each ecosystem type.
Value score prior to compensation measure (relative to benchmark)	**0.001** Planting will onto land where indigenous vegetation characteristic of indigenous terrestrial ecosystems (and particularly VS2 or VS5) do not currently cover.
Value score after compensation measure (relative to benchmark)	**2.48** Species assemblages will represent like for like VS2, VS5 and WF11 systems with similar biodiversity (flora and fauna assemblages), based on restoration plantings of similar maturity and acknowledging plantings will be adjacent to, or in between established VS2 and VS5 vegetation and habitats. Value weighted by area for revegetation within predator proof fence (3) versus outside the fence (2).

Appendix E Revegetation species lists and DBH Calculations

Table 21. Proposed revegetation species list for VS5 planting areas. Species that are larger than 10cm DBH are highlighted, as only these species contributed to the final basal area per hectare value used in the BOAM models. Final basal area of revegetation measured as 60.7305 m^2/ha at 20 years.

Common Name	Scientific name	Regetation Area (ha)	% Plant mix	spacing (m)	Plants per ha (%mix by total number of plants)	Total trees	start DBH (mm)	Growth rate (mm/year)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Total Basal area per ha (Including 15% dieoff)	Total Basal Area over entire revegetation site m2)
Wineberry	*Aristotelia serrata*	8	5	1.4	357	2857	3	1	20	2.3	0.00042	0.14838	0.12613	1.18707
Cabbage tree	*Cordyline australis*	8	5	1.4	357	2857	3	13	20	26.3	0.05433	19.40186	16.49158	155.21487
Marble leaf	*Carpodetus serratus*	8	2.5	1.4	179	1429	3	1	20	2.3	0.00042	0.07419	0.06306	0.59354
Kanuka	*Kunzea robusta*	8	10	1.4	714	5714	3	15	20	30.3	0.07211	51.50473	43.77902	412.03783
Akepiro	*Olearia furfuracea*	8	5	1.4	357	2857	3	1	20	2.3	0.00042	0.14838	0.12613	1.18707
Manuka	*Leptospermum scoparium*	8	15	1.4	1071	8571	3	3	20	6.3	0.00312	3.33991	2.83892	26.71925
Karamū	*Coprosma robusta*	8	10	1.4	714	5714	3	1	20	2.3	0.00042	0.29677	0.25225	2.37415
Shining karamū	*Coprosma lucida*	8	10	1.4	714	5714	3	1	20	2.3	0.00042	0.29677	0.25225	2.37415
Māhoe	*Melicytus ramiflorus*	8	10	1.4	714	5714	3	3	20	6.3	0.00312	2.22660	1.89261	17.81283
Māpou	*Myrsine australis*	8	10	1.4	714	5714	3	1	20	2.3	0.00042	0.29677	0.25225	2.37415
Ngaio	*Myporum laetum*	8	2.5	1.4	179	1429	3	3	20	6.3	0.00312	0.55665	0.47315	4.45321
Kōhūhū/black matipo	*Pittosporum tenuifolium*	8	10	1.4	714	5714	3	1	20	2.3	0.00042	0.29677	0.25225	2.37415
Kōwhai	*Sophora microphylla*	8	5	5	100	800	3	4	20	8.3	0.00541	0.54106	0.45990	4.32849
Totals			100		5814	46514						**79.12884**	**67.25952**	631.84367
Totals (only species over >10 cm DBH at 20 years)												**71.44765**	**60.73050**	

Bioresearches
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Table 22. Proposed revegetation species list for VS2 planting areas. Species that are larger than 10cm DBH are highlighted, as only these species contributed to the final basal area per hectare value used in the BOAM models. Final basal area of revegetation measured as 155.6531 m²/ha at 20 years.

Common Name	Scientific name	Regetation Area (ha)	% Plant mix	spacing (m)	Plants per ha (%mix by total number of plants)	Total trees	start DBH (mm)	Growth rate (mm/year)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Total Basal area per ha (Including 15% dieoff)	Total Basal Area over entire revegetation site m2)
Marble leaf	*Carpodetus serratus*	46	5	1.4	357	16429	3	1	20	2.3	0.0004	**0.1484**	**0.1261**	5.8018
Karamū	*Coprosma robusta*	46	10	1.4	714	32857	3	1	20	2.3	0.0004	**0.2968**	**0.2523**	11.6036
Kanuka	*Kunzea spp*	46	35	1.4	2500	115000	3	15	20	30.3	0.0721	**180.2665**	**153.2266**	7048.4221
Māhoe	*Melicytus ramiflorus*	46	10	1.4	714	32857	3	3	20	6.3	0.0031	**2.2266**	**1.8926**	87.0602
Kōhūhū/black matipo	*Pittosporum tenuifolium*	46	5	1.4	357	16429	3	1	20	2.3	0.0004	**0.1484**	**0.1261**	5.8018
Tānekaha	*Phyllocladus trichomanoides*	46	10	5	200	9200	3	5	20	10.3	0.0083	**1.6665**	**1.4165**	65.1585
Tōtara	*Podocarpus totara*	46	5	5	100	4600	3	6	20	12.3	0.0119	**1.1882**	**1.0100**	46.4597
Five-finger	*Pseudopanax arboreus*	46	5	1.4	357	16429	3	1	20	2.3	0.0004	**0.1484**	**0.1261**	5.8018
Lancewood	*Pseudopanax crassifolius*	46	5	1.4	357	16429	3	4	20	8.3	0.0054	**1.9324**	**1.6425**	75.5553
Mataī, black pine	*Prumnopitys taxifolia*	46	5	5	100	4600	3	0.5	20	1.3	0.0001	**0.0133**	**0.0113**	0.5190
Kōwhai	*Sophora microphylla*	46	5	5	100	4600	3	4	20	8.3	0.0054	**0.5411**	**0.4599**	21.1555
Totals			**100**		**5857**	**269429**						**188.5765**	**160.2900**	**7256.7511**
Totals (only species over >10 cm DBH at 20 years)												**183.1212**	**155.6531**	

Table 23. Proposed revegetation species list for WF11 planting areas. Species that are larger than 10cm DBH are highlighted, as only these species contributed to the final basal area per hectare value used in the BOAM models. Final basal area of revegetation measured as 71.3039 m²/ha at 20 years.

Planting Stage	Common name	Scientific name	Regetation Area (ha)	% Plant mix	spacing (m)	Plants per ha (%mix by total number of plants)	Total trees	start DBH (mm)	Growth rate (mm/year)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Total Basal Area over entire revegetation site m2)
Pioneer															
	Wineberry/makomako	*Aristotelia serrata*	7	10	1.4	714	5000	3	1	20	2.3	0.0004	0.2968	0.2523	1.7658
	Tōtara	*Podocarpus totara*	7	5	5	100	700	3	6	20	12.3	0.0119	1.1882	1.0100	7.0700
	Karamū	*Coprosma robusta*	7	15	1.4	1071	7500	3	1	20	2.3	0.0004	0.4452	0.3784	2.6487
	Kanuka	*Kunzea spp*	7	15	1.4	1071	7500	3	15	20	30.3	0.0721	77.2571	65.6685	459.6797
	Mānuka	*Leptospermum scoparium*	7	20	1.4	1429	10000	3	3	20	6.3	0.0031	4.4532	3.7852	26.4966
	Māpou	*Myrsine australis*	7	10	1.4	714	5000	3	1	20	2.3	0.0004	0.2968	0.2523	1.7658
	Māhoe	*Melicytus ramiflorus*	7	15	1.4	1071	7500	3	3	20	6.3	0.0031	3.3399	2.8389	19.8724
	Five-finger	*Pseudopanax arboreus*	7	5	1.4	357	2500	3	1	20	2.3	0.0004	0.1484	0.1261	0.8829
	Lancewood	*Pseudopanax crassifolius*	7	5	1.4	357	2500	3	4	20	8.3	0.0054	1.9324	1.6425	11.4975
	Total			**100**		**6886**	**48200**						**89.3579**	**5.8191**	**531.6793**
	Totals (only species over >10 cm DBH at 20 years)												**78.4453**	**66.6785**	**466.7497**
Enrichments															
	Rewarewa	*Knightia excelsa*	7	5	3	167	1167	3	8	16	13.1	0.0135	2.2464	1.9094	13.3659
	Kauri	*Agathis australis*	7	5	5	100	700	3	8	16	13.1	0.0135	1.3478	1.1456	8.0195

	Marble leaf	*Carpodetus serratus*	7	5	1.4	357	2500	3	1	20	2.3	0.0004	0.1484	0.1261	0.8829
	Kahikatea	*Dacrycarpus dacrydioides*	7	3	5	60	420	3	8	16	13.1	0.0135	0.8087	0.6874	4.8117
	Rimu	*Dacrydium cupressinum*	7	5	5	100	700	3	7	16	11.5	0.0104	1.0387	0.8829	6.1802
	Pukatea	*Laurelia novae-zelandiae*	7	3	5	60	420	3	4	16	6.7	0.0035	0.2115	0.1798	1.2587
	Miro	*Pectinopitys ferruginea*	7	5	5	100	700	3	2.5	16	4.3	0.0015	0.1452	0.1234	0.8641
	Tānekaha	*Phyllocladus trichomanoides*	7	5	5	100	700	3	5	16	8.3	0.0054	0.5411	0.4599	3.2193
	Mataī, black pine	*Prumnopitys taxifolia*	7	3	5	60	420	3	0.5	16	1.1	0.0001	0.0057	0.0048	0.0339
	Kōwhai	*Sophora microphylla*	7	5	5	100	700	3	4	16	6.7	0.0035	0.3526	0.2997	2.0978
	Total			**44**		**1204**	**8427**						**6.8460**	**5.8191**	**40.7340**
	Totals (only species over >10 cm DBH at 20 years)												**5.4416**	**4.6253**	**32.3774**
Total Planting (Pioneer and Enrichment)															
	Total			**144**		**8090**	**56627**						**96.2039**	**0.3784**	**572.4133**
	Totals (only species over >10 cm DBH at 20 years)												**83.8869**	**71.3039**	**499.1270**

Table 24. Proposed basal area values calculated for monitoring of revegetation for VS5 planting areas. Species that are larger than 10cm DBH are highlighted, as only these species contributed to the final basal area per hectare value used.

Common Name	Scientific name	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)
Wineberry	*Aristotelia serrata*	5	0.8	0.0001	0.0180	0.0153	10	1.3	0.00013	0.0474	0.0403	15	1.8	0.0003	0.0909	0.0772	20	2.3	0.0004	0.1484	0.1261
Cabbage tree	*Cordyline australis*	5	6.8	0.0036	1.2970	1.1025	10	13.3	0.01389	4.9618	4.2175	15	19.8	0.0308	10.9967	9.3472	20	26.3	0.0543	19.4019	16.4916
Marble leaf	*Carpodetus serratus*	5	0.8	0.0001	0.0090	0.0076	10	1.3	0.00013	0.0237	0.0201	15	1.8	0.0003	0.0454	0.0386	20	2.3	0.0004	0.0742	0.0631
Kanuka	*Kunzea robusta*	5	7.8	0.0048	3.4131	2.9011	10	15.3	0.01839	13.1324	11.1626	15	22.8	0.0408	29.1630	24.7885	20	30.3	0.0721	51.5047	43.7790
Akepiro	*Olearia furfuracea*	5	0.8	0.0001	0.0180	0.0153	10	1.3	0.00013	0.0474	0.0403	15	1.8	0.0003	0.0909	0.0772	20	2.3	0.0004	0.1484	0.1261
Manuka	*Leptospermum scoparium*	5	1.8	0.0003	0.2726	0.2317	10	3.3	0.00086	0.9164	0.7789	15	4.8	0.0018	1.9388	1.6480	20	6.3	0.0031	3.3399	2.8389
Karamū	*Coprosma robusta*	5	0.8	0.0001	0.0359	0.0305	10	1.3	0.00013	0.0948	0.0806	15	1.8	0.0003	0.1818	0.1545	20	2.3	0.0004	0.2968	0.2523
Shining karamū	*Coprosma lucida*	5	0.8	0.0001	0.0359	0.0305	10	1.3	0.00013	0.0948	0.0806	15	1.8	0.0003	0.1818	0.1545	20	2.3	0.0004	0.2968	0.2523
Māhoe	*Melicytus ramiflorus*	5	1.8	0.0003	0.1818	0.1545	10	3.3	0.00086	0.6109	0.5193	15	4.8	0.0018	1.2925	1.0987	20	6.3	0.0031	2.2266	1.8926
Māpou	*Myrsine australis*	5	0.8	0.0001	0.0359	0.0305	10	1.3	0.00013	0.0948	0.0806	15	1.8	0.0003	0.1818	0.1545	20	2.3	0.0004	0.2968	0.2523
Ngaio	*Myporum laetum*	5	1.8	0.0003	0.0454	0.0386	10	3.3	0.00086	0.1527	0.1298	15	4.8	0.0018	0.3231	0.2747	20	6.3	0.0031	0.5567	0.4732
Kōhūhū/black matipo	*Pittosporum tenuifolium*	5	0.8	0.0001	0.0359	0.0305	10	1.3	0.00013	0.0948	0.0806	15	1.8	0.0003	0.1818	0.1545	20	2.3	0.0004	0.2968	0.2523
Kōwhai	*Sophora microphylla*	5	2.3	0.0004	0.0415	0.0353	10	4.3	0.00145	0.1452	0.1234	15	6.3	0.0031	0.3117	0.2650	20	8.3	0.0054	0.5411	0.4599
Totals					**5.4400**	**4.6240**				**20.4172**	**17.3546**				**44.9801**	**38.2331**				**79.1288**	**67.2595**
Totals (only species over >10 cm DBH at 20 years)					**4.7517**	**4.0389**				**18.2394**	**15.5035**				**40.4714**	**34.4007**				**71.4476**	**60.7305**

Table 25. Proposed basal area values calculated for monitoring of revegetation for VS2 planting areas. Species that are larger than 10cm DBH are highlighted, as only these species contributed to the final basal area per hectare value used.

Common Name	Scientific name	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per in-dividual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)
Marble leaf	*Carpodetus serratus*	5	0.8	0.00005	0.01795	0.01526	10	1.3	0.00013	0.04740	0.04029	15	1.8	0.00025	0.09088	0.07725	20	2.3	0.00042	0.14838	0.12613
Karamū	*Coprosma robusta*	5	0.8	0.00005	0.03590	0.03052	10	1.3	0.00013	0.09481	0.08059	15	1.8	0.00025	0.18176	0.15450	20	2.3	0.00042	0.29677	0.25225
Kanuka	*Kunzea spp*	5	7.8	0.00478	11.94591	10.15402	10	15.3	0.01839	45.96346	39.06894	15	22.8	0.04083	102.07035	86.75979	20	30.3	0.07211	180.26655	153.22657
Māhoe	*Melicytus ramiflorus*	5	1.8	0.00025	0.18176	0.15450	10	3.3	0.00086	0.61093	0.51929	15	4.8	0.00181	1.29254	1.09866	20	6.3	0.00312	2.22660	1.89261
Kōhūhū/black matipo	*Pittosporum tenuifolium*	5	0.8	0.00005	0.01795	0.01526	10	1.3	0.00013	0.04740	0.04029	15	1.8	0.00025	0.09088	0.07725	20	2.3	0.00042	0.14838	0.12613
Tānekaha	*Phyllocladus tricho-manoides*	5	2.8	0.00062	0.12315	0.10468	10	5.3	0.00221	0.44124	0.37505	15	7.8	0.00478	0.95567	0.81232	20	10.3	0.00833	1.66646	1.41649
Tōtara	*Podocarpus totara*	5	3.3	0.00086	0.08553	0.07270	10	6.3	0.00312	0.31172	0.26497	15	9.3	0.00679	0.67929	0.57740	20	12.3	0.01188	1.18823	1.00999
Five-finger	*Pseudopanax arboreus*	5	0.8	0.00005	0.01795	0.01526	10	1.3	0.00013	0.04740	0.04029	15	1.8	0.00025	0.09088	0.07725	20	2.3	0.00042	0.14838	0.12613
Lancewood	*Pseudopanax crassifolius*	5	2.3	0.00042	0.14838	0.12613	10	4.3	0.00145	0.51864	0.44085	15	6.3	0.00312	1.11330	0.94631	20	8.3	0.00541	1.93236	1.64251
Mataī, black pine	*Prumnopitys taxifolia*	5	0.55	0.00002	0.00238	0.00202	10	0.8	0.00005	0.00503	0.00427	15	1.05	0.00009	0.00866	0.00736	20	1.3	0.00013	0.01327	0.01128
Kōwhai	*Sophora microphylla*	5	2.3	0.00042	0.04155	0.03532	10	4.3	0.00145	0.14522	0.12344	15	6.3	0.00312	0.31172	0.26497	20	8.3	0.00541	0.54106	0.45990
Totals					**12.6184**	**10.7257**				**48.2333**	**40.9983**				**106.8859**	**90.8531**				188.57646	160.28999
Totals (only spe-cies over >10 cm DBH at 20 years)					**12.1546**	**10.3314**				**46.7164**	**39.7090**				**103.7053**	**88.1495**				183.12124	155.65305

Table 26. Proposed basal area values calculated for monitoring of revegetation for WF11 planting areas. Species that are larger than 10cm DBH are highlighted, as only these species contributed to the final basal area per hectare value used.

		Scientific name	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)	Growth years	Final DBH (cm)	Total basal area per individual (m2)	Total Basal area per ha (m2)	Including dieoff (15%)
Pioneer	Wineberry/makomako	*Aristotelia serrata*	5	0.8	0.0001	0.0359	0.0305	10	1.3	0.0001	0.0948	0.0806	15	1.8	0.0003	0.1818	0.1545	20	2.3	0.0004	0.2968	0.2523
	Tōtara	*Podocarpus totara*	5	3.3	0.0009	0.0855	0.0727	10	6.3	0.0031	0.3117	0.2650	15	9.3	0.0068	0.6793	0.5774	20	12.3	0.0119	1.1882	1.0100
	Karamū	*Coprosma robusta*	5	0.8	0.0001	0.0539	0.0458	10	1.3	0.0001	0.1422	0.1209	15	1.8	0.0003	0.2726	0.2317	20	2.3	0.0004	0.4452	0.3784
	Kanuka	*Kunzea spp*	5	7.8	0.0048	5.1197	4.3517	10	15.3	0.0184	19.6986	16.7438	15	22.8	0.0408	43.7444	37.1828	20	30.3	0.0721	77.2571	65.6685
	Mānuka	*Leptospermum scoparium*	5	1.8	0.0003	0.3635	0.3090	10	3.3	0.0009	1.2219	1.0386	15	4.8	0.0018	2.5851	2.1973	20	6.3	0.0031	4.4532	3.7852
	Māpou	*Myrsine australis*	5	0.8	0.0001	0.0359	0.0305	10	1.3	0.0001	0.0948	0.0806	15	1.8	0.0003	0.1818	0.1545	20	2.3	0.0004	0.2968	0.2523
	Māhoe	*Melicytus ramiflorus*	5	1.8	0.0003	0.2726	0.2317	10	3.3	0.0009	0.9164	0.7789	15	4.8	0.0018	1.9388	1.6480	20	6.3	0.0031	3.3399	2.8389
	Five-finger	*Pseudopanax arboreus*	5	0.8	0.0001	0.0180	0.0153	10	1.3	0.0001	0.0474	0.0403	15	1.8	0.0003	0.0909	0.0772	20	2.3	0.0004	0.1484	0.1261
	Lancewood	*Pseudopanax crassifolius*	5	2.3	0.0004	0.1484	0.1261	10	4.3	0.0015	0.5186	0.4408	15	6.3	0.0031	1.1133	0.9463	20	8.3	0.0054	1.9324	1.6425
	Total					**6.1334**	**5.2134**				**23.0465**	**19.5895**				**50.7880**	**43.1698**				**89.3579**	**75.9542**
	Totals (only species over >10 cm DBH at 20 years)					**5.2052**	**4.4244**				**20.0104**	**17.0088**				**44.4237**	**37.7602**				**78.4453**	**66.6785**
Enrichments	Rewarewa	*Knightia excelsa*	5	4.3	0.0015	0.2420	0.2057	10	8.3	0.0054	0.9018	0.7665	15	12.3	0.0119	1.9804	1.6833	16	13.1	0.0135	2.2464	1.9094
	Kauri	*Agathis australis*	5	4.3	0.0015	0.1452	0.1234	10	8.3	0.0054	0.5411	0.4599	15	12.3	0.0119	1.1882	1.0100	16	13.1	0.0135	1.3478	1.1456
	Marble leaf	*Carpodetus serratus*	5	0.8	0.0001	0.0180	0.0153	10	1.3	0.0001	0.0474	0.0403	15	1.8	0.0003	0.0909	0.0772	20	2.3	0.0004	0.1484	0.1261
	Kahikatea	*Dacrycarpus dacrydioides*	5	4.3	0.0015	0.0871	0.0741	10	8.3	0.0054	0.3246	0.2759	15	12.3	0.0119	0.7129	0.6060	16	13.1	0.0135	0.8087	0.6874
	Rimu	*Dacrydium cupressinum*	5	3.8	0.0011	0.1134	0.0964	10	7.3	0.0042	0.4185	0.3558	15	10.8	0.0092	0.9161	0.7787	16	11.5	0.0104	1.0387	0.8829
	Pukatea	*Laurelia novae-zelandiae*	5	2.3	0.0004	0.0249	0.0212	10	4.3	0.0015	0.0871	0.0741	15	6.3	0.0031	0.1870	0.1590	16	6.7	0.0035	0.2115	0.1798
	Miro	*Pectinopitys ferruginea*	5	1.55	0.0002	0.0189	0.0160	10	2.8	0.0006	0.0616	0.0523	15	4.05	0.0013	0.1288	0.1095	16	4.3	0.0015	0.1452	0.1234

	Tānekaha	*Phyllocladus tricho-manoides*	5	2.8	0.0006	0.0616	0.0523	10	5.3	0.0022	0.2206	0.1875	15	7.8	0.0048	0.4778	0.4062	16	8.3	0.0054	0.5411	0.4599
	Mataī, black pine	*Prumnopitys taxifolia*	5	0.55	0.0000	0.0014	0.0012	10	0.8	0.0001	0.0030	0.0026	15	1.05	0.0001	0.0052	0.0044	16	1.1	0.0001	0.0057	0.0048
	Kōwhai	*Sophora microphylla*	5	2.3	0.0004	0.0415	0.0353	10	4.3	0.0015	0.1452	0.1234	15	6.3	0.0031	0.3117	0.2650	16	6.7	0.0035	0.3526	0.2997
	Total					**0.7541**	**0.6410**				**2.7510**	**2.3383**				**5.9991**	**5.0993**				**6.8460**	**5.8191**
	Totals (only species over >10 cm DBH at 20 years)					**0.5878**	**0.4996**				**2.1860**	**1.8581**				**4.7976**	**4.0780**				**5.4416**	**4.6253**
Total Planting (Pioneer and Enrichment)	**Total**					**6.8875**	**5.8544**				**25.7974**	**21.9278**				**56.7871**	**48.2690**				**96.2039**	**81.7733**
	Totals (only species over >10 cm DBH at 20 years)					**5.7930**	**4.9241**				**22.1964**	**18.8669**				**49.2214**	**41.8382**				**83.8869**	**71.3039**

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