OGNZL Wharekirauponga mine:

Assessment of effects on native frogs

Report prepared for

OceanaGold (NZ) Ltd

Prepared by

RMA Ecology Ltd

Report number and date

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BETTER ECOLOGICAL OUTCOMES

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1.0 Background and scope

1.1 Background

Part of our brief for the Wharekirauponga Underground Mine (**WUG**) component of the Waihi North Project for OceanaGold (NZ) Ltd (**OGNZL**) is to prepare an assessment of effects on native frogs including an ecological risk assessment[1].

The focus of the effects and risk assessment is Archey's frog (*Leiopelma archeyi*) and Hochstetter's frog (*L. hochstetteri*), and our work takes into account all proposed activities associated with the WUG that may adversely affect these species, including their habitat.

The expert team involved in this effects and risk assessment has been:

- **Dr Graham Ussher** (RMA Ecology Ltd) as effects and risk assessment project lead and key author on this report;

- **Katherine Muchna** (Boffa Miskell Ltd) as project ecologist involved with leading/ undertaking site-based frog assessment work and preparing the overall terrestrial ecology effects assessment for the WUG component of the Project; and

- **Dylan van Winkel** (Bioresearches [Babbage Consultants]) as specialist peer reviewer on the Archey's frog-focussed work at Wharekirauponga undertaken by Boffa Miskell, and as site investigation lead for the survey of Hochstetter's frog within the project area. The results of the surveys, and analysis of frog populations in the project area, as well as an assessment of the potential effects of vibration on Archey's and Hochstetter's frogs is contained within Bioresearches, 2024.

Support for the risk assessment team has been provided by the following in technical coordination and technical expert roles:

- Stephanie Hayton (NGZNL) - OGNZL cross-discipline lead/ coordinator
- Cassie McArthur - OGNZL cross-discipline lead/ coordinator
- John Heilig (Heilig & Partners) – Vibration modelling
- Richard Chilton (T+T) - Air quality modelling from mine vents
- Chris Simpson (GWS Ltd) - Hydrogeological assessment of dewatering risk
- Helen Blackie (Boffa Miskell) - Pest control programme design
- Brian Lloyd (Lloyds Consulting) – Biostatistical analysis

1.2 Footprint for assessment

The current Waihi life of mine plan is to complete production by the end of 2030. Study work conducted between 2016 and 2020 identified opportunities to expand the Waihi operation with one new open pit and a new underground development beneath Wharekirauponga, within Coromandel Forest Park. The WNP will integrate these new developments with OGNZL's existing mines and existing and consented mining infrastructure.

The WNP will integrate with OGNZL's existing mines and existing and consented mining infrastructure in the Waihi Epithermal District.

[1] Our work has been undertaken under OGNZ Master Consulting Agreement OGN-3144.

The WNP comprises several distinct project components inside and outside of the Coromandel Forest Park, including the Wharekirauponga Underground Mine ("WUG") and the Wharekirauponga Dual Tunnel, both of which involve underground works beneath the Park.

Apart from the underground works involved in developing the mine, surface activities above the ore body will include (data sourced from OGNZL Staged Fast-Track Project Description dated August 2024):

- The ability to position a total of 8 exploration drill sites within the WUG WKP Access Arrangement Area;
- A total of six operational drill rigs;
- A total of six camps and messing facilities;
- A total of four helipads, located on any existing or new drill site;
- A total of four surface geotechnical exploration drill sites within the WUG WKP AA Area to confirm suitable vent shaft sites;
- A total of four surface geotechnical exploration drill sites outside the WUG WKP AA Area above the dual access alignment;
- A total of four exploration drill sites for the purpose of drilling additional piezometer holes to assist with pumping test investigation and/or other hydrogeological testing or baseline data collection;
- Surface vegetation clearing and construction of larger pads (up to 900 m^2) for hydrogeological pump test investigations and ventilation construction;
- A total of five river pump sites for abstracting surface water; and
- The use of a man-portable rig for up to 50 sites for drilling shorter (<100 m) holes.

The above listed activities will result in the clearance 0.5328 ha of existing vegetation, which at the completion of mining operations will be rehabilitated back to native forest.

1.3 Approach

The process applied by the assessment team has been as follows:

1. Literature search, information review, experience collation, and personal communications with experts elsewhere regarding the range of potential adverse effects that mining or similar activities may have on Archey's and Hochstetter's frogs, New Zealand frogs, or any frogs elsewhere where results may be transferable to this Project. The context for this review was the Project Description (as included in the AEE) provided by OGNZL for the WUG component of the Project[2], and the existing knowledge of the project held by Katherine Muchna and Kerry Watson;

2. Weekly meetings to develop, review and test a risk assessment matrix which brings together the identified potential adverse effects and provides an assessment in terms of likelihood of effect, status of qualifying information, and potential magnitude and significance of potential effects;

    - Identification of information gaps to OGNZL along with (where possible) means of addressing specific information gaps, so that the OGNZL team or other appropriate experts can action these;

[2] Mitchell Daysh Limited, Waihi North Project – Resource Consent Applications and Assessment of Environmental Effects, dated June 2022.

- An evaluation of other specialist technical assessments for construction and operational aspects of the WUG[3] against the adopted engineering design to confirm (as far as we are able to as non-experts in those matters) how avoidance, remediation or mitigation of potential adverse effects on Archey's and Hochstetter's frogs have been, or can be addressed through the risk assessment matrix; and

- Identification of potential adverse effects on Archey's and Hochstetter's frogs after good design practice and after the proposed mitigation have been considered. A framework for responding to a spectrum of potential adverse effects by way of enhancements and protections through biodiversity offsetting and ecological compensation for Archey's frogs is proposed.

We understand that it is OGNZL's intention that this report and, in particular the framework for offsetting and compensation, will be socialised with other experts representing Hauraki District Council (**Council**) and the Department of Conservation (**DOC**). The purpose of doing so is to seek agreement on the matters relating to Archey's frogs and Hochstetter's frogs that are of interest to Council and DOC, and to discuss appropriate management responses where potential adverse effects (impacts) are not able to be avoided.

Archey's frog is present within terrestrial habitats across the land environment above the proposed underground mine. Hochstetter's frog is also present within parts of the WUG area within stream and river margins. The analysis presented in this assessment is equally relevant to Hochstetter's frog as it is to Archey's frog, for the reasons laid out in the analysis by Bioresearches 2024, which are:

- Both species are present within the WUG area and may be at risk of potential adverse effects, including vibration for both species, and the potential for dewatering of stream habitat for Hochstetter's frog;

- Data from the long-term study on Hochstetter's frog at Golden Cross mine and the confirmed presence of both Hochstetter's and Archey's frog at the Golden Cross mine site (same locations) post-mine closure, suggests that both species of frogs did persist during mining and did not appear to disperse away or perish from areas subject to mining vibration (2–4 mm/s) stimuli;

- Hochstetter's frog monitoring data at Golden Cross mine provided no evidence for even temporal effects (e.g., local population declines, avoidance, or dispersal behaviours) on frog populations in the immediate vicinity of the mining operations; and

- The persistence of both Archey's and Hochstetter's frog populations in the immediate vicinity of the mining operations at Golden Cross suggests both species can tolerate vibration of 2–10 mm/s[4] for Hochstetter's frog (**Attachment B**) and 2 mm/s (maybe up to 4 mm/s) for Archey's frog (although this data does not provide evidence of a vibration threshold).

[3] See **Attachment A** for a list of the OGNZ-generated reports reviewed to inform this assessment.

[4] Vibration magnitude distribution curves indicated that while Hochstetter's frogs in one location may have experienced one blast that caused a vibration up to 10 mm/s, such magnitude of vibration was not typically generated. Most of all blasts generated vibration no greater than about 4 mm/s.

2.0 Assessment of potential adverse effects

A master list of potential adverse effects was developed from literature and other reviews (**Table 1**).

The ecological effects assessment relies upon several sources of information. These are:

1. An understanding of the Waihi North Project and its construction footprint, the construction process, and the operation of the various aspects of the proposed mine, all in the context of the 'baseline state' (i.e. the existing environment); and

2. A framework for synthesising the ecological values being considered and the magnitude, severity, and persistence of an adverse effect. The tool that we have applied is the effects assessment matrix approach as described by the Environment Institute of Australia and New Zealand (EIANZ). This informs an assessment of the level of effect of the project on ecological values and from there allows consideration of how and what effects management tools may be applied to lessen or balance residual effects to an acceptable level.

   The EIANZ matrix approach, and the guidelines within which it is included, has been developed as a guide for ecologists undertaking effects assessments under the RMA (EIANZ, 2018). The EIANZ guidelines and the impact assessment matrix in particular, provides a robust, concise and consistent approach to effects assessment, whilst ensuring that individual expert evaluation and opinion is preserved.

See **Attachment C** for key tables from the EIANZ guidance that we have used to assess magnitude, values, and level of potential adverse effect. Added to this, we have provided context in terms of our opinion on the likelihood of an adverse effect occurring at the site insofar as native frogs are concerned, given the controls in place and our experience with the subject site.

Table 1 provides a summary of the activities or aspects of the WUG that may result in adverse effects on Archey's and Hochstetter's frogs. The initial description we provide of the potential adverse effects associated with each activity does not include any actions to manage those effects.

For each activity or aspect in **Table 1** we go on to provide our assessment of the potential level of adverse effect after adoption of the mitigation measures that OGNZL has agreed to as part of the WUG design and as are recorded in the proposed conditions of consent.

Values and magnitude have been assessed according to Tables 5, 6 and 8 in the EIANZ framework (see **Attachment B**). Level of effect is assessed using a risk matrix approach as per Table 10 of the EIANZ guidance. A level of effect after mitigation has been applied that corresponds to Moderate, High or Very High is generally accepted by ecologists to constitute a 'significant ecological effect' under the RMA, while a Low or Very Low level of effect after mitigation has been applied is usually considered to correspond to a 'minor ecological effect' or 'less than minor ecological effect' under the RMA. It is usual for a 'Very High' level of effect to trigger re-design or avoidance.

The level of effect presented in **Table 1** may change if additional technical information is provided to us, especially where it includes additional measures to avoid or reduce the magnitude of adverse effect, or where effective mitigation is provided to further minimise the severity of effect. The level of effect concluded in **Table 1** is <u>after</u> efforts to avoid, remedy or mitigate have been applied (that is, for clarity, magnitude of effect is assigned after to the application of avoidance/ mitigation measures).

The ecological values of Archey's frog and Hochstetter's frog are scored as 'High', following the criteria listed in EIANZ Table 5 when considering species with an 'At Risk -Declining' threat classification.

Where an activity may result in a loss of Archey's or Hochstetter's frogs, we have considered that the potential loss of frogs constitutes a 'low' magnitude of effect – whether that loss is considered in the context of direct mortality effects from the small areas of vegetation clearance for vent raises and drill rigs, or at the much wider level of potential indirect effects caused by vibration and dewatering.

The key reasons for considering some potential loss of frogs being a 'low' magnitude is because:

1. Work by Dr Lloyd for this project, which is supported by on the ground surveys, measured Archey's frog densities across different habitat types and elevations and from that analysis estimated the likely population size for Archey's frogs in the Coromandel (not including elsewhere and not including a substantial area of the Coromandel for which information on Archey's frog presence is unknown). That work indicates that our best estimate for the number of adult Archey's frogs within the >2 mm/ sec vibration footprint is 48,888 – 152,774 individuals[5], and comprises habitat for frogs that are distributed across a much broader area of the Coromandel Ranges; in other words, the WUG area is not a 'stronghold' for Archey's frogs. Habitat quality within the WUG area is different to the higher-altitude habitats elsewhere in the Coromandel Ranges in which these frogs are found, and densities found within the WUG area cover a range of smaller, similar and greater abundances compared to records nearby or elsewhere. One of the conclusions of Dr Lloyd's work is that a substantially greater number of Archey's frogs exist in the southern Coromandel Ranges, throughout a wide distributional range, which differs significantly from our original assumptions of population size, which was based on DOC's estimates of between 5,000 - 20,000 mature individuals for the national population[6].

2. The work by Dr Lloyd for this project indicates that a conservative (that is, high) estimate is that Archey's frogs living within the potential disturbance area of the WUG occupy 0.61 % of the total area of Archey's frog habitat available within areas where frogs are currently known on the Coromandel (this excludes a very large area of the Coromandel potentially also occupied by Archey's frogs but for which there are no records in the national database, and also excludes two other Archey's frog populations from Whareorino and Pureora Forest Park). If instead this analysis is performed at the spatial scale of the southern Coromandel range of Archey's frog (see Lloyd 2023 Table 13), the potential disturbance area of the WUG occupies 2.29 % of the area of potential Archey's frog habitat, which we still consider to be 'low'. We acknowledge that an assessment of 'Low' magnitude does not potentially recognise other values of frogs in this location, including social or cultural values of frogs in this landscape or the near-southern limits of Archey's frogs in this location.

3. Subsequent work by Dr Lloyd has provided an assessment of the abundance of Hochstetter's frogs within the potential disturbance area of the WUG[7] based on Hochstetter's frog transect searches within streams in an area of the project footprint that may be at risk of dewatering.

[5] Lloyd, B. 2023. Estimating the proportion of the Coromandel's Archey's frog population in the area affected by vibrations from the proposed Wharekirauponga Mine. Report prepared for OGNZL. 6 April 2023.

[6] DOC Threat Classification listing qualifiers.

[7] Lloyd, B. 2024. Analyses of the results of surveys for Hochstetter's frog undertaken in 2024 to assess the impacts of stream flow reductions associated with the Wharekirauponga Underground Mine. Report prepared for OGNZL. 14 October 2024.

That analysis found that between 238 and 1,597 Hochstetter's frogs may be within the potentially affected dewatering area.

4. Over the course of this assessment, OGNZL has provided more detailed assessments of the modelled blasting programme and profiles for the WUG, including contours and frequency histograms for vibrations expressed at the surface, and the areas of Archey's frog habitat likely to be subject to vibration. In addition, there has been a range of work undertaken by OGNZL which has investigated the ability of Hochstetter's and Archey's frogs to survive in the presence of surface vibration generated by mining and road traffic.

5. That work is summarised in a separate piece of research undertaken by Mr van Winkel[8], which assesses the range of potential outcomes that may result from Archey's and Hochstetter's frog exposure to surface vibration events generated by the WUG.

6. The range of possible outcomes for frogs if they are sensitive to blast-induced surface vibration beyond levels recorded elsewhere for Archey's and Hochstetter's frogs includes potential movement away from vibration areas, loss of breeding for several years, and behavioural responses (some of which place frogs at greater risk of predation). It is not anticipated that there will be any mortality directly resulting from the activities.

Over 2023 and 2024, OGNZ has undertaken detailed investigations into the risk that activities underground will lead to dewatering of streams within the project area, with a focus on the potential for adverse effects on streams, wetlands and Hochstetter's frog habitat and populations. The investigations behind this have been extensive and have involved assessments of geology, hydrogeology, water balance modelling, stream flow, stream habitat assessments, Hochstetter's frog population surveys, and flow modelling in order to determine the risk that underground works may pose to the extent of Hochstetter's frog wetted stream margin habitat, and the potential effects on Hochstetter's frog breeding and survival.

The technical detail of this work is laid out in the reports by:

- NIWA (20024) – instream habitat assessments
- FloSolutions – Conceptual groundwater model and numerical modelling
- Intera – Model calibration and sensitivity analysis
- GHD – Hydrology modelling
- AECOM – Post closure geochemistry
- WWLA (2024) – effects on groundwater and surface water
- Bioresearches – Hochstetter frog surveys
- Boffa Miskell (2024) – likely ecological effects arising from potential dewatering in natural state streams at WUG

An assessment of the potential scale and severity of adverse effects on Hochstetter's frogs is provided in the 2024 Bioresearches report.

[8] Bioresearches, 2024. Proposed Wharekirauponga Underground Mine: DRAFT native frog effects assessment. Report prepared for OGNZL by van Winkel, D, 17 October 2024.

In summary:

- The WUGG will result in deep groundwater dewatering. Potential drainage of the shallow groundwater system (groundwater drawdown) is generally unlikely, but if it did occur it could reduce surface water discharges to streams, and could potentially impact frog populations if changes result to streams.
- Of the nine stream catchments within the project area, the Edmonds and Thompsons are predicted to potentially experience the largest reductions in flow due to deep groundwater dewatering. Worst case, modelled reductions in the 7-day MALF in the Edmonds Stream of 10.8% [Mean] or 11.5% [5th%ile] are predicted. Whereas, the 7-day MALF in the Thompson Stream is predicted to reduce by 11.5% [Mean] or 12.4% [5th%ile] (GHD 2024). Hochstetter's frogs are known or reasonably expected to occur in both catchments.
- Given the small, predicted reductions in wetted width, the relatively wide streamside margins that Hochstetter's frogs inhabit, and their ability to move freely to more favourable conditions along a stream, it is highly unlikely that any significant impacts on the resident frogs above the WUG will result from potential reductions in wetted stream width. Since wetted width reductions are not expected outside of the Wharekirauponga Catchment, populations of Hochstetter's frogs in the surrounding areas will remain unaffected.

Overall, we regard that:

1. The likelihood that Archey's or Hochstetter's frogs within the predicted WUG surface footprint will die or be extirpated as a direct result of vibration to be very low; rather potential adverse effects (if any) may be expressed through more subtle changes to distribution, breeding, and population structure, over a temporary (during mining) period; and

2. The likelihood that Archey's or Hochstetter's frogs within the predicted WUG surface footprint will die or be extirpated as a direct result of deep groundwater dewatering to also be very low, and some cases for Hochstetter's frog may be beneficial if it results in a greater areas of wetted width habitat.

Although the experts involved in these assessments of potential adverse effects consider the possibility of measurable impacts on frog populations to be very low, we acknowledge that there is no evidential basis to assume nil risk, and that uncertainty with the scale and magnitude of outcome must be acknowledged.

OGNZL has responded to this by proposing a comprehensive habitat enhancement programme across the project area and surrounds to address this uncertainty (see next section).

Table 1. Potential adverse effects on ecological values and an assessment of level of ecological effect.

Activity	Potential adverse effect (unmanaged)	Avoidance/ Mitigation proposed	Magnitude of effect after management (Table 8 EIANZ)	Level of effect (Table 10 EIANZ)
Short term surface vibration (sustained/ steady/ continuous)	During surface drilling and vent shaft installation. Consistent with existing exploration drilling. John Heilig modelling indicates that vibration will drop off after 20 m. The frog fenced areas (where there are no frogs present) are 20 m x 20 m in area with the drill rig occupying part of that area. Setbacks from the drill rig to the fenced area edge is 6 m so most of the increase to vibration may be out of range of known frogs.	**Mitigation:** nil.	Negligible	Very Low over a very small area with very few frogs
Short term surface noise (sustained/ steady/ continuous)	During surface drilling and vent shaft installation. Consistent with existing exploration drilling.	**Mitigation:** nil.	Negligible	Very Low over small area
Light from surface construction activities (short-term)	Lighting during surface drilling. Light spill into the forest could influence presence/ behaviours/ predation risk. Consistent with existing use of drill platforms.	**Mitigation:** Orientate to face inwards to platform (also see Pederson Read report regarding lighting mitigation). Cannot be reduced because of safety considerations for workers.	Low	Very Low over a small area
Odour from surface construction activities (short-term)	Odour release into the environment and potential impacts on frog olfactory/ chemosensory system (e.g. diesel fumes from generator).	**Mitigation:** nil.	Low	Very Low over a very small area
Dust creation from surface construction activities (short-term)	Drill platform construction and surface exploration drilling.	**Mitigation:** nil.	Negligible	Very Low over a small area
Water pollution from surface drilling (short-term)	Centrifuge system in place to refine waste from surface drilling, sumps to contain any spills. Removal off site as is currently undertaken.	**Mitigation:** Separation of waste, sumps, off-site disposal.	Negligible	Very Low over a very small area

Activity	Potential adverse effect (unmanaged)	Avoidance/ Mitigation proposed	Magnitude of effect after management (Table 8 EIANZ)	Level of effect (Table 10 EIANZ)
Vegetation/ habitat loss	Vegetation/ habitat removal is unavoidable to allow for vent shafts and exploratory drill sites. The total vegetation clearance is 5,328 m^2.	**Mitigation:** Avoid large trees. Salvage/ relocate frogs if found during construction (as per best practice guidelines and with monitoring included). For the loss of frog habitat over 0.75 ha, see the Boffa Miskell terrestrial ecology report which details the extensive mitigation and offset planting proposed within Willows Farm	Low	Very Low over a small area
Vegetation growth/ density/ quality	Regenerating vegetation following clearance might be structurally different and of differing quality compared to pre-development level. Revegetation forest structure notably different to secondary/ primary forest structure.	**Mitigation:** Requirements for vegetation handling and site rehabilitation.	Low	Very Low over a small area
Erosion and sedimentation (short-term)	Sediment generation and erosion may occur where best practice methods fail, potentially affecting habitat quality, egg laying and brooding sites.	**Mitigation:** Requirements for vegetation handling and site rehabilitation. Present controls include fencing drill site with silt fence equivalent to exclude frogs – may also reduce sediment movement.	Negligible	Very Low over a very small area
Pest influx and associated predation pressure (short-term)	Rodents potentially attracted to disturbed habitats during works and potentially increased predation risk to local frogs.	**Mitigation:** Pest animal trapping and control over wider surface activities area.	Negligible	Very low over a wide area
Increased human presence/ foot disturbance (short-term, then much reduced during longer-term maintenance phase)	Human activities during construction and maintenance may disturb or kill frogs. Potential for disease introduction.	**Mitigation:** Requirements to stay to set tracks/ paths/ within fenced areas. Boot and equipment wash stations.	Negligible	Very Low over a wide area
Short-distance relocation (short-term)	Effects of moving animals into adjacent habitat and/ or homing abilities of frogs could potentially impact frog health/ survival. This could only occur where approved sites yield frogs during clearance (very low number of individuals that could be affected).	**Mitigation:** Nil, although could require provision of additional habitat (logs, ground covers, cover objects).	Low	Very Low over very few occurrences

Activity	Potential adverse effect (unmanaged)	Avoidance/ Mitigation proposed	Magnitude of effect after management (Table 8 EIANZ)	Level of effect (Table 10 EIANZ)
Vibration (episodic) - caused by blasting associated with the construction and operation of the WUG	Blasting may generate perceptible levels of vibration at the surface. Potential adverse effects include disruption of male Archey's frogs during the breeding season (e.g. clutch abandonment), movement of individuals away from territories, and increased vulnerability to introduced predators. Potential loss of significant recruitment if effects persist or repeat over several years. Duration of potential effects may be up to 10 years over parts of the site (i.e. less than the expected reproductive lifespan for mature Archey's frogs). The nature of the blasting in transitory - that is it will only occur whilst a particular stope is being worked, then the work will move to the next area and so forth. Modelling of vibration at WKP site by OGNZL based on Golden Cross vibration effects on Hochstetter's frogs and Archey's frogs, and persistence of Archey's frogs from roadside monitoring, indicates that surface vibration levels above those known from other locations where Archey's frogs persist with anthropogenic vibration will affect around 314 ha of WUG. That area is estimated to support less than 0.61 % of total estimated Coromandel Archey's population. The number and distribution of vibration events that are above the level measured at other Archey's frog sites (i.e. above 2 mm / sec) comprises a mix of vibration levels spaced over time (for example in areas subject to the highest vibration years, blasts that generate a level of vibration above 2 mm /sec can comprise up to 78 % of the total blasts; however total number of such events would be around 3-4 events per day, each of around 10-12 seconds in duration, with a total time of such events around 30-50 seconds per day).	1. Reduce blast package size to smallest practicable level. 2. Undertake best practice pest control over 314 ha where any measurable vibration may be expressed on the surface, to a level designed to promote Archey's frog population recovery.	Low (or nil if pest control increases frog population over existing pre-mine levels).	Low (or net-benefit if pest control increases frog population over existing pre-mine level).
Vent shaft – design	Discharge vent stack x 4. Discharge vent stack design has a 10 m x 15 m footprint.	1. Install Animex exclusion fence around vent shafts. 2. Choose sites with no recorded frogs where practicable. 3. Salvage/ relocate frogs if found during construction.	Negligible	Very Low

Activity	Potential adverse effect (unmanaged)	Avoidance/ Mitigation proposed	Magnitude of effect after management (Table 8 EIANZ)	Level of effect (Table 10 EIANZ)
Vent shaft - discharge of air pollutants	Dust, silica and diesel pollutants emitting from the stacks (as use of electric vehicles is not guaranteed). Discharges are assumed for the life of the mine (9 years). Discharge particle composition and dispersal radius is based on modelling by Richard Chilton (T+T emissions expert; T+T, 2022[9]). The key discharges to air from the proposed vents are fine particulate matter less than ten microns (PM10) and nitrogen dioxide (NO2). Predicted cumulative ambient air concentrations of PM10 and NO2 in the vicinity of the proposed vents are very low when compared against human health assessment criteria. PM10 concentrations are likely to be similar in areas adjacent to an unpaved public road in the Coromandel (north of the WUG) where baseline ecological assessments of Archey's frog habitat have been undertaken. Therefore, it can be inferred that Archey's frogs at roadside Coromandel locations are exposed to greater levels of PM10 than anticipated in the vicinity of the proposed vents. There are likely to be many frogs near to the proposed 4 x vent stacks. Frogs are very vulnerable to absorbing emissions in the air through their skin. The emissions will be vented 24 hours/ day – i.e. at night when frogs are active on the ground. The implications of long-term exposure to emissions at an unknown level from the vent stacks is unknown but a precautionary approach would suggest that it is not nil. A higher level of exposure to these discharges occurs within roadside areas where Archey's frogs have been recorded and are known to persist in the Coromandel.	No filters or scrubbers are proposed in the vent stacks. Mitigations proposed that are relevant to this part of the WUG site are: 1. Dampen exposed underground surfaces.	Negligible	Very Low
Vent shafts – discharge of warm air	Higher temperatures around vent shafts potentially attract frogs, their prey and introduced predators, leading to increased rates of frog predation and localised population decline. Temperature of emissions is not likely to be significantly different to ambient and will disperse quickly in air when discharged at 11 m elevation.	The OGNZL vent shaft design stands up to 8 m tall and emits from the top. An Animex exclusion fence will exclude animals from close proximity to vent shaft raises.	Negligible	Very Low

[9] Tonkin & Taylor. June 2022. Assessment of mine vent air quality impacts to inform assessment of ecological effects on Archey's frog. Report prepared for OGNZL.

Activity	Potential adverse effect (unmanaged)	Avoidance/ Mitigation proposed	Magnitude of effect after management (Table 8 EIANZ)	Level of effect (Table 10 EIANZ)
Dewatering of mine workings	Dewatering of surface water features or drying out of regolith and soils such that wetted habitat reduces for Hochstetter frogs, or that roots systems of old-growth forest are stressed and lead to wholesale forest decline, habitat loss and frog mortality, potentially over ca. 100 ha. The analyses undertaken on groundwater, interflow, and stream flows indicates that it is highly unlikely that any significant impacts on the resident frogs above the Wharekirauponga Underground Mine will result from potential reductions in wetted stream width or dewatering of the regolith. We note that the resource consent conditions include methods to trigger mitigative actions where there is a risk of measurable changes to the hydrology at the surface, except for those changes caused by changes in the flow of the identified warm spring.	Grout major water ingress points into mine (if this occurs) - however note that modelling of geology and hydrology indicates limited connection between mine-depth hydrology and surface water/ sub-surface groundwater, and only possibly at streams. Potential effects are therefore limited to habitat used by Hochstetter's frogs, and only over part of the site.	Negligible – this effect is not feasibly possible	Very Low
Failure of proposed mitigation measures described above and the risk of habitat or frog effects as described in the Level of Effect for each individual activity listed above, in aggregate.	Reduction of frog habitat or frog population as a result of all of the other potential adverse effects, under the assumption that the above listed mitigations fail, and assuming a pre-cautionary approach to assigning likelihood of potential effect. Overall, if this were to occur, most effects would be small-scale, short-duration and very localised. The potential effect of vibration at surface could have the broadest level of adverse effect, however, that is unlikely to have a direct mortality effect on frogs, but rather potential indirect effects on breeding success, movement, and predation vulnerability (if any).	This is a contextual analysis. If the above mitigations fail, what will be the potential adverse effect on the persistence of Archey's and Hochstetter's frogs on the Coromandel? Potential Archey's frog habitat in the Coromandel Peninsula is estimated to cover 578 km^2. This estimate excludes lower-altitude areas (where frogs are known to occur) and excludes a 314 km^2 block in central Coromandel Peninsula where there is apparent frog habitat but no survey records to confirm presence. Under the conservative estimates above, the potential vibration area for WUG includes an estimated 0.61 % of the total frog habitat available in the 578 km^2 block of habitat with Archey's frog records within the Coromandel Peninsula part of the entire range of Archey's frogs in New Zealand.	Low	Very Low

3.0 Management of potential residual adverse effects

3.1 Potential residual adverse effects

The assessment provided in **Table 1** indicates that, under a worst-case scenario, that there could be residual adverse effects after mitigation has been applied.

There are five potential residual adverse effects that we have identified which may result in direct or indirect impacts on Archey's or Hochstetter's frogs within the Wharekirauponga project area.

The potential effects are listed in **Table 2** with a likelihood of occurrence and an estimate of the spatial area of Archey's frog habitat and number of frogs that could be potentially affected. In this analysis we have treated pest control within the WUG surface area as mitigation, but have separated it from the potential effects of vibration, vent shaft air emission discharges and cumulative potential loss of frogs from mitigation failure. The potential benefits of pest control as mitigation or offset (depending on where the pest control is applied) is provided in the next section of this report.

Note that for the loss of potential frog habitat due to vegetation clearance (0.53 ha), is addressed in the Boffa Miskell report with respect to extensive mitigation and offset planting proposed at Willows Farm.

Table 2. Likelihood of occurrence and potential effects on frogs and frog habitat of potential adverse effects that may be associated with the WUG project. Estimates of loss of Archey's frog habitat and loss of Archey's frogs are based on estimates provided by Dr Lloyd. Estimates of loss are independent between rows (i.e. not cumulative). Estimates for Hochstetter's frogs are not provided.

Potential effect	Likelihood of occurrence of the effect	Potential loss of frog habitat	Potential loss of frogs if low likelihood assessment is incorrect
Vibration (episodic and transitory) – vibration at ground level at rates leading to loss of breeding success/ frog movement away	Low – based on information from Golden Cross mine on Hochstetter's frogs, vibration measurements for Archey's frogs along Coromandel roadsides, and research by Mr van Winkel (Bioresearches).	Nil	Some number less than the estimated population within the potential effects footprint (estimated at between 31,096 and 152,774 adult Archey's frogs).
Vegetation clearance - associated with drill sites and vent shafts	Certain	5,328 m^2 (0.53 ha) of potential frog habitat	Nil, as Wildlife Act permit requires salvage and relocation of frogs to a secure location.
Vent shaft - discharge of air pollutants, leading to localised pollutant effects on frogs	Very low – based on information from Archey's frogs adjacent to Coromandel roads and research report by Mr Chilton (T+T)	Nil	Several thousands of frogs may be in the vicinity of vent stacks and exposed to elevated levels of air emissions compared to the current background state (although less than levels that roadside Archey's frogs

			elsewhere are currently exposed to).
Dewatering of mine workings – effects on wetted habitat for Hochstetter's frog	Very low – based on the modelled potential change to wetted width being unlikely and if it does occur very slight over part of the site. The effect may be positive if more habitat for frogs is created.	Very Low (possibly a 5% reduction in wetted width) and restricted to streams in the Edmonds and Thompsons catchments.	The Hochstetter's frog population in those locations is estimated at 238 to 1,597 individuals, although as a mobile species, many/ all would be expected to move to adjoining catchments or downstream to remaining suitable habitat
Failure of proposed mitigation measures leading to loss of any frogs within WUG above ground footprint – resulting in increased risk of extinction or lowered population viability of the local Coromandel population	Very low – as maximum vibration surface expression will be set by consent requirements, and other technical applications (frog-proof mesh exclosure, dampening mine face workings, survey to ensure vent stack locations have no frogs) are proven.	Low (less than 1 ha; which constitutes far less than 0.3 % of the local WUG area occupied by Archey's frogs, and around 0.61 % of known occupied habitat by Archey's frogs on the Coromandel Peninsula	Some number less than the estimated population within the potential effects footprint (estimated at between 48,888 and 152,774 adult Archey's frogs).

The potential residual adverse effects in **Table 2** all have an assessed likelihood of potentially causing adverse effects on frogs of Low or Very Low magnitude. Combined with the value of these At Risk species of frogs, the EIANZ matrix indicates a Low or Very Low level of effect.

Under the EIANZ framework, residual adverse effects (level of effect) that are predicted to be Low or Very Low require that normal design, construction, and operational care should be exercised to minimise adverse effects. Low or very-low level effects can generally be classed as 'not more than minor' effects under the RMA 1991.

The underlying context for frog populations at this site is assumed to be the same for Archey's and Hochstetter's frogs elsewhere – that populations are moderate to large with ongoing or predicted decline. Predicted long-term (i.e., over three generations or ~30-45 years) declines of 10-30 %, primarily the result of mammal predation (rodent and larger predators), are anticipated. Furthermore, loss of recruitment through loss of adults, or loss of young frogs possibly caused by smaller predators (such as mice), may eventually lead to the loss of Archey's and Hochstetter's frog populations across this site and others.

Where possible loss or decline is predicted to occur, this suggests that there must be research and management avenues to investigate practical means of stabilising or reversing decline trends.

The WUG project adds risks on the persistence frogs that are in addition to the probable risks already faced by the populations at this site by introduced predators. At the smallest end of the risk scale – i.e. the loss of small areas of habitat from vegetation clearance and human activities around the surface of WUG – the loss of, or increased vulnerability of, frogs may result. We note however, that this also results in opportunity, which is derived from having a consent holder that undertakes ongoing monitoring and research into the population.

The intention by OGNZL is to manage these above-ground effects through a suite of on-site management interventions (as outlined in **Table 1**); however, there is scope to include positive initiatives within the adaptive management programme described below, which is proposed to address the key potential effects described in **Table 2**.

Because there is no available information on the sensitivity of Archey's and Hochstetter's frogs to blast vibration (beyond the levels measured elsewhere), potential changes to wetted width habitat for some streams, and air discharges (albeit less than roadside locations where Archey's and Hochstetter's frogs persist), there is a case to be made for either:

1. Avoiding works that create vibration and air discharges in the Wharekirauponga area; or

2. Applying the most stringent engineering designs practicable to minimise likelihood of adverse effects; or

3. Proposing a range of initiatives that could provide benefits to Archey's and Hochstetter's frogs at this site or elsewhere to balance the risk of loss at WUG.

There is no feasible means of mining the resource at WUG without creating some vibration and air discharges; therefore, avoidance of all vibration and air discharges is incompatible with the development of the WUG mine.

Dewatering of the mine is an accepted and necessary approach to water management in underground workings; grouting is a mitigative strategy for dealing with water ingress and this is promoted as being so for this project in the relevant technical reports.

There are a range of initiatives that could be undertaken by OGNZL within and outside of the WUG that could result in tangible, additional benefits for Archey's and Hochstetter's frog populations at Wharekirauponga and elsewhere. These constitute actions that minimise or mitigate effects, or provide biodiversity offsetting, or ecological compensation and, for this project, would seek to provide measurable benefits for Archey's and Hochstetter's frogs.

OGNZL is proposing to commit to the initiatives laid out below irrespective of whether consenting authorities agree that the risk of loss of Hochstetter's and Archey's frog habitat and individuals is low or higher, and irrespective of whether initial monitoring of these populations during mining shows nil effect. We are of the view that the proposed enhancement programme may not be needed to address an adverse effect, however, we acknowledge that OGNZ intents committing to this in order to provide benefits to frogs across the site and wider area – and in doing so provide substantial additional benefits to the wider ecology and rare species within these areas as well.

The intended outcome of either of these approaches (on-site or off-site programmes) is supported by OGNZL and aligns well with its company ethic of providing for 'net-gain' or a clear benefit for areas of environmental risk in the locations that it operates. The Department of Conservation has also recently started to pursue 'net benefit' outcomes, under the concept of 'protective benefit'[10] as a requirement of Wildlife Act Authorities that are issued where unavoidable or unintended losses to herpetofauna may result.

[10] As recently adopted by DOC following the PauaMAC5 Court of Appeal and Supreme Court cases in 2018 and 2019 (otherwise known as the "shark cage diving" cases) which reinforced that authorised activities must fall within the purpose of the Act which is "for the protection and control of wildlife", or **protective benefit**.

3.2 Net gain

Offsetting or compensating to achieve net-gain ('net positive benefit') is a management approach used to address unavoidable losses of biodiversity after actions to avoid, remedy, and mitigate have been sequentially applied, and residual adverse effects remain.

Net-gain extends further than no-net-loss to provide an unequivocal benefit over and above equivalent redress for the risk of losses at an impact site.

In the context of WUG, an unequivocal net-gain would need to include programmes that result in demonstrated benefits for Archey's frogs (and Hochstetter's frogs if necessary) and which are generally agreed by stakeholders and regulators – whether those gains are realised on the ground as active management or through 'indirect' conservation through advocacy, research, or education.

In most situations on other projects that seek to change land use or human development of a location the risk around an adverse effect occurring, that cannot be avoided, remedied or mitigated, is certain or almost-certain and an assessment of overall net-loss: gain relies upon enhancement works delivering benefit with certainty. In the case of WUG, the risk of an adverse effect occurring is low or very low and applying a standard effects management framework (EIANZ) results in no need for further mitigation, offset or compensation beyond that already included as part of the mine design.

However, as previously discussed, it is proposed to undertake a net-gain outcome through extensive positive environmental enhancements as part of its agreed overall design package for the WUG project, and to ensure certainty of benefits for Archey's frogs and for Hochstetter's frogs.

OGNZL has previously sought comment from DOC regarding beneficial works that it could contribute to as part of a net-benefit programme[11]. Those initiatives are listed below in **Table 3**, with an explanation of what these could include.

Table 3. Initiatives that could assist with providing benefits for Archey's and Hochstetter's frogs.

Conservation initiative	Description and example
1. Predator control area around WUG area	Intensive, long-term pest animal control above the WUG (or other areas where Archey's and Hochstetter's frogs are present), with a core area under more intensive (e.g. mouse) management.
2. Distribution surveys to better assess population status for Archey's frogs	Fund distributional surveys to assess population extent and revisit long-term monitoring sites for Archey's frogs.
3. Fund research programmes	Targeted funding for graduate, PhD or post-doctoral research programmes on approved topics relating to Archey's frog conservation. Priorities for research would be informed by the DOC Frog Recovery Group or the Frog Recovery Plan (or both).
4. Investigate translocation and population establishment	Develop and implement a programme of assessing translocation potential and trial re-establishment of Archey's frog in new location(s). Investigate or trial potential candidate sites such as Great Barrier Island, Little Barrier Island, Maungatautari Mainland Sanctuary, and other mainland sites.
5. Fund research or advisor position	Annual stipend to fund a position within a university or DOC as a dedicated frog management/ science role.

[11] DOC's response is covered in its letter dated 31 May 2018 (DOCCM-5483966) in which it concluded that there is insufficient information known about the success of any actions to benefit Archey's frogs such that the Recovery Group recommends that avoidance of further potential adverse effects is the preferred option.

6.	Captive breeding research	Work with established captive breeding facilities (e.g. Auckland Zoo) to improve husbandry of Archey's frogs.

Under usual practice, a biodiversity offset or ecological compensation package would be developed to be proportionate to the level of potential adverse effect. Often, accounting models or compensation ratios are applied to provide an estimate of the amount (or quantum) of management needed to provide equivalent benefits.

In this case, there is uncertainty over the degree to which frogs may be affected. The level of effect could range from a negligible change to localised conditions that are reversible after the completion of mining, through to wider-ranging effects on the Archey's (or Hochstetter's) frog population within WUG that may take many years to reverse (that is, a potential effect on recruitment such that an unknown but likely negligible or small proportion of eggs (or larvae for Hochstetter's frogs) that would have otherwise hatched, fail to do so.

The approach to managing the (low) potential for residual adverse effects on Archey's and Hochstetter's frogs by OGNZL has three components. These are:

1. **Further mitigation** – intensive pest control within 314 ha of the WUG surface footprint (where surface vibrations >2 mm / sec are expected) to deliver benefits specifically for Archey's frogs and associated benefits for Hochstetter's frogs; and

2. **Offset enhancements** – intensive pest control within 318 ha of habitat for Archey's frog to the east and west of WUG (these are areas of Archey's frog habitat that are superior to habitat within most of the WUG footprint; associated benefits are anticipated for Hochstetter's frogs); and

3. **Compensation** – in the form of financial support for researchers to undertake investigative work within the WUG and wider frog enhancement areas to assess efficacy of pest control regimes for frog recovery, and surveys of the broader Coromandel Peninsula to better understand the distribution and habitat preferences of Archey's frogs.

The management response proposed for Archey's frogs (i.e., points 1-3 above) will provide a demonstrable net benefit for the species such that consideration of additional actions is not necessary. Benefits are also anticipated for Hochstetter's frogs.

The programme of pest control focussed on delivering benefits for Archey's and Hochstetter's frogs within the further mitigation and offset enhancement areas is the subject of the management plan prepared by Boffa Miskell (Dr Helen Blackie[12]) and has these design components:

1. Pest control designed specifically to supress rats and mice as key predators of frogs, and to reverse destruction of frog habitat caused by ungulates (in particular, pigs), and sustain this over a prolonged period;

2. The design of the programme, including control devices, layout, toxins and trapping programmes, control targets, operational trigger thresholds, and adaptive management responses are based on work undertaken by DOC at Whareorino and the successes of private

[12] Boffa Miskell. 30 October 2024. Draft Pest Animal Management Plan: Wharekirauponga compensation package. Report prepared by Boffa Miskell Ltd for Oceana Gold NZ. 91 pp.

landowners on the Coromandel[13] at controlling pest species over smaller areas with demonstrated benefit for Archey's (and Hochstetter's) frogs; and

3. The spatial location of the proposed pest control areas is intended to buffer and augment existing areas where Archey's and Hochstetter's frogs are known to exist, and target habitat where high densities of frogs are known or predicted to exist (based on habitat-abundance associations modelled through other parts of the Coromandel Peninsula).

With effective pest control in place, the Boffa Miskell report anticipates that a level of population enhancement of both frog species could be expected of at least 2.3 x the current population over a period of 3-4 years (and possibly greater in years after that) for Archey's frog, and substantial increases (in the order of 4 x abundance increases) for Hochstetter's frogs.

This means that in the unlikely event that frogs of either species are adversely affected through either localised mortality, loss of breeding during vibration at that location, or loss of stream margin habitat within the 314 ha area of WUG subject, the potential benefits of undertaking pest control within 318 ha of habitat adjoining the vibration exposure areas of the WUG surface footprint would be more than sufficient to balance losses that may occur under a pessimistic scenario of adverse effects on Archey's frogs within the >2 mm /sec vibration area of the WUG surface footprint (or the much more limited extent of potential stream wetted width change for Hochstetter's frog). Pest control within surrounding buffer areas would provide additional benefits to frogs on top of this.

Collectively, the proposed enhancements to frog habitat through introduced predator control are intended to provide for a net benefit to Archey's and Hochstetter's frogs as a result of the WUG project. Providing assurance around net benefit requires an understanding of how the projected benefits from enhancement (in this case pest control) will result in no-net-loss of frogs, so that benefits beyond no-net-loss can be proposed.

Calculations of potential loss and potential gain (enhancement) for frogs, together with considerations of risk, uncertainty, and time lags, are outlined in the next section of this report.

3.3 Net gain calculations

This section of the report focusses on whether offset calculations are appropriate for the Archey's frog, as that species is the most widespread throughout the WUG and there is a greater level of uncertainty associated with potential adverse effects from surface vibration, as opposed to the potential for adverse (or beneficial) effects of stream wetted width changes for Hochstetter's frog.

The pest control programmes proposed to benefit Archey's frog should also benefit Hochstetter's frog – as pest control has been demonstrated to benefit Hochstetter's frog in other locations with great effect (see Boffa Miskell 2024 Pest Animal Management Plan, and references therein). In addition, the scale of potential adverse effect to Hochstetter's frog habitat within the project area is proportionally far less than for Archey's frog, yet the same areas under pest management will benefit very large areas of Hochstetter's frog habitat; overall, we regard it as unnecessary to attempt to model a loss:gain

[13] These are two programmes on private land on the Coromandel Peninsula that individuals within the OGNZL team are aware of, and for which there is definitive evidence of recovery of Archey's and/or Hochstetter's frogs within several years of intensive control of rats and mice.

outcome for Hochstetter's frog as the area potentially affected is small, the risk of adverse effect is so low, and area over which benefits are certain (or close to certain) is very large.

For Archey's frog, we applied three commonly-used biodiversity accounting tools (models) to assess the potential outcomes for loss of Archey's frogs within the 2 mm/ sec vibration footprint, and the enhancement of Archey's frogs that may result from intensive animal pest control programmes within the footprint and nearby.

Three different methods were applied because there is no national consensus as to the most appropriate offset accounting method to use in situations such as this. In addition, we wanted to assess how precise the outputs were between the models, in order to provide a spread of potential outcomes based on the differing assumptions behind each model.

For each model we also ran a range of scenarios related to the predicted level of adverse effect on frog mortality arising from the effects of vibration, and the level of certainty associated with benefits that result from pest control on frog populations. The range of scenarios modelled covered likelihood and certainty combinations that ranged from (in our opinion) far-fetched, extreme outcomes through to outcomes that, while uncertain, may be more plausible.

The three accounting methods applied were:

1. **Basic model**, where the only inputs required are the estimated density of frogs or population size within the impact area, time lag annualised discount rate, and anticipated level of benefit at the pest control management site(s). Uncertainty is not included in the model.

2. **Biodiversity Offset Accounting Model** (BOAM)[14], where baseline and benchmark numerical values for frog density are included, together with predictions of frog population enhancement over time at management site(s). Uncertainty is included for the enhancement management sites. Time-lag for delivery of benefits is incorporated as an annual multiplier.

3. **Biodiversity Compensation Model** (BCM)[15], where estimates of benchmark, baseline, change to baseline, time lags, and uncertainty at impact and enhancement management sites are included as semi-quantitative scores on a relative scale to provide an estimate of the degree to which a pre-set, net-gain outcome is achieved. The BCM typically provides a very conservative output compared to the Basic and BOAM models, due to the multiplying effect of different levels of uncertainty needing to be recognised and expressed in the calculations.

Each of these models requires that assumptions are made regarding the baseline and benchmark levels of frogs, duration of mining and pest control programmes, and the assumed responses of frogs to pest mammal control. Key assumptions are laid out in **Table 4**.

Table 4. Key assumptions for input data for Archey's frogs used in the Basic, BOAM and BCM models.

Assumption	Explanation
Current (baseline) frog numbers	Lloyd estimates between 48,888 and 152,774 frogs are within the vibration footprint of the mine, although considers a mid-range value is more likely. The mid-range value is 90,000 frogs over the 314 ha vibration footprint. We have used 90,000 Archey's frogs as the baseline within the vibration footprint.

[14] As developed by the Department of Conservation: Maseyk F, Maron M, Seaton R, and Dutson, G. 2014. A biodiversity offsets accounting model for New Zealand: User Manual. Prepared for the Department of Conservation, Wellington. 77 pp.

[15] Baber, M, Dickson, J, Quinn, J, Markham, J, Ussher, G, Heggie-Gracie, S, and Jackson, S (2021). Biodiversity Compensation Model for New Zealand– Excel Calculator Tool (Version 1). Prepared by Tonkin & Taylor Limited. Project number 1017287.0000P.

Current (baseline) frog density	Lloyd analysed frog counts across plots within and near to the vibration footprint. Estimated densities from that analysis across several methods of assessment produced density estimates from 62.9 adult frogs/ ha to 937.1 frogs/ ha. Frog densities on the ground are likely to vary according to habitat and other variables. A coarse estimate of density can be obtained by dividing a mid-range population estimate by the area over the estimate, which gives an estimated density of (90,000 adult frogs/ 315 ha) 286 adult frogs/ ha.
Benchmark frog density	For degraded systems such as is assumed for Archey's frogs, the benchmark is a number greater than the current baseline. Maximum densities estimated from the study by Lloyd indicate that densities of up to 1,654 adult frogs/ ha may be present now, which presumably represents a degraded (reduced) state than if the population was subjected to a long-term intensive pest control programme, or introduced pest mammals were absent for a long time. The benchmark is a nominal number; accuracy is not strictly important to the offset calculations. We have chosen 900 adult frogs/ ha as a reasonable expectation for a long-term benchmark.
Area and duration of vibration footprint	Mine development modelling and blast modelling has identified that an area of around 315 ha may be subject to intermittent surface vibrations above 2 mm /sec. Studies elsewhere indicate that Archey's frogs can tolerate, breed, and persist within areas where artificial vibration (vehicles, mining blasts) is 2 mm /sec. No examples of exposure of frogs at greater vibration levels exist. Therefore, >2mm /sec surface vibration defines the potential impact footprint for the mine. The duration of surface vibration is 11 years, as is described by the time series frequency distribution graph in Figure 1.
Area of mitigation and offset	The area of the proposed pest control areas is described in the Wharekirauponga Pest Animal Management Plan prepared by Boffa Miskell. The mitigation area is the 314 ha vibration footprint. The offset area is a 318 ha area surrounding the vibration footprint. Habitat within the offset area is considered to be superior for Archey's frogs compared to the 'low' quality habitat within the vibration footprint/ mitigation area.
Duration of pest control programme	The duration of the animal pest control programme is set by draft resource consent conditions which prescribe a minimum duration of pest control prior to and following mining activity. This results in pest control being undertaken for a minimum period of 14.5 – 15 years. A duration of 15 years is used for these models.
Benefits of pest control programme for frogs and certainty of benefit	The potential benefits of animal pest control for Archey's frogs have been studied at only one location – Whareorino. Several studies have produced different estimates of benefit. • **Haigh et al., 2007** 55 frogs increased to 166 frogs over a 4-11 month period between 2004-2005 (within 1 year). • **Ramirez, 2017** Frog monitoring between 2005-2013 (9 years) showed 2.3 x more frogs in the rat control area when compared to the non-treatment area. • **Germano et al. ND** 12-year study showed adult frog survival rate was greater (0.74 – 0.78) in the rat control area when compared to the non-treatment area (0.53 – 0.55). 10-year study between 2005 and 2015 showed 2.9 x more frogs in the rat control area when compared to the non-treatment area. Boffa Miskell has concluded that the pest control programme at Whareorino could be improved upon, with potentially greater benefits for frogs – up to 4 x the starting population size over a period of 3-4 years, and possibly greater increases in subsequent years. Based on these studies, we have used a benefit multiplier of 3.0 x over a 15-year period, which we consider to be realistic/ precautionary.

Uncertainty is a common thread when attempting to identify risk of potential adverse effects and benefits to frogs from pest control. The effective sample size of examples to work with is nil or very low, and conclusions are reliant on circumstantial evidence or the results from surrogate programmes (usually on Hochstetter's frog).

Lack of certainty should not prevent an assessment of risk or benefit, especially in this case where research points towards a low risk of potential impacts on frogs from the mine, and a high benefit to undertaking pest animal control to an effective level. We have included uncertainty in our models in several ways. These are outlined in **Table 5**, which provides a comparison of factors between each of the three models.

The BOAM and BCM models require uncertainty to be included in calculations. These models require an explicit statement of uncertainty to be made, with the level of uncertainty chosen determining a multiplier that is added to the area required under pest control or numbers of frogs required to be generated. Not all uncertainty can be addressed by simply 'doing more'. The BCM and BOAM models only allow certainty down to 50 % to be added into the model; anything less than 50 % certainty of outcome is not handled by the model. Rather, where uncertainty is high (less than 50 % certainty) the potential risks of the project should be revisited through project design to avoid potential impacts, or through investigations, field studies or similar to generate a more comprehensive understanding that results in a greater level of certainty of the beneficial outcomes of the project in question.

The sources of uncertainty incorporated into the models are:

1. All models – confidence that vibrations from the mine blasting works will result in a loss of frogs within the footprint. 'Loss of frogs' is defined as dead frogs, rather than disrupted breeding. The mine duration is much less than a life span of an Archey's frog, and it is assumed that if breeding is disrupted during blasting, it will re-commence once blasting is completed. The levels of confidence used to generate scenarios (modelled outcomes) were:
    a. 100% - all frogs die
    b. 75% - most frog die
    c. 65% - more than 50% frogs die
    d. 50% - half of the frog population dies/ half of the frog population survives
    e. 25% - most frogs survive

    From discussion with the other ecologists in the OGNZL advisory group, we collectively are of the opinion that the level of potential effect on frogs will be 25 % or much less. **Figure 1** shows the frequency distribution of vibration events over time. Most events are between 2mm/ sec and 4 mm/ sec. Higher vibration events occur over a much smaller area in any given year, and do not occur every year in every location over the footprint.

    Given that Archey's frogs seems able to survive and persist in 2 mm /sec vibration environments, it is unlikely that all or most frogs will die when exposed to marginally greater vibrations. Frogs that are exposed to much higher vibration events (e.g. greater than 8 mm /sec) are presumably at higher risk of injury or mortality; however, those events and area over which they occur comprise a small part of the overall vibration profile across the site and across the mine life.

    The Department of Conservation considers that Archey's frog populations are declining year-on-year without any change to pest management. This background level of decline is defined by DOC as:

> *The total population comprises 5,000–20,000 mature individuals, and there is an ongoing or predicted decline of 10–30 % in the total population or area of occupancy due to existing threats, taken over the next 10 years or three generations, whichever is longer.*

For the purposes of this modelling, we have assumed that Archey's frog populations would be stable (not increasing or decreasing) over the 15-year period without the mine or pest control. That is perhaps overly optimistic; however, it simply means that loss of frogs attributed to mining in these models would in reality be an aggregate of losses due to introduced mammalian predation as well.

2. BOAM model. The key uncertainty included is confidence that the pest animal control will result in the level of improvement to frog populations entered into the model. The BOAM model includes three levels of confidence – low (>50 %-75 %), moderate (75 %-90 %), and very confident (>90 %). We have run all three scenarios, but consider that an appropriate level of confidence is 'moderate' or 'low' depending on the weight placed on previous studies of the benefits of pest animal control across native species, and the benefits that are known specifically for Archey's frogs.

3. BCM model. The BCM model applies a range of multipliers that take uncertainty into account. We have set '**Impact risk contingency'** and '**Impact uncertainty contingency'** at a high level to recognise the threat status of Archey's frogs and the high-value forest ecosystem in which they live.

4. BCM uncertainty values that we have varied with each scenario/ model run are:

    - **Value score** after impact (relative to prior to impact) to recognise that we are uncertain of the level of adverse effect that vibrations may have on loss of frogs; and

    - '**Compensation confidence contingency'** which is a sliding-scale multiplier added to the area required to manage for pest control depending upon the level of certainty that pest control will deliver the anticipated benefits for frogs.

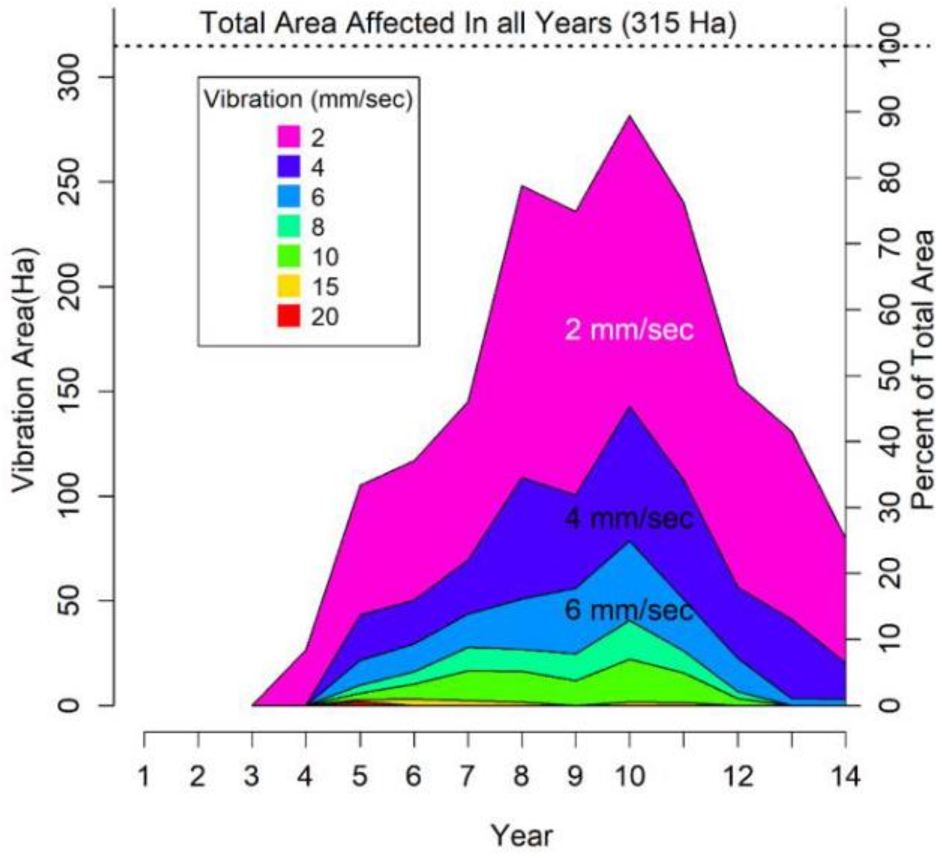

Figure 1. Predicted changes in the extent of areas affected by different vibration intensity levels for the current mine design (sourced from Lloyd 2023). The period of time over which mining-related surface vibrations greater than 2mm /sec occur is 11 years.

Summarised outputs from the scenarios for each model are shown in **Tables 6, 7 and 8**.

Copies of the Basic, BOAM and BCM models are available on request.

Key points are:

1. We ran three different offset accounting models, and up to 15 scenarios for each across a range of predicted loss scenarios for frogs within the mine footprint, and across levels of confidence that pest control would deliver the predicted minimum level of benefit to frogs.

2. Of the 35 models run, 31 of those predicted clear net-gain benefits for frog populations from undertaking 15-year pest animal control programmes within the mine footprint and in the adjoining offset area. The four models that predicted net-losses are predicated on a set of assumptions which experts involved with the project consider to be fanciful (un-realistic) given the weight of expert experience, knowledge of frog vulnerability from elsewhere, and detailed vibration profiles that frogs will be exposed to across the mine site.

3. In most cases, pest control within the mine footprint AND pest control within the adjoining offset is required to fully address potential adverse effects and to result in a clear net-gain, especially when confidence of loss of frogs is considered to be moderate and the magnitude of assumed gains to frog populations is considered to be moderately or highly uncertain.

4. Pest control within the 314 ha mine footprint and adjoining 318 ha offset area is predicted to not result in a net-gain outcome if loss of frogs is very high (75 % or 100 %) together with a very high level of uncertainty that pest control will deliver anticipated benefits. We regard this combination of factors in these scenarios to be fanciful and that these do not describe a realistic outcome.

5. Every scenario where loss of frogs is high (75 %) through to low (25 %) across the mine footprint, and even where the confidence in the benefits of pest control for frog populations is low, results in a clear net gain outcome for frogs when undertaking pest control within the mine footprint and adjacent offset area for a minimum of 15 years.

Table 5. Comparison of input variables for Basic, BOAM and BCM biodiversity models.

Assumption	Basic	BOAM (Biodiversity Offset Accounting Model)	BCM (Biodiversity Compensation Model)
Mine vibration footprint (ha)	314 ha	314 ha	314 ha
Threshold of potential impact	>2 mm/ sec	>2 mm/ sec	>2 mm/ sec
Assumptions on magnitude of impact potential across mine site	Consistent across mine footprint, although it is unknown if fewer, higher vibrations will cause more or less impacts than more frequent, lower vibrations, as is proposed.		
Annual discount rate (loss of future value)	3.0 %	3.0 %	3.0 %
Duration of mining activity leading to surface vibrations	11 years	11 years	11 years
Pest control within mine footprint	Yes – multi-species pest control for 15 years, including at least 18 months prior to commencing stoping works, and 2 years following the completion of blasting activities at the mine		
Risk contingency in mine footprint	none	none	High Risk (impact score is multiplied by 1.1 x) as Archey's frog is an At Risk species.
Contingency to address lack of knowledge of impact level	Individual models run for varying levels of frog loss	Individual models run for varying levels of frog loss	High uncertainty (impact score is multiplied by 1.2 x) as there is no knowledge of impacts to frogs of >2 mm /sec vibrations. AND Individual models run for varying levels of frog loss
Offset area (ha)	318 ha	318 ha	318 ha
Mine enhancement footprint (ha)	314 ha	314 ha	314 ha
Pest control within enhancement sites	15-year, multi-species animal pest control programme		
Pre-project Archey's frog average density / ha for mine footprint and offset site	286 frogs/ ha	286 frogs/ ha	286 frogs/ ha
Level of benefit after 15 years of pest control	3 x	3 x	3 x
Confidence contingency	none	Yes – scenarios run for 'very confident', 'confident' and 'low confidence'. Each attributes a penalty multiplier to increase offset area required.	Yes – scenarios run for 'very high', 'high' and 'moderate'. Each attributes a penalty multiplier to increase offset area required.

The above results provide confidence that the design of the mine blasting programme and associated surface vibration footprint, together with undertaking comprehensive animal pest control within the 314 ha footprint and 318 ha adjoining offset area is likely to result in an increase in the Archey's frog population in and around the mine site such that a clear net-gain will result.

Table 6. Outputs from the Basic offset model. Assumes complete confidence in enhancement outcome and assumes that only frogs not lost (i.e. not dead) can contribute to mitigation enhancement. Net-loss (orange shaded cells) or net-gain (green shaded cells) position for frog populations following mining and pest control within mine footprint and offset sites combined.

Scenario (% loss of population	Loss of adult frogs	Population remaining at end of mine activity	Population loss adjusted for 11 years of lost opportunity (3 % annual discount rate)	Predicted number of adult frogs within mine site at end of blasting	Predicted number of adult frogs within offset site above the starting population, after 15 years if pest control	Net position of frogs for combined population loss during mining (11 years) + enhancement from pest control (15 years)
100 %	90,000	0	124,581	0 (nil)	181,714	+57,133 (net gain)
75 %	67,500	22,500	93,436	67,500	181,714	+155,778 (net gain)
60 %	54,000	36,000	74,749	108,000	181,714	+214,965 (net gain)
50 %	45,000	45,000	62,291	135,000	181,714	+254,423 (net gain)
25 %	22,500	67,500	31,145	202,500	181,714	+353,069 (net gain)

Table 7. Outputs from the BOAM offset model, with varying levels of assumed confidence in the benefits of pest control, and assumed loss of frogs within the mine footprint due to vibration effects. Net-loss (orange shaded cells) or net-gain (green shaded cells) position for frog population following mining and pest control within mine footprint and offset sites combined.

Gain confidence --->	**Low (>50%<75%)**	**Confident (75%-90%)**	**Very confident (>90%)**
Level of adult frog population loss (%)			
100 % loss	-19.4 (net loss)	+7.2 (net gain)	+24.1 (net gain)
75 % loss	+25.5 (net gain)	+58.6 (net gain)	+79.6 (net gain)
65 % loss	+52.3 (net gain)	+89.4 (net gain)	+112.0 (net gain)
50 % loss	+70.3 (net gain)	+110.0 (net gain)	+135.2 (net gain)
25 % loss	+115.1 (net gain)	+161.3 (net gain)	+190.7 (net gain)

Table 8. Outputs from the BCM model, with varying levels of assumed confidence in the benefits of pest control, and assumed loss of frogs within the mine footprint due to vibration effects. Net-loss (orange shaded cells) or net-gain (green shaded cells) position for frog population following mining and pest control within mine footprint and offset sites combined.

Gain confidence --->	Low (>50%<75%)	Confident (75%-90%)	Very confident (>90%)
Level of adult frog population loss (%)			
100% loss	-38.4 % (net loss)	-18.7 % (net loss)	-8.8 % (net loss)
75% loss	+2.3 % (net gain)	+35.1 % (net gain)	+51.5 % (net gain)
65% loss	+27.4 % (net gain)	+68.2 % (net gain)	+88.6 % (net gain)
50% loss	+83.9 % (net gain)	+142.7 % (net gain)	+172.2 % (net gain)
25% loss	+328.6 % (net gain)	+465.7 % (net gain)	+534.3 % (net gain)

4.0 Monitoring

Monitoring provides validation of both management inputs (results) and conservation benefits (outcomes). Monitoring is especially important for a project such as this where is uncertainty over the level of response by frogs to activities associated with the mine that may cause potential adverse effects, and where the level of benefit that the enhancement solution (pest control) may deliver is informed by only one long-term project for Archey's frog (DOC at Whareorino), and a small number for Hochstetter's frog.

For this project we regard the risk that loss of frogs and permanent damage to existing populations within the footprint area to be low, albeit uncertain. In response to this, the proposed to undertake a catchment-level pest control programme, which under all realistic scenarios is likely to provide enormous benefits to populations (and other flora and fauna).

One of the key sources of uncertainty for this project is the surety of benefit that will be generated from pest control. There are few programmes that have invested the resources to assess this elsewhere and none within the Coromandel Ranges. This project is therefore an opportunity to undertake robust monitoring hand in hand with a robust pest animal control programme.

This section of the report provides a very basic summary of the pest control programme and associated monitoring that is proposed by Boffa Miskell and Lloyd's Ecological Consulting in these respects. Our hope is that the Department of Conservation sees the potential in such a programme, and contributes to the design of these programmes so that the programme and its outputs can provide a solid foundation for evidence-based management that DOC, OGNZL and other users can rely upon in the future when contemplating the merits of animal pest control regimes for the conservation of native frogs.

Result monitoring to assess the performance of pest control programmes is laid out in the Boffa Miskell pest animal management plan (Boffa Miskell, 2024). The monitoring includes targets, thresholds for action and contingency measures in order to ensure that pest control is effective and can reduce and sustain pests to agreed levels.

Outcome monitoring involves selecting indicators of frog population health, ideally those that communicate aspects of breeding success, recruitment, conspicuousness, population structure (demographics) and population abundance so that the merits of pest control programmes can be attributed with certainty.

A difficulty for the monitoring of native frogs is that they are cryptic and that intensive effort is required to obtain even basic information on population health (abundance and distribution), let alone dynamics and trends over time. Indeed, it is probably unreasonable to expect that many of the ideal indicators of frog population health will be able to be meaningfully measured on the ground – or at least without a level of effort that is financially unachievable and which would most probably cause considerable damage to frog habitat (and perhaps to the frogs themselves through repeated handling) in the process.

We recognise that effective monitoring of Archey's and Hochstetter's frog populations before and after, and ideally without and outside frog management areas is necessary to validate pest management as a means of providing benefits – particularly where the scale of benefit achieved on the ground may become central to future conclusions over equivalent replacement or net-gain as a result of the WUG project.

A draft monitoring programme for frogs has been developed (Lloyd 2024).

The design of the pest animal control programme allows for a robust BACI (Before, After, Control, Impact) design comparison to be adopted for the frog monitoring programme.

The levels of treatment comparisons that will be included are (see **Figures 2 and 3**):

1. Within the >2 mm/ second vibration zone (314 ha footprint) where frogs are also subject to intensive pest animal control;

2. In an adjoining area (the 318 ha offset area) where frogs are not subject to mine-related vibration, but are subject to intensive pest animal control; and

3. In an area to the west of the WUG intensive pest animal control area, where frogs are not subject to vibration or additional pest animal control as a result of this project.

Three sites therefore allow the comparison of potential effects or benefits of vibration and pest animal control compared to a baseline of the existing level of pests and pest control applied to the southern Coromandel Peninsula.

The monitoring site design, approach and sampling method is laid out in Lloyd 2024, with a summary from that report shown below.

> *To ensure conclusions from monitoring are robust, the monitoring programme will be undertaken using a Before-After-Control-Impact (BACI) design. To separate effects from mining activities and pest control, monitoring will be undertaken in three area: two treatment areas and a non-treatment area. Characteristics of the treatment and non-treatment areas for each species will be as similar as possible. Monitoring will begin before the effects of mining and pest control begin and continue throughout the mine's life.*
>
> *Archey's frog populations will be monitored using the standard capture-recapture method for monitoring Archey's frog populations, but with 30 x 30 m plots instead of 10 x 10 m plots to improve the quality of population estimates.*
>
> *Hochstetter's frog populations will be monitored using replicate searches for frogs in their daytime refuges along 20 m long stream transects. General Linear Mixed Effect Models will be used to compare frog counts on transects in different areas and different surveys. N-mixture modelling will be used to estimate frog abundance on transects. To achieve acceptable statistical power and robust abundance estimates, there will be 45 transects in each of the three treatment and non-treatment areas and 6 replicate searches of each transect during annual surveys. Fewer transects or replicates will reduce the likelihood of correctly identifying 100% increases (or 50% decreases) in frog abundance between surveys to unacceptably low likelihood levels (< 80%).*

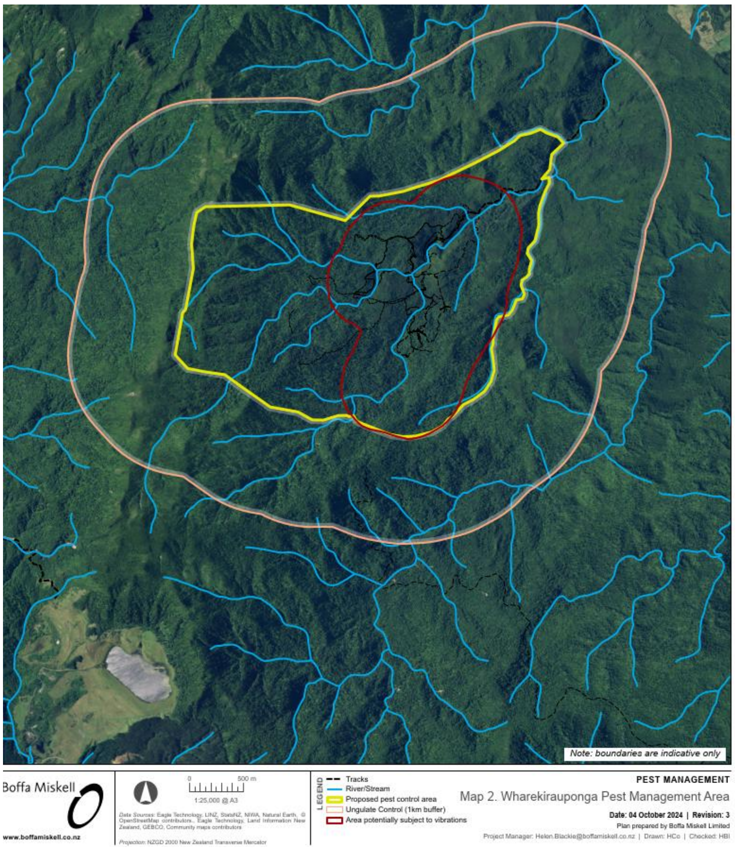

Figure 2. Wharekirauponga pest management area. Red polygon is the area potentially affected by surface vibrations, yellow polygon is the proposed pest control area, and the pink polygon is the ungulate control buffer.

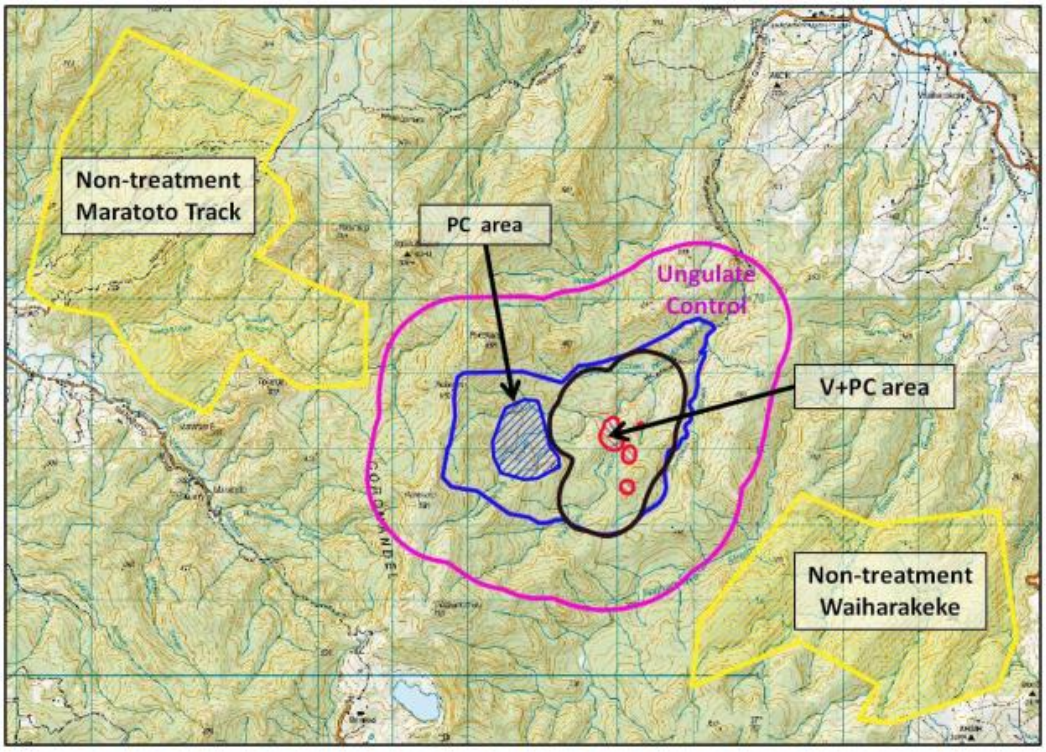

Figure 3. Boundaries of the predicted vibration footprint for the mine (black), the WAMPB pest control area (blue) and ungulate control area (magenta), with suggested areas for locating the (PC) pest control treatment monitoring plot (blue hatching), the vibration and pest control (V+PC) monitoring plot (red hatching) and two areas suggested for locating a non-treatment plot (yellow hatching). (sourced from Lloyd 2024).

OGNZL's intention is to start pest animal control around 2 years ahead of the WUG mine works commencing (which will provide up to 5 years of site data prior to the stoping works under the mine underground area, separate of the works to construct the dual tunnel). That will provide an opportunity to collect baseline information on frog populations within each of the treatment comparison areas prior to any potential adverse effects from mining being expressed on these populations.

In addition to the above key component of the monitoring programme, there are several other aspects that we have considered.

- Monitoring of artificial refuges on an annual basis as a proxy for population abundance.
- Monitoring of egg broods to assess viability.
- Analysis of scats for frog remains from pest trapping to detect relative abundance of predation events (molecular analysis) as a proxy for predation release.
- Trials of less invasive/disturbance methods to assess abundance – such as distance sampling and mark-recapture.

These are possible research avenues that could be funded from the financial contribution that is proposed by OGNZL to be made on an annual basis to and agency or research institution to help with funding frog-related research and management.

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Attachment A

Reports from OGNZL that were reviewed to assess design matters relating to potential adverse effects on Archey's frogs.

- Mitchell Daysh Limited, Waihi North Project – Resource Consent Applications and Assessment of Environmental Effects, dated June 2022 01.

- Beca. 8 July 2021. Waihi North Project air discharge assessment – Exploration and connection tunnels. Prepared for OGNZL.

- Beca. 14 July 2021. Waihi North Project – summary report of air discharge assessments. Prepared for OGNZL.

- Beca. 14 June 2022. Waihi North Project – Air Discharge Assessment – Wharekirauponga Underground Mine. Prepared for OGNZL.

- Boffa Miskell Limited. 27 October 2024. Waihi North Project: Terrestrial Ecology Values and Effects of the WUG. Report prepared by Boffa Miskell Limited for OceanaGold (NZ) Ltd.

- Ozvent Consulting. July 2020. Wharekirauponga access tunnel ventilation study. Report prepared for OceanaGold Corporation.

- Ozvent Consulting. December 2020. Wharekirauponga access tunnel miscellaneous ventilation topics. Report prepared for OceanaGold Corporation.

- Marshall Day Acoustics. 17 June 2022. Oceana Gold New Zealand – Waihi North Project: assessment of noise effects. Report prepared for Oceana Gold (NZ) Ltd.

- Vibration analysis work undertaken by John Heilig (and OGNZL)

    - Assessment of traffic induced vibration (8 September 2021) – comparison of mine blasting and road traffic measurements at Coromandel roads to assess similarly of vibration experienced by roadside Archey's frog populations
    - WKP mine modelled blasting vibration effects at surface with vibration contours. Series of drawings showing modelled surface vibration over time and depth for the proposed WKP mine workings.
    - Golden Cross mine modelled blasting vibration effects at surface with vibration contours. Series of drawings showing modelled surface vibration over time and depth for the Golden Cross mine workings when it was operational, and in relation to surveyed Hochstetter's frog populations prior to, during and following mining activities at that site.
    - Assessment of WUG vibration modelling, frequency histograms, background to underground mining (25 Feb 2022).
    - Heilig & Partners. June 2022. Waihi North Project: Blasting and vibration assessment. WAI-985-000-REP-LC-0018_Rev 0. Report prepared for OGNZL.

- Tonkin & Taylor. June 2022. Assessment of mine vent air quality impacts to inform assessment of ecological effects on Archey's frog. Report prepared for OGNZL.

- Valenza Engineering. June 2022. Wharekirauponga Underground Mine: Wharekirauponga conceptual mitigation: Phase 1 report. Report prepared for Oceans Gold NZ Ltd. 248 pp.

- GWS Limited. 14 June 2022. Waihi North Project: Assessment of groundwater effects. Prepared for OceanaGold Corporation. Doc Ref WAI-985-000-REP-LC-0030_Final Rev 0.

- Lloyd, B. 2023. Estimating the proportion of the Coromandel's Archey's frog population in the area affected by vibrations from the proposed Wharekirauponga Mine. Report prepared for OGNZL. 6 April 2023.

- Lloyd, B. 2024. Analyses of the results of surveys for Hochstetter's frogs undertaken in 2024 to assess the impacts of stream flow reductions associated with the Wharekirauponga Underground Mine. Report prepared for OGNZL. 14 October 2024.

- Lloyd, B. 2024. A plan to monitor the response of populations of two native frog species to the proposed Wharekirauponga Underground Mine project. Report prepared for OGNZL. 22 October 2024.

- Bioresearches, 2024. Proposed Wharekirauponga Underground Mine: DRAFT native frog effects assessment. Report prepared for OGNZL by Van Winkel, D, 17 October 2024.

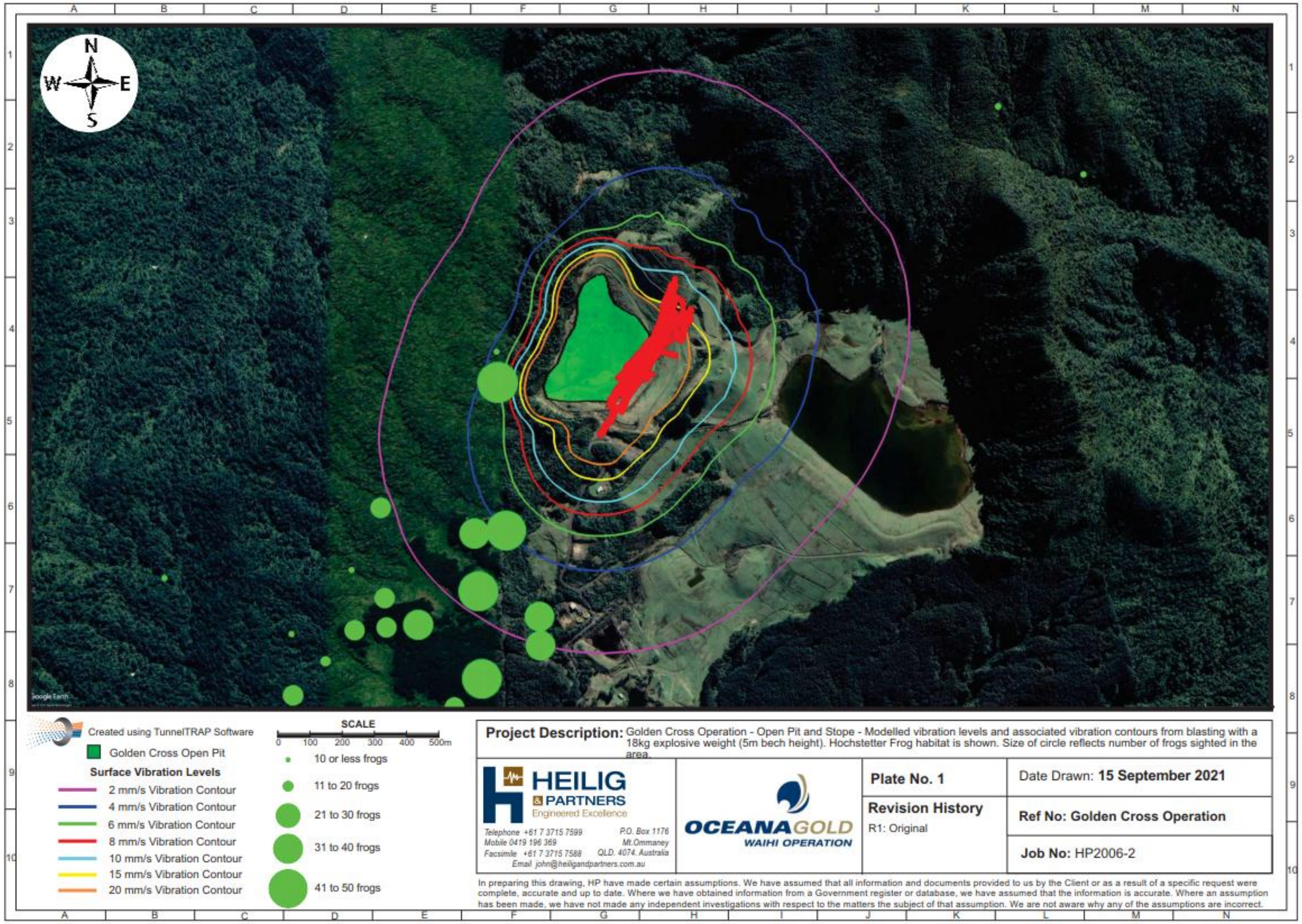
- Boffa Miskell. 30 May 2022. Pest Animal Management Plan: Wharekirauponga compensation package. Report prepared by Boffa Miskell Ltd for Oceana Gold NZ.

- NIWA. 2024. Instream habitat of the Wharekirauponga Stream and tributaries. Report prepared for Oceana Gold NZ. August 2024.

- WWLA. 2024. Waihi North Project – Wharekirauponga Mine dewatering studies – summary of effects on groundwater and surface waters. Report prepared for Oceana Gold NZ. 5 September 2024.

- WWLA. 2024. Draft – Wetland hydrological assessment: wetland identification, delineation & hydrological classification. Report prepared for Oceana Gold NZ. 21 October 2024 (WWLA0996 Rev 3

Attachment B



Golden Cross mine. Modelled vibration levels illustrated as contours in relation to Hochstetter's frogs, with green circles illustrating the location and abundance of Hochstetter's frogs recorded during and after mining. The Golden Cross open pit is shown by the irregular green polygon on the centre of the vibration contours.

Attachment C

EIANZ key tables for assessing level of effect.

Table 5 Factors to consider in assigning value to terrestrial species for EcIA

Determining factors	
Nationally Threatened species, found in the ZOI either permanently or seasonally	Very High
Species listed as At Risk – Declining, found in the ZOI, either permanently or seasonally	High
Species listed as any other category of At Risk, found in the ZOI either permanently or seasonally	Moderate
Locally (ED) uncommon or distinctive species	Moderate
Nationally and locally common indigenous species	Low
Exotic species, including pests, species having recreational value	Negligible

Table 6. Scoring for sites or areas combining values for four matters in Table 4.

Value	Description
Very High	Area rates High for 3 or all of the four assessment matters listed in **Table 4**. Likely to be nationally important and recognised as such.
High	Area rates High for 2 of the assessment matters, Moderate and Low for the remainder, or Area rates High for 1 of the assessment maters, Moderate for the remainder. Likely to be regionally important and recognised as such.
Moderate	Area rates High for one matter, Moderate and Low for the remainder, or Area rates Moderate for 2 or more assessment matters Low or Very Low for the remainder Likely to be important at the level of the Ecological District.
Low	Area rates Low or Very Low for majority of assessment matters and Moderate for one. Limited ecological value other than as local habitat for tolerant native species.
Negligible	Area rates Very Low for 3 matters and Moderate, Low or Very Low for remainder.

Table 8. Criteria for describing magnitude of effect (Adapted from Regini (2000) and Boffa Miskell (2011))

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

Table 10. Criteria for describing level of effects (Adapted from Regini (2000) and Boffa Miskell (2011))

Ecological Value ▶ Magnitude ▼	Very high	High	Moderate	Low	Negligible
Very high	Very high	Very high	High	Moderate	Low
High	Very high	Very high	Moderate	Low	Very low
Moderate	High	High	Moderate	Low	Very low
Low	Moderate	Low	Low	Very low	Very low
Negligible	Low	Very Low	Very low	Very low	Very low
Positive	Net gain	Net gain	Net gain	Net gain	Net gain