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Kings Quarry Stage 2 Expansion

Freshwater Ecology Residual Effects Analysis Report

for: Kings Quarry Limited

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Cover Illustration: Looking downslope at Stream 4 and Wetland 2

EXECUTIVE SUMMARY

Kings Quarry Limited proposes to expand its existing Kings Quarry operation with a Stage 2 pit and fill development (referred to as the Project area). This will require removal of 2,439 linear metres of stream length. The Stage 2 area is zoned 'Special Purpose Zone: Quarry' (SPQZ) under the Auckland Unitary Plan – Operative in Part (AUP) and the streams within the Project Area were classified as intermittent, modified intermittent and permanent streams. The Assessment of Ecological Effects (Bioresearches, 2025) identified that the reclamation of the streams would represent a 'very high' level of effect, and these significant residual adverse effects would require biodiversity offset or compensation.

This report outlines the proposed biodiversity offset and compensation package, applying the Environmental Compensation Ratio (ECR) methodology to determine the level of action required to achieve a no net loss, and preferably a net gain, of freshwater ecological values. The full extent of stream loss cannot be practicably replaced; therefore, additional compensation is required.

To offset the loss of 852 linear metres (or 445 m^2) of stream value, 3,391 linear metres of stream restoration will be undertaken at 142 Oldfield Road (referred to as the offset and compensation site). To compensate for the residual loss of 1,587 linear metres of stream habitat and 445 m^2 of stream bed area - and achieve additional ecological gains - 1.74 ha of degraded wetland habitat will be restored to indigenous wetland. The offset and compensation site selected is within the same ecological district (Rodney district) located approximately 26 km north of the Project area. Stream restoration and enhancements will include riparian planting, fencing, stock exclusion and the removal of culverts. Wetland restoration and enhancement will include wetland and buffer planting, and fencing. In addition, the removal of a weir from the Waitoki Stream will reinstate connectivity to approximately 3.468 km of upstream habitat, restoring hydrology, sediment transport, fish passage, and overall stream processes.

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

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

1 INTRODUCTION

Kings Quarry Limited (KQL) is proposing to expand its existing quarry operation, known as 'Kings Quarry', to develop a Stage 2 pit and associated fill areas. Collectively, the Stage 2 pit and fill areas, and associated infrastructure are hereafter referred to as the 'Project area' (Figure 1). The ecological habitats, including aquatic habitats, within the Project area have been assessed and recommendations for the mitigation, offset and compensation of ecological effects of the proposed expansion have been made in the Ecological Impact Assessment (EcIA) report (Bioresearches, 2025). The expansion of the quarry will include the loss of all streams within the Project area (Figure 1). The loss of the streams was assessed as a significant residual adverse effect requiring offset and compensation.

This report provides a summary of the approach, methodologies and analysis used to determine the stream ecological offset and compensation requirements for the expansion of Kings Quarry.

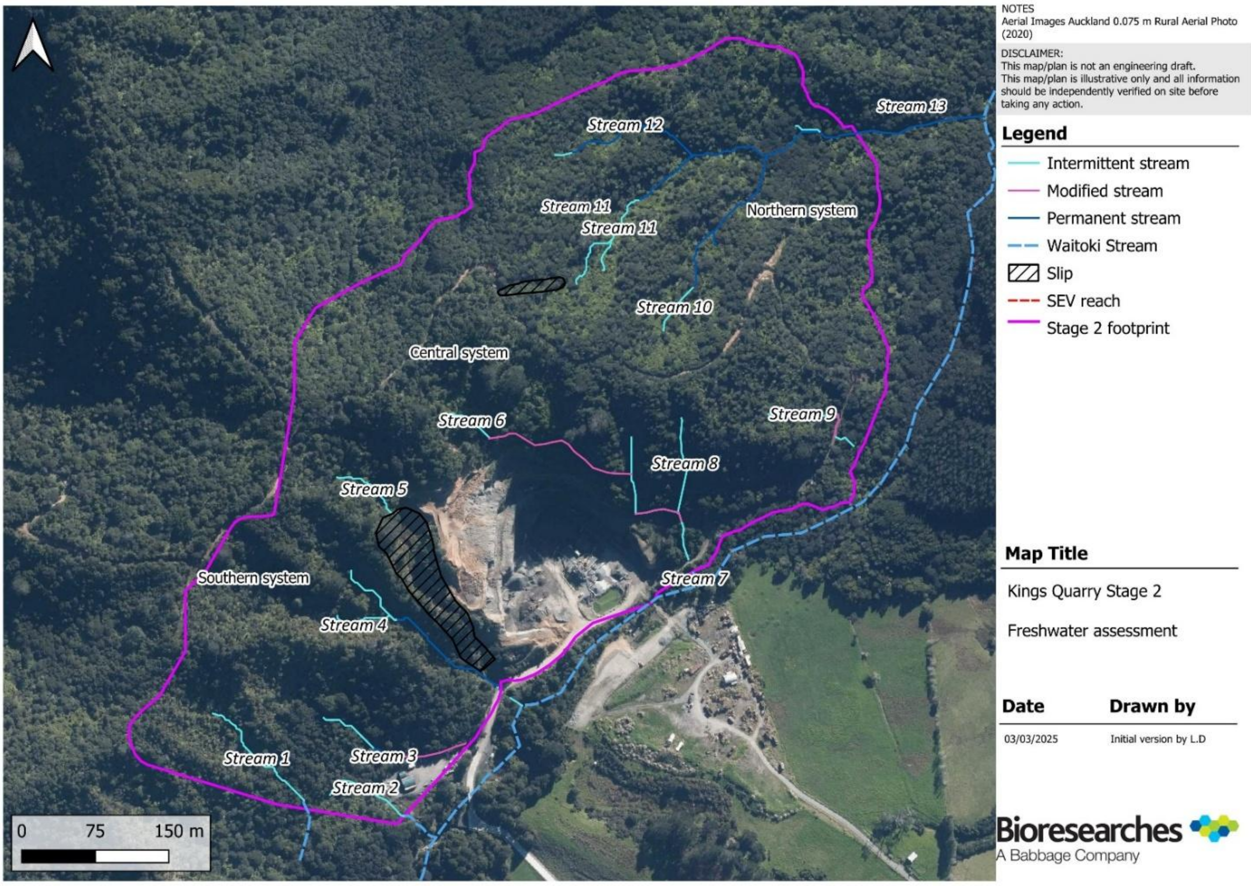

Figure 1. Kings Quarry Project Area and Stream Locations

2 STATUTORY CONTEXT

This section summarises the legislation, policy, plans and strategies relevant to the protection, conservation and enhancement of nature conservation interests associated with the Project Area. The ecological values described in this report allow significant ecological issues and adverse effects to be identified as they relate the Resource Management Act 1991 (RMA) and the Fast Track Approvals Act (FTAA). The identification of significant values and subsequent management recommendations to mitigate adverse effects are consistent with standards and objectives of the following legislative, policy statement and regional plan documents.

2.1 Legislation

2.1.1 Resource Management Act 1991 (RMA)

The purpose of the RMA is to promote the sustainable management of natural and physical resources. An important element of this is the protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna. The RMA requires that adverse effects of activities on the environment be avoided, remedied, or mitigated. These elements are given effect in Sections 5, 6 and 7, and Schedule 4 sets out the requirements for effects assessments.

2.1.2 Fast Track Approvals Act (FTAA)

The purpose of the FTAA it to facilitate the delivery of infrastructure and development projects which have a significant regional or national benefit.

2.1.3 National Environmental Standards for Freshwater (NES-F, 2020)

The National Environmental Standards for Freshwater 2020 (NES-F) set requirements and regulations for carrying out certain activities that pose risks to freshwater and freshwater ecosystems.

Reclamation of wetlands is a Discretionary Activity under Regulation 45A of the NES-F (‘Quarrying activities’), provided that there is a functional need for the reclamation in that location; and the effects management hierarchy is applied.

2.2 National Policy Statements

2.2.1 Freshwater Management

The National Policy Statement for Freshwater Management 2020 (NPS-FM) provides direction under the RMA to local authorities on managing activities that affect the health of freshwater, provides for the protection of freshwater bodies, including natural inland wetlands, includes provisions for monitoring and reporting on freshwater quality and quantity, as well as provisions providing for addressing the impacts of land use activities on freshwater resources.

2.3 Regional Plans and Policies

The Auckland Unitary Plan (AUP) is the principal statutory planning document for the Auckland Region. It was prepared by Auckland Council for the purpose of giving effect to the RMA as a territorial authority. Other regional planning documents relevant to this report include the Regional Pest Management Plan.

The AUP indicates that stream extent and ecological value should be assessed together as an integrated concept when considering freshwater ecological effects (see Policy 8.3.3). In line with this policy, we have adopted a holistic approach to assessing extent and value throughout the report, although we do look at extent and values separately at times as part of our assessment in sections 6 and 7.

3 CURRENT STREAM HABITATS AND PROPOSED LOSS

Due to the topography and characteristics of streams within the Project area, representative aquatic habitats within the Project area were assessed. These comprised thirteen un-named intermittent and permanent streams, all tributaries to the Waitoki Stream. The location and description of each stream and the five representative sections of the streams where more detailed assessments were carried out are presented in Table 1 and Figure 1. No natural inland wetlands were identified throughout the Project area, and none were expected due to the topography and steepness of the Project area.

Table 1. Waitoki Stream Tributaries and their locations within the Project Area

Site Name	Location	Map Reference NZTM*
Stream 1	Intermittent stream to the Waitoki Stream on the southern side	E 1739298 N 5947767
Stream 2	Intermittent and permanent stream to the Waitoki Stream on the southern side	E 1739403 N 5947738
Stream 3	Intermittent and permanent stream to the Waitoki Stream on the southern side	E 1739382 N 5947803
Stream 4	Intermittent and permanent stream to the Waitoki Stream on the southern side	E 1739490 N 5947868
Stream 5	Intermittent stream to the Waitoki Stream on the southern side	E 1739401 N 5948049
Stream 6	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches	E 1739530 N 5948096
Stream 7	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches	E 1739682 N 5948034
Stream 8	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches	E 1739733 N 5948082
Stream 9	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches	E 1739843 N 5948117
Stream 10	Intermittent and permanent tributary to Stream 13 on the northern side	E 1739758 N 5948295
Stream 11	Intermittent and permanent tributary to Stream 13 on the northern side	E 1739669 N 5948306
Stream 12	Intermittent and permanent tributary to Stream 13 on the northern side	E 1739706 N 5948408
Stream 13	Permanent stream and tributary to the Waitoki Stream, northern most watercourse in the expansion footprint.	E 1739873 N5948404

*to approximate mid-point of watercourse

The results of the detailed stream assessments and site characteristics are summarised in Appendix 1 and briefly described below. More detailed descriptions are provided in the EcIA report (Bioresearches, 2025).

Eight streams (Stream 1 – 5 and Stream 10 - 12) were assessed as having 'High' freshwater ecological values, four streams (Stream 6- 9) were assessed as being of 'Low' ecological value, and one (Stream 13) was assessed as having 'Very High' ecological value. The riparian vegetation cover was good to excellent along many of the stream reaches, however four stream reaches (Streams 6, - 9) have been subject to historic modification through diversion.

The streams, with the exception of Steam 13 had beds which were dominantly compacted clay with some hard substrate habitat and bedrock. Stream 13 was predominantly hard bottomed with areas of hard clay present. The degree hydraulic variation was variable between each reach, ranging from shallow, steep runs to scour pools, to shoots, runs, waterfalls, riffles and pools within the stream channel. There was evidence of slipping and erosion throughout the catchment, including a major hillside slip destroying a large proportion of an intermittent stream; and sediment affecting the movement of water throughout most stream reaches. Water quality parameters showed temperatures and dissolved oxygen concentrations were well within the range that is considered suitable for most benthic invertebrates and conductivity levels were moderate to low, showing minimal signs of nutrient enrichment.

Macroinvertebrate communities in all the unmodified tributaries were found to be dominated by taxa indicative of good habitat quality. The macroinvertebrate sample from Stream 7, a modified intermittent stream, was dominated by Chironomid flies, and indicated lower habitat quality than that of the other streams. A low to moderate range of taxa was recorded (8 to 16 taxa), including 12 EPT taxa and 6 taxa with individual MCI scores >8, which are typically sensitive to reduced water quality. The overall MCI scores indicated 'good' to 'excellent' instream habitat quality and, with the exception of the sample from the modified stream (Stream 7), SQMCI scores indicated 'good' and 'excellent' quality. (Stark & Maxted, 2007a, b)

The smaller tributaries (Stream 1 – Stream 10) provided limited habitat for native freshwater fish due to the shallow water and steep flow paths, including the permanent reaches. Although, longfin eel (*Anguilla dieffenbachii*) was detected through eDNA in the intermittent tributaries, the depth and availability of water would limit their presence to juveniles, and likely transitory juveniles. The permanent stream provided a good variety of habitats for both longfin eel and shortfin eel (*A. australis)*, bullies (*Gobiomorphus* spp.), and galaxiids (*Galaxias* spp.), however a significant barrier to fish passage is present in the Waitoki Stream, prohibiting access to swimming fish. The freshwater fish Index of Biotic Integrity (IBI) indicated that stream habitats had a 'Good' diversity of fish in comparison to other Auckland streams (Joy & Henderson, 2004). The presence of longfin eel (rated as 'At Risk - Declining') elevated the value of the lower tributaries as habitat for aquatic fauna.

The Stream Ecological Valuation (SEV) scores for the entire Project Area were moderate to high, with the highest score (0.83) attributed to the highly forested watercourses (Streams 10 - 12) and the lowest score (0.64) to the stream reaches which have been historically modified through diversion i.e. the smaller tributary watercourses at the base of the very steep gully system in the north-west of the catchment (Streams 6 to 9). The good riparian cover and hilly landscape throughout the Project Area provide high shading to support sensitive invertebrate taxa and has resulted in largely unmodified high-quality streams.

The aquatic habitat within the Project Area that will be impacted by the Stage 2 expansion comprises an estimated 2,439 linear metres of low to very high value streams (permanent and intermittent), resulting in the overall loss of stream values and extent.

4 AQUATIC OFFSETTING AND COMPENSATION

4.1 Freshwater Habitat Loss

Thirteen streams, all tributaries to the Waitoki Stream, were assessed within in the Project area. The proposed use of the Project area for quarrying aggregate will result in the total loss of the tributary streams. There will be no direct effects on freshwater habitats in the Waitoki Stream.

4.2 Principles of Stream Offsetting

The loss of the 2,439 m (1,119 m^2) of aquatic habitat in the Project area is considered a significant residual adverse effect under the AUP, and a Very High Level of effect under the EcIA guidelines (Roper-Lindsay *et al.*, 2018), and would require aquatic offset and/or aquatic compensation.

Guidance on, and the Principles for, good practice aquatic biodiversity offsetting is provided in the AUP, Ministry for the Environment *et al.* (2014), and in Appendix 6 of the National Policy Statement for Freshwater Management (NPS-FM). In summary, the offsetting restoration and enhancement documents recommend:

a) The site be located as close as possible to the subject site;
b) Be 'like-for-like';
c) Preferably achieve no net loss;
d) Consideration of the use of biodiversity offsetting; and
e) The use of Storey *et al.* (2011), Appendix 8 of the AUP (Operative in part, 2016), and Ministry for the Environment *et al.* (2014) for guidance.

With the eleven principles for aquatic offsetting being (NPS-FM):

1. Adherence to effects management hierarchy;
2. When aquatic offsetting is not appropriate;
3. No net loss and preferably a net gain;
4. Additionality;
5. Leakage;
6. Long-term outcomes;
7. Landscape context;
8. Time lags;
9. Science and mātaurana Māori;
10. Tangata whenua or stakeholder participation; and
11. Transparency.

Under the effects management hierarchy, where adverse effects cannot be offset, they must be compensated for.

The thirteen principles for aquatic compensation being (NPS-FM):

1. Adherence to effects management hierarchy;
2. When aquatic compensation is not appropriate;
3. Scale of aquatic compensation;
4. Additionality;
5. Leakage;
6. Long-term outcomes;
7. Landscape context;
8. Time lags;
9. Trading up;
10. Financial contribution;
11. Science and mātauranga Māori
12. Tangata whenua or stakeholder participation
13. Transparency.

4.3 Environmental Compensation Ratio (ECR)

The Stream Ecological Valuation (SEV) methodology combined with the calculation of the Environmental Compensation Ratio (ECR) is a transparent, well-recognised methodology for calculating the quantum of offset required for stream loss, and is the preferred method of stream offset under the AUP (Storey *et al.,* 2011).

For permanent and intermittent streams, SEV scores can be utilised to calculate environmental offset for any loss or modification to natural stream habitat by using the Environmental Compensation Ratio (ECR; Storey *et al.*, 2011). The ECR considers the SEV values of both the affected or impacted stream/s and the proposed restoration site stream/s, and determines any differential between the scores to provide a ratio for compensation which will result in "no net loss of area weighted stream function" (Storey *et al.*, 2011). The SEV score used in the ECR calculation does not include two biotic functions relating to fish and macroinvertebrates due to the difficulty of predicting changes to these communities (Storey *et al.*, 2011).

The ECR equation is calculated as follows:

ECR = [(SEVi-P – SEVi-I) / (SEVm-P – SEVm-C)] x 1.5

Where:

- SEVi-P and SEVi-I are the potential SEV value and SEV value after impact, respectively, for the site to be impacted.
- SEVm-C and SEVm-P are the current and potential SEV values, respectively, for the site where the environmental compensation (mitigation) works are to be applied.

- 1.5 is a multiplier that allows for the delay in achieving compensation benefits.

The ECR calculations are, unavoidably, carried out using a number of assumptions. The 'Potential' SEV scores are calculated by altering parameter scores assuming best practice riparian restoration of the stream has taken place and is well established to a level providing at least 70% shade to the stream bed. As most of the streams within the Project Area have full riparian cover, no additional 'potential' will be added to the SEV scores for Streams 1-5, and Stream 10 – 13. The potential for the Streams 6 - 9 has assumed planting of the 10 m riparian yard has been provided.

Calculation of the 'Impact' SEV scores would assume an outcome as proposed, with the full length of the stream being lost. Calculation of the 'Potential' score for a restoration site have assumed native riparian restoration of a 40m margin (20m to 20m either side of the watercourse) and the removal of barriers to fish passage.

Following calculation of the ECR, the area of stream impacted (based on length and width of the stream) is multiplied by this value to determine the stream area required for restoration works.

A detailed Restoration Planting Plan and Weed Management Plan has been prepared for the stream offset and compensation sites by a qualified plant ecologist, ensuring good quality native habitat is created (Bioresearches, 2025b). A minimum of a five-year defects and maintenance contract would be required for the restoration planting to ensure cover is achieved, weed control is maintained and to ensure the proposed biodiversity offset and compensation is achieved over the medium term.

4.4 Offset and Compensation Site

One offset and compensation site has been selected as it meets the required offsetting and compensation attributes.

142 Oldfield Road, Wellsford, (the offset and compensation site) is located 26 km north of the Project area (Figure 2). The stream habitats are located within farmland with stock able to access the streams. The site has an elevation of 80 – 190 m above sea level, and is topographically steep and hilly resulting in a greater proportion of intermittent headwater streams, with a pastoral catchment. This is similar to Kings Quarry, (Stage 2 is approximately 70 m to 170 m above sea level), with streams within the Stage 2 area consisting of small intermittent headwater streams.

Figure 2. Offset site locations, 142 Oldfield Road (yellow polygon) and its proximity to Kings Quarry (pink polygon)

4.5 Stream and Wetland Assessment Methodology

Following a high-level constraints analysis, detailed assessments of the proposed stream offset and compensation site was undertaken in 2023, 2024 and 2025. Stream assessments at the offset and compensation site were carried out on 26 June 2024, and wetlands on 3 February 2025. Additional surveys were completed on 11 August 2025, within the central eastern portion of site, where dense gorse (*Ulex europaeus*) restricted access to stream habitats.

Due to the inaccessibility of certain watercourses, high-resolution drone imagery was employed to determine the extent of stream and/or wetland habitats present. These drone survey results were integrated with existing contour and catchment models to inform the classification of the waterbody likely to be present.

The SEV methodology (Storey *et al.*, 2011) was applied to suitable streams. It enables the overall function of the streams to be assessed and compared to the quality of other streams in the Auckland Region. The SEV procedure involves the collection of habitat data (e.g. stream depth, substrate type, riparian cover), and sampling of fish communities and macroinvertebrates (e.g. insect larvae, snails), with the latter being recognised indicators of habitat quality. SEV data is then entered into a SEV calculator to calculate an averaged SEV value.

Potential wetland areas were assessed following the Ministry for the Environment's (MfE) wetland delineation protocols (MfE, 2020a), to ascertain if the area presented with the physical characteristics to be considered a Natural Inland Wetland. Consequently, the first step in delineating a Natural Inland Wetland is to ensure it meets the definition of a wetland under the RMA, referred to as 'the Act'. If the potential wetland met the definition of an RMA wetland, it was then under also checked under the NPSFM to see if any of the exclusions in the Natural Inland Wetland Definition applied to the area. Finally, if the potential wetland did not meet any of the NPSFM exclusions, the remainder of the MfE wetland delineation process was carried out to determine if the area was a natural inland wetland. (MfE, 2020b)

When following the MfE wetland delineation process, if the rapid test was not appropriate for determining if an area was an RMA wetland, vegetation assessment in accordance with Clarkson (2013) was undertaken; based on the dominance and prevalence of plant species assigned the following 'wetland plant indicator ratings' within a vegetation plot:

- Obligate wetland vegetation (OBL) – almost always a hydrophyte, rarely in uplands;
- Facultative wetland (FACW) – usually a hydrophyte but occasionally found in uplands;
- Facultative (FAC) – commonly occurs as either a hydrophyte or non-hydrophyte;
- Facultative upland (FACU) – occasionally a hydrophyte by usually occurs in uplands; and
- Upland (UPL) – rarely a hydrophyte, almost always in uplands.

5 FRESHWATER VALUES OFFSET AND COMPENSATION

5.1 Freshwater features of 142 Oldfield Road

Six stream groups and four natural inland wetland groups were assessed and were considered appropriate for freshwater offset and compensation. The streams and wetlands are described below and illustrated in Figure 3.

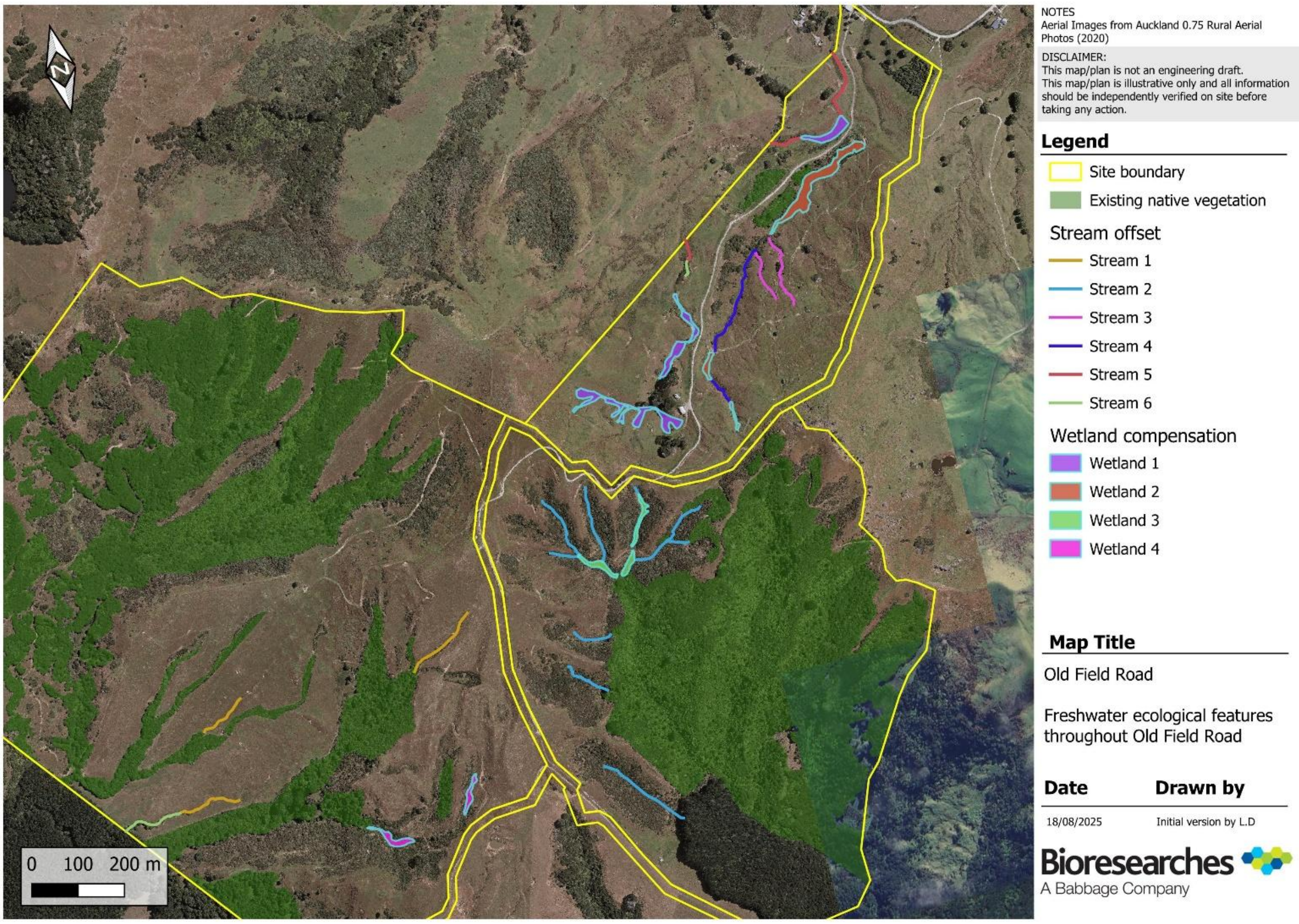

Figure 3. Freshwater offset locations within Oldfield Road. Note terrestrial offset planting not shown for clarity.

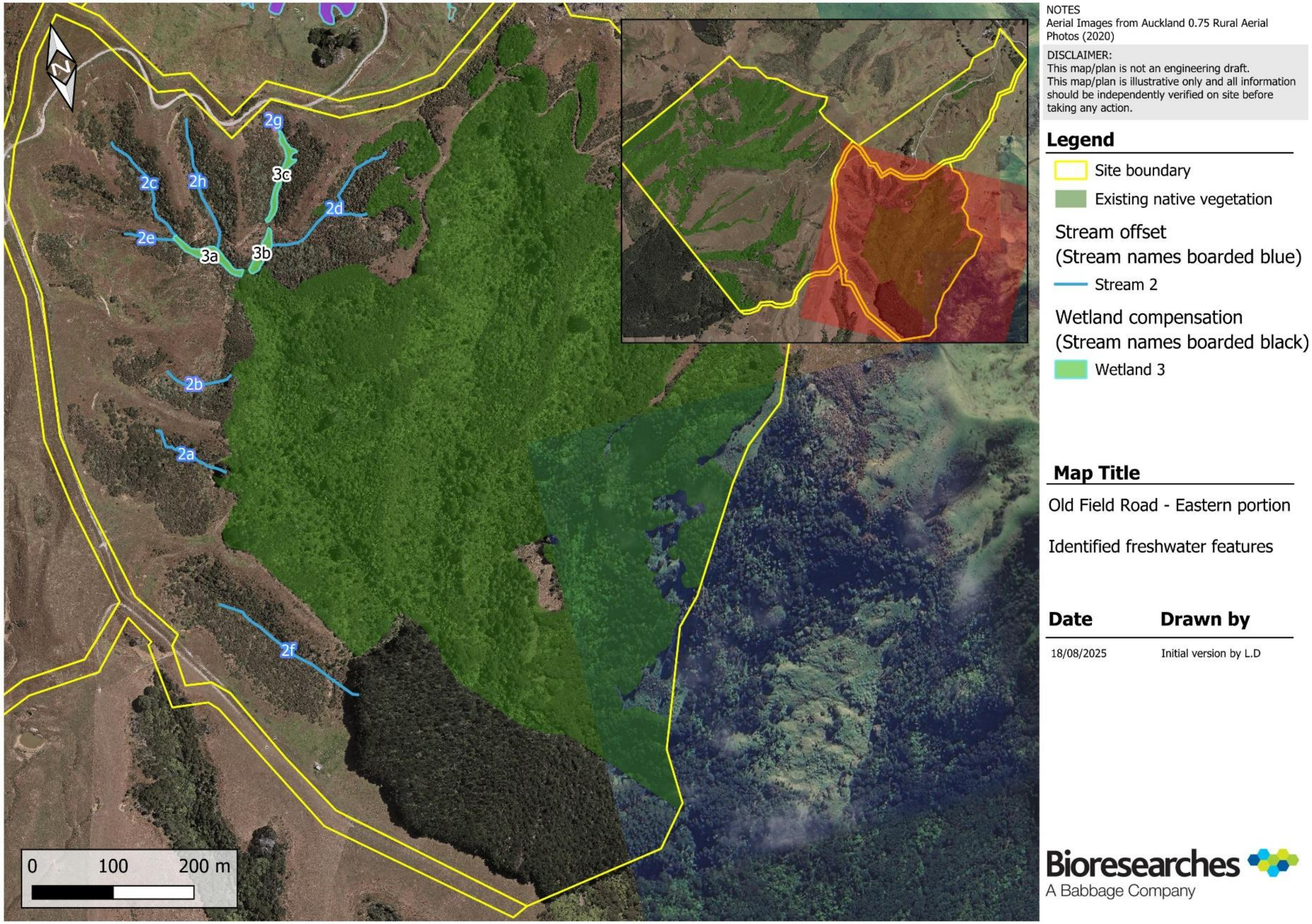

Figure 4. Freshwater features identified in the eastern portion of the site.

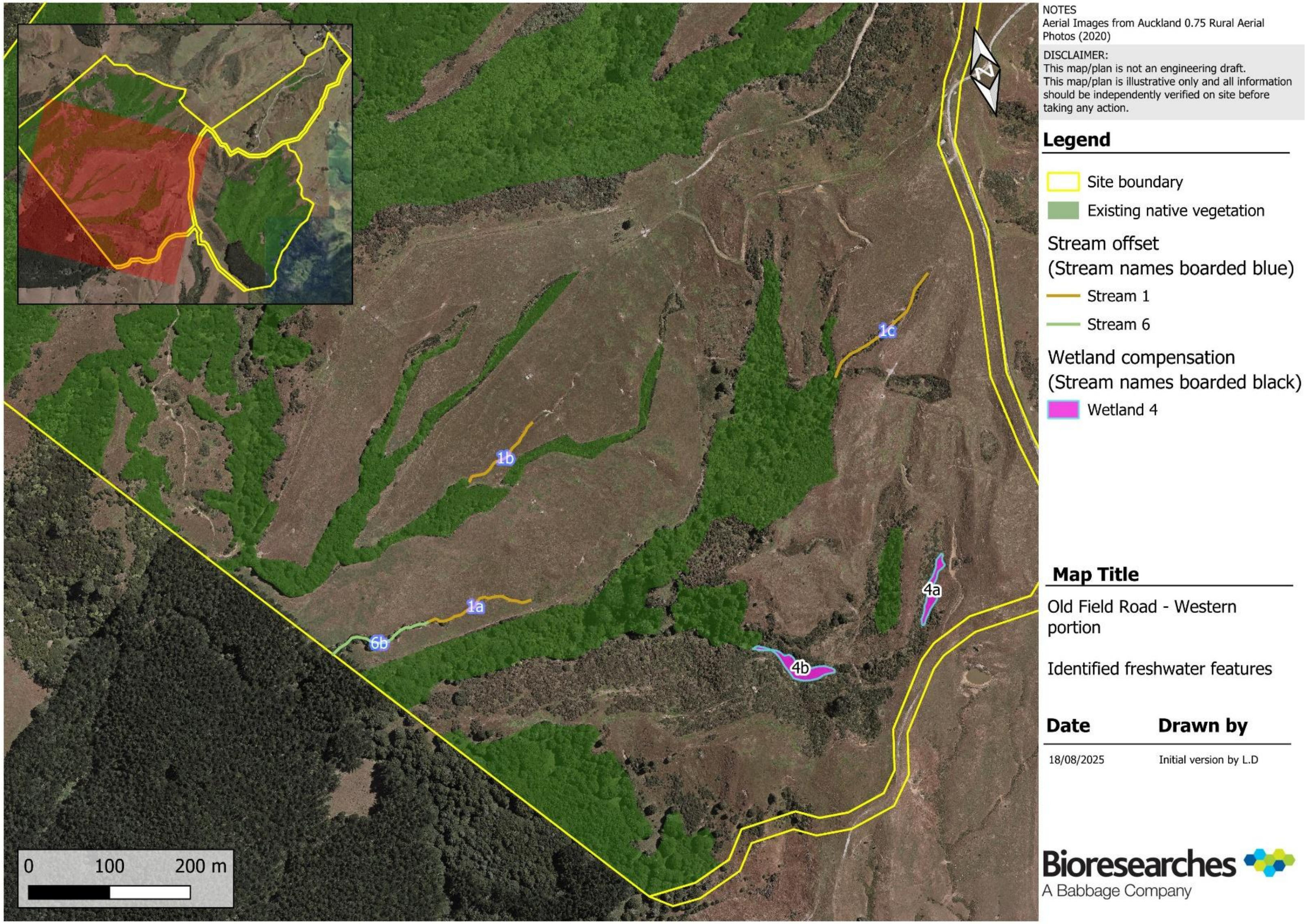

Figure 5. Freshwater features identified in the western portion of the site.

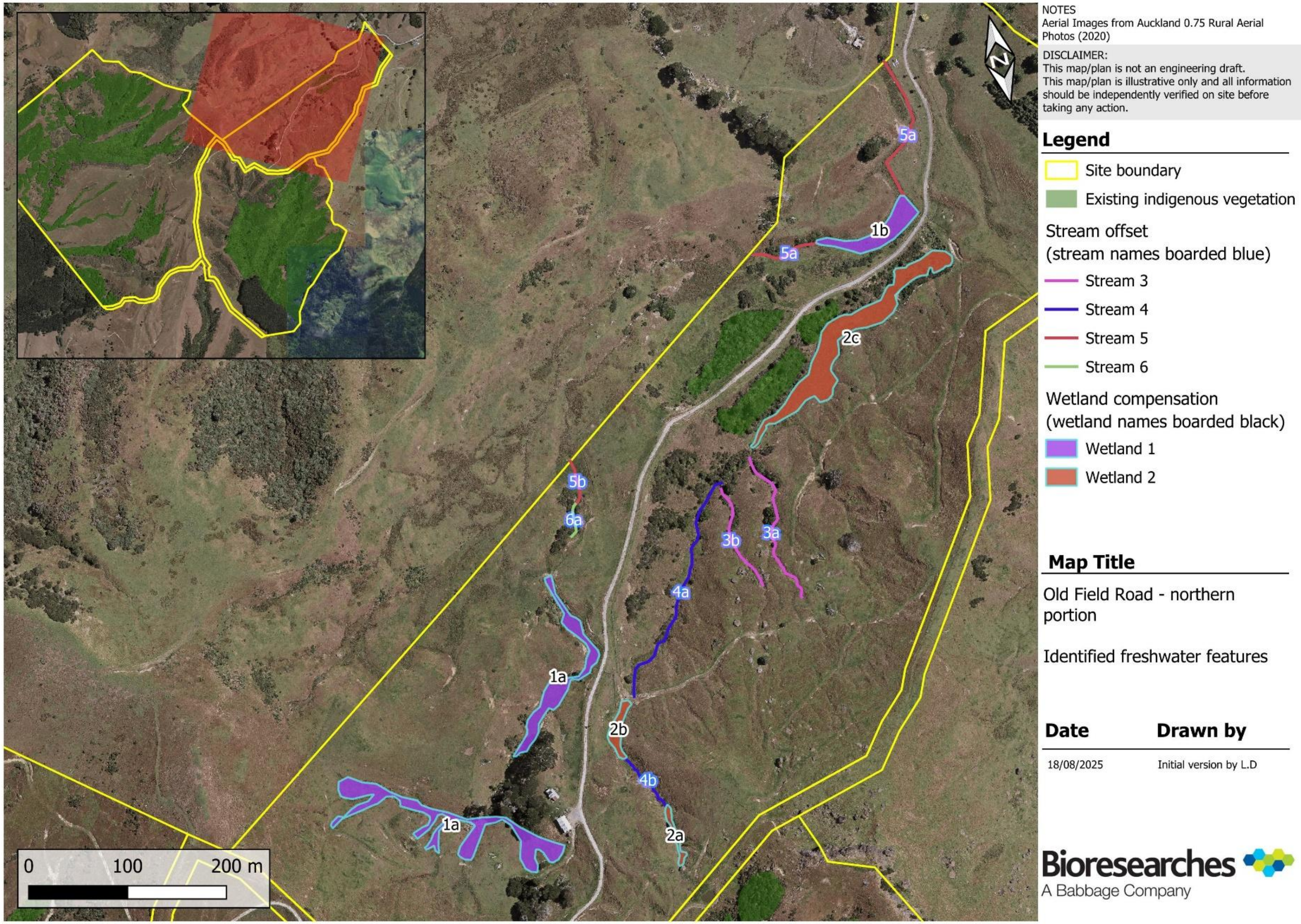

Figure 6. Freshwater features identified in the northern portion of the site.

5.1.1 Stream 1a and 1b – SEV1

Stream 1a and Stream 1b (both classified as intermittent streams) are located on the western portion of the offset site, and flowing east to west before, draining into areas of indigenous bush (Figure 5).

SEV1 was undertaken on intermittent Stream 1a, and used as a representative assessment of Stream 1b, as both watercourses share comparable channel characteristics, stream classification and surrounding land use (Photo 1 to Photo 4).

Photo 1. Stream 1a

Photo 2. Stream 1b

Photo 3. Stream 1a

Photo 4. Stream 1b

The intermittent streams had an average width of 0.57m (0.24 m – 0.83 m) and an average depth of 0.08 m (0.01 m – 0.17m), with water slow flowing. The banks were highly incised throughout the entirety of both reaches restricting connectivity to the floodplain, with the exception of the headwaters which showed evidence of bank collapse due to stock access.

Hydrological heterogeneity was considered to be low and consisted of a slow run with the occasional shallow pool. Oxygen reducing process were sub-optimal. The dominant substrate throughout the reaches were silts, with occasional small gravels present and a high loading of fine sediment. Organic matter observed included woody debris, leaf litter and some root mats with the macrophytes watercress

(*Nasturtium officinale*), starwort (*Callitriche stagnalis*) and water forget-me-not (*Myosotis laxa* subsp. *caespitosa*) present (Photo 5).

The riparian yard of Stream 1a and 1b was poor, and consisted of rank pasture grasses, and gorse with a small stand of native trees present on the downstream reach. This low-quality riparian yard provided very low riparian yard functions such as filtration and bank stability. However, the topography of the site and channel incision provided good shade to the length of the reach (Photo 6).

Aquatic habitat and diversity were considered to be moderate to low, with available habitat for indigenous fauna limited to patchy areas of woody debris, gravels, pools and rooted macrophytes. It is likely shortfin eel and banded kōkopu (*Galaxias fasciatus*) would be able to access and reside within the reach.

Photo 5. Macrophyte cover

Photo 6. Topography and bank incision provided good shade.

Stream 1a and Stream 1b had a SEV score of 0.46 and were considered to be of low ecological value due to the lack of good quality aquatic habitat and diversity, and likely low diversity of in-stream fauna. The streams were highly channelised and impacted through livestock with a lacking riparian yard.

5.1.2 Stream 2 catchment - SEV2

The catchment of Stream 2 is located on the eastern side of the site, where dense gorse is present (Figure 4; Photo 7 & Photo 8). SEV2 was able to be undertaken in an area where gorse density was lower, on intermittent Stream 2a. This assessment is considered representative of 1,038 m of stream present throughout this catchment (Stream 2a – 2g).

This catchment flows predominantly in a north-west to south-east direction before draining into a permanent stream situated within a gully vegetated with indigenous vegetation and supports a Significant Ecological Area (SEA).

Photo 7 & Photo 8. Extent of gorse and noxious vegetation restricting access through Stream 2's catchment

Stream 2a had an average width of 0.34 m (0.18 m– 0.49 m), and an average depth of 0.04 m (0.02 m – 0.14 m). The assessed reach (SEV2) was heavily impacted by stock access and pugging, resulting in bank slumping and sediment deposition into the channel, which restricts natural water flow in some sections of the reach (Photo 10). Despite these impacts, the overall shallow banks provided some connectivity to the floodplain.

The dominant substrate consisted of silts and with occasional gravel and woody debris. Hydrological heterogeneity was overall low, with the reach largely consisting of a shallow run. Removal of stock would likely result in water flow creating small pools and cascades within the reach. The riparian yard of SEV2 reach was poor, and gorse, pampas (*Cortaderia selloana*) and woolly nightshade (*Solanum mauritianum*) present, with some native trees, including pigeon wood (*Hedycarya arborea*), and kānuka (*Kunzea robusta*), twiggy coprosma (*Coprosma rhamnoides*) and tōtara present (Photo 9). This overall low-quality riparian yard provided very low riparian yard functions such as filtration and bank stability. The representative SEV has been assumed following the clearance of gorse, a registered pest plant, where the topography does not sufficiently shade the stream to provide moderate shading conditions.

Aquatic habitat and diversity within the reach were considered low, reflecting the shallow nature of the stream. Available habitat for indigenous fauna is limited to deeper sections of the run, and it is likely juvenile shortfin eel may access the reach.

Photo 9. Primarily exotic riparian yard.

Photo 10. Bank slumping and damage present in the reach

Stream 2a and its representative reaches had an SEV score of 0.47 and was considered to be of low ecological value due to the lack of aquatic habitat, degradation and damage to the stream banks and pest infested riparian yard.

5.1.3 Stream 3a & 3b - SEV3

Streams 3a and 3b are intermittent streams located on the northern extent of the site (Figure 6). Both streams share similar characteristics in terms of topography, channel form, catchment size, and position within the catchment. A natural inland wetland is located at the headwaters of Stream 3a, where the representative SEV (SEV3) was undertaken.

Stream 3a had an average width of 0.45 m (0.12 m– 0.50 m), with an average water depth of 0.04 m (0.02 m – 0.18 m). Similarly, to Stream 1a, Stream 3a contained highly incised stream banks (Photo 11), restricting connectivity to the floodplain and it is likely all flows would be contained within the channel. The dominant substrate throughout SEV3 was silts, however a good proportion of rocky substrates and bedrock was present throughout. This indicates the level of silt to be unnaturally high and likely generated by the lack of riparian yard and land use practices. Hydrological heterogeneity was low, with shallow runs, pools and cascades present (Photo 12), however the topography and gradient of the stream bed would likely restrict the reach to climbing capable species during periods of flow.

The riparian yard was dominantly rank pasture grasses, with occasional native trees such as tōtara present. Whilst the riparian yard was largely pasture, the degree of bank incision, narrow channel width and height of the grass provided an overall high level of shade to the stream reach. However, the degree of filtration and bank stability was low.

Photo 11. Stream 3a and 3b had highly incised banks.

Photo 12. Narrow wetted width within Stream 3a

Stream 3a and its representative reaches had a SEV score of 0.45. The stream was considered to be of low ecological value due to the limited riparian yard function and low provision of aquatic habitat.

5.1.4 Stream 4 – SEV4

Stream 4 is located on the northern portion of the site (Figure 6) and flows south to north for approximately 190 m before entering a planted wetland outside the site boundary. The upper 72 m of Stream 4 (Stream 4b) is classified as intermittent, flowing between two wetlands, while the lower reach (Stream 4a) is classified as a permanent stream, of approximately 250 m in length.

The intermittent reach was considered representative of the conditions of Stream 3, as it lacked substantive riparian vegetation with the exception of sparse trees, likely contains incised banks due to the topography of the area and shallow flow. Accordingly, the SEV scores obtained for Stream 3 were applied to this intermittent reach (Stream 4b).

The permanent reach (Stream 4a) had an average width of 0.6 m (0.34 m – 1.52 m), and an average depth of 0.08 m (0.01 – 0.28 m). Stream 4a was classified as a permanent stream, and was flowing well at the time of assessment, with a variety of hydrology including runs, pools, chutes and waterfalls, however areas of still pools were present (Photo 13, Photo 14).

Photo 13. Incised channel

Photo 14. Waterfall system.

Substrate throughout the reach was bedrock covered by an unnatural loading of fine sediment with some gravels present throughout. Organic matter included leaf litter, woody debris and some macrophyte growth. The banks of the stream were variable, with the lower reaches incised with some bank slumping, and the upper reaches containing some connectivity to the floodplain but limited due to the naturally steep gully. Macrophyte cover was moderate to high throughout the reach, and included watercress (*Nasturtium* sp.), forget-me-not (*Myosotis laxa*) and reed-sweet grass (*Glyceria maxima*). The high macrophyte biomass in winter indicated the oxygen reducing processes were low, additional factors included a sulphuric odour, sediment bubbling and infestation of reed-sweet grass present within sections of the channel.

Riparian vegetation throughout Stream 4a predominantly consisted of grazed grasses with discrete patches of indigenous vegetation such as red matipo (*Myrsine australis*), kānuka, and ponga. Whilst canopy cover through the reach was low, shade was high due to the topography of the area (Photo 15 and Photo 16). Riparian yard functions such as filtration and bank stability were considered to be low due to the prevalence of grazed pasture grasses.

Photo 15. Upper portion riparian yard.

Photo 16. Lower portion with non-woody banks.

Aquatic habitat abundance and diversity was low to moderate, with habitat available for indigenous freshwater fauna including pools, woody debris, cobbles and undercut banks. There were no records from the FFDB for the stream catchment, however nearby catchments show shortfin eel, īnanga (*Galaxias maculata*), and bullies (*Gobiomorphus* sp.) to be nearby. It is likely shortfin eel and potentially bullies would access and reside within Stream 4.

Stream 4a had an SEV score of 0.46 was considered to be of low ecological value. The stream provided some variety in terms of aquatic habitat; however, the stream channel was incised with some areas of anaerobic sediment and a low-quality riparian yard.

5.1.5 Stream 5 -SEV5

SEV5 was undertaken on the north-western portion the site (Figure 6). The assessed reach exhibited channel conditions, such as depth, to Stream 4 and riparian characteristics comparable to Stream 1 (Photo 17, Photo 18). This mid-reach of a permanent stream flows adjacent to the site on the neighbouring property, before re-entering the site beneath a wire fence, continuing through a degraded wetland, and becoming re-channelised to form a defined stream channel (Photo 19, Photo 20). The banks and floodplain of this stream reach showed evidence of pugging and areas of bank collapse observed.

Photo 17. Upper reach of Stream 5

Photo 18. Small farm crossing Stream 5 exits the site through and flows through the neighbouring property.

The stream is approximately 0.56 m wide, with water depth low, (approximately 0.06 m) at the time of assessment during summer. Whilst no SEV was undertaken, the stream appears to be soft bottomed and may contain some hard substrates which have been covered in a layer of fine sediments. Hydrological variation was overall low, with the stream reach consisting of a run and occasional pools. No organic substrates such as woody debris or leaf litter was observed, with some in-stream vegetation present due to reed-sweet grass infestation from the upstream wetland.

Riparian vegetation was low throughout Stream 5a and Stream 5b, with the riparian margins containing pasture grasses, common pasture weeds and occasional gorse bushes. This low-density riparian yard provides an overall low degree of shade, filtration and bank stability to the watercourse.

Photo 19. Lower reach of Stream 5 where it exits the wetland

Photo 20. Lower reach of Stream 5.

Aquatic habitat abundance and diversity is restricted within the stream due to the lack of hydrological variation, in stream organic matter such as woody debris and degraded banks limiting overhanging vegetation and undercuts. An undersized culvert is present within the stream reach, and may reduce potential fish passage upstream.

Stream 5a and 5b was considered to be of overall low ecological value, with an SEV score of 0.46. The stream provided limited aquatic habitat due to its channelised and homogenous stream banks with limited fish and macroinvertebrate cover. The stream lacked riparian vegetation, which likely reduces water quality through increased temperatures and turbidity.

5.1.6 Stream 6a and 6b – SEV6

Stream 6a is located on the south-western portion of the site, directly downstream of Stream 1a, while Stream 6b is situated immediately upstream of Stream 5a (Figure 5 & Figure 6). SEV1 was used as the representative SEV for Stream 6a & 6b, however SEV functions such as shade, riparian yard factors and connection was scored higher due to the presence of a partially vegetated riparian yard (Photo 21, Photo 22).

Photo 21. Looking upstream towards Stream 6b riparian vegetation

Photo 22. Looking upstream where Stream 6a starts

The streams had an average width of 0.55 m and an average depth of 0.05 m, with water slow flowing. The banks were highly incised throughout the entirety of both reaches, restricting connectivity to the floodplain. Hydrological heterogeneity was considered to be low and consisted of a slow run. The dominant substrate throughout the reaches were silts, with occasional small gravels present and a high loading of fine sediment.

The riparian yard of these streams provides an overall high degree of shading to the watercourse which would provide some control over water temperature. This riparian vegetation likely provides good inputs of organic matter and some bank stability.

Stream 6a and 6b was considered to be of overall low ecological value, with an SEV score of 0.42. The stream provided limited aquatic habitat due to its channelised and homogenous stream banks with limited fish and macroinvertebrate cover. The stream contained riparian vegetation which provides some shading to the stream bed.

5.1.7 Wetland 1

Wetland 1 was located within the central northern portion of the site, forming the headwaters and upper reaches of a catchment draining in a northern direction (Figure 6). The wetland is a low value palustrine swamp, cumulatively 7,479 m^2 in size and formed two distinct portions which are hydrologically connected by 100 m of permanent stream (Stream 5).

The upper headwaters portion of the wetland (Wetland 1a) was 5,850 m^2 in size and contained within a wide vale with a narrow stream channel separating upper and lower bodies. The vegetation consisted of mixed exotic and indigenous wetland plants including; sharp-spike sedge (*Eleocharis acuta*), tall fescue (*Lolium arundinaceum*), lotus (*Lotus pedunculatus*), jointed rush (*Juncus articulatus*), soft rush (*Juncus effusus*) and fan-flowered rush (*Juncus sarophorus*) (Photo 23 - Photo 26).

The lower portion of Wetland 1 (Wetland 1b) was 1,628 m^2 in size and laid within wide gully floor with steeper sloping banks. The vegetation within this lower portion was largely a reed-sweet grass monoculture with some water cress and water pepper (Photo 27), before discharging into Stream 5b (Photo 28).

The entirety of Wetland 1 was unfenced and severely impacted by stock access, with extensive pugging and grazing observed, especially throughout the lower portion (Wetland 1b). The wetland was permanently saturated with one hydrological unit, where non-channelised water flows through vegetation (Photo 24). No open water or areas of pools were present, with the exception of the pugging holes (Photo 26). The wetland buffer is limited in how it can form protective services to the wetland, with the vegetation consisting of rank pasture grasses or gorse.

Photo 23. Upper portion of Wetland 1a vegetation

Photo 24. Bed conditions in upper portion of Wetland 1a

Photo 25. Monoculture in lower portion of Wetland 1a

Photo 26. Bed condition in lower portion of Wetland 1a.

Photo 27. Wetland 1b

Photo 28. Wetland 1b where it discharges to Stream 5b

5.1.8 Wetland 2

Wetland 2 consists of two small wetlands located on the upper reaches of Stream 4 (Wetland 2a and 2b), and one large wetland (Wetland 2c) on the downstream extent of Stream 4 (three wetlands in total) on the northern portion of the site (Figure 6). These wetlands are hydrologically connected via Stream 4, and are palustrine swamps of low ecological value. The wetland within the headwaters was 280 m^2 in size, the upper portion of Wetland 2 was 570 m^2 in size, and was located within a vale, with steep gullies immediately upstream and downstream of the wetland; whilst the lower portion covers the base of a wide gully and is approximately 4,970 m^2. Wetland 2 consists of a monoculture of grazed reed-sweet grass with sparse fan-flowered rush, lotus and buttercup (*Ranunculus* sp.) present (Photo 29, Photo 30).

The wetland was not fenced and impacted by livestock through pugging and grazing. Standing water and saturated soils were present throughout the wetland, however the bed damage from livestock has likely restricted water flows through the wetland to be still or very slow flowing (Photo 31, Photo 32). Like Wetland 1, the wetland buffers were poor and did not provide any protective services and consisted of grazed pasture grasses.

Photo 29. Upper wetland 2 vegetation.

Photo 30. Bed condition of Upper Wetland 2.

Photo 31. Variable riparian vegetation on the largest portion of Wetland 2

Photo 32. Typical vegetation composition within the large portion of Wetland 2

5.1.9 Wetland 3

Wetland 3 cumulatively consists of three wetlands (Wetland 3a – 3c), located within the same catchment as Stream 2 (Figure 4). Due to the topography and site conditions, these wetlands were surveyed via high quality drone imagery (Photo 33 – Photo 36). Collectively, they form low-value palustrine wetlands situated at the base of gullies, with widths of up to 14 m wide and a cumulative area of 752 m^2.

Vegetation within the wetlands was dominated by herbaceous species, with evidence of stock access, including pugging depressions. It is likely these wetlands were historically stream systems that, through stock access, these conditions have facilitated the development of natural inlands wetland features. This is apparent when compared to streams (Stream 2), where shading and reduced stock intrusion have maintained more defined stream channels. Drone imagery confirmed the presence of standing water and saturated soils in more exposed areas. Hydrology within these wetlands is likely characterised by sheet flow through vegetation and discrete pools. Riparian vegetation was poor, consisting of gorse with pampas and woolly nightshade, however the lower extents closest to the SEA has a higher proportion of mature indigenous vegetation.

Photo 33 – Photo 36. Typical wetland characteristics within Wetland 3a, 3b and 3c.

5.1.10 Wetland 4a – 4b

Wetland 4a – 4d are herbaceous wetlands located within overland flow paths on the western portion of the site (Figure 5), contributing to the same catchment as the Stream 1 systems. Collectively, they form low-value palustrine swamps within a narrow flow path, with a cumulative area of 1,714 m^2.

Vegetation within Wetland 4 supported a higher indigenous species richness compared to other site wetlands, including sharp spike sedge, and fan-flowered rush. However, exotic species remained dominant, with high cover of Yorkshire fog, soft rush and floating sweet grass (*Glyceria* sp.) (Photo 37 – Photo 40).

Hydrological conditions consisted of standing water and boggy ground, though dense vegetation limited the degree of open water pooling. Evidence of livestock access and damage was present, with the wetland bed and banks pugged, however the high density of gorse within the riparian yard may have limited the degree of stock access.

Photo 37-40. Typical wetland characteristics within Wetland 4a and 4b.

6 FRESHWATER OFFSET

As the proposed stream loss cannot be avoided, minimised or remedied, it will instead be addressed through offsetting and compensation measures through the enhancement of aquatic habitats. This section details the stream offsetting approach via the application of the SEV/ECR methodology.

The loss of stream habitat will be offset through the restoration of the aforementioned streams at the offset and compensation site to ensure a no-net-loss outcome. The SEV/ECR methodology, as recommended by Auckland Council, accounts for both values and extent (length and bed area) of a stream. An integral part of the model is that there should be no loss in stream extent in the calculations, and if, when all the stream habitat functions have been accounted for, the proposed offset length is less than the impacted length, then additional offset length must be included, to a minimum of the impact length.

All suitable stream lengths available for offset at Oldfield Road has been utilised through the ECR methodology, however a residual 1,587 m of stream extent and value (namely Stream 4, Stream 7 and Stream 9-13) remains unaccounted for under the ECR framework. To address this, it is proposed that the residual stream length and values be compensated for through the restoration of natural inland wetland, as described in Section 8 - Freshwater Compensation. It is likely that following restoration activities, including stock exclusion, fencing and revegetation of the 20 m riparian yard, some of these wetland features will revert back to their original aquatic habitat and may reform as streams (such as Wetland 3).

As outlined above, values and extent should be considered as a single, integrated concept under AUP OP policy E3.3(18) and the NPS-FM. To ensure a net gain, and in recognition of the loss of high value streams, additional compensation measures are proposed through wetland restoration and enhancement beyond that required to address residual loss.

6.1 Environmental Compensation Ratio

The current SEV scores for streams within the Project Area range from 0.64 and 0.83 (Table 3). The potential SEV scores were assessed as equivalent to the current values, as the ‘potential’ assessment assumes land use practices such as riparian planting, and the Project Area is already fully vegetated. For Stream 6 – 9, the potential for riparian planting was considered low due to adjacent roading along the modified reaches, resulting in a potential SEV score of 0.66. The proposed loss of the stream reaches would therefore produce an impact SEV of 0.0.

The current SEV score of the proposed restoration streams at 142 Old field Road range from 0.42 to 0.47. Following restoration and enhancement of riparian vegetation (including instream enhancements), these streams have the potential to achieve SEV scores between 0.70 – 0.84.

Table 2 presents a summary of the SEV inputs to the ECR, including the areas of loss and the parameters of the offset site, with further summary data presented in Appendix B.

Table 3 provides the range of offset site data used for the ECR, while Table 4 summarises the offset SEV scores, stream lengths, and stream widths applied in the ECR calculations. Additional detail is presented in the Appendices.

Table 2. Estimation of area of compensation and ECR Inputs

ECR Inputs and Calculation	
Impact Streams	
SEVi-Current (range)	0.64-0.83
SEVi-Potential (range)	0.66-0.83
SEVi-Impact	0.0
Stream bed area loss m²	1,119
Stream length loss m	2,439
Average stream width (range) m	0.22 – 0.93
142 Oldfield Road	
SEVm-Current (range)	0.42-0.47
SEVm-Potential (range)	0.70 – 0.84
Average stream width (range) (m)	0.29 – 0.60
Length of stream offset (m)	852

Table 3. Summary SEV, stream length and stream width data from the 142 Old Filed Road Offset Site for ECR

Offset stream	SEV Current	SEV Potential	Length (m) available	Stream Width (m)
Stream 1a & 1b (SEV1)	0.46	0.74	430	0.57
Stream 2a – 2g (SEV2)	0.47	0.75	1,038	0.60
Stream 3a & 3b (SEV3)	0.45	0.71	283	0.29
Stream 4 (SEV4 permanent)	0.48	0.84	250	0.60
Stream 4 (SEV4 intermittent)	0.45	0.71	72	0.56
Stream 5a & 5b (SEV5)	0.44	0.72	268	0.56
Stream 6a & 6b (SEV6)	0.38	0.71	310	0.57

The ECR calculations area presented as a rolling calculation table in Appendix C, and in summary as Table 4.

Table 4. Summary of Results of ECR calculations location of offset for each Impact Stream reach (refer Appendix C).

Impact Stream ID	Offset Stream/s and SEV	ECR	Compensation method
Stream 1	SEV4 and SEV1	3.32 & 4.5	Enhancement
Stream 2	SEV1 and SEV2	4.5 & 4.5	Enhancement
Stream 3	SEV2	4.34	Enhancement
Stream 5	SEV4(i) and SEV5	4.85 & 4.85	Enhancement
Stream 6	SEV2, SEV3 & SEV6	3.41, 3.81 & 3.30	Enhancement
Stream 8	SEV6 & SEV5	3.30 & 3.81	Enhancement

The ECR methodology accounts for stream extent and value through and recognises that there are values associated with edge habitat and the proximity to banks and requires that the minimum replacement length must at least be equal to stream length lost to appropriately offset the loss of stream extent and value at the Project Area. The quantum of offset for the stream that will be lost to Stage 2 works, using the SEV/ECR methodology, is greater than the 3,391 linear metres and 1,145 m^2 of stream bed is available at Oldfield Road. As although the extent and value of stream proposed for restoration at Oldfield Road exceeds the stream length being lost, the ECR ratio analysis indicates that the ecological gains are insufficient to fully offset the loss in terms of stream value and extent. Specifically, 1,587 linear metres of stream length and its associated values cannot be accounted for under the ECR framework, representing a residual loss.

To address this, the residual stream extent and values will be compensated through additional measures, as described in Section 7.

6.2 Biodiversity Gains and Habitat Enhancement

Biodiversity gains at the offset site will be achieved through a suite of restoration and enhancement measures designed to improve overall habitat condition. These include restoration planting within the 20 m riparian yard of the streams, exclusion of livestock through fencing, and ongoing weed control to support the establishment and persistence of the restoration plantings (Figure 8).

Further gains will be realised through the removal of three culverts located on the northern portion of the site (Figure 7), reinstating natural stream connectivity and improving fish passage. Collectively, these actions will enhance aquatic and riparian habitat quality, contributing to long-term ecological resilience and biodiversity outcomes.

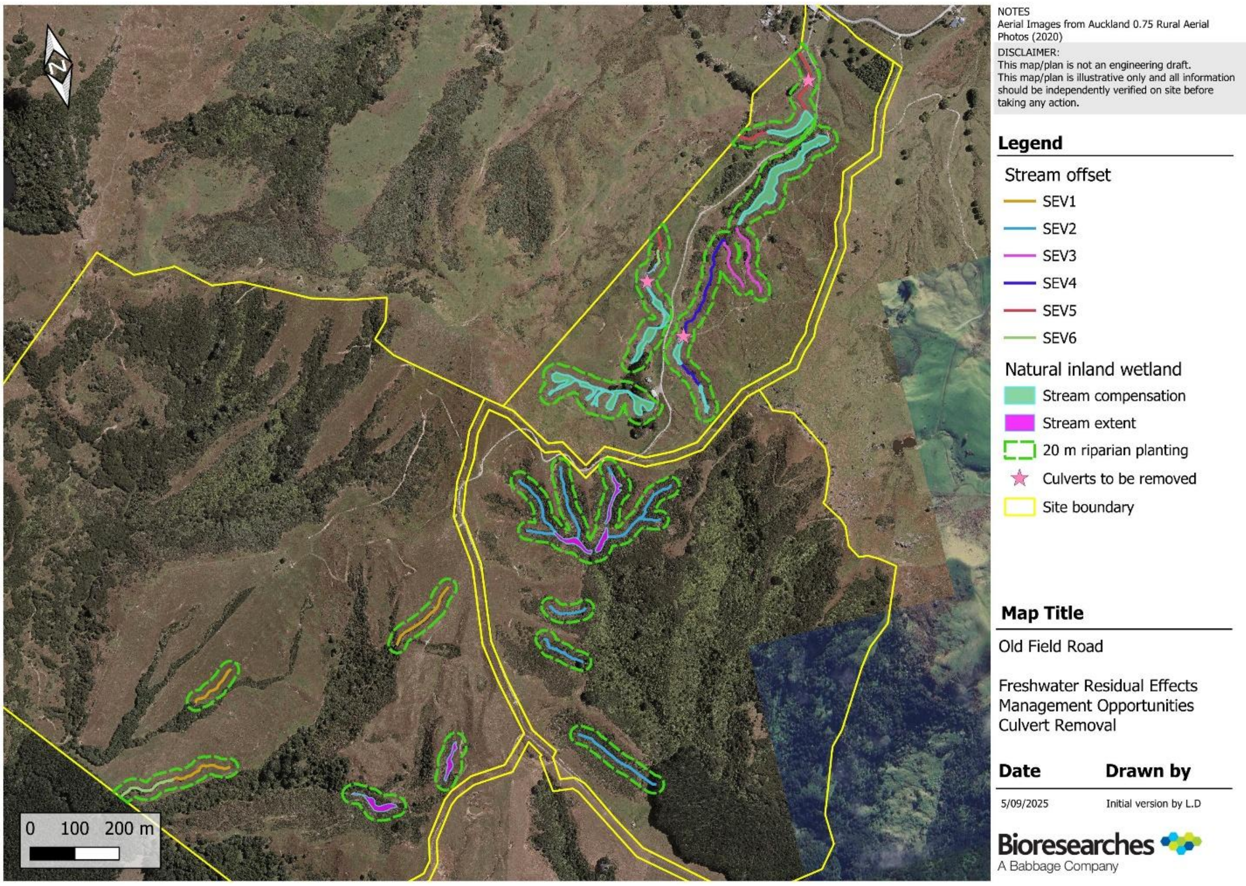

Figure 7. Location of the three culverts to be removed for biodiversity gains. Note wetland and stream names have been removed for clarity.

Combined with these enhancement activities, habitat creation is proposed through restoration planting of species representative of the early successional stages towards a native forest habitat. The restoration planting will deliver a range of aquatic ecological benefits by replacing pasture grass and/or weed species with native shrubs and trees in the riparian zone. Benefits include improved temperature regulation and shading (reducing nuisance aquatic vegetation growth), the recruitment of woody debris in the streams (increasing habitat complexity and refuges for invertebrates and fish), stabilisation of channel banks and morphology, and reduced nutrient and sediment inputs into the streams.

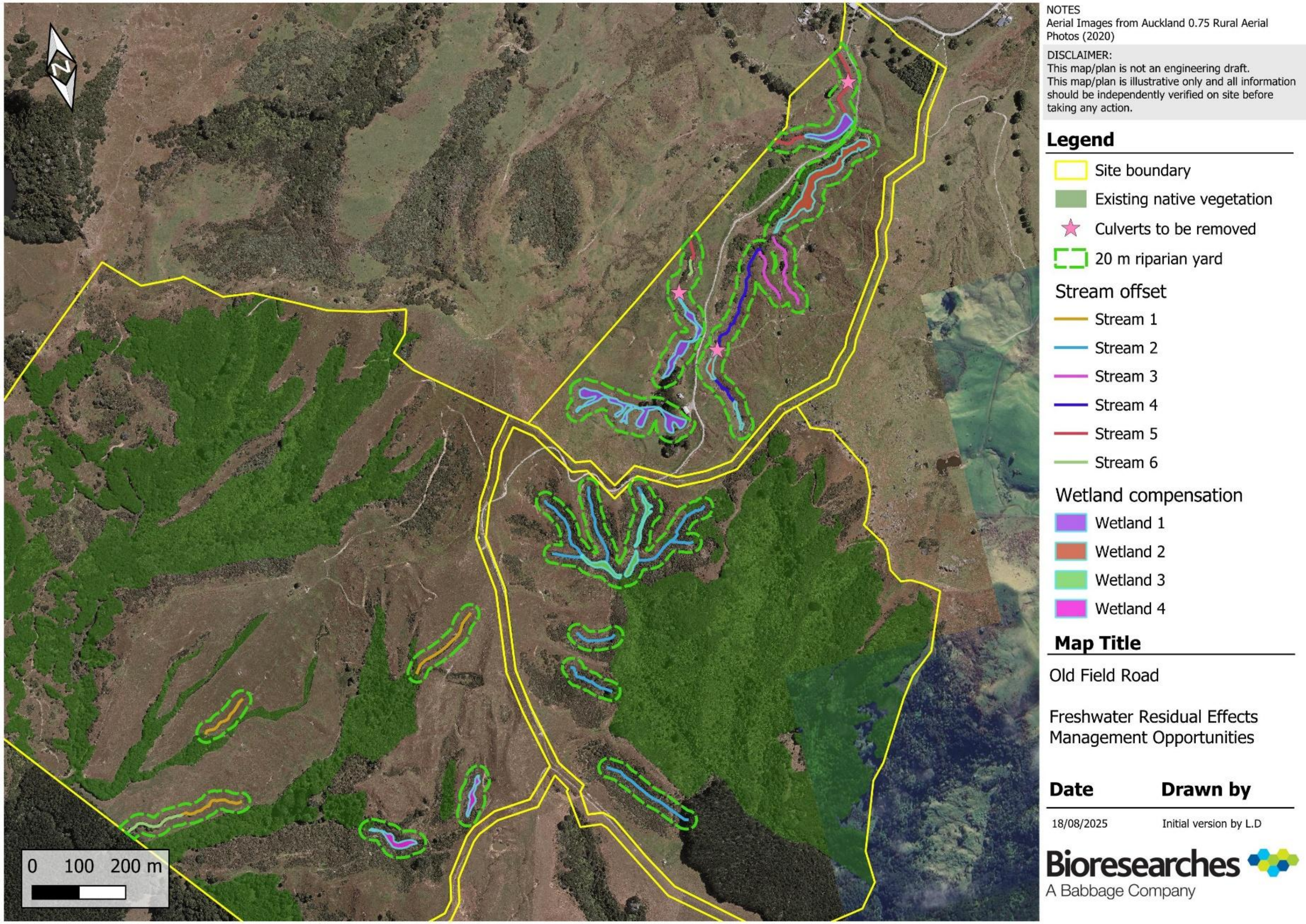

Figure 8. Proposed freshwater offset (riparian planting) and compensation (wetland planting) measures to be undertaken at Oldfield Road

7 FRESHWATER COMPENSATION

7.1 No-Net-Loss

When referring to stream loss, both the NPS-FM and AUP OP define it in terms of *extent and values*. We concur with this interpretation of stream extent and values as one concept. It is acknowledged, however, that debate exists among practitioners regarding this issue, as raised during the Covid-19 Fast Track consent application for Kings Quarry. The argument raised is that SEV and ECR calculations account only for the loss of stream *values*, while the Project will also result in the net-loss of stream *extent*. We do not agree with this approach as the SEV/ECR methodology was designed for stream loss in the Auckland Region, accounting for extent and values in a single concept (i.e. stream reclamation).

In addition, once all the stream biodiversity values have been offset (including ensuring the offset extent is at a minimum equivalent to the length lost), there are no additional and separate biodiversity values associated with length i.e. length has absolutely no biodiversity values to offset if all the ecological values have already been offset over an equivalent length. If these two concepts were to be addressed separately extent alone would then require a minimum of 2.4 km of stream creation would therefore be required; through the construction of new channels (by diverting water from another aquatic habitat) or the daylighting of urban streams.

Daylighting is not considered practicable due to the scale of piped stream length that would be required for this, with such infrastructure typically associated with the urban environments. Even if feasible, daylighting would not achieve a like-for-like offset: restored streams would be located within an urban settings, where riparian buffers are constrained and would be dissimilar to those buffers in the Project Area. Urban environments typically receive high inputs of pollutants from roading run-off, diffuse source pollution, rubbish and refuse, and potentially wastewater overflow (Chakravarthy *et al.*, 2019), compromising water quality where sensitive organisms, such as spiny gilled mayfly (*Coloburiscus humeralis*), present in the Project Area which would be unlikely to colonise (Gadd *et al.*, 2020). Additionally, there would likely be restrictions on the continual length of pipe able to be daylighted, with the proposed offset being fractured into multiple sections, rather than a continuous stream channel. This would therefore result in sections of piped reach throughout the offset that may not be possible to daylight with possible barriers to fish passage associated with these piped sections. Considering these constraints and limitations in the urban environment, it is unlikely a greater than 'Moderate' ecological value would be achieved

Similarly, the creation of stream length, likely within the rural setting due to space requirements, is considered to be inappropriate. It may be possible to achieve 'Moderate' to 'High' ecological values through careful design and accounting for the natural movement of sediments (being dependant on the underlying geologies and landform of the area), connectivity to the wider environment, in-stream structures and habitats, and riparian planting. If the system of channels were to be constructed to the required bed area (i.e. 2,439 m) to offset the Stage 2 expansion were to be constructed to replace the lost stream extent and achieve no -net-loss, adverse effects to the immediate catchment will likely occur. This would likely result in the permanent diversion of water (and to an extent, groundwater) likely resulting in adjacent stream reaches and/or wetlands drying out or experiencing reductions in hydrological inputs, such as water flow and level, which would in turn lead to increased temperatures and nutrient/contaminant concentrations, reduced aquatic habitat and aquatic connectivity (Ministry for the Environment, 2020c), which would require these values to then be offset. This reduction in contributing catchment is observable through the historic implementation of farm drains, throughout rural New Zealand leading to a reduction in wetland extent.

Putting aside the impracticality of daylighting and/or creating 2.4 km of stream reach, these restoration activities would result in a perverse ecological outcome, as they would result in streams which are not ecologically feasible or of 'Very High' or greater ecological value to adequately replace those streams lost at the Project Area, or may result in adverse effects to adjacent waterbodies, leading to an overall poor ecological outcome.

7.2 Residual stream loss

Due to the lack of sufficient stream extent available at 142 Oldfield Road and Kings Quarry (outside the project footprint), the ECR and SEV methodology cannot sufficiently offset the stream loss. As a result, 1,587 linear metres and 830 m^2 of stream bed habitat remain unaccounted for within the ECR model. To compensate for this residual loss of stream extent and values, restoration of degraded natural inland wetlands at Oldfield Road is proposed.

The ratio/quantum of ecological restoration and enhancement was determined using the ECR values, applying both minimum and maximum ECR scores to capture stream extent and value. The ECR analysis indicated that between 3.3 times and 4.85 times the impacted stream area should be restored. On this basis, a wetland restoration ratio of 1:8.15 was determined (1:3.3 for stream extent and 1:4.85 stream value). This equates to a minimum of 15,507 m^2 of wetland restoration required to compensate for the residual loss.

The Project is proposing to restore a total of 17,420 m^2 of wetland habitat across Oldfield Road. This provides approximately 1,900 m^2 of additional natural inland wetland being restored to account for above the calculated minimum requirement of 1.55 ha. The scale of this restoration (1.74 ha) far exceeds the extent of stream habitat lost, and the proposed compensation is expected to result in a net positive outcome for freshwater ecological values.

7.3 Wetland Restoration

The project will result in an overall loss of stream extent and values. To compensate for this, wetland restoration is proposed at Oldfield Road, which would provide significant biodiversity gains through the enhancement and buffering of 17,420m^2 of degraded headwater wetlands.

7.3.1 Ecological and landscape context

This stream compensation approach will replace the loss of stream with a rare and threatened ecosystem type of natural inland wetland. The Oldfield Road wetlands are located approximately 36 km from the marine environment at the Kaipara Harbour, with an elevation of 120 – 180 m above sea level, within the upper portions of hilly land with a pastoral catchment. This is similar to Kings Quarry, where Stage 2 is approximately 70 m to 170 m above sea level and drains into the Kaipara Harbour 29 km downstream.

7.3.2 Restoration approach

The proposed enhancement vegetation will be complex with multiple structural tiers and appropriately designed for the Rodney Ecological District. The planting will create an indigenous wetland ecosystem and buffers while also providing for green corridors up the site, into the terrestrial offset planting, resulting in an increase in ecological linkages and steeping stones to indigenous forest within the local area. This planting will also consolidate a large portion of both the freshwater and terrestrial offset and compensation planting to one area, rather than establishing discreet and isolated patches of restoration throughout the Rodney Ecological District. Additionally, the removal of reed-sweet grass from the upper reaches will then minimise the spread of seeds and rhizomes to the lower reaches.

7.3.3 Biodiversity benefits

Fauna habitat will be greatly improved through animal pest control, planting and weed control and buffer enhancements to create a high-quality ecosystem which will increase in habitat for At Risk fauna throughout the wetland, including fish and avifauna. The wetlands currently contain one hydrological unit which will be enhanced and diversified through wetland planting and restoration. This will likely result in a more naturalized hydrological regime and increase the wetlands ability to act as a filter for nutrients and sediment, and a regulator of water flows.

The restoration of headwater wetlands will benefit lower reaches through reducing the levels of contaminants and sediments transported downstream through the natural wetland filtration process (Uuemaa *et al.*, 2018). This would particularly benefit the offset gains on Stream 4, with the quality of water being discharged into the downstream receiving environment being of higher water quality following fencing and planting of the wetland and its margins (Brydon *et al.*, 2006). This higher water quality will likely result in the colonisation of more sensitive taxa, such as the spiny-gilled mayfly to the offset stream habitats. Plant diversity, biomass and rarity will be improved upon through the wetland planting, which will become a regenerating ecosystem over time.

7.3.4 Implementation and monitoring framework

All proposed restoration activities will have their methodologies detailed in a Wetland Restoration Planting Plan, covering both the wetland and riparian buffers. Due to the extent of the wetland, the restoration activities will likely be undertaken in staggered blocks, to allow for a comprehensive restoration.

- The enhancement/restoration wetland will be divided into bands, in which the restoration activities will be staggered. This will allow for the intensive works associated with the restoration to be comprehensively carried out.
- Vegetation removal of pest vegetation, namely willow and reed-sweet grass. Vegetation removal will ideally be undertaken within the warmer summer months, where water levels are lowest. This will also be aided by the canopy cover of the willows providing shade to the wetland. Reed-sweet grass is intolerant of full shade (Weedbusters, 2024).
- Replanting of the currently 'Exotic wetland' portion of the restoration wetland with indigenous wetland species, allowing it to develop the characteristics for an indigenous wetland ecosystem. Due to the hydrology of the wetland, multiple planting zones are available, with the planting of obligate wetland species used.
- Fencing of the restoration wetland and its 20 m buffer (as prescribed in the AUP OP E3), using a combination of new and existing fencing.
- Carrying out ongoing weed control, and if needed, replacement planting to ensure at least a 90% coverage is maintained in the wetland and replanted buffer areas.
- Carrying out pest control within the wetlands and 20 m buffers to reduce pest animal densities. Monitoring of pest control success should be undertaken.
- Monitoring of planting success, to be undertaken at year 1, 2, 3, 4, 5 post planting for each restoration block.
- Annual wetland monitoring should be undertaken in general accordance with Clarkson *et al.* (2004). This monitoring should include sufficient measures to assess of the expected uplift in ecological value is occurring, and if not, recommended additional measures to ensure this occurs.

7.4 Additional Stream Extent Compensation

In addition to the wetland enhancement actions at Oldfield Road, it is proposed to remove an instream structure within Waitoki Stream (at Project Area) to provide further compensation for the loss of stream extent.

Instream structures typically result in modified habitats through changes in water depth, water velocities, alterations to sediment distribution and deposits and erosion, and stream fragmentation and species loss/biodiversity reductions (Poff and Hart 2002; Jellyman and Harding 2012; Birnie-Gauvin et al. 2017). The Waitoki Stream weir currently restricts freshwater connectivity through altering flow regimes and the movement and flows of sediments and aquatic fauna with increases in water depth, proportions of fine sediments, and decreases in water velocity, all of which is observable upstream of weir, indicating alteration through backwatering is present. The weir acts as a barrier to fish passage, with only those species with very strong climbing ability, such as juvenile eels (*Anguilla* sp.) and juvenile banded kōkopu (*Galaxias fasciatus*), likely to navigate the structure, resulting in a reduction in the dispersal of freshwater fish through the Waitoki Stream. While common bully (*Gobiomorphus cotidianus*), were detected upstream of the weir, it is likely a population was present upstream prior to the installation of the weir, and established a "landlocked" breeding population following the weir installation.

The removal of the weir will result in the restoration in connectivity to 3,468 m linear metres of stream extent in the upper Waitoki Stream. The removal of the weir will enable the movement of a diverse range of fish populations, through all life stages, to the upstream environment and provide access to a variety of high value aquatic habitats. Additionally, there may be an increase in the genetic diversity of common bully, if the population above the weir have been "landlocked" for a period of time.

Ecological benefits extend beyond fish passage. Removal of the weir will improve connectivity and movement of particles, such as natural sediments and substrates, leaf litter and wood, throughout the Waitoki Stream. Backwatering effects of the weir in the upstream reach are present, with much of the upper catchment consisting of slow flowing runs over fine sediments. The removal of the weir will remove the backwater effects, and restore the hydrological variation throughout the upper Waitoki Stream. It is likely that within a short-term scale, run-pool-riffle sequences will be restored throughout the upstream reach as hydrology and sediment transportation are naturalised, increasing the degree of bully habitat and variety of other native fish habitats throughout the reach.

The primary adverse effect of the weir removal is the release of fine sediments to the downstream receiving environment during works. An Erosion and Sediment Control Plan should be prepared and implemented during the removal of the weir to minimise the degree of disturbance to the watercourse, including specific measures to avoid localised sedimentation and the release of fine sediments to the downstream receiving environment. The affected bed and banks of the Waitoki Stream should be stabilised through rock armaments or a similar structure, replicating the existing stream substrates and minimising erosion and scour.

8 PRINCIPLES OF AQUATIC OFFSET AND COMPENSATION

Because the stream reclamation results in the permanent loss of open, natural stream habitat, it is not possible to address all the adverse effects via mitigation. The NPS-FM sets out eleven principles that underpin the concept of aquatic biodiversity offsetting and compensation. These principles are identified in Table 5 and

Table 6 with a brief explanation of how the proposed aquatic habitat offset for the site will appropriately implement or satisfy them.

Table 5. Principles of Aquatic Offsetting from the NPS-FM, and how these will be achieved for the proposed works.

Offsetting principle	How this will be achieved
Adherence to effects management hierarchy	Ecological values and effects assessments prior to works. Avoidance/ minimisation of ecological effects through design. Mitigation of potential adverse effects on freshwater fauna with a Native Fish Recovery and Relocation Plan. Identification of residual adverse effects, after avoid, remedy and mitigate measures, and where significant, calculate offset to provide no net loss, and preferentially a net biodiversity gain.
When aquatic offsetting is not appropriate	Assessments prior to offset. The ecological values of the habitats proposed for offset are assessed as High, but the streams and stream type is well represented in the local area.
No net loss and preferably a net gain	Accounting using the SEV and ECR methodology for stream loss. The proposal will not result in a measurable reduction in the population size, range or long-term viability of indigenous species. The restoration of streams will result in a net gain in stream area quality and biodiversity values.
Additionality	There are no current or future plans to undertake any of the proposed revegetation and restoration actions.
Leakage	The aquatic offset design and implementation will avoid displacing harm to this location, and will ensure that potential harm to existing biodiversity will be mitigated and temporary.
Long term outcomes	All restoration actions will be legally protected in perpetuity, and monitored for a minimum 5 years to ensure offset targets are achieved.
Landscape context	Restoration and offsets, including habitat creation, will be carried out within 26 km from the Project Area. The lengths of streams and wetlands will be planted with riparian vegetation to create ecological linkages and green corridors through the intermittent headwater streams, and create buffered areas that provide habitat for fauna to access both the permanent streams and its tributaries will be subject to offset planting.

Offsetting principle	How this will be achieved
Time lags	The SEV/ECR model has a time lag component incorporated within the methodology and improvements at the offset site will be effective immediately upon restoration and planting of the offset streams and wetlands as minimal trees or shrubs are currently present, with canopy closure resulting in at least 70% shading to the streams predicted well within the five-year maintenance period.
Science and mātauranga Māori	The design of the biodiversity offset will be based on established and proven methods for fauna and flora management and restoration. The biodiversity offset will provide careful consideration to opportunities for maximising ecological outcomes as well as providing for interests of the landowners and including tangata whenua.
Tangata whenua or stakeholder participation	Ngāti Whātua o Kaipara have been consulted through this process and have visited the Project Area, including a number of the watercourses to be removed and provided input via their CIA. Auckland Council has been consulted via an application review process.
Transparency	The Stream Ecological Valuation (SEV) methodology combined with the calculation of the Environmental Compensation Ratio (ECR) is a transparent, well-recognised methodology for calculating the quantum of offset required for stream loss. (Storey *et al.*, 2011). Although the methodology was originally developed in Auckland, it has been reviewed by NIWA for use in Wellington, Hawke's Bay and Southland, and is considered applicable without modification to most stream and river types in those regions. (Storey *et al.*, 2011). Accounting using the SEV and ECR methodology for stream loss, are tabulated in the report with additional data provided in the Appendices.

Table 6. Principles of aquatic biodiversity compensations outlined in the NPS-FM, and how these will be achieved for the proposed works.

Compensation principle	How this will be achieved
Adherence to effects management hierarchy	An Ecological Effects Assessment has been completed (Bioresearches, 2025), and through this process the effects management hierarchy has been applied. Avoidance/ minimisation of ecological effects through design has been proposed where-ever this has been practicable/possible. Mitigation of potential adverse effects on freshwater with a Native Fish Recovery and Relocation Plan has been undertaken for other aspects of the project. The loss of stream extent and residual stream extent and values cannot be reasonably offset through the construction and/or daylighting of 2.4 km of new stream length. Therefore, the loss of stream extent must be compensated for. Identification of

Compensation principle	How this will be achieved
	residual adverse effects, after undertaking all feasible avoidance, remediation and/or mitigation measures, has identified stream loss.
When aquatic compensation is not appropriate	Compensation can achieve the conservation outcomes specified in the NPS FM. There is no net loss of irreplaceable habitat; there is adequate certainty about the success of the proposed compensation measures; and it is the most technically feasible option to address the residual effects after application of the initial steps of the effect's management hierarchy.
Scale of aquatic compensation	The proposed expansion will result in a loss in stream extent. The proposal will result in 17,420 m^2 of wetland restoration from exotic, unbuffered wetlands to indigenous wetlands with native buffer planting which far exceeds the proposed of stream loss at the impact site. Downstream effects of the quarry will be avoided through hydrological mitigation and management where required. Effects to fauna utilising the streams are adequately managed as described above. It is expected that the uplift in ecological value and consequently the ecosystem services provided by the restoration of a of wetland will adequately compensate for the loss in stream bed area; and will lead to a net positive outcome for biodiversity values, including wetland function and habitat availability for fauna (such as wetland birds) within the wider ecological area.
Additionality	There are no current or future plans to undertake any of the proposed revegetation and restoration actions.
Leakage	The aquatic compensation design and implementation will avoid displacing harm to the restoration wetland location; and will ensure that potential harm to existing biodiversity will be mitigated and temporary.
Long term outcomes	All restoration actions will be legally protected in perpetuity and monitored for a minimum 5 years to ensure compensation targets are achieved.
Landscape context	The proposed compensation wetland is located 26 km from the Project Area. They are within the same ecological region and ecological district; and are all considered to be a very similar wetland type. This is discussed further in Section 6.1.

Compensation principle	How this will be achieved
	Both wetlands, and impact streams drain into the Kaipara Harbour, within a similar landscape, elevation and distance prior to entering the marine environment.
Time lags	Within the restoration wetlands, herbaceous wetland planting tiers will establish within a season, and will be replacing dominantly exotic species; with the shrub and tree-tiers taking longer to establish. This is time lag is assessed as temporary and short term. Monitoring of the plantings will be undertaken in general accordance with the Clarkson et al., 2003 'Handbook for Monitoring Wetland Condition'. A five-year period for monitoring is considered adequate.
Trading up	When trading up forms part of aquatic compensation, the proposal demonstrates that the aquatic extent gained are demonstrably of greater or higher value than those lost. The loss of intermittent and permanent stream extent, considering some values will be offset, and residual stream length and values will be replaced with the restoration of indigenous wetlands, a recognised rare and threatened ecosystem type. The proposal also shows the values lost are not comprised of Threatened or At Risk/Declining flora or fauna species or species considered vulnerable or irreplaceable. The compensation wetland replacing the stream extents will be of higher ecological value and ecosystem rarity.
Financial contribution	This is not a consideration at this site.
Science and mātauranga Māori	The design of the biodiversity compensation will be based on established and proven methods for fauna and flora management and restoration. The compensation will provide careful consideration to opportunities for maximising ecological outcomes as well as providing for interests of the landowners and including tangata whenua.
Tangata whenua or stakeholder participation	Ngāti Whātua o Kaipara have been consulted through this process and have visited the Project Area, including a number of the watercourses to be removed and provided input via their CIA. Auckland Council has been consulted via an application review process.
Transparency	The wetland compensation calculations are based on the primary attributes of the wetlands, which have been assigned in accordance with nationally and regionally accepted reference documents,

Compensation principle	How this will be achieved
	including Johnson and Gerbeaux (2004) as published by the Department of Conservation and the Ministry for the Environment; as well as the EIANZ guidelines for assigning ecological values. Detailed mapping of the existing condition of the restoration wetlands and their existing riparian buffer zones was also undertaken. These maps are provided within this report. A site-specific planting plan will be developed, and success monitoring of the restoration activities is recommended; and regular maintenance and monitoring reports will be provided to Council and (where appropriate) other stakeholders.

9 CONCLUSION

The expansion of Kings Quarry will result in the permanent loss of 2,439 linear metres of stream. To address this loss, offsetting and compensation measures are proposed using the SEV / ECR methodology, applied to streams located approximately 26 km north of the impact site. As part of the offset package, stream enhancements will include riparian planting and fencing. At 142 Oldfield Road, 3,391 linear metres of stream will be enhanced with 20 m of riparian planting and stock exclusion.

Residual stream extent and values that cannot be accounted for through the ECR methodology will be compensated via the restoration of 1.74 ha of degraded wetland habitat, reinstated to indigenous wetlands with associated 20 m buffer. Additional ecological gains will be procured through the removal of a weir, acting as a barrier to fish passage within the Waitoki Stream (at the Project Area); its removal will restore connectivity to approximately 3.468 km of stream extent. This will result in the restoration of stream hydrology, sediment transportation and the movement of aquatic fauna through all life stages. This action will increase fish biodiversity, and restore habitats and natural stream processes through the upper Waitoki catchment.

Collectively, the restoration and enhancement of degraded aquatic habitats will deliver a positive aquatic ecological outcome, secure biodiversity gains and restore connectivity to existing habitats.

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Appendix A

Kings Quarry Stage 2 Stream Summary

Appendix 1. Stream characteristics within the Kings Quarry Stage 2 Footprint.

	Southern System	Central System	Northern System	Stream 13
Representative Stream	Stream 4	Stream 7	Stream 10	-
Habitat Features				
Average width (m)	0.64	0.47	0.37	0.93
Average depth (m)	0.05	0.04	0.04	0.11
Dominant substrate	Gravels and bedrock	Gravels	Silt/clay	Gravels
Macrophyte abundance	Nil	Nil	Nil	Nil
Riparian vegetation	Mature indigenous vegetation	Regenerating indigenous vegetation, long grasses, exotic shrubs	Mature indigenous forest	Mature indigenous forest
Water Quality				
Date	08/09/2023	08/09/2023	07/09/2023	07/09/2023
Time	13:55	11:25	13:00	
Temperature (°C)	12.1	11.5	13.2	12.6
Oxygen Saturation (%)	89.1	89	89	93
Dissolved Oxygen (mg/L)	9.7	9.8	9.3	10.0
Conductivity (µS/cm)	103.1	54.3	93.6	140.7
Macroinvertebrates				
Sampling protocol	Hard bottomed	Hard bottomed	Soft bottomed	Hard bottomed
No. of taxa	10	8	11	16
Dominant taxon	*Potamopyrgus* snail	Orthcladiinae	*Potamopyrgus* snail	*Coloburiscus*
EPT	5	3	4	9
%EPT*	46	17	22	92
MCI	102 'Good'	103 'Good'	139 'Excellent'	139 'Excellent'
SQMCI	6.00 'Good'	2.93 'Poor'	5.78 'Good'	7.62 'Excellent'
Fish				
Species Recorded	*Kōura*	Nil	Longfin eel	*Kōura*
Number of Fish	-		1	-
Fish IBI score**	-		30 'Fair'	-
Stream Ecological Valuation	SEV2*	SEV 3	SEV2	SEV1
SEV score	0.73	0.47	0.79	0.62

Appendix 2. Impact stream locations in relation of the wider catchment

Site Name	Location
Stream 1	Intermittent and stream to the Waitoki Stream on the southern side
Stream 2	Intermittent stream to the Waitoki Stream on the southern side
Stream 3	Intermittent and permanent stream to the Waitoki Stream on the southern side
Stream 4	Intermittent stream to the Waitoki Stream on the southern side
Stream 5	Intermittent stream to the Waitoki Stream on the southern side
Stream 6	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches
Stream 7	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches
Stream 8	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches
Stream 9	Intermittent stream to the Waitoki Stream within the centre. Contains modified reaches

Site Name	Location
Stream 10	Intermittent and permanent tributary to Stream 13 on the northern side
Stream 11	Intermittent and permanent tributary to Stream 13 on the northern side
Stream 12	Intermittent and permanent tributary to Stream 13 on the northern side
Stream 13	Permanent stream and tributary to the Waitoki Stream, northern most watercourse in the expansion footprint.

Appendix 3. Impacts stream extents

Stream	Classification	Length (m)	Width (m)	Stream bed area (m^2)
Stream 1	Intermittent	204	0.41	59
Stream 2	Intermittent	136	0.3	26
Stream 3	Modified Intermittent	70	0.22	15
	Intermittent	65	0.22	14
	Permanent	30	0.22	7
Stream 4	Intermittent	153	0.22	89
	Permanent	132	0.64	84
Stream 5	Intermittent	78	0.49	38
Stream 6	Intermittent	55	0.29	16
	Modified intermittent	161	0.35	56
Stream 7	Intermittent	153	0.47	52
	Modified intermittent	54	0.35	19
Stream 8	Intermittent	53	0.31	16
Stream 9	Intermittent	131	0.27	27
	Modified intermittent	23	0.35	8
Stream 10	Intermittent	58	0.37	21
	Permanent	187	0.37	69
Stream 11	Intermittent	166	0.38	63
	Permanent	77	0.38	29
Stream 12	Intermittent	19	0.4	8
	Permanent	150	0.4	60
Stream 13	Permanent	284	0.93	169
Total	**-**	**2,439**	**-**	**1,119**
Total Modified		**308**	**-**	**99**
Total Intermittent		**1,271**	**-**	**507**
Total Permanent		**860**	**-**	**514**

Appendix B

Current and potential SEV scores of the impact and offset streams

Table 7. Summary Current SEV data from impact streams

Function Category	Report Section	Function	Stream 4	Stream 7	Stream 10	Stream 13
Hydraulic	4.1	NFR	0.93	0.80	0.93	0.83
Hydraulic	4.2	FLE	0.68	0.05	0.68	0.16
Hydraulic	4.3	CSM	1.00	1.00	1.00	1.00
Hydraulic	4.4	CGW	0.90	0.90	0.96	0.92
Biogeochemical	4.5	WTC	0.92	0.68	0.92	0.90
Biogeochemical	4.6	DOM	1.00	1.00	1.00	1.00
Biogeochemical	4.7	OMI	0.95	0.67	0.95	1.00
Biogeochemical	4.8	IPR	0.96	0.76	0.96	0.90
Biogeochemical	4.9	DOP	0.69	0.42	0.69	0.63
Habitat provision	4.10	FSH	0.12	0.10	0.12	0.17
Habitat provision	4.11	HAF	0.99	0.86	0.99	0.56
Biodiversity	4.12	FFI	-	-	0.63	0.80
Biodiversity	4.13	IFI	0.77	0.55	0.87	0.61
Biodiversity	4.14	RVI	0.90	0.50	0.90	0.90
Overall mean SEV score			**0.83**	**0.64**	**0.83**	**0.78**

Table 8. Summary Current SEV data from offset streams

Function Category	Report Section	Function	SEV1	SEV2	SEV3	SEV4 (p)	SEV4 (i)	SEV5	SEV6
Hydraulic	4.1	0.83	0.60	0.61	0.61	0.61	0.61	0.84	0.28
Hydraulic	4.2	0.23	0.06	0.38	0.07	0.38	0.07	0.10	0.10
Hydraulic	4.3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Hydraulic	4.4	0.83	0.73	0.86	0.77	0.86	0.77	0.99	0.56
Biogeochemical	4.5	0.26	0.56	0.68	0.30	0.68	0.30	0.24	0.24
Biogeochemical	4.6	0.45	0.60	0.40	0.60	0.40	0.60	0.40	0.40
Biogeochemical	4.7	0.05	0.06	0.11	0.05	0.11	0.05	0.05	0.05
Biogeochemical	4.8	0.91	0.80	0.52	0.74	0.52	0.74	0.68	0.68
Biogeochemical	4.9	0.42	0.47	0.52	0.38	0.52	0.38	0.35	0.38
Habitat provision	4.10	0.05	0.05	0.05	0.40	0.05	0.40	0.40	0.40
Habitat provision	4.11	0.49	0.51	0.65	0.50	0.65	0.50	0.43	0.48
Biodiversity	4.12								
Biodiversity	4.13								
Biodiversity	4.14	0.14	0.09	0.01	0.03	0.01	0.03	0.06	0.02
Overall mean SEV score			**0.46**	**0.47**	**0.45**	**0.48**	**0.45**	**0.44**	**0.38**

Table 9. Summary Potential SEV data from impact sites

Function Category	Report Section	Function	Stream 4	Stream 7	Stream 10	Stream 13
Hydraulic	4.1	NFR	0.93	0.80	0.93	0.83
Hydraulic	4.2	FLE	0.68	0.05	0.68	0.16
Hydraulic	4.3	CSM	1.00	1.00	1.00	1.00
Hydraulic	4.4	CGW	0.90	0.90	0.96	0.92
Biogeochemical	4.5	WTC	0.92	0.68	0.92	0.90
Biogeochemical	4.6	DOM	1.00	1.00	1.00	1.00
Biogeochemical	4.7	OMI	0.95	0.67	0.95	1.00
Biogeochemical	4.8	IPR	0.96	0.76	0.96	0.90
Biogeochemical	4.9	DOP	0.69	0.42	0.69	0.63
Habitat provision	4.10	FSH	0.12	0.10	0.12	0.17
Habitat provision	4.11	HAF	0.99	0.86	0.99	0.56
Biodiversity	4.12	FFI	-	-	0.63	0.80
Biodiversity	4.13	IFI	0.77	0.55	0.87	0.61
Biodiversity	4.14	RVI	0.90	0.50	0.90	0.90
Overall mean SEV score			**0.83**	**0.66**	**0.83**	**0.78**

Table 10. Summary Potential SEV data from offset sites

Function Category	Report Section	Function	SEV1	SEV2	SEV3	SEV4 (p)	SEV4 (i)	SEV5	SEV6
Hydraulic	4.1	NFR	0.63	**0.88**	**0.67**	**0.93**	0.67	**0.84**	**0.81**
Hydraulic	4.2	FLE	0.32	**0.54**	**0.22**	**0.68**	0.22	**0.22**	**0.22**
Hydraulic	4.3	CSM	1.00	**1.00**	**1.00**	**1.00**	1.00	**1.00**	**1.00**
Hydraulic	4.4	CGW	0.90	**0.90**	**0.81**	**0.90**	0.81	**0.99**	**0.92**
Biogeo-chemical	4.5	WTC	0.84	**0.84**	**0.84**	**0.92**	0.84	**0.84**	**0.84**
Biogeo-chemical	4.6	DOM	1.00	**1.00**	**1.00**	**1.00**	1.00	**1.00**	**1.00**
Biogeo-chemical	4.7	OMI	1.00	**1.00**	**1.00**	**0.95**	1.00	**1.00**	**1.00**
Biogeo-chemical	4.8	IPR	0.80	**0.95**	**0.82**	**0.96**	0.82	**0.68**	**0.68**
Biogeo-chemical	4.9	DOP	0.69	**0.63**	**0.65**	**0.69**	0.65	**0.59**	**0.62**
Habitat provision	4.10	FSH	0.30	**0.10**	**0.40**	**0.12**	0.40	**0.05**	**0.40**
Habitat provision	4.11	HAF	0.75	**0.83**	**0.82**	**0.99**	0.82	**0.86**	**0.86**
Biodiver-sity	4.12	FFI							
Biodiver-sity	4.13	IFI							
Biodiver-sity	4.14	RVI	0.60	**0.31**	**0.31**	**0.90**	0.31	**0.60**	**0.30**
Overall mean SEV score			**0.74**	**0.75**	**0.71**	**0.84**	**0.71**	**0.72**	**0.71**

Assumptions:

1. Riparian planting of 20 m either side of the stream
2. Removal of all total and partial barriers to fish passage i.e. undersized and perched culverts
3. Small areas of natural instream enhancements (natural rock, large wood) where erosion or bank slumping is identified as a risk to property or riparian planting
4. Increase in ecosystem functions associated with established riparian planting, i.e. up to 70% shade, increase in organic matter inputs, increase in filtration.

Appendix 4. Potential SEV score assumptions

Function and Variable	Impact Streams	Off-set Streams
Hydraulic		
Vchann	No change.	Some naturalisation with increase in roughness (addition of rock) and riparian vegetation.
Vlining	No change.	Decrease in heavy load of silt.
Vpipe	No change.	No change.
Vbank	No change.	No change.
Vrough	No change.	Changed to reflect riparian margins, with regenerating indigenous vegetation and fenced, to 20m on both banks.
Vbarr	No change.	Removal of hanging culverts where applicable
Vchanshape	No data entry required.	No data entry required.
Biogeochemical	No change.	
Vshade	No change.	Increased to reflect change in riparian margins.
Vdod	No change.	Increase with stock restricted and reduction in macrophytes.
Vveloc	No change.	Reduction in stagnant areas with reduction in macrophytes.
Vdepth	No change.	No change.
Vripar	No change.	Changed to reflect riparian margins 20 m on each bank.
Vdecid	No change.	No change, no deciduous
Vmacro	No change.	Reduction in macrophytes with increased shading
Vretain	No data entry required.	No data entry required.
Vsurf	No change..	Increase in wood, gravel and cobbles component but reduction of macrophytes.
Vripfilt	No change.	Changed to reflect riparian margins.
Habitat provision	No change	
Vgalspwn	No change.	No change due to topography.
Vgalqual	No change.	Increase with shading and provision of overhanging vegetation.
Vgobspawn	No data entry required	No data entry required
Vphyshab	No change.	Increase in parameters associated with riparian planting.
Vwatqual	No change.	No change.
Vimperv	No change.	No change.
Biodiversity		
Vfish	Removed for ECR.	Removed for ECR.
Vmci	Removed for ECR.	Removed for ECR.
Vept	Removed for ECR.	Removed for ECR.
Vripcond	No data entry required.	No data entry required
Vinvert	Removed for ECR.	Removed for ECR.
Vripconn	No change.	Changed to reflect riparian margins.

Appendix C

Rolling ECR Calculations

		Impact					Compensation/Offset							ECR		Compensated	Residual
Stream ID	Impact type	SEVi-P	SEVi-I	Length (m)	Average width (m)	Streambed area (m2)	Stream ID	Compensaton method *	SEVm-P	SEVm-C	Average width (m)	Length available (m)	Steambed area available (m2)	ECR	Strembed area compensation required (,m2)	Proportion of impact reach compendated	Compensation stream bed area still available (m2)
Stream 1	Reclamation	0.84	0	204	0.41	84	SEV 4 Perm	Enhancement	0.84	0.48	0.6	250	150	3.50	292.74	0.51	0.0
		0.84	0			41	SEV1 int south	Enhancement	0.74	0.46	0.57	430	245.1	4.50	183.52	1.34	61.6
Stream 2	Reclamation	0.84	0	136	0.3	41	SEV1 int south	Enhancement	0.74	0.46	0.57	430	61.6	4.50	183.60	0.34	0.0
		0.84	0		0.3	27	SEV2 gorse	Enhancement	0.75	0.47	0.29	1038	301.02	4.50	122.02	2.47	179.0
Stream 3	Reclamation	0.84	0	165	0.22	36	SEV2 gorse	Enhancement	0.75	0.47	0.29		179.0	4.50	163.35	1.10	15.6
Stream 6	Reclamation	0.66	0	216	0.32	69	SEV2 gorse	Enhancement	0.75	0.47	0.29		15.6	3.54	244.39	0.06	0.0
		0.66	0			65	SEV3 intermittent north	Enhancement	0.71	0.45	0.29	283	82.07	3.81	246.34	0.33	0.0
		0.66	0			43	SEV6 Int south planted	Enhancement	0.71	0.38	0.57	310	176.7	3.00	129.42	1.37	47.3
Stream 8	Reclamation	0.66	0	53	0.31	16	SEV6 Int south planted	Enhancement	0.71	0.38	0.57	310	47.3	3.00	49.29	0.96	0.0
		0.66	0			1	SEV5 pasture west	Enhancement	0.72	0.44	0.56	268	150.08	3.54	2.37	63.28	147.7
Stream 5	Reclamation	0.84	0	78	0.49	38	SEV5 pasture west	Enhancement	0.72	0.44	0.57		147.7	4.50	171.99	0.86	0.0
		0.84	0			5	SEV4 - intermittent reach		0.71	0.45	0.56	72	40.32	4.50	24.28	1.66	16.0

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