EXHIBIT A

verdantas

2544 Industrial Blvd.
West Sacramento, CA 95691
916-231-6052

October 6, 2026

Ms. Carmen Borg
Shute, Mihaly & Weinberger LLP
550 California St. Suite 1200
San Francisco, CA 94104
minner@smwlaw.com

Technical Review of Final Environmental Impact Report
CEMEX Rockfield Quarry
Verdantas Project Number 066.0000032576

Dear Ms. Borg:

I have been retained by Shute, Mihaly & Weinberger LLP (SMW) to review the Final Environmental Impact Report (FEIR) for the CEMEX Rockfield Quarry Project located in Fresno County, California. This review focuses on the response to general and specific comments to the Draft Environmental Impact Report (DEIR), especially responses to my letter titled “Review of Draft Environmental Impact Report, CEMEX Rockfield Quarry Modification Project, Fresno County, California” dated March 6, 2025. Based on this review, it is still my professional opinion that the EIR is inadequate in evaluating the potential significant impacts of project actions on flooding, interconnected surface water (ISW), groundwater dependent ecosystems, and associated biological resources. The rationale for this opinion is presented below.

1. Response 58A-2: No consideration of Climate Change in Flood Hazard Analysis

The following comments also apply to FEIR Collective Response #17 (Flooding and Bank Stability). Response 58A-2 states, “The Draft EIR Hydraulic Analysis’ use of the FEMA 100-year floodplain to analyze the project's flood hazards is sufficient for the purposes of analyzing potential flooding impacts under CEQA, nevertheless.” Collective Response #17 states, “The Fresno County General Plan previously only required the investigation of the 100-year water surface elevations for the San Joaquin River, but was revised in 2024 to require the investigation of the 200-year water surface elevation of the San Joaquin River.” As a result, the FEIR presents analyses of the 200-year floodplain for both the Plant and Quarry sites and showed no flooding impacts. The EIR used FEMA’s effective 100- and 200-year flow rates of 71,000 cubic feet per second (cfs) and 95,000 cfs, respectively. As a result of the 200-year flood analysis, selected levees around the portions of the project were raised by up to four feet to provide 200-year flood protection to the project.

The 100- and 200-year flood hazard analyses presented in the EIR do not consider or analyze the effects of long-term climate change on San Joaquin River flood flow rates at the Quarry and Plant Sites. In my 2025 DEIR comment letter, I introduced a study completed by the California

Department of Water Resources (DWR) (Nemeth et al., 2021[1]) that evaluated how climate change could affect future flood magnitudes throughout the Central Valley Flood Protection Plan (CVFPP) system, including the San Joaquin River below Millerton/Friant Dam.

The analysis was based on the climate-change modeling framework developed for the 2022 CVFPP Conservation Strategy Update (Nemeth et al., 2021). It used a multi-step modeling approach using best available science that included the following.

- Climate projections: a) Downscaled CMIP5 global climate model results were used to develop low, median, and high climate-change scenarios; and b) historical climate records (1915-2011) were adjusted to reflect projected future climate conditions.

- Hydrologic modeling: a) the Variable Infiltration Capacity (VIC) model simulated watershed runoff under future climate conditions; and b) future reservoir and river operations were simulated using HEC-ResSim and HEC-RAS.

- Flood-frequency analysis: a) the study compared 2022 existing conditions vs. 2072 future conditions; and b) for the Upper San Joaquin River Climate Preparedness Assessment area, the analysis point was SJ01, located below Millerton Lake/Friant Dam.

The resulting 100-year peak flow estimate was 126,800 cfs for the 2072 future conditions (Nemeth et al., 2021). The study attributes the increase primarily to climate-driven changes in runoff generation driven by: higher temperatures that reduce snowpack accumulation; more winter precipitation falls as rain rather than snow; snow melts earlier in the season; runoff becomes concentrated during winter storms instead of being stored as mountain snowpack; and during large events, Millerton Reservoir has insufficient available storage to capture all incoming floodwaters, requiring larger releases downstream. A key finding is that the reservoir can continue to moderate smaller floods, but it becomes less effective during rare, extreme events. As a result, the magnitude of the 100-yr flood increases substantially (126,800 cfs under future conditions versus FEMA's estimate of 71,000 cfs under existing) though moderate floods show little change. The CVFPP estimate of the future conditions 100-year flood is also higher than the FEIR's 200-year flood estimate (95,000 cfs), suggesting that the proposed levee improvements identified in the FEIR will be overtopped – a notable significant adverse hydrology and water quality impact that is not mitigated in the EIR. For example, flooding of the Project's Plant and Quarry sites could result in the release of harmful pollutants, a significant impact under EIR Impact 4.10-17: Release of Pollutants in Flood Hazard, Tsunami, or Seiche Zones Due to Project Inundation.

Response 58A-2 also contains the statement, "Climate change impacts to the floodplain are not required to be analyzed in the EIR." It is my understanding that the effects of climate change on

[1] CVFPP Conservation Strategy 2022 Update available at https://resources.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Flood-Management/Flood-Planning-and-Studies/CVFPP-Conservation-Strategy/Files/2022-CS-Update-and-Appendices/Conservation_Strategy_Update_with-Appendices.pdf

flooding must be evaluated under CEQA when they could exacerbate a project's environmental impacts or affect the project's long-term performance and safety. Historically, CEQA focused on a project's impact on the environment. Over the last decade, CEQA practice and case law have increasingly recognized the need to also consider how climate change may affect the environmental setting in which a project is built. The Governor's Office of Land Use and Climate Innovation notes that climate change is an important CEQA consideration and that environmental analyses should reflect evolving scientific knowledge[2]. Therefore, it is my professional opinion that the 2022 CVFPP Conservation Strategy Update (Nemeth et al., 2021) contains the available scientific information for analyzing future climate change flood conditions within the proposed project operational timeline and this or a similar analysis should be incorporated into the EIR. Without this analysis, the Project's flood hazard measures are inadequate and the impact remains significant.

2. Response 58A-3: Failure to analyze actual river level data below Friant to the Project sites

There is no new information presented in this response that refutes my original opinion that the comparison of site groundwater elevations to San Joaquin River levels used in the DEIR is flawed. If I were doing this analysis following standards of practice in my field, I would only rely on actual water surface elevations (WSE) that were measured from wells and river locations within and immediately adjacent to the project site of interest. While actual (tied to a known vertical/elevation datum) measurements exist for groundwater, the EIR does not present any actual water level measurements for the river. The debate isn't about relative changes in river stage between up- and down-stream locations, it is a question of comparing actual river levels adjacent to the Quarry site so there can be a real and known comparison to groundwater surface elevations. The DEIR does not present or use defensible river WSEs at the project site because none were collected. Instead, the DEIR simply applies relative river stage changes from the Below Friant gauge to the project site and tie those stages to an arbitrary elevation datum as no datum correction factor was generated from actual field measurements. The main point is that you can't definitively determine which direction water flows between wells and river without having actual representative field measurements of both water surface elevations. Therefore, it is my professional opinion that without having actual field measurements of river water surface elevations for comparison to site well water levels, the EIR analysis of surface and groundwater interactions at the site is incomplete and its approach in transposing upstream river stage levels is inconclusive.

[2] CEQA and Climate Change – Governor's Office of Land Use and Climate Innovation available at https://lci.ca.gov/ceqa/ceqa-climate-change/

3. Response 58A-4: Effectiveness of mitigation measures for lowering groundwater levels is Unsupported

The EIR contends that groundwater recharge via the infiltration trenches will mitigate potential adverse changes in groundwater levels caused by project activities. The main reasoning for this conclusion is that the trenches are achieving this mitigation under existing conditions and operations. However, future project conditions include the notable expansion, deepening, and dewatering of mining pits. These actions will alter aquifer hydraulic properties, especially the head (water surface) differentials between the mining pits and surrounding groundwater systems that radiate away from the pits. In simpler terms, the creation and dewatering of a large hole in the ground will alter local groundwater conditions, creating large groundwater level differences between pit and surrounding groundwater systems akin to a cone of depression caused by groundwater pumping from a well. Stating that the existing infiltration trenches will work to mitigate potential project impacts because they work now during wet years does not ensure they will work in the future – the scale of changes to the hydrologic system in the future is vastly larger than it is now. It continues to be my professional opinion that the DEIR has not demonstrated that the existing and proposed infiltration trenches will work in the future under a completely altered surface terrain and groundwater system. It would be entirely possible to conduct a quantitative analysis to determine if the existing infiltration trenches will mitigate potential adverse changes in groundwater levels caused by project activities. Without this analysis, it is my professional opinion that the trenches most likely will not adequately mitigate this impact, and it remains potentially significant.

4. Response 58A-5: No analysis of potential impacts on Groundwater Dependent Ecosystems

The following comments also apply to FEIR Collective Response #25 (Interconnected Surface Water, Groundwater Dependent Ecosystems, and Impacts on Flows in the San Joaquin River). The FEIR relies on the North Kings Groundwater Sustainability Agency Groundwater Sustainability Plan (GSP) determination on the presence and absence of Groundwater Dependent Ecosystems (GDE) at and around the project site. A GSP determination might eliminate the presence of most of the potential GDE at the project site because if assumes the underlying depth to groundwater is greater than 30 feet. However, as presented in my 2025 DEIR comment letter, information and data within the DEIR demonstrate the existence of mapped GDE underlain by groundwater at a depth of less than 30 feet. In short, the DEIR itself contains data that refutes the findings of the GSP, yet the DEIR relies on the GSP determination to eliminate the presence of GDE around the site. Therefore, the incorrect information and findings within the EIR pertaining to the absence of GDE at the project site need to be corrected. Given the evidence of mapped GDE, an assessment of potential project impacts on GDE must be conducted.

5. Response 58A-6: No quantitative analysis of streamflow depletions from the San Joaquin River and compliance with SGMA

There is no new information presented in the FEIR that alters my opinion that the DEIR has not demonstrated that it complies with SGMA requirements with regards to ISW depletions because no data or analyses are presented that: identify potential unreasonable impacts to beneficial uses of surface water; quantify the amount of depletions; or develop mitigations for any potential undesirable results due to Project depletions of San Joaquin River flow. Response 58A-6 states that the GSP does not indicate the presence of any geologic units conducive to groundwater recharge in the project area. Thus, the project would not conflict with or obstruct implementation of the GSP due to streamflow depletions. However, under CEQA, the EIR needs to evaluate potential project impacts on surrounding alluvial water supply wells. These alluvial groundwater supplies are conducive to and reliant on groundwater recharge. Accordingly, the lowering of groundwater levels from the proposed quarry and plant operations could result in potentially significant impacts to surrounding domestic and other wells.

Please feel free to contact me with any questions regarding the material and conclusions contained in this letter.

Sincerely,

Verdantas



Gregory Kamman
Sr. Consultant

References Cited

Nemeth, K., Tjernell, K.A., and Lippner, G. (2021). *Revised Draft Central Valley Flood Protection Plan Conservation Strategy 2022 Update*. California Department of Water Resources.

EXHIBIT B

HAMILTON BIOLOGICAL

October 7, 2026

Ms. Carmen Borg
Shute, Mihaly & Weinberger LLP
550 California Street, Suite 1200
San Francisco, CA 94104

SUBJECT: RESPONSES TO FEIR
ROCKFIELD QUARRY MODIFICATION PROJECT
COUNTY OF FRESNO, CALIFORNIA

Dear Ms. Borg,

At your request, Hamilton Biological, Inc., has reviewed the Final EIR (FEIR) for the Rockfield Quarry Modification Project (the project) and provides these additional comments on the CEQA documentation for the proposed project. The intent of this letter is to provide additional information for County decisionmakers to consider when determining whether to certify the FEIR. The attached curriculum vitae provides my qualifications for conducting this review.

My review included the Draft EIR (DEIR) and FEIR, focusing mainly on the EIR preparer's responses to comments regarding biological resources, including potential impacts to sensitive biological resources on and near the project site associated with potential changes in hydrological conditions resulting from proposed actions. I also reviewed a three-page supplemental memorandum dated July 29, 2026, from Nick Brinton-McBean of WRA Environmental Consultants to Bruce Steubing of Benchmark Resources entitled, *WRA Task Summary, CEMEX Rockfield Quarry Draft Environmental Impact Report*.

EIR Provides Inadequate Baseline Information

In my experience, biological surveys conducted for CEQA analysis are normally considered valid only for one or two years. The Rockfield Quarry DEIR relies on a single general biological survey of the project site, conducted **more than seven years ago** (April 30, 2019), and therefore the EIR does not evaluate current or recent site conditions.

CEQA Section 15125(a)(1) states, "Generally, the lead agency should describe physical environmental conditions as they exist at the time the notice of preparation is published." CEQA Section 15108 of CEQA states, "With a private project, the lead agency shall complete and certify the final EIR as provided in Section 15090 **within one year** after the date when the lead agency accepted the application as complete. Lead agency

316 Monrovia Avenue Long Beach, CA 90803 562-477-2181 robb@hamiltonbiological.com

procedures may provide that the one-year time limit may be extended once for a period of **not more than 90 days** upon consent of the lead agency and the applicant."

In this case, the NOP was filed on June 3, 2020, meaning that the lead agency should have completed and certified the EIR some time in 2021, five years ago. Because this timeline was not followed, the biological baseline information must be updated in order for the DEIR and FEIR to reflect current or recent site conditions. A survey conducted in 2019 cannot accurately or adequately describe baseline conditions in 2026.

Furthermore, the one-day survey effort in 2019 was inadequate to accurately determine the status of several special-status species that have potential to occur on or adjacent to the site. The comments of Jeff Davis (58-B5, 58-B6) note the potential for Swainson's Hawk and Tricolored Blackbird (both State-listed as Threatened) to occur on or adjacent to the site. The FEIR responds by stating, "CEQA does not require protocol surveys be conducted for the purpose of analyzing potential impacts to wildlife or special status species" and by directing readers to Collective Response #13, which identifies "a more rigorous survey requirement for nesting birds and other wildlife in the vicinity of the project sites . . . following approval" of the project. Future surveys cannot establish the current baseline conditions as needed for the public and decisionmakers to have a reasonable understanding of whether these special-status species occur on or adjacent to the project site. The EIR's failure to provide current or recent baseline information, which is required to evaluate and mitigate the project's environmental effects **before the project is approved**, violates a basic tenet of CEQA.

Similarly, comment 15-15 from the California Department of Fish and Wildlife (CDFW) requests that the lead agency conduct adequate surveys and analyses for the Western Pond Turtle (WPT) and Western Spadefoot (WESP), both of which are proposed for federal listing as Threatened:

> CDFW recommends that the DEIR include a more robust analysis of potential impacts to WPT and WESP from ongoing Project activities, particularly for the blasting and mining proposed at the Quarry Site, and that this analysis include a sufficient area around the Project site. This additional analysis should consider information within several published research studies on various toad species which demonstrate that vibrations outside of typical emergence cues like rainfall can result in the emergence of toads from underground refugia, including during times of hibernation. It is also important to note that thunder, or sounds like thunder, can stimulate toad emergence. The vibrations and sounds associated with blasting could result in the atypical and seasonally inappropriate emergence of spadefoot, resulting in direct mortality, reduced survival, and impacts to reproductive success.

In response, the EIR preparer suggests that the brief general assessments conducted several years ago were adequate to determine that "western pond turtle (WPT) and western spadefoot (WESP) have a low potential to occur on the sites." The biologists at CDFW apparently disagree with this assessment, and the EIR preparer cannot cite any recent or focused survey data, collected by qualified biologists, substantiating their claim that these and other special-status species have low potential to occur on/adjacent to the site. To reiterate, CEQA requires an EIR to provide the level of information

needed to evaluate the project's environmental effects **before the project is approved**, and this EIR relies on outdated and inadequate surveys that do not adequately support its findings of no significant impacts. In my experience, surveys should be adequate to provide a reasonable level of certainty that special-status species are either present or absent at the time of the survey. For species listed as Threatened or Endangered, protocol surveys may be appropriate, but as a more general rule a biologist qualified to survey for the relevant special-status species has made a thorough enough search of the project site (and the surrounding area, if project effects would extend beyond site boundaries) to have likely found the species, if present. For a species like the Western Spadefoot, for example, multiple surveys should be conducted to search or adults and/or metamorphs in and around potential breeding pools. In this case, the single general survey conducted on April 30, 2019, does not provide a reasonable level of certainty that Western Spadefoots (or other special-status species) are absent from the project site and surrounding areas.

Potentially Significant Impacts on WESP and WPT from Blasting Remain and the EIR's Conclusion is Unsupported

Response to comment 15-15 also states:

> Though no species-specific information is available for indirect effects of blasting on WESP and WPT, it is reasonable to assume that the low amount of overpressure that would result from the proposed project would not have a significant impact on these species if they were present and that the mitigation measures proposed to ameliorate effects on these species would further minimize impacts to a less than significant level. As such, no additional analysis or mitigation is required.

Contrary to the EIR preparer's unfounded assumptions, stated above, comment 15-15 refers to "several published research studies on various toad species which demonstrate that vibrations outside of typical emergence cues like rainfall can result in the emergence of toads from underground refugia, including during times of hibernation." According to CDFW, "thunder, or sounds like thunder, can stimulate toad emergence. The vibrations and sounds associated with blasting could result in the atypical and seasonally inappropriate emergence of spadefoot, resulting in direct mortality, reduced survival, and impacts to reproductive success." Furthermore, project activities could result in "collapse of burrows, inadvertent entrapment, direct mortality of individuals, and displacement due to sound or vibration."

Mitigation Measure 4.4-1b "would require pre-construction clearance surveys of the ponds on the Plant Site and Quarry Site to be conducted no more than 14 days prior to the removal of a pond," **but it provides no replacement of the previously occupied habitat, and therefore a potentially significant impact would remain after mitigation**.

Additionally, Mitigation Measure 4.4-1b is aimed at addressing only construction impacts. Therefore, if WESP were to occur in the project vicinity during the lifetime of the

project, the EIR provides no mitigation for the potentially significant noise and vibration impacts from twice-weekly blasting, as described in CDFW comment 15-15.

For an example of a thorough evaluation of the potential effects of blasting and dewatering on special-status amphibians (three frog species), refer to the attached report, *Proposed Wharekirauponga Underground Mine Native Frog Effects Assessment*, prepared in 2025 by the firm Bioresearchers for OceanaGold New Zealand Limited. The assessment includes focused surveys for the amphibian species of concern, establishment of a vibration footprint for the proposed mining operation, and an extensive discussion of "seismic (vibration) detection by animals," including the following paragraph on page 28:

> Amphibians are highly sensitive to air-borne sound and among terrestrial vertebrates, are the most sensitive to vibrations (Caorsi et al. 2019). Typically, the tympanic middle ear and inner ear structures of anurans function to detect airborne sound by transferring sound energy to fluid vibrations sensed by hair cells in the inner ear (Pereyra et al. 2016). These structures, and specifically those associated with the inner ear (i.e., three organs: the amphibian papilla, the basilar papilla and the sacculus; Caorsi et al. 2019), are also responsible for sensing seismic (vibration) signals (Narins & Lewis 1985; Christensen-Dalsgaard & Narins 1993; Christensen-Dalsgaard & Jørgensen 1996). The pathway for substrate vibration sensing occurs via the operculum, a cartilaginous disc that is in physical contact within in the oval window of the inner ear in amphibians (i.e., their movement is coupled), which transfers substrate vibrations to the inner ear organs. In amphibians, the saccule remains sensitive to low-frequency seismic vibration due to the relative movement between the sensory epithelia and otoconia caused by traveling waves in the substrate (Han & Carr 2024 and references within).

In contrast, the biological analysis in the EIR for this project is truncated and misleading. Under CEQA, impact analysis cannot be overly brief and conclusory. An adequate CEQA impact analysis involves objective evaluation of current and adequate baseline information as informed by the best available scientific information, which the DEIR and FEIR do not provide. To meet CEQA's requirement, the project biologists should conduct current focused surveys for special-status species on or near the project site, consistent with CDFW's direction. The biologists should then use the data to provide a thorough and objective analysis of the potential effects of the project on species found to be present, or potentially present, on or near the project site. A revised DEIR should be circulated so that the public and decisionmakers can review an EIR that adequately discloses the environmental consequences of the proposed actions and that provides compensatory mitigation for loss or degradation of habitats occupied by special-status species.

Responses to Comments 58-40 and 58-41 are Inadequate

Comment 58-40 states, in part:

> . . . the DEIR fails to consider particulate matter impacts of blasting on species—even though it admits in later sections that the generation of dust resulting from blasting would cause fine materials and dust to settle on vegetation, thereby indirectly harming habitats.

The FEIR's response is to simply reiterate that "the impacts of dust emissions from blasting would be temporary and minimized to less than significant levels after

implementation of Mitigation Measure 4.3-2a and 4.3-2b." The cited mitigation measures do not address the control of dust from blasting activities, which are proposed to occur twice weekly for several decades. Each blast would send a new plume of particulate matter high into the atmosphere, so the FEIR's characterization of blasting impacts as "temporary" is completely inaccurate and misleading.

Page 1 of the attached article (Mumini Babatunde Saka and Mohd Hazizan Mohd Hashim. 2024. *Preliminary Investigation of Dust Generation in Granite Quarry*. Journal of Physics: Conference Series 2907) provides additional relevant information regarding the production of harmful dust at granite quarries:

> The emission of particulate matter (PM) from quarries is notable . . . The impacts of dust emissions originating from quarries encompass local and regional scales. Meanwhile, Quiroz et al. (2023) opined that the detrimental effects of air pollution and ground vibration resulting from blasting, crushing, and releasing harmful gases have adverse consequences on human health and overall welfare.

And:

> Dust emissions from quarrying can have far-reaching effects, affecting the quarry site, the nearby environment, and public health. PM of varying sizes, from fine to coarse, constitutes a significant portion of quarry dust emissions. When dispersed in the air, these particles can be transported over substantial distances, impacting air quality and posing hazards to the respiratory health of nearby communities.

And:

> Dust generation and dispersion are critical concerns in atmospheric quality modelling for surface mines. This necessitates the monitoring, safeguarding, and managing of air pollution to ensure the mining sector's long-term sustainability.

Page 1 of another attached article (Bhandari, S. 2012. *Fines and Dust Generation and Control in Rock Fragmentation by Blasting*. 10th International Symposium on Rock Fragmentation by Blasting, November 24-29, 2012) also addresses the generation of dust by blasting:

> Fines and dust resulting from mining operations is a serious nuisance and a health hazard to mine workers and population living in the vicinity of a mine. Though the blasting dust cloud is raised for few minutes but most of the dust settles in and around mining area and some of it is dispersed before settling down. Depending on meteorological conditions this dust can disperse to substantial distances endangering health of communities. Some of the settled dust is raised again by mining activities for example by travelling vehicles. Damage to vegetation and agriculture is possible.

The EIR cannot simply ignore and/or mischaracterize as "temporary" the potentially significant impacts on vegetation providing habitat for special-status species from repeatedly blasting particulates into surrounding areas. Project effects from blasting are not addressed in Mitigation Measures 4.3-2a (retrofitting or upgrading of off-road engines) or 4.3-2b (preparation of a Fugitive Dust Control Plan) or the project's Fugitive Dust Control Plan (which does not address dust from blasting).

Responses to Comments 58-42, 58C-17, 58C-18 are Inadequate

Comment 58-42 states, in part, that the DEIR:

> . . . completely omits any analysis of blasting impacts on wildlife and other nearby riparian habitat. Because the DEIR's analysis of noise and vibration impacts is so deficient, impacts to wildlife remain largely unknown. And since there are no noise and vibration mitigation measures that control operational noise or blasting vibration—such as stopping blasting during times when birds are nesting near the Project Site—noise and vibration from the Project will likely disrupt nearby wildlife.

Response to comment 58-42 states, in relevant parts, that "the Salter Report does not reference any wildlife noise studies," and:

> Furthermore the Blasting Protocols (see Draft EIR Appendix H-9) specifically state that noise measurements would be continually measured at those receptor locations and if they were to exceed specified thresholds, then blasting activities would cease, the County would be notified, and a corrective action plan would be developed (see Draft EIR Appendix H-9 at page 5). This is sufficient to ensure that wildlife is protected because, as described below, the species have already adapted well to the ambient noise conditions on the sites, therefore it is sufficient to only cease blasting activities if the noise and vibration levels exceed established thresholds.

The response remarks on a lack of cited wildlife noise studies in the Salter Report, but CEQA requires that the lead agency, not commenters, conduct the research needed to substantiate claims made in an EIR. Nevertheless, in the interest of providing relevant information from the peer-reviewed literature, I attach one relevant study:

- Bednarz, J. C. 1980. The effect of mining and blasting on breeding Prairie Falconn (*Falco mexicanus*) occupancy in the Caballo Mountains, New Mexico. *Journal of Raptor Research* 18:16–19.

The study found:

> In conclusion, I believe the data presented here suggest that there is a difference in Prairie Falcon nest occupancy between the Caballo Mountains and the 2 control ranges **most likely due to blasting and mining or associated human activities**. To my knowledge, no study has examined the long-term effects of mining or blasting on occupancy of raptor nest sites, but **short-term impacts have been documented** (Stahlecker and Alldredge 1976). Ellis (1981), based on a 2 y study of simulated sonic boom noise, implied that both adverse short-term and long-term impacts of such activities were probably negligible on nesting raptors. **My results indicate that this conclusion cannot be extended to more intensive blasting and mining activities**, and I urge further observation, and particularly, controlled experimental studies **to address the long-term impacts of such disturbances on breeding raptors**. [emphasis added]

The EIR preparer's response, that "the species have already adapted well to the ambient noise conditions on the sites, therefore it is sufficient to only cease blasting activities if the noise and vibration levels exceed established thresholds," and "a typical blasting event would occur for one to two seconds," ignores important considerations:

1. Species that adapt to the relatively constant and predictable noise of current aggregate mining and processing operations may not adapt to twice-weekly explosive blasts, which may be perceived by some species as catastrophic and unpredictable. The short duration of each blast does not equate to harmlessness any more than the short duration of a gunshot equates to harmlessness. The results of the above-cited study by Bednarz — in which Prairie Falcons were found nesting in the Fra Cristobal and Florida Mountains of New Mexico (which were not subject to mining and blasting) but not the similar Caballo Mountains (where mining and blasting were conspicuous) — indicate that some wildlife species may respond to periodic blasting by avoiding the project vicinity altogether.

2. The noise thresholds established in the EIR make no reference to wildlife, and so are not applicable to this impact analysis.

3. The EIR does not include mitigation measures to address the potentially significant impacts from blasting on wildlife species, such as nesting birds and special-status species that are known to potentially occur in the vicinity. Response to comment 58-42 suggests that, if the inapplicable noise thresholds are exceeded, then a corrective action plan would be developed. CEQA requires development of that plan now, however, to provide the public an opportunity to evaluate its likely effectiveness in mitigating significant impacts on wildlife species, and to identify any additional mitigation measures that should be implemented. There is no indication that such a plan could effectively address the harm from blasting.

In the absence of any actual analysis substantiating the FEIR's findings regarding noise impacts to wildlife, a potentially significant impact should be identified. See also comments 15-23 and 58-48, which raise related concerns about the EIR's lack of adequate analyses regarding the effects of blasting on various special-status wildlife species.

Response to Comment 58-48 is Inadequate

Comment 58-48 notes that the DEIR's analysis of Impact 4.4.3 ("Have an Adverse Effect, Directly or Indirectly, on Special-Status Wildlife Species in Riparian Habitat Surrounding the Plant Site and Quarry Site During Mining Operations") lists examples of wildlife habituating to various human activities but does not provide any actual analysis of the anticipated or potential effects of the proposed blasting on special-status wildlife species. As noted in the comment:

> Many of these examples, including the primary example offered, Cajon Creek Conservation Bank, were projects involving alluvial surface mining without blasting, and are therefore not reflective of whether species exposed to blasting on the Quarry Site are likely to habituate or not. Id. The DEIR's conclusion that impacts to special-status wildlife species in riparian habitat surrounding the Plant and Quarry sites during mining operations will be less than significant lacks any basis.

Instead of providing the required and requested analysis of the potential effects of several decades of twice-weekly blasting on wildlife use of the project site and surrounding areas, the FEIR's response to comment 58-48 simply reiterates that bighorn sheep are known to occur near the Castle Mountain Mine, and that a blasting event lasts for about 1 second. These anecdotes do not constitute a CEQA impact analysis.

As discussed on page 6 of this letter, some species that adapt to the relatively constant and predictable noise of current aggregate mining and processing operations may not adapt to twice-weekly explosive blasts, which may be perceived by some species as catastrophic and unpredictable. The short duration of each blast does not equate to harmlessness any more than the short duration of a gunshot equates to harmlessness. The results of the above-cited study by Bednarz — in which Prairie Falcons were found nesting in the Fra Cristobal and Florida Mountains of New Mexico (which were not subject to mining and blasting) but not the similar Caballo Mountains (where mining and blasting were conspicuous) — indicate that some wildlife species may respond to periodic blasting by avoiding the project vicinity altogether. Given the lack of current and adequate biological survey information, and absent any actual impact analysis, in my opinion the project could have potentially significant impacts to special-status wildlife species in riparian habitat surrounding the plant site and quarry site resulting from blasting operations. The EIR must identify this impact.

Response to CDFW Comment 15-20 is Non-responsive

This comment states, in part:

> The reduction of flow traveling downstream, by a surface or subsurface diversion associated with mining pit capture would . . . cause the San Joaquin River to warm sooner and at a faster rate. This can cause lethal/sub-lethal conditions for salmon and other fishes.

And:

> CDFW would like to reiterate that any surface or subsurface flow of water from the Project site would have the potential to warm the San Joaquin River and cause water quality issues that can result in lethal/sublethal conditions for fishes and potentially hinder SJRRP's efforts.

The FEIR's response includes a lengthy discussion of rock types, an assertion that "the proposed project would not significantly impact surface water quality," and an assertion that "Implementation of several Draft EIR Mitigation Measures . . . would reduce impacts on water quality issues, and no further analysis is required." **Missing from the response is any analysis of the project's anticipated effects on water temperature in the San Joaquin River. Therefore, the FEIR is not responsive to CDFW's comment.**

Responses to CDFW Comments 15-21, 15-22, 15-23 are Inadequate

These three comments from CDFW note that "rock blasting may cause an avoidant behavior in salmon," that physical vibrations from blasting "could result in premature emergence on alevin/fry from the redd incubation environment," and recommend

biological monitoring of the San Joaquin River during blasting "to look for signs of impacts to species (e.g., unusual behavior, mortality), and "do not address potential impacts on other animal species." CDFW "strongly recommends a comprehensive evaluation of the potential effects of acoustic and vibration impacts . . . particularly in relation to impacts to special-status species."

The FEIR's responses emphasize the brevity of each blasting event without providing any rationale for concluding that brief, but violent, blasting events taking place twice weekly for several decades would not result in potentially significant impacts to various special-status species. The EIR preparer is required to either explain or support with evidence why CDFW's concerns are invalid or revise the impact analysis to acknowledge potentially significant adverse effects to various special-status species that occur, or potentially occur, on or near the project site.

Response to CDFW Comment 15-24 is Inadequate

This comment notes that the 20-foot-deep lake that would remain after project completion would provide only "limited benefit to wildlife" and recommends a "more naturalistic approach" that would provide habitat of greater value to wildlife in this ecologically sensitive area. The comment recommends emulating the reclaimed lake at nearby Ball Ranch (K'uik'ui Ranch) as a feasible way to reduce the project's adverse effects on the environment, as CEQA requires.

In response, the EIR preparer argues that "the proposed design was developed to ensure stability, water quality protection, and consistency with approved reclamation objectives," and claims without any evidence that "the proposed open water habitat would provide beneficial wildlife use." The EIR preparer fails to demonstrate that a design comparable to the reclaimed lake at Ball Ranch would not also provide stability, water quality protection and consistency with approved reclamation objectives **while also providing superior wildlife habitat**. CEQA requires the lead agency to evaluate recommendations to reduce a project's environmental impacts rather than rejecting them out of hand without making a legitimate effort to determine their efficacy and feasibility.

Response to CDFW Comment 15-25 is Non-responsive

This comment states, in part, "Overall, CDFW does not concur with the proposed reclamation plan. CDFW recommends the development of a more comprehensive reclamation plan in collaboration with relevant agencies."

In response, the EIR preparer states, in relevant part:

> The Reclamation Plan proposed complies fully with all requirements of SMARA and CEQA. The Reclamation Plan is included in its entirety as Appendix B-1, "Surface Mining and Reclamation Plan," of the Draft EIR, and the CDFW had the opportunity to review and comment on its contents in accordance with CEQA.

Compliance with CEQA is not achieved by the EIR preparer insisting that the plan is adequate and suggesting that CDFW missed its opportunity to review and comment on the plan. In fact, CDFW has reviewed and commented the reclamation plan provided in the DEIR and found it to be inadequate (as explicitly stated in comment 15-25). For the proposed reclamation plan to fully with "all requirements of CEQA," the EIR preparer must evaluate the reasons why CDFW rejects the proposed reclamation plan and legitimately address all of the agency's valid concerns.

Response to CDFW Comment 15-36 is Inadequate

This comment states, in part, "conclusions reached in the cumulative impacts analysis are not supported by substantial evidence and the analysis lacks sufficient rigor and transparency to adequately develop reasonable and feasible measures to reduce harm."

In response, the EIR preparer reiterates the discussion of cumulative effects on page 5-12 of the DEIR, which states, in part:

> The project-specific impacts to special-status species . . . in conjunction with those from other past, present, and reasonably foreseeable future cumulative projects have the potential to result in significant cumulative impacts to burrowing owl, western pond turtle, western spadefoot, and nesting birds through the direct and indirect disturbance of the species and their habitats. This is a potentially significant cumulative impact. However, the implementation of Mitigation Measures 4.4-1a, -1b, and -1c would effectively avoid or substantially reduce the proposed project's impacts to these species by requiring preconstruction surveys and avoidance measures. Thus, the proposed project's contribution to cumulative impacts to special-status species, after mitigation, would be less than cumulatively considerable.

As discussed in several comments on the DEIR, and reiterated in this letter, the EIR preparer did not conduct adequate surveys to reliably determine the status of special-status species on or near the project site. Therefore, nobody knows the actual status of these species on and around the project site. The pre-construction surveys for the Western Pond Turtle and Western Spadefoot, identified in Mitigation Measures 4.4-1b, call for a qualified biologist to "be present during the draining and removal of the pond and [to] monitor removal of the pond until no areas that could ensconce pond turtle or spadefoot remain." Thus, regardless of whether individual animals are saved, the project's contribution to past and ongoing loss of habitat occupied by these candidates for federal listing would still be cumulatively considerable, because no compensatory habitat would be provided.

SUMMARY AND CONCLUSION

The FEIR for the Rockfield Quarry Modification Project is deficient as a CEQA document in the ways detailed in these comments. Once current and adequate biological surveys are required to establish current baseline conditions, as required by CEQA, a new impact analysis should be conducted and provided for public review in a recirculated Draft EIR.

I appreciate the opportunity to evaluate the CEQA documentation for this important project. Please call me at 562-477-2181 if you have questions or wish to further discuss any matters; you may send e-mail to robb@hamiltonbiological.com.

Sincerely,



Robert A. Hamilton
President, Hamilton Biological, Inc.
316 Monrovia Avenue
Long Beach, CA 90803

Attachments

Curriculum Vitae for Robert A. Hamilton

Bednarz, J. C. 1980. The effect of mining and blasting on breeding Prairie Falcon (Falco mexicanus) occupancy in the Caballo Mountains, New Mexico. Journal of Raptor Research 18:16–19.

Bhandari, S. 2012. *Fines and Dust Generation and Control in Rock Fragmentation by Blasting*. 10th International Symposium on Rock Fragmentation by Blasting, November 24-29, 2012

Bioresearchers. 2025. *Proposed Wharekirauponga Underground Mine Native Frog Effects Assessment*. Technical report prepared for OceanaGold New Zealand Limited.

Mumini Babatunde Saka and Mohd Hazizan Mohd Hashim. 2024. *Preliminary Investigation of Dust Generation in Granite Quarry*. Journal of Physics: Conference Series 2907

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ATTACHMENT 1

Robert A. Hamilton

President, Hamilton Biological, Inc.

Expertise

Endangered Species Surveys
General Biological Surveys
CEQA Analysis
Population Monitoring
Vegetation Mapping
Construction Monitoring
Noise Monitoring
Open Space Planning
Natural Lands Management

Education

1988. Bachelor of Science degree in Biological Sciences, University of California, Irvine

Professional Experience

1994 to Present. Independent Biological Consultant, Hamilton Biological, Inc.

1988 to 1994. Biologist, LSA Associates, Inc.

Permits

Federal Permit to survey for the Coastal California Gnatcatcher and Southwestern Willow Flycatcher

MOUs with the California Dept. of Fish and Game to survey for Coastal California Gnatcatcher, Southwestern Willow Flycatcher, and Coastal Cactus Wren.

California Scientific Collecting Permit

Robert A. Hamilton has been providing biological consulting services in southern California since 1988. He spent the first six years of his career at the firm of LSA Associates in Irvine, where he was a staff biologist and project manager. He has worked as an independent consultant since 1994, incorporating his business as Hamilton Biological, Inc., in 2009. The consultancy specializes in the practical application of environmental policies and regulations to land management and land use decisions in southern California.

A recognized authority on the status, distribution, and identification of birds in California, Mr. Hamilton is the lead author of two standard references describing aspects of the state's avifauna: *The Birds of Orange County: Status & Distribution* and *Rare Birds of California.* Mr. Hamilton has also conducted extensive studies in Baja California, and for seven years edited the Baja California Peninsula regional reports for the journal *North American Birds*. He served ten years on the editorial board of *Western Birds* and regularly publishes in peer-reviewed journals. He is a founding member of the Coastal Cactus Wren Working Group and in 2011 updated the Cactus Wren species account for *The Birds of North America Online*. Mr. Hamilton's expertise includes vegetation mapping. From 2007 to 2010 he worked as an on-call biological analyst for the County of Los Angeles Department of Regional Planning. From 2010 to 2021, he conducted construction monitoring and focused surveys for special-status bird species on the Tehachapi Renewable Transmission Project (TRTP). He is a former member of the Los Angeles County Significant Ecological Areas Technical Advisory Committee (SEATAC).

Mr. Hamilton conducts general and focused biological surveys of small and large properties as necessary to obtain various local, state, and federal permits, agreements, and clearances. He also conducts landscape-level surveys needed by land managers to monitor songbird populations. Mr. Hamilton holds the federal and state permits and MOUs listed to the left, and he is recognized by federal and state resource agencies as being highly qualified to survey for the Least Bell's Vireo. He also provides nest-monitoring services in compliance with the federal Migratory Bird Treaty Act and California Fish & Game Code Sections 3503, 3503.5 and 3513.

Board Memberships, Advisory Positions, Etc.

Friends of Colorado Lagoon, Board Member (2014–present)

Coastal Cactus Wren Working Group (2008–present)

Los Angeles County Significant Ecological Areas Technical Advisory Committee (SEATAC) (2010–2014)

American Birding Association: Baja Calif. Peninsula Regional Editor, North American Birds (2000–2006)

Western Field Ornithologists: Associate Editor of Western Birds (1999–2008)

California Bird Records Committee (1998–2001)

Nature Reserve of Orange County: Technical Advisory Committee (1996–2001)

California Native Plant Society, Orange County Chapter: Conservation Chair (1992–2003)

Professional Affiliations

American Ornithologists' Union

American Ornithological Society (Fellow)

Cooper Ornithological Society

Institute for Bird Populations

California Native Plant Society

Southern California Academy of Sciences

Western Foundation of Vertebrate Zoology

Mr. Hamilton is an expert photographer, and typically provides photo-documentation and/or video documentation as part of his services.

Drawing upon a robust, multi-disciplinary understanding of the natural history and ecology of his home region, Mr. Hamilton works with private and public land owners, as well as governmental agencies and interested third parties, to apply the local, state, and federal land use policies and regulations applicable to each unique situation. Mr. Hamilton has amassed extensive experience in the preparation and independent review of CEQA documents, from relatively simple Negative Declarations to complex supplemental and recirculated Environmental Impact Reports. In addition to his knowledge of CEQA and its Guidelines, Mr. Hamilton understands how each Lead Agency brings its own interpretive variations to the CEQA review process.

Representative Project Experience

From 2018 to 2020, Mr. Hamilton worked on behalf of Endangered Habitats League to review and eventually challenge and overturn the findings of an EIR for the proposed Village 14 project on 1,200+ acres in the middle of Proctor Valley. This important area is located in southwestern San Diego County, near the Rancho Jamul Ecological Reserve and San Diego National Wildlife Refuge. Among many listed and special-status plant and wildlife species, Proctor Valley is home to the endangered Quino Checkerspot Butterfly. Ultimately, Mr. Hamilton was able to demonstrate that the EIR did not accurately describe the biological resources present on the project site or on a nearby parcel that the project proponent had offered to the State of California in a land-exchange. Mr. Hamilton reviewed, analyzed, and rebutted numerous biological reports and memoranda prepared by the project proponent's consultants. When the County of San Diego certified EIR anyway, Mr. Hamilton worked with Endangered Habitats League to educate members of the State Wildlife Conservation Board, whose approval was required for the land-exchange deal. In December 2020 the Board unanimously rejected the deal, citing the inaccurate reporting of resources that Mr. Hamilton brought to light, and in January 2024 the State purchased the land for conservation purposes.

Insurance

$3,000,000 professional liability policy (Hanover Insurance Group)

$2,000,000 general liability policy (The Hartford)

$1,000,000 auto liability policy (State Farm)

Other Relevant Experience

Field Ornithologist, San Diego Natural History Museum Scientific Collecting Expedition to Central and Southern Baja California, October/November 1997 and November 2003.

Field Ornithologist, Island Conservation and Ecology Group Expedition to the Tres Marías Islands, Nayarit, Mexico, 23 January to 8 February 2002.

Field Ornithologist, Algalita Marine Research Foundation neustonic plastic research voyages in the Pacific Ocean, 15 August to 4 September 1999 and 14 to 28 July 2000.

Field Assistant, Bird Banding Study, Río Ñambí Reserve, Colombia, January to March 1997.

References

Provided upon request.

From 2008 to 2023, Mr. Hamilton served as the main biological consultant for the Banning Ranch Conservancy, a local citizens' group that successfully defeated efforts to implement a large proposed residential and commercial project on the 400-acre Banning Ranch property in Newport Beach. Mr. Hamilton reviewed, analyzed, and responded to numerous biological reports prepared by the project proponent, and testified at multiple public hearings of the California Coastal Commission. In September 2016, the Commission denied the application for a Coastal Development Permit for the project, citing, in part, Mr. Hamilton's analysis of biological issues. In March 2017, the California Supreme Court issued a unanimous opinion (*Banning Ranch Conservancy v. City of Newport Beach*) holding that the EIR prepared by the City of Newport Beach improperly failed to identify areas of the site that might qualify as "environmentally sensitive habitat areas" under the California Coastal Act. In nullifying the certification of the EIR, the Court found that the City "ignored its obligation to integrate CEQA review with the requirements of the Coastal Act."

From 2012 to 2014, Mr. Hamilton collaborated with Dan Cooper on *A Conservation Analysis for the Santa Monica Mountains "Coastal Zone" in Los Angeles County*, and worked with Mr. Cooper and the County of Los Angeles to secure a certified Local Coastal Program (LCP) for 52,000 acres of unincorporated County lands in the Santa Monica Mountains coastal zone. The work involved synthesizing large volumes of existing baseline information on the biological resources of the study area, evaluating existing land use policies, and developing new policies and guidelines for future development within this large, ecologically sensitive area. A coalition of environmental organizations headed by the Surfrider Foundation selected this project as the "Best 2014 California Coastal Commission Vote."

Contact Information

Robert A. Hamilton, President
Hamilton Biological, Inc.

316 Monrovia Avenue
Long Beach, CA 90803

562-477-2181 (office, mobile)

robb@hamiltonbiological.com
http://hamiltonbiological.com

Third Party Review of CEQA Documents

Under contract to cities, conservation groups, homeowners' associations, etc., Mr. Hamilton has reviewed EIRs or other project documentation for the following projects:

- Federal ICE Detention Center, Gilroy (agriculture conversion, County of Santa Clara)
- Camino Rosas (residential, City of Oceanside)
- Pacific Place (FEIR for self-storage project; settlement items City of Long Beach)
- Bay Bridge Lighting Projects (LED light impact evaluation, San Francisco Bay)
- Piraeus Point (residential, City of Encinitas)
- Cottonwood Sand Mine (golf course to aggregate mine, County of San Diego)
- Alpine County Regional Park (park establishment, County of San Diego)
- Trails at Carmel Mtn. Ranch (golf course to residential, City of San Diego)
- Otay Village 13 (residential, County of San Diego)
- Otay Village 14, Planning Areas 16/19 (residential, County of San Diego)
- Western Snowy Plover Mgmt. Plan (resource management, City of Newport Beach)
- Sanderling Waldorf School (commercial, City of Encinitas)
- Diamond Bar General Plan (open space planning, City of Diamond Bar)
- UC San Diego Long-range Development Plan (institutional, UC Regents)
- El Monte Sand Mining Project (resource extraction, County of San Diego)
- Faria/Southwest Hills Annexation Project (residential, City of Pittsburg)
- Los Cerritos Oil Consolidation/Wetland Restoration Project (resource extraction/habitat restoration, City of Long Beach)
- Safari Highlands Ranch (residential, City of Escondido)
- Newland Sierra (residential, County of San Diego)
- Harmony Grove Village South (residential, County of San Diego)
- Vegetation Treatment Program (statewide fire management plan, California Department of Forestry and Fire Protection)
- Watermark Del Mar Specific Plan (residential, City of Del Mar)
- Newport Banning Ranch (residential/commercial, City of Newport Beach)
- Davidon/Scott Ranch (residential, City of Petaluma)
- Mission Trails Regional Park Master Plan (open space planning, City of San Diego)
- Esperanza Hills (residential, County of Orange)
- Warner Ranch (residential, County of San Diego)
- Dog Beach, Santa Ana River Mouth (open space planning, County of Orange)
- Gordon Mull subdivision (residential, City of Glendora)
- The Ranch at Laguna Beach (resort, City of Laguna Beach)
- Sunset Ridge Park (city park, City of Newport Beach)
- The Ranch Plan (residential/commercial, County of Orange)
- Southern Orange County Transportation Infrastructure Improvement Project (Foothill South Toll Road, County of Orange)
- Gregory Canyon Landfill Rest. Plan (proposed mitigation, County of San Diego)
- Montebello Hills SP EIR (residential, City of Montebello; 2009 and 2014 circulations)
- Cabrillo Mobile Home Park (illegal wetland filling, City of Huntington Beach)
- Newport Hyatt Regency (timeshare conversion project, City of Newport Beach)
- San Diego Creek "Emergency Repair Project" (flood control, County of Orange)
- Tonner Hills (residential, City of Brea)
- The Bridges at Santa Fe Units 6 and 7 (residential, County of San Diego)
- Villages of La Costa Master Plan (residential/commercial, City of Carlsbad)
- Whispering Hills (residential, City of San Juan Capistrano)
- Santiago Hills II (residential/commercial, City of Orange)
- Rancho Potrero Leadership Academy (youth detention facility, County of Orange)
- Saddle Creek/Saddle Crest (residential, County of Orange)
- Frank G. Bonelli Regional County Park Master Plan (County of Los Angeles)

Selected Presentations

Hamilton, R. A. Birds of Colorado Lagoon. 2018-2026. 60-minute multimedia presentation on the history and avifauna of Colorado Lagoon in southeastern Long Beach, given at several Audubon Society chapter meetings.

Hamilton, R. A. Six Legs Good/Invertebral Limit. 2012-2020. 60-to-90-minute multimedia presentation on the identification and photography of dragonflies, damselflies, butterflies, and other invertebrates, given at Audubon Society chapter meetings, Irvine Ranch Conservancy, etc.

Hamilton, R. A., and Cooper, D. S. 2016. Nesting Bird Policies: We Can Do Better. Twenty-minute multimedia presentation at The Wildlife Society Western Section Annual Meeting, February 23, 2016.

Hamilton, R. A. 2012. Identification of Focal Wildlife Species for Restoration, Coyote Creek Watershed Master Plan. Twenty-minute multimedia presentation given at the Southern California Academy of Sciences annual meeting at Occidental College, Eagle Rock, 4 May. Abstract published in the Bulletin of the Southern California Academy of Sciences No. 111(1):39.

Hamilton, R. A., and Cooper, D. S. 2009-2010. Conservation & Management Plan for Marina del Rey. Twenty-minute multimedia presentation given to different governmental agencies and interest groups.

Hamilton, R. A. 2008. Cactus Wren Conservation Issues, Nature Reserve of Orange County. One-hour multimedia presentation for Sea & Sage Audubon Society, Irvine, California, 25 November.

Hamilton, R. A., Miller, W. B., Mitrovich, M. J. 2008. Cactus Wren Study, Nature Reserve of Orange County. Twenty-minute multimedia presentation given at the Nature Reserve of Orange County's Cactus Wren Symposium, Irvine, California, 30 April 2008.

Hamilton, R. A. and K. Messer. 2006. 1999-2004 Results of Annual California Gnatcatcher and Cactus Wren Monitoring in the Nature Reserve of Orange County. Twenty-minute multimedia presentation given at the Partners In Flight meeting: Conservation and Management of Coastal Scrub and Chaparral Birds and Habitats, Starr Ranch Audubon Sanctuary, 21 August 2004; and at the Nature Reserve of Orange County 10th Anniversary Symposium, Irvine, California, 21 November.

Publications

Hamilton, R. A. 2022. Book review: Bird Versus Bulldozer. *Western Birds* 53:335–339.

Hamilton, R. A. 2022. Book review: All About Birds, California. *Western Birds* 53:177–179.

Hamilton, R. A. 2022. Book review: Sacramento County Breeding Birds. *Western Birds* 53:83–85.

Gómez de Silva, H., Villafaña, M. G. P., Nieto, J. C., Cruzado, J., Cortés, J. C., Hamilton, R. A., Vásquez, S. V., and Nieto, M. A. C. 2017. Review of the avifauna of The Tres Marías Islands, Mexico, including new and noteworthy records. *Western Birds* 47:2–25.

Hamilton, R. A. 2014. Book review: The Sibley Guide to Birds, Second Edition. *Western Birds* 45:154–157.

Cooper, D. S., R. A. Hamilton, and S. D. Lucas. 2012. A population census of the Cactus Wren in coastal Los Angeles County. *Western Birds* 43:151–163.

Hamilton, R. A., J. C. Burger, and S. H. Anon. 2012. Use of artificial nesting structures by Cactus Wrens in Orange County, California. *Western Birds* 43:37–46.

Hamilton, R. A., Proudfoot, G. A., Sherry, D. A., and Johnson, S. 2011. Cactus Wren (*Campylorhyn-chus brunneicapillus*), *in* The Birds of North America Online (A. Poole, ed.). Cornell Lab of Ornithology, Ithaca, NY.

Hamilton, R. A. 2008. Cactus Wrens in central & coastal Orange County: How will a worst-case scenario play out under the NCCP? *Western Tanager* 75:2–7.

Erickson, R. A., R. A. Hamilton, R. Carmona, G. Ruiz-Campos, and Z. A. Henderson. 2008. Value of perennial archiving of data received through the North American Birds regional reporting system: Examples from the Baja California Peninsula. *North American Birds* 62:2–9.

Erickson, R. A., R. A. Hamilton, and S. G. Mlodinow. 2008. Status review of Belding's Yellowthroat *Geothlypis beldingi*, and implications for its conservation. Bird Conservation International 18:219–228.

Hamilton, R. A. 2008. Fulvous Whistling-Duck (*Dendrocygna bicolor*). Pp. 68-73 *in* California Bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California (Shuford, W. D. and T. Gardali, eds.). Studies of Western Birds 1. Western Field Ornithologists, Camarillo, CA, and California Department of Fish and Game, Sacramento, CA.

California Bird Records Committee (R. A. Hamilton, M. A. Patten, and R. A. Erickson, editors.). 2007. Rare Birds of California. Western Field Ornithologists, Camarillo, CA.

Hamilton, R. A., R. A. Erickson, E. Palacios, and R. Carmona. 2001–2007. *North American Birds* quarterly reports for the Baja California Peninsula Region, Fall 2000 through Winter 2006/2007.

Hamilton, R. A. and P. A. Gaede. 2005. Pink-sided × Gray-headed Juncos. *Western Birds* 36:150–152.

Mlodinow, S. G. and R. A. Hamilton. 2005. Vagrancy of Painted Bunting (*Passerina ciris*) in the United States, Canada, and Bermuda. *North American Birds* 59:172–183.

Erickson, R. A., R. A. Hamilton, S. González-Guzmán, G. Ruiz-Campos. 2002. Primeros registros de anidación del Pato Friso (*Anas strepera*) en México. Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoología 73(1):67–71.

Hamilton, R. A. and J. L. Dunn. 2002. Red-naped and Red-breasted sapsuckers. *Western Birds* 33:128–130.

Hamilton, R. A. and S. N. G. Howell. 2002. Gnatcatcher sympatry near San Felipe, Baja California, with notes on other species. *Western Birds* 33:123–124.

Hamilton, R. A. 2001. Book review: The Sibley Guide to Birds. *Western Birds* 32:95–96.

Hamilton, R. A. and R. A. Erickson. 2001. Noteworthy breeding bird records from the Vizcaíno Desert, Baja California Peninsula. Pp. 102-105 *in* Monographs in Field Ornithology No. 3. American Birding Association, Colorado Springs, CO.

Hamilton, R. A. 2001. Log of bird record documentation from the Baja California Peninsula archived at the San Diego Natural History Museum. Pp. 242–253 *in* Monographs in Field Ornithology No. 3. American Birding Association, Colorado Springs, CO.

Hamilton, R. A. 2001. Records of caged birds in Baja California. Pp. 254–257 *in* Monographs in Field Ornithology No. 3. American Birding Association, Colorado Springs, CO.

Erickson, R. A., R. A. Hamilton, and S. N. G. Howell. 2001. New information on migrant birds in northern and central portions of the Baja California Peninsula, including species new to Mexico. Pp. 112–170 *in* Monographs in Field Ornithology No. 3. American Birding Association, Colorado Springs, CO.

Howell, S. N. G., R. A. Erickson, R. A. Hamilton, and M. A. Patten. 2001. An annotated checklist of the birds of Baja California and Baja California Sur. Pp. 171–203 *in* Monographs in Field Ornithology No. 3. American Birding Association, Colorado Springs, CO.

Ruiz-Campos, G., González-Guzmán, S., Erickson, R. A., and Hamilton, R. A. 2001. Notable bird specimen records from the Baja California Peninsula. Pp. 238–241 *in* Monographs in Field Ornithology No. 3. American Birding Association, Colorado Springs, CO.

Wurster, T. E., R. A. Erickson, R. A. Hamilton, and S. N. G. Howell. 2001. Database of selected observations: an augment to new information on migrant birds in northern and central portions of the Baja California Peninsula. Pp. 204–237 *in* Monographs in Field Ornithology No. 3. American Birding Association, Colorado Springs, CO.

Erickson, R. A. and R. A. Hamilton, 2001. Report of the California Bird Records Committee: 1998 records. *Western Birds* 32:13–49.

Hamilton, R. A., J. E. Pike, T. E. Wurster, and K. Radamaker. 2000. First record of an Olive-backed Pipit in Mexico. *Western Birds* 31:117–119.

Hamilton, R. A. and N. J. Schmitt. 2000. Identification of Taiga and Black Merlins. *Western Birds* 31:65–67.

Hamilton, R. A. 1998. Book review: Atlas of Breeding Birds, Orange County, California. *Western Birds* 29:129–130.

Hamilton, R. A. and D. R. Willick. 1996. The Birds of Orange County, California: Status and Distribution. Sea & Sage Press, Sea & Sage Audubon Society, Irvine.

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Erickson, R. A., and Hamilton, R. A. 1995. Geographic distribution: *Lampropeltis getula californiae* (California Kingsnake) in Baja California Sur. *Herpetological Review* 26(4):210.

Bontrager, D. R., R. A. Erickson, and R. A. Hamilton. 1995. Impacts of the October 1993 Laguna fire on California Gnatcatchers and Cactus Wrens. *in* J. E. Keeley and T. A. Scott (editors). Wildfires in California Brushlands: Ecology and Resource Management. International Association of Wildland Fire, Fairfield, Washington.

Erickson, R. A., R. A. Hamilton, S. N. G. Howell, M. A. Patten, and P. Pyle. 1995. First record of Marbled Murrelet and third record of Ancient Murrelet for Mexico. *Western Birds* 26: 39–45.

Erickson, R. A., and R. A. Hamilton. 1993. Additional summer bird records for southern Mexico. *Euphonia* 2(4): 81–91.

Erickson, R. A., A. D. Barron, and R. A. Hamilton. 1992. A recent Black Rail record for Baja California. *Euphonia* 1(1): 19–21.

ATTACHMENT 2

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Journal of Raptor Research

Volume 18 | Issue 1 Article 4

January 2024

The Effect of Mining and Blasting on Breeding Prairie Falcon (falco Mexicanus) Occupancy in the Caballo Mountains, New Mexico

James C. Bednarz

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THE EFFECT OF MINING AND BLASTING ON BREEDING PRAIRIE FALCON *(Falco mexicanus)* OCCUPANCY IN THE CABALLO MOUNTAINS, NEW MEXICO

JAMES C. BEDNARZ

ABSTRACT - I surveyed 3 small isolated mountain ranges in southcentral New Mexico for the presence of breeding Prairie Falcons (*Falco mexicanus*). Of these, the Caballo Mountains were intensively impacted by mining and blasting activity, while the other 2 were essentially undisturbed. No falcons were found in the disturbed mountain range, but a total of 8 nests were documented in the 2 control ranges. The 3 areas were extremely similar in all respects except for the number of mining claims.

Almost no published information is available concerning the impacts of mining and blasting on birds of prey. The limited data available are restricted to observation of short-term impacts on actively nesting raptors (Stahlecker and Alldredge 1976). Several works (Allen 1979, Call 1979, Becker and Ball 1981) contain speculation about the impending impacts of mining operations on raptors and offer suggestions to minimize potentially adverse effects. Follow-up or controlled experimental studies of such impacts are virtually nonexistent.

Herein I report the numbers of breeding Prairie Falcons observed during a survey of 3 small and very similar mountain ranges in southcentral New Mexico. One of these ranges, the Caballo Mountains, has been intensively impacted by mining operations and associated human intrusions for several years. The other 2, the Fra Cristobal and Florida mountains, have minimal or no disturbance from mining. If mining and the associated blasting has no influence on Prairie Falcon nest occupancy, I would expect the numbers of breeding falcons at all 3 study areas to be similar. The habitat and number of cliffs at all 3 mountain ranges seems comparable.

STUDY AREAS AND METHODS

I surveyed the Fra Cristobal Mountains on 15-18 April and 19-23 May 1980, the Florida Mountains on 21-25 April 1980, and the Caballo Mountains on 5-9 May 1980. These ranges were searched for raptors as part of a larger statewide survey with emphasis on endangered raptors on lands administered by the Bureau of Land Management (BLM). These 3 ranges are isolated, but located in relatively close proximity (Fig. 1). The climate of all 3 ranges is similar; all are extremely dry with summer daytime temp often exceeding 38° C and winter temp commonly dropping below 0° C at night. The vegetation in all 3 study areas can be characterized as creosote bush (*Larrea tridentata*) dominated shrubland on the lower slopes grading into a sparse juniper-oak (*Juniperus* spp.; *Quercus* spp.) woodland on the summits and upper, north-facing slopes (Table 1). Elements of Chihuahuan desert vegetation (e.g. *Prosopis glandulosa, Yucca* spp., *Opuntia* spp.) are more common in the Florida Mountains. Suitable cliff habitat, elevation and topographic relief above basins are comparable for all 3 study areas (Table 1). Area of suitable cliff habitat (Table 1) includes only that contiguous mountain habitat that contains cliffs potentially usable as nest sites. Foothill habitats without cliffs surrounding mountain ranges were not included in this area measurement.

Geologically, the Fra Cristobal and the Caballo mountains are nearly identical, consisting primarily of marine sedimentary rock resulting from an uplift along the Rio Grande Rift (Kelly and Silver 1952). The Florida Mountains differ in this respect as they are of a rhyolitic formation.

Field surveys in all 3 areas emphasized the most prominent cliffs, which in my experience are preferred by Prairie Falcons for nest sites. I have found that cliffs < 50 m in height are generally used only in New Mexico when larger cliffs are not available. During this study I examined numerous smaller cliffs (< 50 m in height) but none contained active Prairie Falcon nests. Surveys were accomplished by climbing to an observation point that allowed observation of 1 or more large cliffs (> 50 m of vertical or near vertical rock). I studied cliffs for falcon-like excrement ("whitewash") with binoculars and spotting scope and watched for falcon activity for periods of several hours as outlined by Bond et al. (1977) and Call (1978). Cliff observations were made in the early morning or late afternoon. After cliffs were watched for at least 2 h without success, I approached from below and attempted to disturb (by shouting and clapping hands) any previously unobserved raptor. Observations were discontinued at cliff sites when nests of the Golden Eagle (*Aquila chrysaetos*) or Prairie Falcon were located. Field examinations in all areas were conducted when falcons were expected to be incubating or possibly tending small young.

Accessibility of mountain ranges differed considerably. The Caballo range had numerous roads on talus slopes providing easy access to excellent observation perches close to prominent cliffs. On the other hand, the Fra Cristobal range was extremely remote and almost no roads approach the foothills. Although I spent nearly twice as many field days in this area, most of the additional time was used in travel. Access roads circled around the Florida Mountains, but generally stopped at the base of the talus. Search and observation effort at all 3 ranges was comparable (Table 2).

RESULTS AND DISCUSSION

I located 5 active Prairie Falcon nests in the Florida range and 3 active sites in the Fra Cristobal range (Table 2). No nests or large falcons were observed in the Caballo Mountains. I also found 2 Golden Eagle nests in the Fra Cristobal range. In all observable physical and ecological characteristics, except for the intensity of mining, the 3 mountain

Table 1. Characteristics of 3 mountain study areas in southcentral New Mexico.

	Fra Cristobal Mountains	Caballo Mountains	Florida Mountains
Approx. area of suitable cliff habitat (km^2)	36	26	34
Maximum elevation (m)	2083	2301	2270
Elevation relief above basin (m)	730	1000	915
Primary rock type	marine sedimentary	marine sedimentary	rhyolite
Dominant vegetation community on slopes	creosote shrubland	creosote shrubland	creosote-mesquite shrubland
Dominant vegetation community at summit	juniper-oak woodland	juniper-oak woodland	juniper-oak woodland

ranges appeared to be extremely similar (Tables 1 and 2).

The area I surveyed (26 km^2) in the Caballo Mountains contained 125 active mining claims (mining claim records dt 21 June 1980, BLM State Office, Santa Fe, New Mexico). I witnessed blasting during 1 of my 5 field survey days in this area. Numerous shallow shafts were blasted into rock walls and talus slopes throughout the range. These blast shafts were concentrated at or just above the base of both large and small cliffs examined. In addition, several ladders were bolted to the vertical

Table 2. Results of field survey for Prairie Falcon nests and active mining claims in 3 mountain study areas in southcentral New Mexico.

	Fra Cristobal Mountains	Caballo Mountains	Florida Mountains
Field days	9	5	5
Cliff observation (time h)	25.9	25.0	25.0
# of major cliffs examined (> 50 m in height)	10	8	9
# of major cliffs not examined (> 50 m in height)	3	3	4
# nests located	3	0	5
Mining claims recorded at BLM office	0	125	29
Mining activity observed	none	intense	none

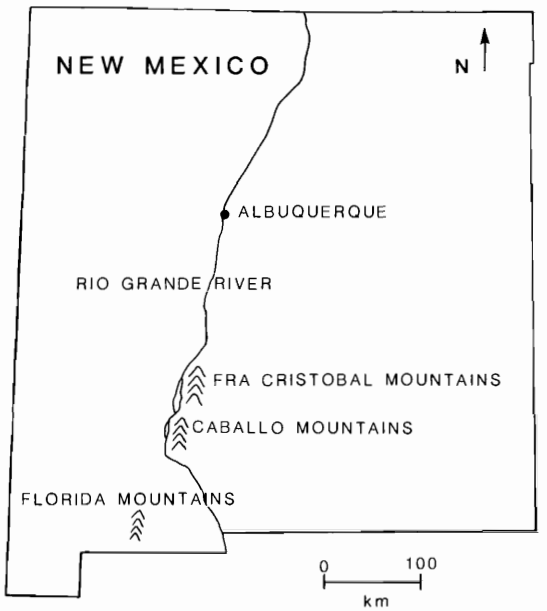


Fig. 1. Location of 3 mountain tudy areas in southcentral New Mexico.

rock walls and 2 compressors were parked high on the talus slopes adjacent to cliffs.

In the Florida Mountains, with 29 mining claims in the area surveyed (34 km²), I observed no evidence of active mining. I did note 1 probable mining road leading up the talus slope on the north side of the mountain range. No evidence of mining activity was observed in the Fra Cristobal range.

The absence of nesting Prairie Falcons from the Caballo range was an unexpected finding. Prominent cliffs in the 2 control study areas provided habitat for 8 pairs of breeding falcons. Evidence of mining activity and related human disturbance was obvious in the Caballo Mountains, but minimal in the 2 control ranges.

Breeding falcons may have occurred in the Caballo Mountains in 1980, but if so, they must have occupied the smaller, less preferred cliffs. Given that I did not observe any Prairie Falcons, during the field survey, I suspect that few, if any, breeding falcons were present. No historical data on raptor breeding populations are available for any of the 3 ranges surveyed.

A possible alternative explanation is that low numbers of available prey made the Caballo range unsuitable as falcon breeding habitat in 1980. I feel, however, this is unlikely because the Fra Cristobal Range 30 km to the north and the Florida range 90 km to the south provided enough prey to support at least 8 pairs. The vegetative cover in the vicinity of all ranges was extremely similar in all appearances. An absence of Prairie Falcons from the Caballo Mountains could only be caused by an extreme depression in prey populations in a very localized area around these mountains, which seems highly improbable.

The Florida Mountains were used by almost twice as many falcon pairs (5 vs 3) as the Fra Cristobal Mountains. This difference may be due to the dispersion of cliffs in the respective ranges. Prominent cliffs in the Florida range were uniformly distributed along the west face, whereas in the Fra Cristobal range, cliffs were aggregated in 2 relatively small parts of the range (1 aggregation in the north portion and the other in the south). The uniform cliff dispersion probably enables more falcons to use a small mountain range without intruding into defended areas around neighboring eyries. The cliffs in the Caballo range are distributed in a manner similar to that found in the Florida Mountains. Therefore, I would expect to find between 3-5 Prairie Falcon nests if the Caballo Mountains were undisturbed.

All raptors have individual differences in the amount of disturbance that will be endured. I am aware of 1 case in Wyoming where a pair of Prairie Falcons tolerated intensive coal mining activity including blasting, heavy equipment operation, and settling pond construction within 75 m of the nest (S. Platt, pers. comm.). Falcons returned to the same general area for 3 consecutive years (1981-1983) following the disturbance. These birds were not successful in producing young in any of the years monitored, but adverse weather conditions may have been a factor (S. Platt, pers. comm.). In this case the primary disturbance was limited to 1 breeding season and was apparently of similar intensity throughout the disturbance period. Tolerant falcons may more readily habituate to a steady, predictable intensity of disturbance. In contrast, mining and blasting activity in the impacted range surveyed during this study was probably of a highly variable and unpredictable nature.

Blasting and mining operations in the Caballo Mountains are primarily the endeavaors of individual prospectors or small part-time mining partnerships. One larger corporation was mining barite at the time of my survey, but this mining was

in the foothills >3 km from the area of suitable nesting cliffs. Since the climate in this area is relatively mild and there are no restrictons on blasting, I assume that all active claims are worked periodically throughout the year. All mining in the survey area seemed to be on a part-time basis. Placer gold was probably the principle mineral that was being extracted. Also, much of the mining activity is suspected to be treasure hunting in search of legendary "Spanish gold" thought to be hidden in the Caballo Mountains (T. Custer, BLM Geologist, White Sands Resource Area; pers. comm.). Treasure hunters may pursue their hobby under the facade of a mining claim which allows them to legally blast natural cliff faces. The combination of mining and treasure hunting has resulted in an extremely high intensity of blasting in the Caballo Mountains.

In conclusion, I believe the data presented here suggest that there is a difference in Prairie Falcon nest occupancy between the Caballo Mountains and the 2 control ranges most likely due to blasting and mining or associated human activities. To my knowledge, no study has examined the long-term effects of mining or blasting on occupancy of raptor nest sites, but short-term impacts have been documented (Stahlecker and Alldredge 1976). Ellis (1981), based on a 2 y study of simulated sonic boom noise, implied that both adverse short-term and long-term impacts of such activities were probably negligible on nesting raptors. My results indicate that this conclusion cannot be extended to more intensive blasting and mining activities, and I urge further observation, and particularly, controlled experimental studies to address the long-term impacts of such disturbances on breeding raptors.

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Department of Biology, University of New Mexico, Albuquerque, NM 87131.

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ATTACHMENT 3

10th International Symposium on Rock Fragmentation by Blasting, November 24-29, 2012

Fines and Dust Generation and Control in Rock Fragmentation by Blasting

Sushil Bhandari,
Earth Resource Technology Consultants, Jodhpur, India

ABSTRACT: Fine materials resulting from blasting have varied utilization. Sometimes fines are considered useful in further metallurgical and chemical processing, while at other times fines are rejected and become economical waste as well as environmental problem. Some fines get air borne and are dispersed as dust. Considerable work has been carried out about reducing or increasing fines in blasting. It has been proposed by many researchers that fines originate from crushed zone near the hole. Based on small scale blasting tests, it is shown that fines not only come from the crushed zone but are also dependent on other parameters such as the burden. Blast parameters and geology also influence them. Appropriate blasting can reduce generation of fines and ejection of dust and fines during blasting. Another step is to stop fines getting air borne. Modelling of dust plume and difficulties in measurements to quantify dust dispersal through a particular area are described. Also practical examples of dust dispersal methods are given.

1. INTRODUCTION

Fines and dust resulting from blasting operations sometime become both an environmental issue and an economical loss for the producers. Dust is a general term-fine particles (below 75 micron range) that are suspended in the atmosphere. Dust is formed when fine particles become entrained in the atmosphere by the turbulent action of wind, by the mechanical disturbance of fine materials, or through the release of particulate-rich gaseous emissions. In reality fines may be useful or detriment to the operation. Most often less fines generation is needed in overburden blasting, aggregate production or in steel grade limestone production (where anything less than 40/30mm size is not used) and often this material becomes waste. Whereas in situations where material is further crushed and processed, it is better to break the material by blasting to smallest size (Mine to Mill concept –JKMRC,1998). Even in later situation dust continues to be a matter of concern. Fines and dust resulting from mining operations is a serious nuisance and a health hazard to mine workers and population living in the vicinity of a mine. Though the blasting dust cloud is raised for few minutes but most of the dust settles in and around mining area and some of it is dispersed before settling down. Depending on meteorological conditions this dust can disperse to substantial distances endangering health of communities. Some of the settled dust is raised again by mining activities for example by travelling vehicles. Damage to vegetation and agriculture is possible.

Modern surface mining often involves huge tonnages thus increasing potential for greater dust hazard. Blasting is carried out in most mines, producing very large quantities of fines/dust. In aggregate production amount of fines produced ranges between 20%-40% (Mitchell et al, 2008). Mines have to face the problem of storage and use of fines. It is important to achieve the goal of reduced fines generation.

Two steps are needed to reduce the nuisance resulting from blasting — generate less fines/dust during blasting and then reduce the dispersion of dust which gets airborne. Fines/dust generation and dispersion are influenced by blast design parameters and execution (Bhandari et al, 1904). The fine material is assumed to originate from a cylindrical crushed zone around the blast hole, within which particles are generated by the crushing of the rock due to comprehensive-shear failure (Kanchibotla et al, 1999). The radius of zone is assumed as the distance from the blast

hole zone to the point where radial stresses exceed the compressive strength of rock mass. However, Svahn, (2003) and others have shown that much of the fines generated in blasting do not originate in the crushed zone around the blasthole. Efforts are needed to understand the process of fines/dust generation and dispersion. Laboratory blasting experiments carried out by Bhandari (1975a and b), Bhandari (1983), Bhandari and Badal (1990), Badal (1990) have been reassessed. Size distribution has been analyzed (Ouchterlony, 2011) using Swebrac function throw important light on the generation of fines. Also steps to reduce fines/dust generation and dispersal need to be laid out for practical blasting operations. Experiments were carried out at full scale in limestone mines and simultaneous measurements of dust plume dispersal, fragmentation, displacement were recorded. Modeling of plume movement also helps in getting some ideas for controlling dust generation and dispersal.

1. GENERATION OF FINE FRAGMENTS

An occasional problem lies in the realistic assessment of fines. It is felt that these fines can be generated both by the equipment loading the rock, and through weak binding material between mineral grains in addition to the intensive crushing of rock around the boreholes during blasting. Within the research project, "Less fines production in aggregate and industrial minerals industry", which was funded by the European Union, Moser (2004) states that Europe is consuming 2.25 billion tons of blasted rock, 80% being building industry aggregate and industrial minerals. Out of this blasted material 10-15% cannot be sold, being too fine i.e. smaller than 4 mm. In favour of fines to benefit the SAG (Semi Autogenous grinding) mill throughput, Grundstrom et al. (2001) state that the blast fragmentation affects mill throughput and finer ROM (Run of Mine) from modified blasts increased the mill throughput substantially. Similarly, Kanchibotla et al. (1998) witnessed primary crusher product size reduction and significant increase in throughput due to the generation of more fines, achieved by changing the powder factor.

2.1 Crushed Zone Model

Considerable research work has been going on with regards to fines generation and size distribution (Hagan1979, Moser2005, Mitchel et al, 2008, Damenegas, 2008, Djordjevic, 1999). Several models have been used for fragment size distribution. The models used are Kuz-Ram Model (Cunningham, 1987), Crushed Zone Model of JKMRC (Scott et al, 1998, Kanchibotla et al, 1999, Onedra et al., 2004)) and KCO model combining extended Kuzram and Swebrac function (Ouchterlony, 2005a and b). There are significant differences in the model predictions for the finer ranges in the fragment size distribution curve while the differences are reduced in the course range. Kanchibotla et al. (1998) pointed out that the Kuz-Ram model underestimates the contribution of fines. In the case of the finer fractions, it is hypothesized that they are produced by the pulverizing or crushing action of the explosive in a blasthole. The crushing zone radius around each blasthole determined based on the peak blasthole pressure and strength of the rock. Although this has been generally believed to be the major source, no one has so far been able to prove it, as it was not known where inside the bench such material originates.

How the blasting process can be refined to provide the optimum feed size range for the crushing circuit fines in the blast muckpile has been subject of investigations (Scott et al, 1998). Kojovic et al. (1998) state that rock in the crushed zone is assumed to be completely pulverized to generate fines, which are assumed to be less than 1mm in size. The coarse part of the distribution is predicted using the conventional uniformity index based on blast design

parameters proposed by Cunningham (1987) while the finer part is based on the percentage assumed pulverized around the borehole.

2.2 Test parameters and data collection

Small scale blasting tests were carried out in bench shaped cement mortar and granite blocks to study effect of variation of burden on fragmentation and utilization of energy (Bhandari, 1975a, Bhandari, 1975b). Detonating cord (5.3g/m) was used as long cylindrical charges either single hole or two/three simultaneously blasted holes. Some tests were carried out using gun powder as an explosive charge. In some granite blocks, simulated joint was created parallel to face with three fillers namely air, plaster of Paris and cement. Bhandari (1983), Bhandari and Badal (1990) and Badal (1990) and others have studied fragmentation on reduced scale in different orientation of joints and on production scale.

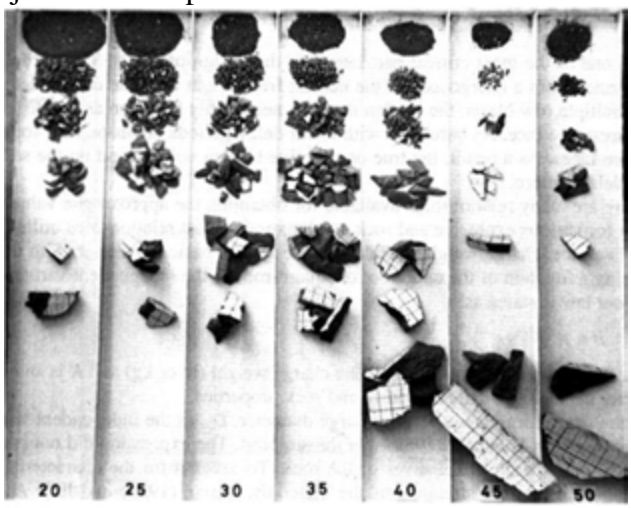


Figure 1 Sized fragments of 20, 25,30,35, 40, 45 and 50 mm burdens placed in vertcal rows for small to largest sizes, .33, +3.33, +6.57, + 12.7, + 25.4, +38.1, +50.8 and +63.6 mm

Bhandari (1975 a & b) distinguished between optimum breakage burden and optimum fragmentation burden (Figure 1). At the optimum breakage burden maximum volume or mass of rock is broken but the fragmentation obtained is not essentially acceptable as it has greater fines and some large boulders. This was shown by laboratory scale blasting where it was found that optimum fragmentation burden was 30-40% less than the optimum breakage burden. In small scale blasting tests, Figure 1 shows that smaller burdens produce very high amount of fines with lesser values at optimum fragmentation burdens. A typical Swebrec distribution of fragments obtained in tests is given in Figure 2. At optimum breakage burden though the rock broken volume is maximum but there are boulders and fines.

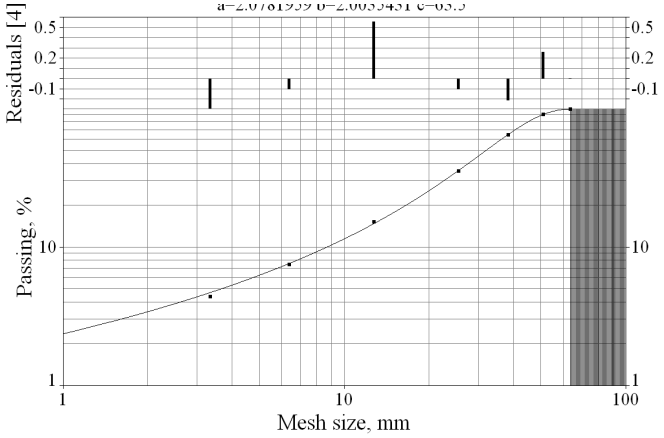


Figure 2 Showing size distribution using Swebrac

At lower burden, amount of fines is higher. F-test indicates a significant influence of burden (Ouchterlony, 2011) on the amount of fines (Figure 3). The mass of -3.33 mm fines is denoted by f (g), the burden by B (mm) and the spacing by S (mm). There is no significant dependence on spacing. If there was a zone that followed the Crushed Zone Model lines (admittedly JKMRC use -1 mm fines) and thus was based on the initial blasthole pressure, then we would have no dependence on the burden. If the crushed zone was the only zone of origin of fines then significant influence of burden would not have been there. Amount of fines produced from 3 holes is almost three times that is produced from single hole that means fines are not dependent on crushed zone alone. It is suggested that micro-structural damage by stress waves help in branching of radiating cracks propagating under gas action.

Similar observations about fines and burden were made with regard to granite blocks (Bhandari, 1975a) and in homogeneous limestone blocks (Badal, 1990). At smaller burdens, stress waves cause scabbing and also create micro cracking, extension of existing cracks along with crushing near the hole. Low explosive tests show fines with large amount of boulders (Figure 4). The amount of -3,33 mm fines from granite tests (everything else being the same) is about twice the amount from mortar tests, despite that the uniaxial compressive strength of granite (172.4 MPa) is more than three times higher than that (49,6 MPa) of the mortar. According to crushed zone model (CZM) lower compressive strength rock should have given higher amount of fines.

Stress wave action also has important influence on the generation of fines. At lower burden stress waves are predominantly acting and hence a large generation of fines occurs as stress waves have an important role in the generation of more micro-structural cracks and thus fines. When the role of stress waves was further investigated then it showed that at lower burdens mass of fines is much higher.

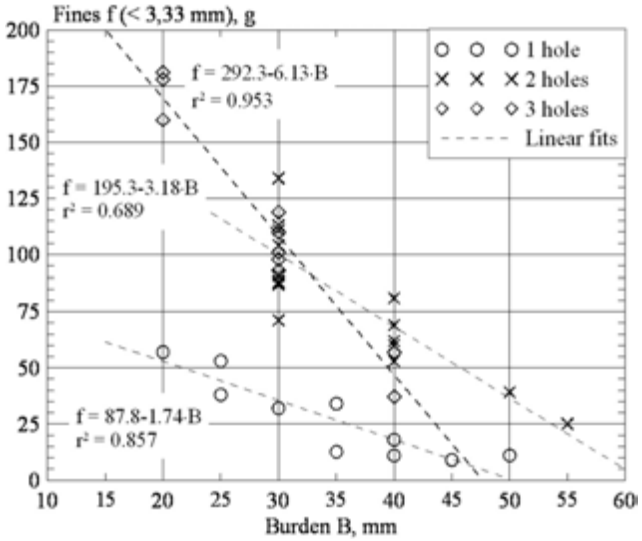


Figure 3 Fines generated vs burden during single and multihole experiments

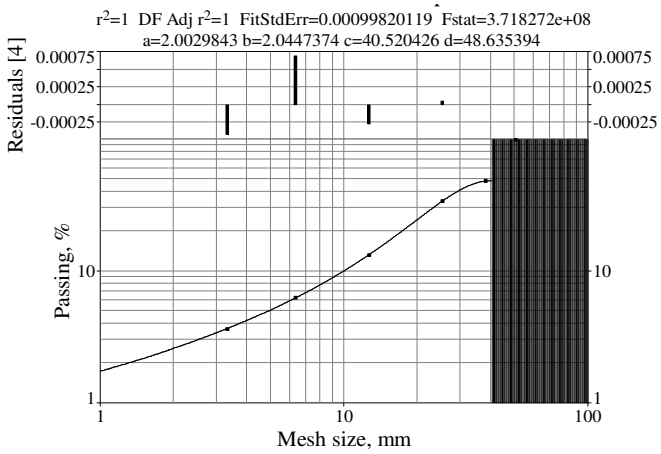


Figure 4 Size distribution and retention for low explosive test

To reduce role of stress waves decoupling tests were carried out by keeping explosives diameter same but increasing hole diameter. Less amount of fines were produced (Figure 6). Fines produced are less at larger burden of 35 mm and with increase in diameter thus increased decoupling and reducing role of tress waves. Further test were carried out with wave trapping, by placing a plate on bench face with grease between them. Figure 7 shows that with stress waves participating fines produced are amount is greater for corresponding burden.

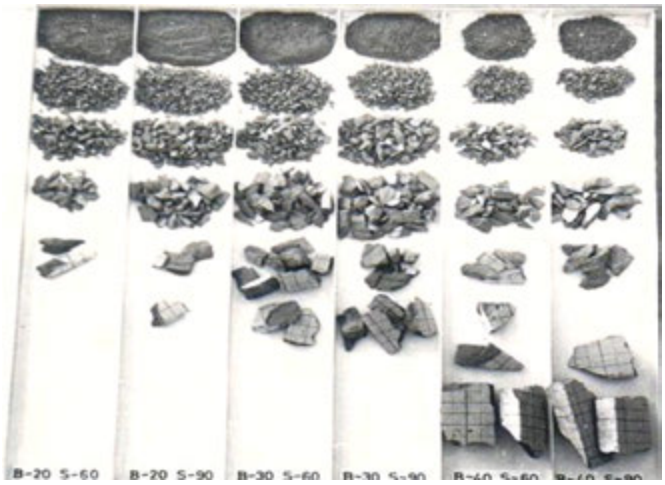


Figure 5 Variable spacing at burdens of 20, 30 and 40mm and spacing of 60 and 90mm shows that by reducing role of stress waves in multihole fines get reduced.

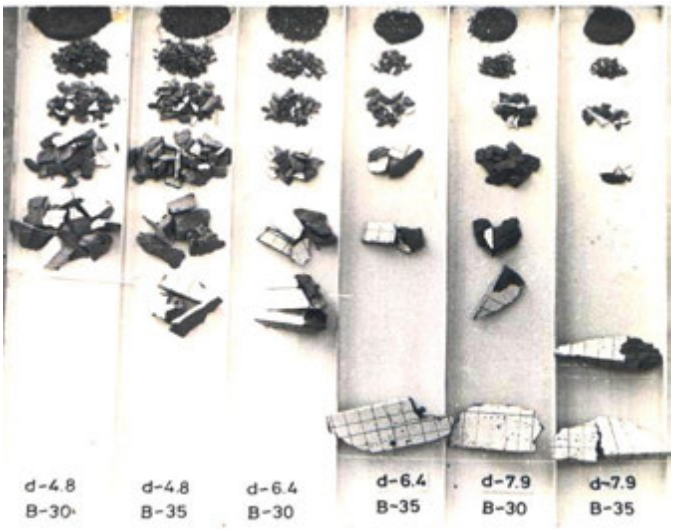


Figure 6 Sized fragments, from single tests with vari ous hole diameters (4.8, 6.4 and 7.9 mm) shows much larger amount of fines at smaller diameter.

2.2 Influence of Joints

Bhandari (1983), Bhandari and Badal (1990) and Badal (1990) and others have studied on reduced scale and on production scale, the relationship between orientation of joints and some blast parameters. The filler materials of the joints also have influence on the fragmentation. Bhandari (1975) showed in case of tests on granite blocks that the fine fragments increased in case of cemented joints compared to joints which were filled with weaker material or were open joints. Thus indicating that participation of stress waves was better in case of joints filled with strong filler material and produced greater amount of fines. Bhandari and Badal (1990) and Badal (1990) observed that maximum new surface area was created with horizontal joints, whereas the parallel vertical joints generated minimum amount of new surface area. (Figure 8 to 12). Homogeneous rock produced lesser fines compared to jointed rock tests. Although shape of fragments changed with orientation of joints.

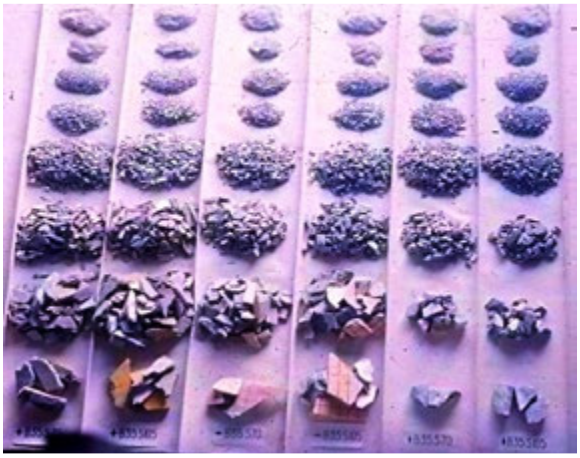


Figure 8 Size distribution for horizontal, parallel to face and perpendicular to face joints with 35mm burden & spacing of 70 and 105mm



Figure 9 Fragment distribution and displacement for hori-zontal joints



Figure 7 Sized fragments from single hole tests (a) wave trapping tests (WB) and without wave trapping tests for different burden values



Figure 10 Fragment distribution and displacement for joints vertical perpendicular to face

Displacement of fragments indicated that it is also affected by orientation of joints. For example for dipping joints perpendicular to the face the direction the displacement is directed towards the up dip side, whereas for down dip joints parallel to face and perpendicular to blasting direction the scattering is widely spread. The shape of particles is also influenced. For example in case of vertical joints parallel to the face and perpendicular to blasting direction provide thinner platy particles, whereas joints parallel to face and perpendicular to blasting direction results in cubical shape of particles..



Figure 11 Fragment distribution and displacement for joints parallel to face

By providing liners in holes, crushing near the hole were reduced thus fines generated in the crushed zone reduce (Rathore and Bhandari, 2005). Thus fines can be reduced by providing liners & providing air gap in the charge column or using lower energy explosives.



Figure 12 Fragment distribution and displacement for joints 30^{o} dipping across the face

2. DUST DISPERSAL

Meteorological parameters such as wind speed and direction, temperature, cloud cover and humidity will affect the dispersion of dust. Wind provides the mechanical energy for particle entrainment. A certain minimum wind velocity, often-called threshold wind velocity is required before the dust particles raised in the atmosphere or lying on the surface begin to move. Above this level, particle entrainment may be expected to depend strongly on wind velocity. Atmospheric stability affects dispersion of the emission plume, determining the extent of the vertical and horizontal, transverse and axial spreading of the emitted particulates (Evans et al, 1981, Chock, 1997). Atmospheric stability depends upon the extent of solar insulation, cloudiness and wind speed. These factors determine vertical thermal gradient and corresponding atmospheric turbulence. Stability is both seasonal and diurnal. For long-term dust dispersion estimates, an average estimate of stability condition is desirable.

Soil moisture content affects the cohesive forces between soil particles and thus their entrainment. Above certain soil moisture content, the particle may be bound together so tightly that no fugitive emissions may be expected. Moisture affects cohesiveness differently for different soils. For long-term emission estimates, average soil moisture content is needed along with frequency of precipitation. In both cases one needs to carry out dust sampling.

3.1 Experimental measurements

Measurement of dust resulting from blasting has been very difficult work. This is required because it is important to see effectiveness of control measures. Experiments were conducted at opencast mine site at Sanu Limestone Mines – Jaisalmer, physical measurement of particulate matter ($P.M._{10}$) dust particles were made with the help of high volume dust samplers. High volume air samplers were used for the estimation of the mass(g) of the SPM in a given volume of air ($V.\tau$), where V is the known rate at which air is drawn through the apparatus and τ is the duration of sampling process

Hence, good correlation between dust cloud spread and the intensity of the turbulence exists irrespective of the condition of the surface reference and stability. This is a significant result, in

the theoretical modeling of the dispersing puff of dust cloud. Therefore, wind measurement and σ values at blast site are of great in the dispersion process.

Five instruments were laid out in downwind direction at safe distance from the blast. Three were on the path central line of expected (1st, 3rd & 5th) plume path. Transverse to 3rd instrument two instruments are kept at equal distance on either side.

2.2 Experiments at Sanu Mines, Jaisalmer

Experimental studies were carried out at Sanu Limestone mines. This mine is located in western part of Rajasthan in Thar Desert. The limestone belongs to Khuila formation of Eocene age. The area is deprived of the overburden except in the northern region where a layer of 2-4 m top soil exists. Limestone horizon is of 15-20 m thickness and is further divided into hard, compact bouldary limestone and chalky limestone. Steel grade lime stone is produced which is available in top layer only which is 1 to 5 m thick. The lower limestone layer is of cement grade. Steel mills need limestone of a particular size. There is size restriction; in general anything below 30 mm is of no use. This material is dumped back in the mine or sold at lower price. Therefore, there is need to reduce generation of fines and dust. Drill holes were of 120mm diameter holes for a depth ranging from 4.0m – 5.0m. The usual blast parameters are 3.0m of spacing and 2.5m of burden. These holes were blasted using ANFO and aluminized slurry explosives as bottom charge. Detonating cord and cord relays were used. Five blasts were conducted where dust measurements were carried out and blast results including fragment sizes were analysed using Wipfrag software. Measurements of the dust were made at various distances from the point of blast. Table 1 gives details of blasts and results obtained from these tests showed that by change of explosives average fragment size increased with ANFO and wood dust compared to slurry explosives. Blast Nos. 1 and 2 used cap sensitive slurry explosive only. Blast Nos. 3 and 4 utilised cap sensitive slurry explosive as booster and ANFO as a column charge. In blast No. 5, 10% sawdust was added to



Figure 13 Poor fragmentation resulted in boulders and fines



F igure 14 Excessive fragmentation leads to the generation of a significant proportion of fine material.

ANFO and in the stemming water filled cartridges (ampoules) were put with the stemming. By the addition of sawdust, energy of explosive is reduce and by the addition of water ampoules in the stemming dust ejected from the blasthole gets moistened thus dispersal is hampered. Blast No. 5 shows more uniform fragmentation than in Blast Nos. 1 and 2 where stronger slurry explosives were used. Many large boulders and a greater amount of fines were observed, indicating that much energy was being consumed in crushing and energy utilization was not optimum thereby producing boulders. Figure 15 shows that dust was collected by high volume respiratory sampler collected dust upto 70 minutes after blast.

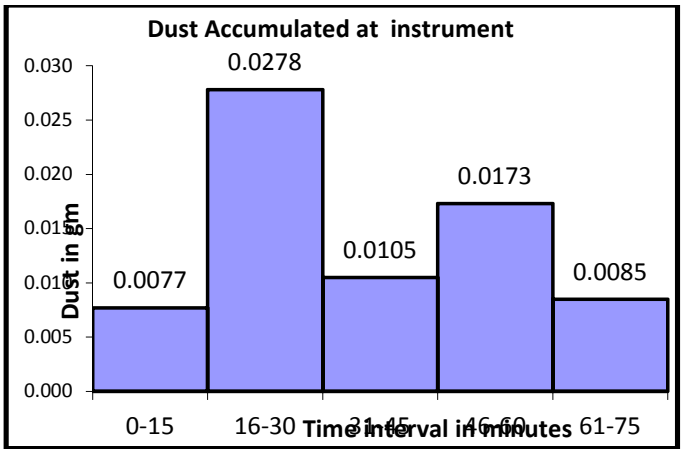


Figure 15 Monitoring dust concentration using high volume dust sampler

Table 1 Blast observations from the blast carried out at Sanu limestone mine, Jaisalmer

Explosive used	Slurry	**Slurry**	**Slurry + ANO**	**Slurr +ANFO**	**Slurry + ANFO+ Water bag + saw dust**
Average Burden , m	**2.27**	**1.93**	**2.44**	**2.42**	**2.62**

Average Spacing, m	**2.83**	**2.10**	**2.19**	**2.85**	**2.08**
Max. Charge Per delay	**103.8**	**66.48**	**53.56**	**298.3**	**44.30**
Average Throw, m	**5.80**	**7.43**	**6.00**	**9.00**	**5.95**
Average Back break , m	**1.37**	**1.66**	**1.64**	**1.85**	**1.01**
Average over break , m	**0.65**	**0.85**	**1.77**	**1.80**	**1.66**
Average Fragments size, mm	**727**	**755**	**275**	**317**	**106**
Powder factor	**6.42**	**5.00**	**6.81**	**8.23**	**6.48**
Fragmentation	**No t Good**	**Not Good**	**Goo**	**Good**	**Good**

A software was developed for predicting dust plume dispersion from blasting operations using the Eulerian mathematical algorithm and Bhandari and Kumar (2002), Kumar and Bhandari (2002). This model considers atmospheric stability and wind velocity and direction for computing dust concentrations at different distances from the blast. The software simulates movement of dust plume at a given horizontal distance from the blast location and time elapsed after the blast. Concentration of dust is also given in vertical planes. It takes into account ground profile & atmospheric conditions such as temperature, pressure, humidity, wind velocity, wind direction & shear.

The impediment in establishing correlation between the predicated and the observed results was lack of information with respect to the total quantity of dust (Q) spewed up in the atmosphere due to initial blasting.

Possible causes of error and difficulties in field measurement are as below:

(a) Incorrect identification of central line of plume

(b) Incorrect rate of suction leading to erroneous dust weight.

(c) Uneven surface levels of instruments 1, 2, 3, 4 and 5.

(d) Incorrect assumption of uniform dust distribution in the vertical column.

(e) Wind direction, may sometimes, suddenly change at the last moment, after the entire set of instrument have been laid. This may result in either partial dust capture by the set of RDS or no dust, at all, may reach to any of the five instruments. Exact identification of the central line of plume is also, therefore, difficult.

A model for predicting dust plume dispersion from blasting operations using the Eulerian mathematical algorithm has been developed and is presented. This model considers atmospheric stability and wind velocity and direction for computing dust concentrations at different distances from the blast. Software has been developed which simulates movement of dust plume at a given horizontal distance from the blast location and time elapsed after the blast. Concentration of dust

is also given in vertical planes. It takes into account ground profile & atmospheric conditions such as temperature, pressure, humidity, wind velocity, wind direction & shear.

4. DUST CONTROL MEASURES

Industry has been able to develop fines and dust control measures. (Bhandari et al, 2004) To some extent by discontinuing use of detonating cord as downline and also by use of aggregates as stemming material in the holes compared to use of drill cuttings has considerably reduced dust. Based on the above analysis some ways to reduce dispersal were tried. Water is important in controlling dust generated by blasting. The area surrounding the blast should be thoroughly sprayed beforehand. This precaution will prevent dust settled out during previous operations from becoming airborne. A uniform rock moisture content of only 1% greatly reduces dust compared to dry rock. However, since it is difficult to wet rock uniformly under realistic mining conditions, the optimum moisture content can be much higher. The water used for dust suppression, particularly in drilling and in blasting, should be as clean as possible, because the evaporation of dirty water can also release dust. The following were tried during the experimental work:

(a) Stemming Rock Lock filled with water

High tensile, non-brittle plastic balls; have been used in stemming column (Shann, 2002). The ball works as a lock or obstruction to blown out of stemming material for a little time where as water inside when the ball breaks and sprays water it in reduces dust dispersion. Trials were made with this arrangement. Though there was some help but in realistic situation this would involve lot of work. The effort made did not give very good results.



Figure 16 Placing water filled rock lock in blast hole

(b) Water filled ampoule with stemming.

PVC ampoules (water filled or gel filled) are used as safe stemming material in underground coal mines. They significantly reduce dust and fumes from blasting. Water filled plastic bags are permitted device for stemming. In experimental work water stemming bags have proven very effective in providing confinement and reducing dust (Figure 17 and 18). When shot were fired with use of water ampoules, reduction in dust concentration was observed. The force of detonation was reduced when water ampoules were used, which resulted in better and uniform fragmentation and much lower degree of projection of fragmented material.





Figure 17 Placing water bags into the blast hole.

(c) Water Sprinkling area surrounding the blast area prior to stopping dust being raised. Besides bench being blasted when fragı falls on the lower bench, another dust cloud is raised. Therefore sprinkle water before hand.

(d) Water sprinkling after blast using the photocells. Shadow resulting from blasting plume can operate the photocell which can start the water sprinkling.

(e) Another method that found to be effective in protecting areas adjacent to the mine from blasting dust involved delaying blasting under unfavorable wind and atmospheric conditions. This required some flexibility in blasting schedules, but can be highly effective

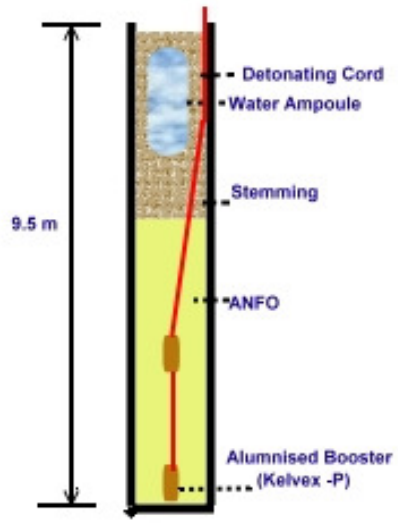


Figure 18 Placement of water filled bags in stemming

5. CONCLUSIONS

Two steps are needed to reduce dust nuisance resulting from blasting — generate less fines/dust during blasting and then reduce the dispersion of dust which gets airborne. There are several blasting parameters which would influence generation of fines and dust. Type of explosives determines amount of fines and dust generated during blasting. Proper combination of blasting parameters such as burden distance, blast hole spacing, stemming height, effective sub drilling and the ratio of charge diameter to blast hole diameter may give reduced fines. To achieve the goal of reduced dust proper explosive type, blast parameters, initiation sequence, and charge distribution need to be tailored in such a way to produce optimum size distribution of fragments. Generation of dust gets affected by many geological and blasting parameters. Dust dispersal needs to be prevented even if fines generated have particles which can be raised as dust. Prediction of dust plume movement and use of water as to prevent dust dispersal can be made.

6. ACKNOWLEDGEMENT

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ATTACHMENT 4

Bioresearches
A Babbage Company

Proposed Wharekirauponga Underground Mine

Native Frog Effects Assessment

for: OceanaGold New Zealand Limited



Job No: 67436#BIO3
Version: 4
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This document has been produced for New Zealand consenting purposes only. Information contained herein must not be relied on for investment purposes.

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Author(s)	Dylan van Winkel	
	Senior Ecologist	
Reviewer(s)		
	Chris Wedding	
	Ecology Manager, Bioresearches	

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Cover Illustration: Hochstetter's frog (*Leiopelma hochstetteri*) in streamside habitat. Image not taken in Wharekirauponga.

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1 EXECUTIVE SUMMARY

Bioresearches was engaged by OceanaGold (New Zealand) Limited (OGNZL) to undertake an assessment of the ecological effects on native frogs in relation to the proposed Wharekirauponga Underground (WUG) Mine, which forms part of the Waihi North Project.

Activities associated with construction and operation of the Wharekirauponga Underground Mine such as blasting and dewatering, have been identified as potential risks to populations of Archey's frog (*Leiopelma archeyi*) and Hochstetter's frog (*Leiopelma hochstetteri*) that inhabit the forests and streams above the proposed mine. Specifically, seismic vibrations from underground blasting, that propagate through the rock mass to the surface could disturb frogs over an area of approximately 315 ha. Hydrological modelling has predicted potential surface water impacts in the form of baseflow reductions in streams within the Wharekirauponga catchment due to dewatering associated with the Wharekirauponga Underground Mine. Baseflow reductions and associated effects on instream habitat could potentially impact semi-aquatic Hochstetter's frogs that live on the edges of forested streams.

This report adopts an integrated approach to assessing the potential effects of vibration and dewatering on native Leiopelmatid frogs. It combines detailed literature reviews and fauna database analyses with reviews of technical reports across engineering, hydrology, ecology, and biostatistics. Additionally, information from recent field surveys has been incorporated to improve knowledge on *Leiopelma* frog distribution and abundance, and allow an evidence based assessment of potential effects to be presented.

A summary of the report's findings includes:

- Leiopelmatid frogs represent a unique evolutionary lineage among amphibians and have high conservation value in New Zealand and worldwide.
- Two species—Archey's frog and Hochstetter's frog—are known to occupy the forests and streams above the Wharekirauponga Underground Mine footprint. Both are legally protected, and both are in decline.
- Archey's frog is terrestrial and Hochstetter's frog is semi-aquatic; the latter requires water to complete their reproductive cycle.
- Potential ecological impacts of frogs, associated with the proposed Waihi North Project, include:
    - Surface vibration due to blasting – the vibrations experienced are unlikely to result in measurable effects on Archey's or Hochstetter's frog populations occupying the forests above the proposed Wharekirauponga Underground Mine or across the Coromandel Range because:
        - Vibration footprints cover a small proportion of the total area occupied by native frogs in Wharekirauponga and the Coromandel.
        - Vibrations will be intermittent and are at levels unlikely to result in biological responses that negatively impact frogs and their reproduction.

        - Frog populations (both Archey's and Hochstetter's frog) persisted in the vicinity of the historical Golden Cross mine, where similar vibrations from blasts would have been experienced.
    - Potential dewatering effects associated with mine dewatering and associated groundwater drawdown – this is unlikely to have measurable effects on frog populations because:
        - Reductions in flow and wetted width are unlikely to negatively impact semi-aquatic Hochstetter's frog habitat quantity or quality (i.e., food resources, refuges, breeding habitat) in lower stream catchments, and would not affect higher order catchments where most of the Hochstetter's frog population occurs.
        - Potential dewatering will have no impact on terrestrial Archey's frogs as their habitat is maintained by surface water, which is not expected to be affected by the mining activities.

Overall, it is considered that measurable adverse effects are unlikely on Leiopelmatid frogs occupying the forests and stream habitats above the Wharekirauponga Underground Mine as a result of vibration and dewatering. However, it is acknowledged that uncertainty surrounding scale and magnitude remains and an assumption of nil risk is not justified based on available evidence. Accordingly, OGNZL has proposed a comprehensive habitat enhancement programme, which includes ~633 ha of pest management, across the project area and surrounds (including areas of high value frog habitat) to address any uncertainty surrounding potential effects on native frogs.

Ongoing monitoring of activities such as blasting, dewatering, and potentially affected biological communities over the life of the mine will help validate the expected project outcomes for frogs.

2 INTRODUCTION

Bioresearches was engaged by OceanaGold (New Zealand) Limited (OGNZL) to assess the ecological effects of the Waihi North Project on native frog populations. The focus of this assessment included the potential impacts of blast vibrations and surface water changes from potential dewatering within the Coromandel Forest Park, related to the proposed Wharekirauponga Underground (WUG) Mine.

Additional potential impacts on native frogs—such as noise, light, air pollution, and biotic factors (e.g., vegetation removal)—have been identified and addressed by other specialist ecologists (Boffa Miskell 2025a; RMA Ecology 2025) and are not covered in this report.

In essence, three ecological consultancies have contributed to the broader project-wide native frog assessment. These include:

Boffa Miskell (lead – Katherine Muchna) – responsible for delivering the overall ecology effects assessment for the WUG component of the Project, which included assessing the potential ecological disturbance effects on fauna (including native frogs) from vegetation clearance activities, artificial lighting, drilling and helicopter noise; continuous noise emissions from the vent raises; and potential biosecurity risks (e.g., introduction of kauri dieback disease) (Boffa Miskell 2025a).

Bioresearches (Babbage Consultants; lead – Dylan van Winkel) – responsible for specialist frog advice relating to potential impacts of vibration and dewatering on Archey's and Hochstetter's frogs at Wharekirauponga. Bioresearches also designed and led field surveys for Hochstetter's frog within the project area (this report).

Lloyd's Ecological Consulting (lead – Dr Brain Lloyd) – responsible for estimating the proportion of the Coromandel's Archey's frog population in the area affected by potential blast vibrations (Lloyd 2025a) and analysing the results of surveys for Hochstetter's frogs undertaken in 2024 to assess the impacts of stream flow reductions associated with the proposed WUG Mine (Lloyd 2025b).

RMA Ecology (lead – Dr Graham Ussher) – responsible for delivering the overarching effects and risk assessment relating to potential effects of the proposed WUG Mine on native frogs (RMA Ecology 2025).

2.1 SUMMARY OF THE PROJECT

The Waihi North Project (WNP) comprises several components, including establishing a new open pit (Gladstone Open Pit), a new underground mine (Wharekirauponga Underground Mine), a 6.5 kilometre decline extending from the planned mine Surface Facilities Area at Willows Road to access

the Wharekirauponga Underground Mine, and a tunnel linking the underground to the existing Processing Plant area.

The new Wharekirauponga Underground Mine will be located approximately 11 km north-west of the current Processing Plant under land administered by the Department of Conservation (DOC) (Coromandel Forest Park) (Figure 2.1). Site infrastructure supporting the mine will be located on OGNZL owned farmland located at the end of Willows Road, with only minimal surface features within the forest, in the form of fenced vent raises.

Construction of the access decline and Wharekirauponga Underground Mine will require drilling and blasting to fragment rock into manageable sized fragments for excavation. These activities will result in seismic vibrations that will propagate through the rock mass to the ground surface where populations of Hochstetter's frogs (*Leiopelma hochstetteri*) and Archey's frogs (*Leiopelma archeyi*) are known to occur. The predicted total vibration footprint covers an area of approximately 315 ha. Additionally, hydrological modelling has predicted potential surface water impacts in the form of baseflow reductions in streams within the Wharekirauponga catchment due to dewatering associated with the Wharekirauponga Underground Mine (GHD 2025). Stream flow reductions and associated effects on stream habitat could potentially affect semi-aquatic Hochstetter's frogs that live on the edges of forested streams.

Hochstetter's and Archey's frogs are unique to New Zealand are protected native species and are in decline nationally (Burns *et al.* 2025). Therefore, it is important to determine the type and likelihood of potential effects as a result of the Wharekirauponga Underground Mine on these frogs to ensure adverse impacts are avoided or minimised as far as practicable. Fundamental to determining the extent of potential effects on frogs as a result of the mine, is a good understanding on the biology, ecology, and distribution of these frogs both at the project site and the wider landscape.

2.2 ASSESSMENT APPROACH

To determine the potential effects of blast vibrations and dewatering on native Archey's and Hochstetter's frogs the following approach was taken.

1) **Review of the biology, ecology, and behaviours of Leiopelmatid frogs occurring in the project area.**
    - Literature review of published and grey literature on Leiopelmatid biology and ecology was carried out.
2) **Understand the distribution and abundance of frogs in the Wharekirauponga project area and Coromandel.**
    - Review of historical frog records held in the Department of Conservation (DOC) Bioweb Herpetofauna Database.

- Review of the results of recent surveys and population modelling undertaken by OGNZL as part of the project over the past two years.

3) **Assessment of the effects of vibration on frogs.**
   - Literature review of vibration effects on animals and amphibians.
   - Review of vibration modelling work by Heilig & Partners (2020, 2021) and Lane (2021) for OGNZL.
   - Evidence based assessment of potential vibrations effects on frogs in the project area.
4) **Assessment of the effects of dewatering on frogs.**
   - Literature review of dewatering effects on streams, stream habitat, and amphibians.
   - Review of hydrological modelling reports prepared by GHD (2025) and WWLA (2025c) for OGNZL.
   - Review and analysis of the instream habitat data provided by NIWA (2024) for OGNZL.
   - Evidence based assessment of the dewatering effects on frogs in the project area.
5) **Summary of findings and recommendations for mitigation and monitoring.**

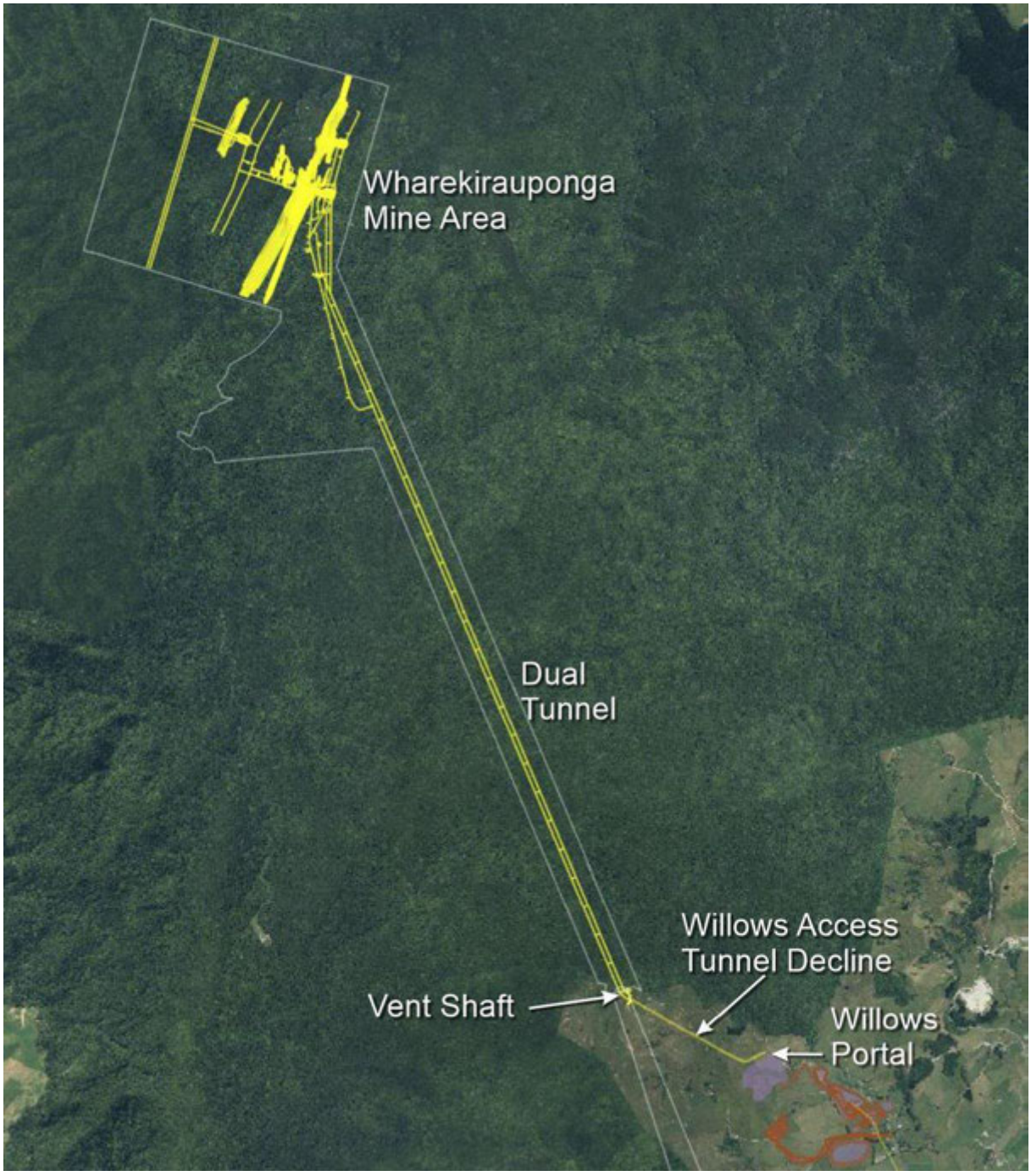


Figure 2.1. Site overview – Location of Willows Access Tunnel Decline and Wharekirauponga Underground Mine. Source: OceanaGold (NZ) Limited.

3 LEIOPELMATID FROG ECOLOGY

3.1 LEIOPELMATID FROGS

Aotearoa/ New Zealand has a small but distinctive endemic amphibian fauna, consisting of three extant species of frogs (Order Anura, Family Leiopelmatidae). All belong to a single genus *Leiopelma* Fitzinger, 1861 and the species include Archey's frog, *Leiopelma archeyi* Turbott, 1942; Hamilton's frog, *Leiopelma hamiltoni* McCulloch, 1919; and Hochstetter's frog, *Leiopelma hochstetteri* Fitzinger, 1861.

The Leiopelmatid frogs represent a unique evolutionary lineage among amphibians and are considered the most archaic frogs in the world (Roelants *et al.* 2007; Ford & Cannatella 1993, Roelants & Bossuyt 2005). They are unique in that they exhibit several plesiomorphic ('ancestral') character traits such as vestigial tail-wagging muscles, cartilaginous inscriptional ribs, the presence of amphicoelous vertebrae, and nine presacral vertebrae (most frogs have eight)[1]. In addition, *Leiopelma* frogs differ from other frogs in that they lack external eardrums (tympanum) and do not have vocal sacs, thus they cannot produce load vocalisations. Rather, it is thought that *Leiopelma* frogs communicate using chemosensory signals (Lee & Waldman 2002; Waldman & Bishop 2004).

All leiopelmatid frogs are carnivorous and eat small invertebrate prey items (Kane 1980; Bell 1995; Eggers 1998; Ziegler 1999; Shaw *et al.* 2012). They are long-lived (e.g. >30 years) and produce small clutches of eggs (not necessarily every year) (Bell 1985, 1994; Bell & Pledger 2010). All species are cryptic and mostly nocturnal, spending the daylight hours under logs or rocks, rarely venturing out during the day. All species also show high site fidelity and have small home ranges (Brown & Tocher 2003; Tocher *et al*. 2006), although broader scale movements have been recorded (Tessier *et al.* 1991; Slaven 1992; Tocher & Pledger 2005).

Leiopelmatid frogs, like most other anurans, have permeable skin that contributes to osmoregulation and electrolyte and fluid homeostasis. Because the skin presents little or no physiological barrier to evaporation per unit surface area, Leiopelmatid frogs need to inhabit saturated or high humidity environments, but behavioural features can also reduce potential evaporative water loss (Cree 1985). During dry periods, Leiopelmatid frogs typically remain on or move to moist substrates in or near humid crevices or refuges. In Archey's frog, the ventral skin absorbs water from the moist or wet substrates, but in Hochstetter's frog the rate of water uptake through the skin is much less, probably because they mostly live in areas where water is constantly available (e.g., streamside retreats) and dehydration is unlikely to occur (Cree 1985). However, some level of fluid absorption through the skin must be possible as Hochstetter's frogs because this species is known to inhabit terrestrial, albeit very humid, environments.

[1] The tailed frogs in the genus *Ascaphus* from North America, are the only other living frogs known to possess these primitive traits.

Leiopelma frog populations have experienced dramatic declines over the past millennium, leading to fragmented and relict distributions. These declines are ongoing, and several biological traits—such as restricted distribution ranges, high longevity, and low reproductive rates (Wells 2007)—contribute to their vulnerability to further population declines and extinction risk. All three species of *Leiopelma* frogs are classified as threatened, both nationally (New Zealand Threat Classification System, Townsend *et al*. 2008; Burns *et al.* 2025) and internationally (IUCN 2018).

Globally, Leiopelma frogs are recognised for their evolutionary distinctiveness and rarity, with all three species included in the top 100 Evolutionarily Distinct and Globally Endangered (EDGE) amphibians. Notably, *Leiopelma archeyi* ranks as the world's most EDGE amphibian species (Zoological Society of London 2008). Consequently, Leiopelmatid frogs hold significant national and global conservation value (Bell 2010).

Two of the three *Leiopelma* frogs (Archey's and Hochstetter's frog) occur in the Wharekirauponga Underground Mine (WUG) project area (Boffa Miskell 2025a; D. van Winkel, pers. obs. 2023). These species differ markedly in their ecology and behaviour and therefore, further detail is provided for each species below.

3.2 ARCHEY'S FROG

Archey's frog (*Leiopelma archeyi*) is a small (≤40 mm snout-urostyle length), terrestrial and nocturnal frog (Figure 3.1). It occurs in small, fragmented populations across the upper North Island and is found in three locations, including Coromandel Peninsula (Coromandel), Whareorino Forest (west of Te Kuiti, Waikato) (Bell *et al.* 1998), and in Pureora Forest (Waikato) where a translocated population is now established (Bishop *et al*. 2013; Cisternas 2018). It occupies dense, damp native forest and ridge tops where humidity is frequently high, from c. 200 to 1,000 m above sea level (a.s.l.). It is not specifically associated with stream, creeks, or other waterbodies. Archey's frog is sympatric[2], and at some locations syntopic[3], with the semi-aquatic Hochstetter's frog (van Winkel *et al.* 2018; Bishop *et al*. 2013).

Archey's frog, like all other *Leiopelma* species, is largely sedentary (Bell 1994; Bell *et al.* 2004; Bell & Pledger 2010, Reilly *et al*. 2015) and employs crypsis and immobility as a primary anti-predator strategy. Indeed, Reilly *et al*. (2015) reported Archey's frog spending 99.86% of their time stationary and none of the Archey's frog they studied exhibited escape behaviour (e.g., jumping or moving away) in response to disturbance stimuli (i.e., an approaching observer). However, at Wharekirauponga, Archey's frog evasion/ escape behaviours (jumping or moving beneath refuges) was recorded in a small proportion (~10–20%) of the frogs that were observed during searches (K. Muchna, pers. comm, March 2022). Archey's frog also employs a sit-and-wait predatory strategy for obtaining food (Bell 1985, Reilly *et al.* 2015).

[2] Occupying the same geographical range.
[3] Joint occurrence of two species in the same habitat at the same time.

Archey's frog is carnivorous and feeds on a variety of small invertebrates, primarily springtails (O. Collembola), mites (Subclass Acari), ants and parasitic wasps (O. Hymenoptera), and land hoppers (O. Amphipoda). The ratio of the largest invertebrate eaten to the frog's snout-urostyle length (SUL) ranged from 0.20 to 0.62 (Eggers 1998). Other invertebrate prey groups include spiders (O. Araneae), flies (O. Diptera), beetles (O. Coleoptera), isopods (O. Isopoda), pseudoscorpions (O. Pseudoscorpiones), hemipterans (O. Hemiptera), and snails (Class Gastropoda) (Eggers 1998; Kane 1980; Shaw *et al*. 2012). Shaw *et al.* (2012) suggested that small collembola were an important prey item for sub-adults, and this is probably true for the smaller juveniles too.

Archey's frog exhibits a specialised mode of reproduction in which there is no free-living tadpole stage, and development occurs entirely within the egg capsule (i.e., there is no free-feeding larval stage). Mating occurs via inguinal amplexus[4] and has been observed in the field during the day in the month of October (Bell 1978). Amplexus was reported among groups of 2–5 frogs in shallow depressions beneath logs where egg clusters were subsequently laid (Bell 1978). The length of time over which amplexus occurs is unknown but considering the nocturnal habits of Archey's frog and the daytime amplexus observations, it is likely that amplexus may extend for up to several hours. Egg laying occurs in spring (November–December) (Bell 1978, 1985). Eggs are unpigmented, about 5 mm in size, and each contain a large yolk. Eggs are laid in clusters (typically 4–15, up to 19 eggs) in dark, damp sites such as under logs and rocks. The male guards (broods) the eggs for a period of 6–9 weeks[5] by sitting high over the eggs with body raised and both fore- and hind-limbs outstretched. The function of egg brooding behaviour in Archey's frog is poorly studied but may represent a strategy to keep the eggs moist (possibly via urinary excretion) (Stephenson 1961). Indeed, male Archey's frogs with eggs or hatchlings store water reserves, presumably for maintaining the necessary hydric environment at the nest site (Bell 1985). Other possible reasons might be to reduce the incidence of fungal or bacterial infection through transfer of chemicals from the adult to eggs, and/ or to protect the eggs from predators. Whatever the function, the males have a strong behavioural predisposition to brood over this period of the lifecycle. Male frogs continue to brood eggs until they hatch and the tiny, tailed froglets then climb onto the back of the male who carries them for up to six weeks while they complete their development (dorsal brooding) (Bell 1978, 1985). Sexual maturity is reached at 3–4 years of age and generation time is approximately 8–10 years. The lifespan of Archey's frog may be more than 35 years.

Archey's frog is currently classified as 'At Risk – Declining' under the New Zealand Threat Classification System (Townsend *et al*. 2008; Rolfe *et al.* 2022; Burns *et al*. 2025), based on a 2024 national population estimate of >100,000 mature individuals and a predicted decline of 10-30% over three generations[6]. It is listed as 'Critically Endangered' (A2ab) on the IUCN Red List (2017, ver. 3.1) based on a dramatic (≥80%) population reduction over 10 years or three generations and a presently stable

[4] Male gripping the female tightly around the groin immediately anterior to the hind legs.
[5] Captive observation.
[6] https://nztcs.org.nz/assessments/169897

population trend (low confidence). Archey's frog is considered the world's most Evolutionarily Distinct and Globally Endangered amphibian species[7,8].

3.3 HOCHSTETTER'S FROG

Hochstetter's frog (*Leiopelma hochstetteri*) is a small (≤48 mm snout-urostyle length), semi-aquatic or amphibious[9], and nocturnal frog (Bell 1986) (Figure 3.1). It is the most widespread and abundant of all the *Leiopelma* frogs but remains restricted to the North Island. It survives in spatially fragmented populations across the northern half of the North Island (from Northland, south of Whangarei, to Waikato [Maungatautari, Pirongia, Whareorino, and the Coromandel Peninsula], and on East Cape), and on Aotea/ Great Barrier Island (Te Paparahi and Mt Hobson catchments) (Baber *et al*. 2006; Bishop *et al*. 2013). There is substantial genetic variation among the 13 fragmented and isolated sub-populations distributed across the northern half of the North Island. Each of these genetically distinct sub-populations is considered an evolutionary significant unit (ESU) worthy of separate conservation management (Green 1994, Gemmell *et al.* 2003, Fouquet *et al.* 2009; Nájera-Hillman *et al*. 2009b).

Hochstetter's frog is closely associated with streams and typically inhabits a narrow zone along small, forested streams and seeps within native forest fragments. This habitat is usually found in cool, temperate headwater streams (first and second order) in densely forested catchments at elevations between 160 and 800 meters above sea level (Nájera-Hillman *et al*. 2009). The ideal habitat consists of unsilted streams featuring small waterfalls, cascades, and pools (Stephenson & Stephenson 1957; Bell 1978). Frogs are more commonly found in areas with cooler water and air temperatures, as well as higher relative humidity (Nájera-Hillman 2009b).

While they generally avoid large, swiftly flowing waterways, sightings in such habitats have been reported (McLennan 1985; Slaven 1994). Hochstetter's frogs are well-adapted to life on the banks of dynamic streams with fluctuating water levels, tolerating a wide range of water flows—from high-velocity waterfalls to slow-moving seeps and springs. In addition to their adaptability in natural settings, these frogs can survive in highly modified environments, such as farmland or exotic pine plantations (Bell *et al.* 2004)) and have even been observed breeding in silted clay areas (Beauchamp *et al.* 2010; Herbert *et al*. 2014).

They take refuge during the day in damp crevices, under stones, in rock piles or under logs, and in thick leaf litter packs within or immediately adjacent to the water column. Generally, frogs prefer wet substrates under refuges but occasionally some frogs will be entirely or partially submerged in water (Herbert *et al.* 2014). Though, they are occasionally found long distances away from streams in damp

[7] As assessed by the Evolutionarily Distinct & Globally Endangered (EDGE) amphibian programme formed by the Zoological Society of London.
[8] EDGE species are scored according to the amount of unique evolutionary history it represents (Evolutionary Distinctiveness, or ED), and its conservation status (Global Endangerment, or GE). The scores are then combined to give each species an EDGE score. Those with high ED and GE get the highest EDGE scores and are considered priority species. The conservation status (GE) is based on the IUCN Red List classification.
[9] Amphibious = able to live both on land and in water.

native forest, where they refuge beneath logs, rocks, and dense leaf litter. Hochstetter's and Archey's frogs are occasionally found together under the same terrestrial refuges in damp native forest.

The diet of Hochstetter's frog is poorly known. Frogs emerge at night to forage on small invertebrates encountered along the stream edge and within riparian vegetation (Chapman & Alexander 2006). Hochstetter's frogs are reported feeding on adult terrestrial arthropods, including land hoppers (Order Amphipoda), slater (Order Isopoda), beetles (Order Coleoptera), flies/ sawflies (Order Diptera), mites (Subclass Acari), dragonflies—presumably dragonfly larvae (Order Odonata), and snails (Class Gastropoda) (Kane 1980; Shaw *et al.* 2012; Nájera-Hillman *et al*. 2009a). Other invertebrates such as spiders (Order Araneae), ants (Order Hymenoptera), millipedes (Class Diplopoda), earthworms (Class Clitellata) and slugs (Class Gastropoda) may contribute to the diet of Hochstetter's frog as these are found where frogs shelter (Sharell 1966). Additionally, Stephenson & Stephenson (1957) reported a small, entire fresh-water crayfish in the stomach of one frog, suggesting an aquatic component in the diet of this species.

Hochstetter's frogs require aquatic environments to reproduce. Their reproductive strategy involves laying eggs (up to 22 in number) in shallow depressions with trickling water on the edges of streams. The eggs hatch at a relatively early development stage into larvae with partially developed limbs and well-developed tail fins that enable them to swim, though they are poor swimmers. They do not feed and remain in the shallow water while they develop into small frogs (Bell 1985). So, rely on parental selection of stable pooled water sites.

Hochstetter's frog is currently classified as 'At Risk – Declining' under the New Zealand Threat Classification System (Townsend *et al*. 2008; Rolfe *et al.* 2022; Burns *et al*. 2025), based on a 2024 national population estimate of 20,000–100,000 mature individuals and a predicted decline 10–30% over three generations[10]. It has an IUCN Red List (2015, ver. 3.1) listing of 'Least Concern' (100,000 mature individuals) with an ongoing decreasing (at least 10%) population trajectory. It is ranked no. 38 on the Zoological Society of London's amphibian EDGE list of the most evolutionarily distinct and globally endangered amphibians of the world[11].

[10] https://nztcs.org.nz/assessments/169900

[11] As assessed by the Evolutionarily Distinct & Globally Endangered (EDGE) amphibian programme formed by the Zoological Society of London. EDGE species are scored according to the amount of unique evolutionary history it represents (Evolutionary Distinctiveness, or ED), and its conservation status (Global Endangerment, or GE). The scores are then combined to give each species an EDGE score. Those with high ED and GE get the highest EDGE scores and are considered priority species. The conservation status (GE) is based on the IUCN Red List classification.



Figure 3.1. Hochstetter's frog (*Leiopelma hochstetteri*) (left) and Archey's frog (*Leiopelma archeyi*) (right).

4 DISTRIBUTION AND POPULATION SIZE OF *LEIOPELMA* FROGS IN COROMANDEL AND WHAREKIRAUPONGA AREAS

Understanding the distribution and abundance of Archey's and Hochstetter's frog populations in areas potentially affected by the proposed Wharekirauponga Underground Mine is essential for conducting a thorough impact assessment. Additionally, it is crucial to place these potentially impacted populations in context by comparing them with others across the species' range (i.e., within the Wharekirauponga catchment and Coromandel Forest Park).

To assess this, historical records from the DOC Bioweb Herpetofauna Database (accessed 2022) were initially reviewed to determine the distribution of Leiopelmatid frogs in the project area and the wider Coromandel region. The results of recent frog surveys conducted by Boffa Miskell and OGNZL, along with detailed analyses by Lloyd (2025a, 2025b), were also evaluated. A summary of the findings is presented below.

4.1 ARCHEY'S FROG

In the Coromandel, there are three naturally occurring sub-populations of Archey's frog, inhabiting approximately 52,000 hectares of native forest above 200 m a.s.l. along the region's main axial mountain range (Figure 4.1). These sub-populations are generally referred to as the 'Moehau,' 'Middle,' and 'Southern' sub-populations (Lloyd 2025a). A notable gap exists between the 'Middle' and 'Southern' sub-populations, likely a result of historical land-use practices such as logging and agricultural clearance. Data indicate that Archey's frog densities are highest in undisturbed, old-growth mixed podocarp-hardwood forests at mid to high altitudes (>400 m a.s.l.) (DOC Bioweb Herpetofauna Database, accessed 2022; Lloyd 2025a).

To improve the understanding of Archey's frog distribution in the Wharekirauponga and wider Coromandel areas, surveys were undertaken by OGNZL over the period of 2018 to 2022 (OGNZL un pub. data). Records obtained from these surveys were pooled with historical records extracted from the DOC database (i.e., 324 valid records between 1970 and 2017), and habitat preference information (altitude, habitat quality/ vegetation type) was used to describe the distribution of Archey's frogs in the Coromandel (Lloyd 2025a).

Approximately 315 hectares of land, ranging from 90 to 330 m a.s.l., in the Wharekirauponga catchment is expected to be affected by vibrations originating from proposed mine blasting activities. Half of this area consists of regenerating forest—a consequence of historical disturbance—resulting in lower-quality habitat for Archey's frog compared to other parts of its range. The 315 ha vibration footprint represents approximately 2.23% of Archey's frog's southern Coromandel distribution, 0.66% of the combined southern and middle Coromandel ranges, 0.61% of the species' inferred 52,000 ha distribution in the Coromandel, and 0.60% of its current natural range in New Zealand (excluding the translocated population at Pureora) (Lloyd 2025a).

Given that the regenerating habitat within the vibration footprint likely supports lower-density populations of Archey's frog compared to other areas, it is estimated that no more than 0.61% of the entire Coromandel population, and significantly less than 0.61% of the national population, resides in this footprint.

Lloyd (2025a) went further to estimate Archey's frog density and population size in the Wharekirauponga Underground Mine footprint using nocturnal plot surveys data from Boffa Miskell surveys in Wharekirauponga (Boffa Miskell 2016, 2018, 2019, 2021) and the results of a capture-recapture study investigating the effect of past vegetation disturbance on abundance of Archey's frogs (Hotham 2019). Using this information, Lloyd (2025a) estimated the number of adult Archey's frogs living in the predicted vibration footprint of the proposed mine ranged between 48,888 and 152,774 (61,406–278,785 for all age frogs) (Lloyd 2025a). This study also suggested that the frog habitat inside the Wharekirauponga study area was relatively low quality for Archey's frogs compared to many other areas in Coromandel and that the frog population within the predicted vibration footprint contributed <1% of the total Coromandel population (Lloyd 2025a).

4.2 HOCHSTETTER'S FROG

Hochstetter's frog is widely distributed and abundant across the Coromandel Peninsula (Figure 4.1). However, prior to 2019, there was limited information on the presence and abundance of Hochstetter's frogs in the Wharekirauponga catchment. Baseline surveys by Boffa Miskell in 2019 and 2020, and a survey in 2024 have added to the information. These surveys and results are briefly described below.

4.2.1 Boffa Miskell investigations 2019-2020

Boffa Miskell undertook baseline monitoring assessments (broad-scale biodiversity inventory) over approximately 200 ha of the Wharekirauponga catchment in the Coromandel Forest Park in 2019 and 2020. Surveys were undertaken across pre-selected sites and assessed terrestrial fauna, vegetation communities, and freshwater environments (Boffa Miskell 2019, 2020). As part of these assessments, Hochstetter's frogs were manually surveyed for along stream margins during the day (between 1200 and 1700 hrs). Rocks, crevices, and other debris were lifted and inspected for frogs. In addition, their freshwater team also undertook Hochstetter's frog surveys during their stream assessment work. Once a frog was found it was photographed in situ and its location marked with a GPS.

In 2019, seven Hochstetter's frogs were found across five streams or tributaries including some larger streams in the catchment: Teawaotemutu, Wharekirauponga and Adams Stream, and some smaller streams such as tributaries to Thompson Stream (Boffa Miskell 2019). In 2020, nine Hochstetter's frogs were found across several smaller tributaries to the larger streams in the catchment and sites surveyed included some that were surveyed in 2019, and other previously un-surveyed tributaries along the Golden Cross Track (Boffa Miskell 2020).

Both surveys identified Hochstetter's frogs of a variety of ages, reflecting a stable population with adequate recruitment in the streams surveyed. Hochstetter's frogs were common in smaller rocky tributaries, including in high-activity areas associated with exploration drilling, and the frogs were also found in some streams and tributaries within the Wharekirauponga catchment. The surveys did not however, detect Hochstetter's frogs in the larger fast flowing streams (Boffa Miskell 2020).

4.2.2 Hochstetter's frog distribution and abundance inside versus outside the potentially affected Wharekirauponga catchment.

Prior to 2023, Hochstetter's frogs were known from scattered records in the Wharekirauponga catchment and historical observations in the surrounding landscape, particularly near the Golden Cross Mine site, approximately 3.5 km southwest of the proposed Wharekirauponga Underground Mine.

In January 2024, a dedicated survey was conducted to enhance the understanding of Hochstetter's frog populations both within and outside of the catchments potentially impacted by the proposed Wharekirauponga Underground Mine. The study aimed to identify any differences in frog distribution and abundance between these areas. To ensure the reliability of the results, a biostatistician was involved in designing the study and analysing the data. A summary of the study design and results are provided below.

4.2.2.1 Hochstetter's frog survey methods

To investigate frog distribution two broad treatment areas were chosen. These included:

1) Affected area – extending along 12.1 km of stream length in the lower reaches of Edmonds Stream sub-catchment (Figure 4.2), and
2) Unaffected ('control') area – extending along 42.1 km of stream length spread among three stream sub-catchments (Edmonds, Marototo, and Waiharakeke) (Figure 4.2).

In each treatment area, 40 randomly selected 20 m lengths of stream were chosen to be searched for Hochstetter's frogs (Figure 4.2). Sites were randomly selected to avoid bias in the survey results, and a range of explanatory variables, such as elevation, vegetation type, and substrate, were included in the analysis to help explain any variations observed between the two areas. The process for selecting the transects is described below.

4.2.2.1.1 Frog survey transect selection

A desktop GIS exercise was conducted to map existing stream alignments and randomly select 80 frog survey transects. This included 40 transects inside the area potentially affected by the Wharekirauponga Underground Mine (e.g., areas subject to potential dewatering effects) and 40 outside the affected area (i.e., areas not exposed to potential dewatering effects). This involved:

1) Importing the drainage layers extracted from the Land Information New Zealand ("LINZ") Data Service into QGIS (ver. 3.34.3.) GIS software.

2) Overlaying the drainage layers provided by Flo Solutions, which refined the LINZ stream alignments.
3) Overlaying 1 m LiDAR contours and converted to a hill shade plot to visualise topography at high resolution. Then added predicted stream alignments based on the hill shading topography.
4) Overlaying the sub-catchment boundaries supplied by OGNZL (Waiharakeke, Thompson, Edmonds, T-Stream East, T-Steam West, Wentworth, Wharekirauponga Main, and Wharekirauponga2).
5) Determining the extent of the potentially affected area, by overlaying the groundwater drawdown and depth to water contours supplied by OGNZL and demarcating the outside boundary where depth to groundwater was <10 m and groundwater drawdown effects may potentially be expected.
6) Dividing the entire lengths of the stream alignments within the potentially affected area into 20 m lengths, each of which were assigned a unique number.
7) Using a random selection function in QGIS to identify transects where frog surveys were to be carried out. Transect selection included:
    a. 40 randomly selected transects (i.e., 20 m long stream length transect) inside the affected areas of Edmonds sub-catchment (i.e., transects where surface ground water was <10 m below the surface and groundwater drawdown is predicted), and
    b. 40 randomly selected transects outside the affected areas, including 10 transects within the Edmonds sub-catchment and 30 transects in the Golden Cross catchment.

4.2.2.1.2 Frog search methodology

1) Two searchers were assigned to each transect.
2) A tape was used to demarcate the 20 m transect.
3) One searcher began searching the transect, moving upstream from 0 m to 10 m, while the other searched from 11 m to 20 m.
4) Searchers move slowly upstream looking for frogs beneath rocks, debris, in rock crevices, in leaf litter packs, and debris dams. Headlamps were used to increase visibility and frog detection.
5) When a frog was encountered
    a. Time of observation was noted;
    b. The frog's position along the tape (measured to the nearest 10 mm) was recorded;
    c. The size of the frog was recorded by hovering a ruler over the frog and measuring snout-urostyle length (i.e., tip of snout to base of hind limbs/ tip of ischium), to the nearest 5 mm. Frogs were not touched or disturbed. Measurements were used to assign age classes: juvenile, sub-adult, and adult frogs (Table 4.1);
    d. Where SULs could not be accurately measured (e.g., where frogs were in deep crevices or jumped away prior to measurement), estimated SULs were recorded (these measurements to be excluded from SUL analyses, but included in age class category/ occupancy estimates); and

e. Microhabitat type was recorded (e.g., under rock, under/within log, under/within vegetation/twigs/roots, within crevice, open habitat).

6) Search time along each 10 m section of the transect was recorded by each person, to give a total search time for the entire 20 m transect length.
7) The intention was for each 20 m transect to be searched three times (i.e., (40+40)*3 = 240 transect searches).

Table 4.1. Hochstetter's frog age class classifications

Age class	Age (years)	Snout-urostyle length (SUL)
Juvenile	0–1	>18 mm
Sub-adult	1–2	18–24 mm
Adult	2+	25–39 mm
Mature adult female		<39 mm

4.2.2.2 Stream characterisation & covariates

Habitat variables (both broad- and micro-scale) were collected to determine the influence (if any) of 'site' effect' (i.e., is frog presence related to specific habitat types, or stream characteristics).

Several environmental variables were recorded during the transect searches and the characteristics of the stream along the 20 m length were documented by recording:

- General weather conditions (e.g., cloud cover, rainfall, wind, etc.).
- Air temperature at the start of the survey
- Relative humidity at the start of the survey
- Water temperature at the start of the survey
- Stream (wetted) width every 2 m along the length of each transect.
- Water depth every 2 m along the length of each transect. For wide streams, a series of depth measurements along width of the stream were taken (e.g., measurement every 200 mm).
- Substrate type every 2 m along the length of each transect.
- Canopy cover – average cover (percentage) along each 10 m transect length.
- Searcher name for each 10 m transect length.
- Start time and end time for each 10 m transect.
- Search date
- Number of refuges searched (using handheld counters).
- Transect elevation.
- Water velocity.
- Representative photographs of the 10 m lengths.

4.3 RESULTS OF FROG DISTRIBUTION AND ABUNDANCE SURVEYS

The results are described in detail in Lloyd (2025b) but are briefly summarised below.

Six of the selected transects could not be surveyed due to access and safety concerns and were replaced by transects at nearby locations. In the Edmonds Affected Area 37 of 40 transects were surveyed three times, and three transects were surveyed four times. Only 12 of 40 transects outside the affected area were surveyed, most (n = 10) transects occurring along the Marototo Stream. Three of the 12 transects were surveyed twice, eight were surveyed three times and one was surveyed four times.

There were differences in elevation, vegetation type, and stream widths between the two treatment areas, making it difficult to directly compared the two treatment areas.

4.3.1.1 Frog distribution, relative abundance, and demographics

- Hochstetter's frogs were found along 16 of 40 transects (40%) in the affected area and eight of 12 transects (67%) outside the affected area.
- Frog encounter rates were significantly ($p<0.001$) lower along transects in the affected area (0.228 frogs/ survey; CI95%: 0.151–0.329) compared to outside the affected area (1.088 frogs/ survey; CI95%: 0.766–1.5).
- The distributions among size classes of frogs found in the two areas were significantly ($p<0.05$) different, with a lower proportion of juvenile frogs (11% vs. 30%) and a higher proportion of mature females (21% vs. 0%) found in the affected area.
- Abundance estimates outside of the affected area (2.9 and 3.1 frogs/ transect) were considerable higher than estimates from in the affected area (0.91 and 1.05 frogs/ transect).
- Detection probabilities were also higher outside the affected area (0.36 compared to 0.25 and 0.26). Difference in estimates from the two areas stem from the much higher numbers of frogs (n = 11) found during surveys of two high elevation (≥400 m) transects. By comparison, all transects in the affected area were <340 m a.s.l.
- Extrapolating abundance estimates for the forty 20 m-long transects in Edmonds Affected Area to the 12.1 km of streams in the area's sampling frame, provides estimates of the total Hochstetter's frog population in the area of 549 (CI95%: 238 – 1,270) and 637 (CI95%: 271 – 1,597) from classical and Bayesian analyses respectively. Estimates of the total Hochstetter's frog population in the sampling frame outside of the affected area by extrapolating from transect abundance estimates were not attempted because of the small, unrepresentative sample of transects.

4.3.1.2 Stream and habitat characteristics

- Streams outside the affected area were generally wider (i.e., greater wetted width; mean = 2.13 m, *n* = 12), compared to streams in the affected area (mean = 1.85 m, *n* = 40). However,

on transects where frogs were found, stream wetted width was significantly ($p<0.05$) greater in the affected area (mean = 2.6 m) compared to outside the affected area (mean = 1.3 m).

Hochstetter's frogs are usually found and are more abundant in narrower headwater streams (Herbert *et al*. 2014) and this was true for transects outside the affected area but not in the affected area. In affected area mean stream wetted width at capture sites was 2.6 m compared to 1.9 m along the 40 transects. Outside the affected area mean width at capture-sites was 1.3 m compared to 2.1 m along all 12 transects.

- A higher proportion of frogs were found in leaf packs (29% *vs.* 11%) and under wood or logs (7% *vs.* 0%) and a lower proportion under rocks (57% *vs.* 78%) in the affected area compared to outside the affected area.
- Inside the affected area, frogs were found more associated with cobble substrate compared to the proportion of cobble substrate available along transects.
- Outside the affected areas, frogs were found more associated with vegetation and less with bedrock compared to what was available (i.e., proportions of habitat along the transects).
- Inside the affected area, the best model showed that frog counts increased with stream wetted width, mean survey duration, and mean number of refuges, but declined as a result of interaction between mean duration and mean number of refuges.
- Outside the affected area, frog counts increased with the increasing total number of refuges searched and total search duration. Frog counts were highest in the mid-elevation class (≥400–<500 m a.s.l.), lowest in the low elevation class (<400 m a.s.l), and intermediate in the highest elevation class (≥500–<700 m a.s.l.).

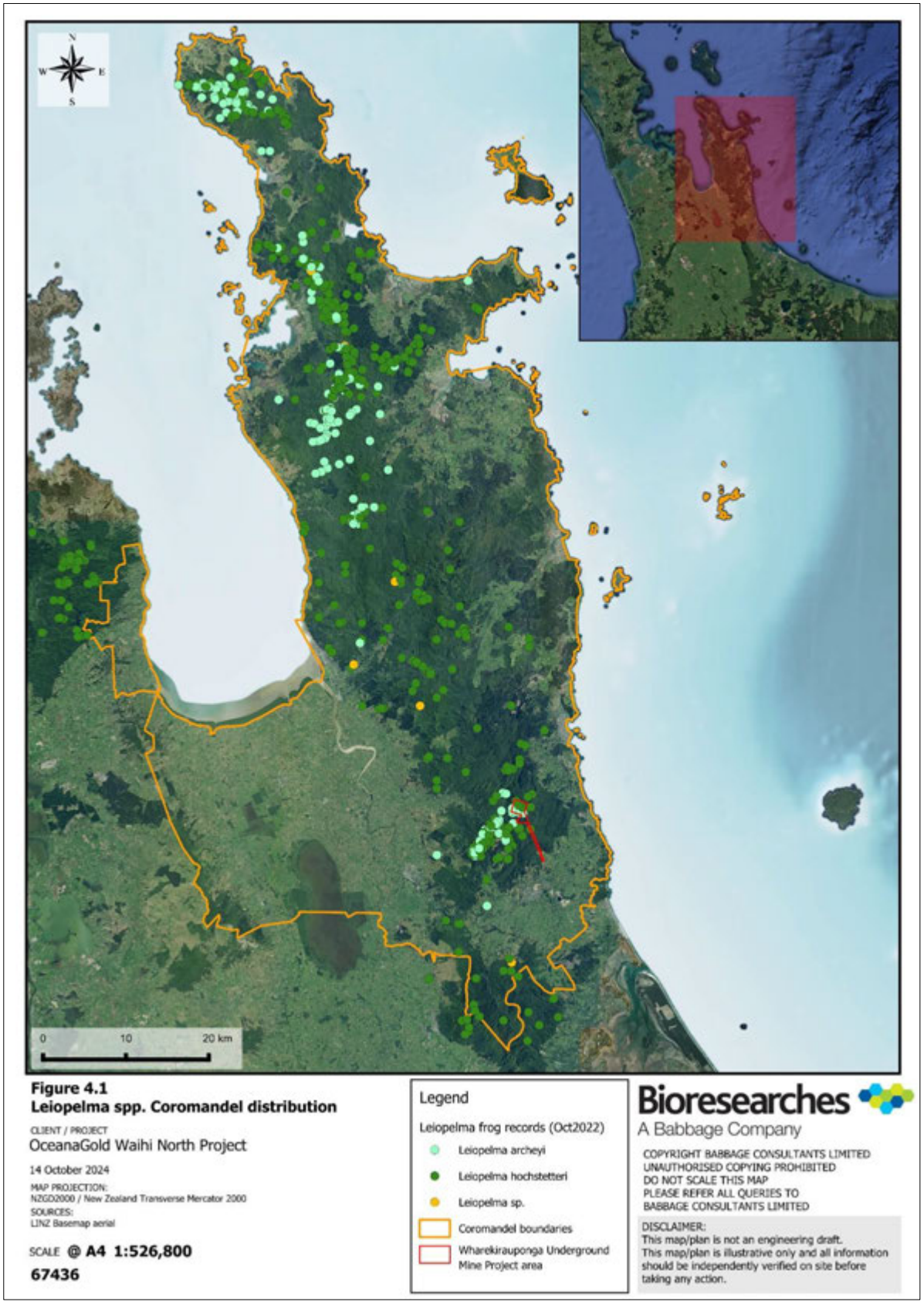


Figure 4.1. Distribution maps of Archey's and Hochstetter's frogs in the Coromandel. Records sourced from DOC Bioweb Herpetofauna Database (accessed 2023).

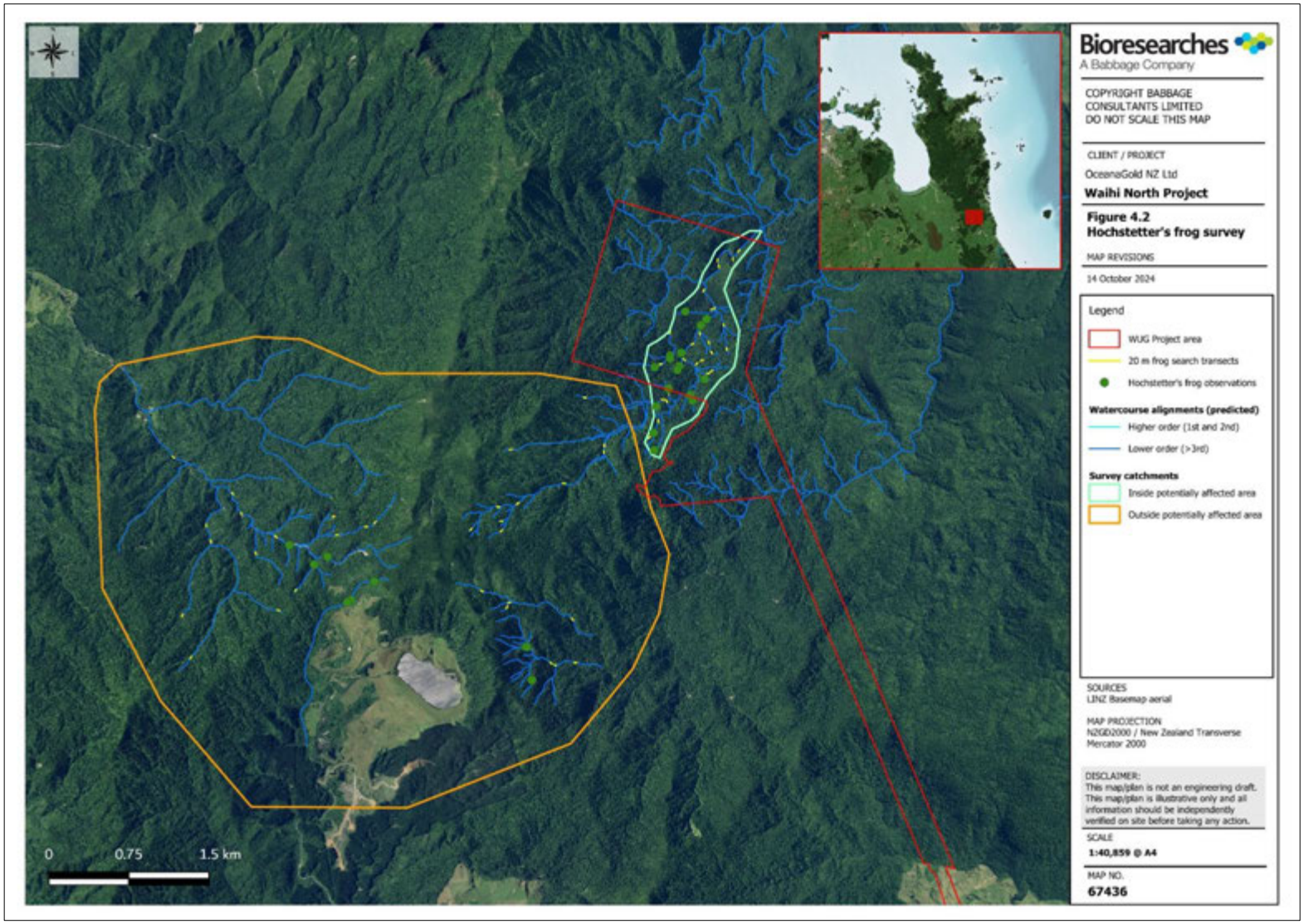


Figure 4.2. Hochstetter's frog transect survey locations, inside and outside the potentially affected stream catchments.

5 VIBRATION EFFECTS ON NATIVE FROGS

Vibration pulses associated with blasting are anticipated as part of the Wharekirauponga Underground Mine activities. Blasting to fragment rock into manageable size fragments generates a great quantity of energy, which in turn creates a vibration pulse that propagates through the rock mass to the ground surface. As the vibrational pulse travels outward from the source, it diminishes or attenuates. With increasing distance, the affected area greatly increases, but the energy becomes widely dispersed.

OceanaGold (NZ) Limited's approach to blasting is to conservatively design blasts to lower levels of vibration, to ensure permitted and consented vibration limits are not exceeded (Heilig & Partners 2022). Nevertheless, blasting may generate perceptible levels of vibration at the surface, including over areas occupied by native frogs. The following assessment determines the likelihood of vibration impacts on these frog populations.

5.1 VIBRATION FOOTPRINT OF THE WHAREKIRAUPONGA UNDERGROUND MINE

The current mine design would see intermittent surface vibrations ≥2 mm/s from underground blasting extending over an area of approximately 315 ha of Coromandel Forest Park (comprising 302.6 ha in the Wharekirauponga catchment and 12.3 ha in the nearby Waiharakeke catchment (Figures 5.1–5.3) (Lloyd 20225a)). Forest areas above the proposed Wharekirauponga Underground Mine and access shaft will be affected by vibrations according to the distribution and frequency shown in Figure 5.1 over an approximately 14 year period. The maximum area affected by vibrations of ≥2 mm/s is expected to reach 282 hectares in Year 10 of the operation. Higher vibration levels will affect smaller areas for shorter durations, with only 3.3% of the total area experiencing vibration levels ≥15 mm/s (Figures 5.2 & 5.3)[12]. Most blast vibrations will be below the maximum values indicated by the contour, and vibration events will be transient—the peak particle velocity lasting only seconds and the total vibration lasting less than 10 seconds—and will occur intermittently, with 7 to 15 blasts expected per week (Lane 2021; Lloyd 2025b).

Blasting associated with the development of the Access Decline (i.e. the tunnel required to access the orebody originating in Willows Road Farm, Years 1–4) will not produce vibration levels >2 mm/s north of Willows Road Farm (i.e. under Coromandel Forest Park) (Heilig & Partners 2022).

[12] For comparison, vehicle traffic along a residential road can generate 1-2 mm/s at 3–6 metres away (Henwood & Haramy 2001), a logging truck between 5–10 mm/s, and a train more than 20mm/s near the tracks and several mm/s at 10 or so metres away (Heilig & Partners, unpub. data).

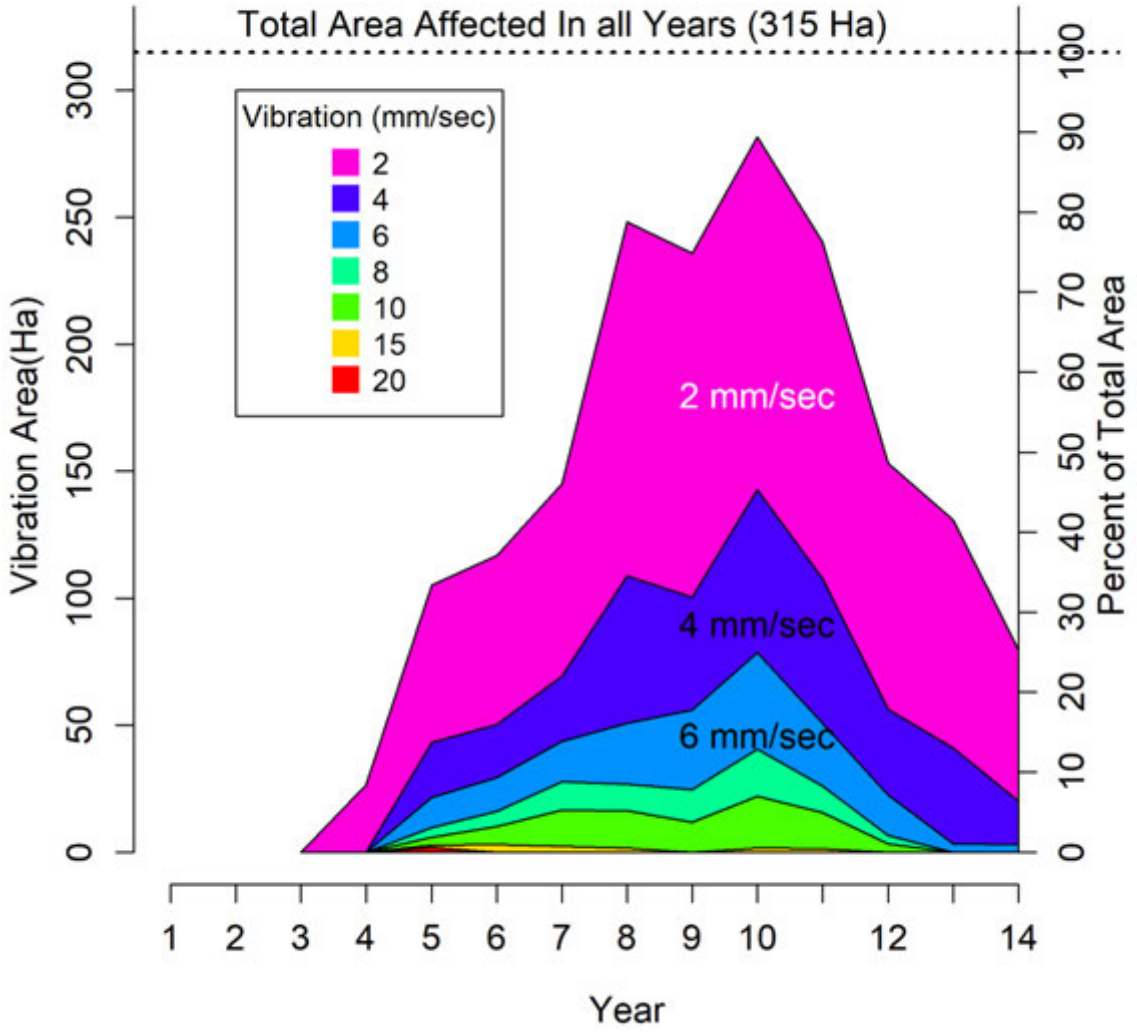


Figure 5.1. Predicted changes in the extent of areas affected by different vibration intensity levels, Years 0 to 14, for the current mine design (figure sourced from Lloyd 2025a). The period over which mining-related surface vibrations >2mm/ s occur is from Year 4 to Year 14 (10 years).

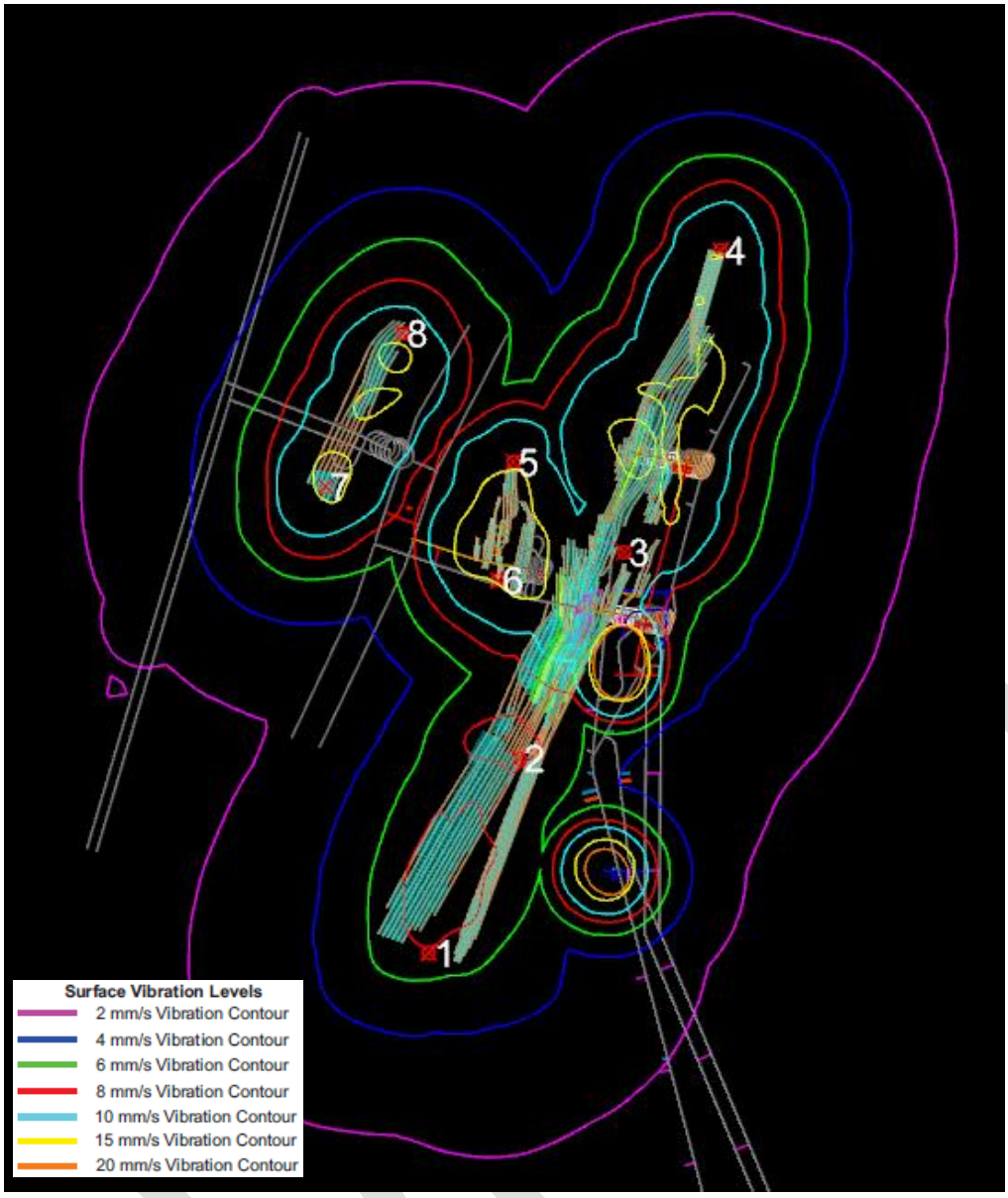


Figure 5.2. The extent of the predicted vibration footprint of the proposed Wharekirauponga Underground Mine for the current mine design. Contours of the vibration levels delineate the maximum extents of seven vibration intensity levels. Figure sourced from Heilig & Partners.

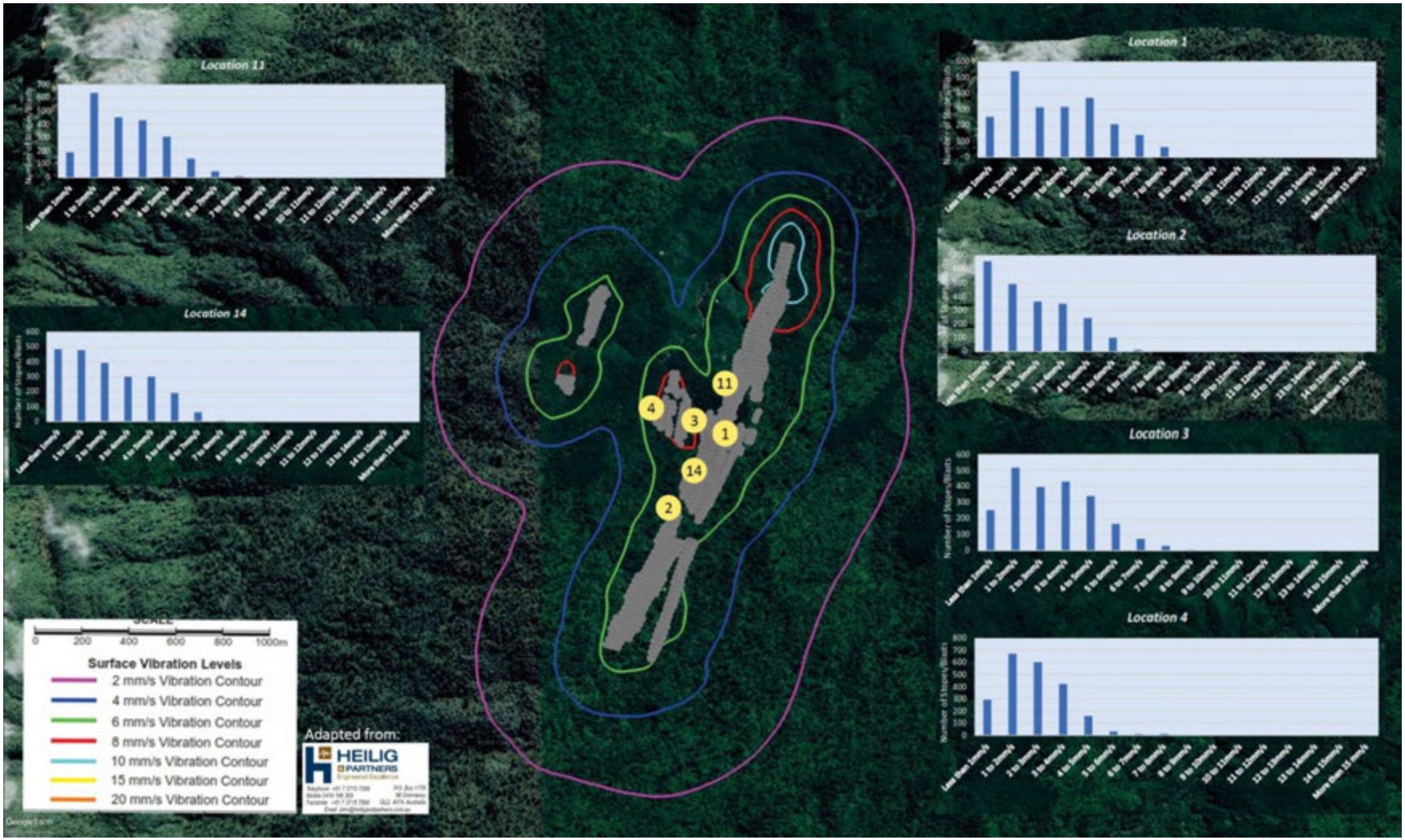


Figure 5.3. Modelled vibration levels and associated vibration contours from blasting at the proposed Wharekirauponga Underground Mine for the current mine design. Contours of the vibration levels delineate the maximum extents of seven vibration intensity levels. Blast histograms for the six sites with the highest vibration experience also shown. Figure adapted from Plates developed by Heilig & Partners (see Lane 2021).

5.2 SEISMIC (VIBRATION) DETECTION BY ANIMALS

Many animals are sensitive to substrate-borne vibrations and vibration detection is an important sense that is used for intra- and interspecific interactions in diverse animal taxa (Takanashi *et al.* 2016). While a growing body of evidence suggests that anthropogenic substrate vibrations (as opposed to anthropogenic noise) could be sources of mechanical disturbance to animals, the field remains under-researched, and the effects on many animal groups are still poorly understood.

Vibration is a form of energy that travels in waves that can be physically felt. These waves are oscillatory in nature and have both an amplitude and frequency. The amplitude contributes to the intensity of the vibration and is represented by how far the peak of the wave moves past the position of equilibrium. Frequency is the amount of time that it takes to complete one cycle from a point on one wave to the same point on the next wave (measured in Hertz). The magnitude of vibration can be measured in relation to the amplitude by displacement from the point of equilibrium (often measured in millimetres), the velocity of wave movement (quantified in mm/s) or acceleration past the neutral point measured in meters per second squared (mm/s^2) (Reynolds *et al.* 2018).

Different species perceive vibration to a lesser or greater degree depending on the frequency (Hz) of the vibration. For example, Norton *et al*. (2011) demonstrated that small rodents (rats and mice) are more likely to be affected by vibration in frequency ranges generated by a vibration source as compared with humans. This also highlights that the degree of perception is dependent on the size of an animal. In addition to the frequency of vibration, other factors that will determine the effects on animals include magnitude, duration, whether the vibration is directed at the whole body or is localized, and potentially individual variation in perception across species or within the same species.

Amphibians are highly sensitive to air-borne sound and among terrestrial vertebrates, are the most sensitive to vibrations (Caorsi *et al.* 2019). Typically, the tympanic middle ear and inner ear structures of anurans function to detect airborne sound by transferring sound energy to fluid vibrations sensed by hair cells in the inner ear (Pereyra *et al.* 2016). These structures, and specifically those associated with the inner ear (i.e., three organs: the amphibian papilla, the basilar papilla and the sacculus; Caorsi *et al*. 2019), are also responsible for sensing seismic (vibration) signals (Narins & Lewis 1985; Christensen-Dalsgaard & Narins 1993; Christensen-Dalsgaard & Jørgensen 1996). The pathway for substrate vibration sensing occurs via the operculum, a cartilaginous disc that is in physical contact within in the oval window of the inner ear in amphibians (i.e., their movement is coupled), which transfers substrate vibrations to the inner ear organs. In amphibians, the saccule remains sensitive to low-frequency seismic vibration due to the relative movement between the sensory epithelia and otoconia caused by traveling waves in the substrate (Han & Carr 2024 and references within).

Because the inner ear structures are responsible for sensing vibration signals, it is not essential that the structures of the middle ear are present. Indeed, studies on ‘earless’ amphibian species (species lacking a middle ear) demonstrate sufficient ability to sense vibration and some groups (e.g., bufonids) show vibrational sensitivities equivalent to ‘eared’ species (Womack *et al.* 2017 and references within).

It has been postulated that the loss of the middle ear could allow freer movement of the operculum, increasing sensitivity to substrate vibrations in 'earless' species (Gridi-Papp & Narins 2010).

Furthermore, species-specific extratympanic pathways, including lung pathway, opercularis pathway, and/ or bone pathways (e.g., skull conduction enhanced by resonation of the oral cavity, lowering head to contact floor, or transmitted to the inner ear fluid directly by the skeletal system along the entire spine) may also be utilised to sense vibration in 'earless' species (Gridi-Papp & Narins 2010; Pereyra *et al.* 2016). Such substrate vibrations that travel through the ground or plants have been suggested as important communication mechanisms for some 'earless' species (Womack *et al.* 2017).

It is important to note that the above observations are general in nature, and there appear to be no studies that explore if and how leiopelmatid frogs (including Archey's and Hochstetter's frogs) perceive vibrations, including those that are not associated with noise.

5.3 EFFECTS OF VIBRATION ON ANIMAL BEHAVIOUR

There is a growing body of evidence on behavioural and physiological responses to vibration stimuli in animals (e.g., rodents – Reynolds *et al*. 2018; poultry – Scott 1994; bats – Snyder *et al.* 2015; frogs – Felt *et al.* 2012; Márquez *et al*. 2016; and Caorsi *et al.* 2017, 2019; and lizards – Han & Carr 2024). Studies on rodents have demonstrated that vibration can cause alterations in reproduction as well as mortality and morbidity in other laboratory species, including frogs (Garner *et al.* 2018). Nevertheless, while anthropogenic substrate vibrations could be sources of mechanical disturbance for animals, including frogs, that disrupt behaviour this field is still in its infancy is poorly understood (Caorsi *et al.* 2019).

With respect to amphibians, while there have been studies examining the impacts of noise (e.g., traffic noise) on behaviour, very few studies have investigated vibration effects. Amphibian response to vibrations is most readily demonstrated in calling or vocalising species, by reduced male calling rates in response to anthropogenic seismic activity (Gridi-Papp & Narins 2010; Mazerolle *et al.* 2015; Caorsi *et al.* 2019). For example, the call frequency reduces or ceases in response to an observer walking at a few meters distance, but not in response to observer-emitted vocalisations (Gridi-Papp & Narins 2010). Caorsi *et al.* (2017, 2019) investigated the effects of seismic sources associated with traffic and wind turbines on frogs and demonstrated a significant reduction in call rate by males and a clear negative effect of anthropogenic vibrations on anuran communication. However, such effects are not relevant for amphibians that do not call or vocalise (e.g., leiopelmatids). Other studies looking at anuran responses to vibration, include stimulated emergence behaviour (Márquez *et al.* 2016), flight/ movement response (Mazerolle *et al.* 2015), and spontaneous or early hatching of eggs (Warkentin 1995). Another study reported rainfall-induced vibrations in soil are the cues that trigger the emergence of arid-zone toads from underground (Márquez *et al.* 2016).

It is not only physical behaviour that is affected by vibration, as vibration can elicit stress-mediated effects such as increases in heart rate (Reynolds *et al.* 2018) and physiological changes (Felt *et al.* 2012). Over time, episodic or sustained vibration could potentially lead to adverse impacts on individuals.

One study demonstrated morbidity and mortality in obligate aquatic African clawed toads in the laboratory in response to nearby high intensity, persistent construction vibration[13], which caused observable vibrations in the water column (Felt *et al.* 2012).

Understanding how vibration influences behaviour is complicated by the interplay between characteristics of vibration, including amplitude, duration and return period (the length of time a vibration is sensed until returning to normal state), and 'frequency' of vibration events[14] (how often vibrations occur). All characteristics need to be considered to completely understand the effects on animals.

Amplitude is the characteristic that describes the severity or intensity of a vibration. Animals may respond in different ways to vibrations depending on the amplitude. In instances where the amplitude is low, animals may not respond at all but where amplitude is high (very intense) and acute or sudden, animals may react with a startle response. A startle response is a largely unconscious defensive response to sudden or threatening stimuli and typically involves abrupt cessation of ongoing movements, such as freezing or thanatosis (long-lasting freezing) or a fast jerky movement with short latency (e.g., jumping, moving away rapidly). In most instances, a startle response is short-lived, and the animal successfully recovers and continues with more controlled and decisive actions. However, where individuals are engaged in important biological behaviours (e.g., feeding, mate attraction, mating, egg brooding), startle responses, especially movement away from the engaged behaviour, may be temporarily disruptive. It could also cause stress response (energy demands) and potentially lead to long-term individual fitness effects if mating or recruitment is affected (e.g., mate desertion, abandonment of eggs, premature hatching). There is paucity of research on startle effects resulting from vibration stimuli yet Götz and Janik (2011) reported that repeated startling by anthropogenic noise sources might have severe effects on long-term behaviour and potentially and reduced individual fitness or reduced longevity of individuals. Since noise and vibration are sensed by the same organs in the body, it is plausible that similar effects could result from repeated startling in response to vibration stimulus.

Alongside amplitude effects, the duration of vibration (length of time a vibration is sensed until returning to normal state) and how often vibration occurs are likely to influence animal behaviour. Intermittent vibration is thought to produce more adverse effects than continuous vibration due to its unpredictability (Carman *et al.* 2007). On the other hand, animals have been shown to adapt to avoid fitness-relevant physiological costs in response to sustained stimuli (e.g., noise-legacy populations of wood frogs have adapted to physiologically costly anthropogenic [traffic] noise; Tennessen *et al.* 2018). Similarly, Garner *et al.* (2018) suggested that rodent responses (e.g., startle and freeze reflexes) seemed to decrease when repeatedly exposed to vibration, though their results were largely inconclusive.

[13] Jack hammer that was being used in an adjacent room approximately 10 ft (~3 m) away.

[14] Not to be confused with "frequency" i.e., the amount of time that it takes to complete one cycle from a point on one wave to the same point on the next wave. The term "Hertz" is used as a unit of measure for frequency and is the number of cycles per second.

Vibration impacts on animals appear to be influenced by a combination of amplitude, duration, and frequency of vibration events, as well as body size characteristics, species ecology, and individual variation in perception across species or within the same species. Consequently, it is exceedingly difficult to determine if and how a species will respond to vibration stimuli and even more difficult to determine what the short- and longer-term affects might be without designed laboratory experiments or intensive monitoring of wild populations pre- and post-stimulus.

5.4 VIBRATION SENSING IN *LEIOPELMA* FROGS

Leiopelmatid frogs possess primitive traits that set them apart from all other frog species. These include the absence of several anatomical features commonly found in other frogs, along with some additional unique characteristics, such as cartilaginous inscriptional ribs and extra presacral vertebrae. Notably, leiopelmatid frogs lack middle ear structures, such as tympanic membranes (a round patch, corresponding to an eardrum, found behind and below the eye in many frogs) and columella. The operculum and inner ear structures remain present (Stephenson 1951; Pereyra *et al.* 2016). Leiopelmatid frogs also lack eustachian tubes and vocal sacs (Stephenson 1961; Bell 2010). As a result, *Leiopelma* are incapable of hearing sound in the traditional sense and vocalisations are very limited compared to most frogs, which typically produce and respond to loud calls during the mating season. The absence of anatomical structures for communication suggests that chemosensory signals might be important in leiopelmatid frog communication; possibly like communication in salamanders where chemosignals are used to recognise the size and individuality of their conspecifics. Furthermore, seismic (vibration) signals may play an important role in communication or behavioural response, as this is seen in other 'earless' anurans (e.g., bufonids; Womack *et al.* 2017).

A small body of research has demonstrated that chemosensory cues play an important role in conspecific communication among *Leiopelma* frogs (Lee & Waldman 2002; Waldman & Bishop 2004). However, communication via other means, such as vibratory modalities, has not been investigated—there is no published literature on vibration sensing in *Leiopelma* (Waldman & Bishop 2004). Additionally, we have been unable to find any research on vibration perception in their closest relatives, the two species of *Ascaphus* frogs from North America. This gap in knowledge makes it difficult to determine the extent to which *Leiopelma* can detect vibrations and whether anthropogenic vibrations might affect them. We also cannot rule out the possibility that seismic (vibratory) signals could play a significant role in their communication or behavioural responses, as has been observed in other 'earless' anurans (Womack *et al.* 2017).

The ecology of leiopelmatids may provide some insights into the importance of vibration sensitivity. These frogs remain stationary for long periods of time, and all employ a sit-and-wait strategy to secure prey. These characteristics allow the frogs to establish strong and constant coupling of the body with the substrate. The low levels of self-generated noise obtained with the lack of body motion and/or optimised coupling might be requirements for the frog to take advantage of a highly sensitive seismic detection system. It is not implausible to suppose that vibration could be used as a means of detecting approaching prey and/ or predators, or potentially associated with con-specific recognition, or even detecting environmental cues (e.g., rainfall) that elicit behavioural responses (e.g., emergence).

Approaching predators (e.g., birds) or other frogs could cause low-frequency vibrations, which may elicit the startle and freezing responses in frogs that assist with concealing themselves from predators/ conspecifics. Detection of approaching conspecifics by their vibrations could allow frogs to prepare for subsequent behaviours, e.g., escaping or mating. These kinds of responses have been reported in studies of other anurans (Lewis & Narins 1985; Narins 1990).

For Archey's and Hochstetter's frog, neither the absence of middle ear structures nor the lack of evidence for extratympanic pathways to transmit vibrations, nor the absence of studies investigating seismic sensing in *Leiopelma* species should preclude the possibility that vibration can be sensed. Rather, uncertainty remains surrounding vibration perception and sensitivity, and the potential importance of seismic stimuli in leiopelmatid frog ecology.

5.5 POTENTIAL IMPACTS OF MINING SPECIFIC VIBRATION ON LEIOPELMATID FROGS

We have established that vibration perception and sensitivity in Leiopelmatid frogs remains unknown but is theoretically possible. To try and understand the potential effects of mine(blast)-generated vibrations on these frogs one can only draw from studies of other anurans and from information on the presence of frogs in areas subject to vibration effects (e.g., frog populations persisting adjacent to roads and historical mining operations).

Leiopelmatid frogs may exhibit several potential responses to vibrations caused by episodic blasting during the construction and operation of the WUG. These could include:

(a) No response, either because Leiopelmatid frogs do not sense vibration at all or do not perceive it as a stimulus that requires a response.

(b) Physiological stress or flight response, resulting in increased heart rate and/ or startling in response to short duration/ high amplitude vibrations. May manifest as freezing or flight behaviour (e.g., jumping, moving away), the latter of which could potentially disrupt sensitive behaviours such as mating amplexus, or in the case of Archey's frog, abandonment of eggs during male brooding if a male moves away from a female or eggs and does not return.

(c) Dispersal response, causing movement away from an area influenced by an annoyance (i.e., blast vibrations), which may increase susceptibility to predators.

(d) Behavioural responses to anthropogenic vibration stimuli erroneously interpreted as honest environmental cues (e.g., blast vibration misinterpreted as rainfall leading to frog emergence).

Of these possible responses, (b)–(d) have the theoretical potential to cause heightened stress, avoidance behaviours, reduced/ failed reproductive output, and/ or changes in species distribution and species composition.

To explore potential responses to vibration in leiopelmatid frogs, three case studies—one of which is somewhat speculative—have been examined and analysed. These are described and discussed in detail below.

5.5.1 Frog persistence over the duration of mining operations at Golden Cross Mine, Waitekauri Valley

The Golden Cross gold mine, in the headwaters of the Waitekauri River at the southern end of the Coromandel Range was established in 1990 and operated by Coeur Gold New Zealand Limited (CGNZL) until 1998, when it was closed due to falling gold prices. The mining licence required CGNZL to maintain rigorous environmental standards and undertake regular environmental monitoring. Hochstetter's frog (*L. hochstetteri*) was chosen as a species to monitor because of the high conservation concern for this species and the sensitivity of frogs as indicator species for the 'health' of the environment (Whitaker 1999).

The population of Hochstetter's frog in the vicinity of the Golden Cross mining operation was surveyed and monitored between 1991 and 1998, which included a baseline survey in 1989 (prior to mining) and monitoring over subsequent years of mining activity (Slaven 1992; Slaven 1994; Whitaker 1996; Whitaker 1999). Key findings of this long-term study indicated that:

- The relative abundances and densities of frogs within the study streams varied markedly over the nine-year (1989–1998) period and these variations were most likely the result of sampling bias rather than changes in actual numbers of frogs.
- The population structure (i.e., the proportion of frogs in each size class) changed significantly over the study period. Initially, the decline in the proportion of juvenile frogs and increasing proportion of adult frogs was interpreted as evidence of declining recruitment and an increasingly aging population (Slaven 1994; Whitaker 1996). However, Whitaker (1999) subsequently reported an increased proportion of sub-adults in the final 1998 survey, suggesting that the observed changes in age structure were the result of actual (natural) fluctuations in recruitment (possibly the result of regional climatic variations) rather than consequences of mining activities or monitoring methodology.
- Whitaker (1996) dismissed vibration effects on frog populations as a result of mining operations as being irrelevant.
- Whitaker (1999) concluded that there was no evidence to suggest that the mining operations had any impact on Hochstetter's frog populations or their habitat in the study streams.

In summary, this study showed that Hochstetter's frog populations at the Golden Cross mine study sites fluctuated naturally over the period of mining operations and that frog populations persisted in the vicinity of mining operations, which included activities such as drilling and blasting, over a seven-year period between 1991 and 1998.

More recent records of Hochstetter's frog from 2008 and 2023, from areas in the vicinity of the original frog monitoring sites (DOC Bioweb Herpetofauna database, accessed April 2022; OGNZL unpub. data), indicate that Hochstetter's frogs continued to persist in the general location post-mine closure. Furthermore, Archey's frog is also known from the same locations. Archey's frog was first recorded there in 1986 and subsequently recorded in 2004 and again in 2011 (DOC Bioweb Herpetofauna

database, accessed April 2022) (Figure 5.4). These records indicate that Archey's frog persisted at the site, and by inference were subjected to the same mining disturbances, alongside Hochstetter's frog over the duration of the mining operations. However, there is no information on the population trends of Archey's frog between 1991 and 1998 because this species was not monitored as part of the mining licence.

More recently, Heilig & Partners assessed the surface vibration effects associated with blasting at the historical Golden Cross mine (Lane 2021). They modelled magnitude distribution curves and vibration contours associated with production blasting (open pit and underground mine) and vibration contours were overlaid with Hochstetter's frog locations recorded during the operating life of the mines to determine influence of vibration on frog populations (Figure 5.5). At the frog location most affected by blast vibration ('Location 1'), 41–50 frogs were subjected to amplitude values of approximately 4–10 mm/s over the life of the mine. However, the vibration magnitude distribution curves indicated that while 'Location 1' may have experienced one blast that caused a vibration up to 10 mm/s, such magnitude of vibration was not typically generated. Indeed, most often (500 times), blasts generated vibration in the 1–1.5 mm/s range, with most blasts generating vibrations no greater than about 4 mm/s (Lane 2021). Since Archey's frog was known to occur in the vicinity of the mine and indeed, occurred within the modelled 2 mm/s vibration contour, it is safe to assume that Archey's frog populations were subjected to vibration values of at least 2 mm/s during the life of the mine.

Vibration amplitude values ranging from 4 to 10 mm/s are highly unlikely to cause the movement or dislodgment of rocks or other objects in streams or on the forest floor where frogs may be taking refuge (Heilig & Partners, pers. comm. 2024). Consequently, there is no reasonable risk of injury or mortality to frogs resulting from the movement or dislodgment of objects due to blast vibrations. In the case of Hochstetter's frogs, which inhabit dynamic streamside environments, natural movements of rocks, boulders, and organic debris (such as branches and logs) during flash floods are relatively common phenomena that these frogs are accustomed to. Furthermore, since Hochstetter's frogs have persisted, despite episodic blast vibrations, near the Golden Cross mine, and there is no evidence indicating that mining operations have adversely affected their populations or habitat quality, the risk of injury or mortality to frogs from blast-induced object movement is considered negligible.

Overall, data from the long-term study on Hochstetter's frogs, along with the confirmed presence of both Hochstetter's and Archey's frogs at the same locations post-mine closure, indicates that both species persisted despite exposure to mine blasts and other mining activities. There was no evidence suggesting that these frogs dispersed from or perished in areas subjected to vibrations up to 10 mm/s. Moreover, the monitoring data for Hochstetter's frogs showed no indications of even temporary effects, such as local population declines, avoidance behaviours, or dispersal in the immediate vicinity of the mining operations.

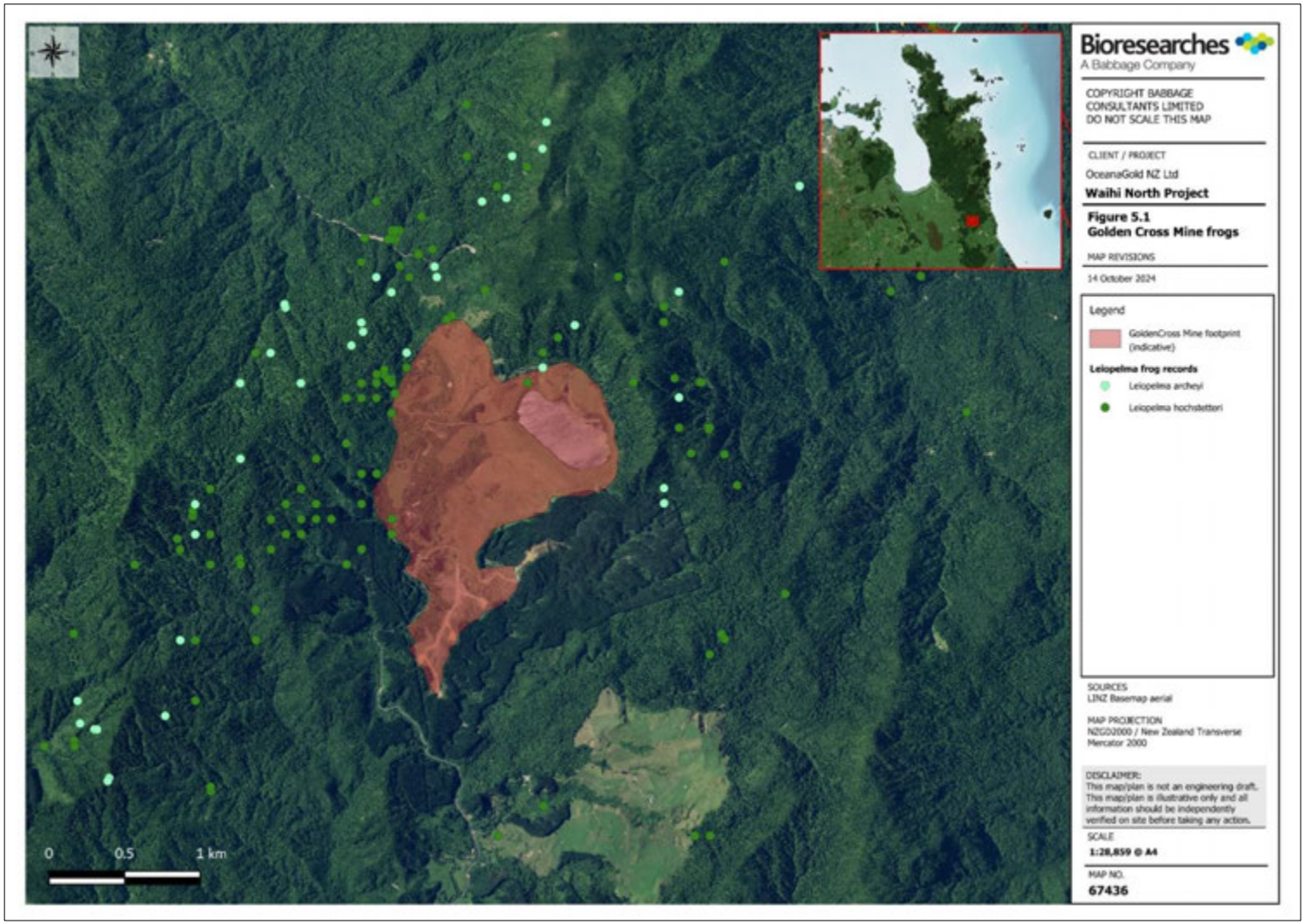


Figure 5.4. Distribution of *Leiopelma* frog records (Hochstetter's and Archey's frog) surrounding the historical Golden Cross Mine. Records sourced from DOC Bioweb Herpetofauna Database (accessed 2023).



Figure 5.5. Modelled vibration levels and associated vibration contours from blasting at Golden Cross Mine. Hochstetter's frog records (shown as number of frogs sighted in discrete areas) are overlaid.

5.5.2 Frog presence at sites subject to roadside vibration

Due to the paucity of sites to accurately measure mining vibration effects against leiopelmatid frog presence/ abundance, surface vibrations at a selection of roadside sites where leiopelmatid frogs (either Archey's frog or Hochstetter's frog) are known to occur were explored. The objective of the investigation was to determine the level of surface vibration experienced by frogs due to road traffic, with road traffic vibration considered as a proxy for the potential impacts of mine-generated vibration stimuli. Heilig & Partners (2021) justified the direct comparison between road vibration and mining vibration by commenting that as long as there is consistency between vibration parameters (amplitude, frequency, duration, and frequency of occurrence) in studies comparing vibration data from various sources, then the vibration could be considered consistent and the impacts interchangeable (i.e., vibration from traffic sources could be like that from the proposed future mine blasting).

A tri-axial geophone (vibration sensor) was installed at four roadside sites in the Coromandel Ranges (309 Road, Kopu-Hikuai, Tapu-Coroglen, and Kennedy Bay Roads) and one site in the Brynderwyn Ranges (SH1) in late September 2021 and early February 2022, respectively (Heilig & Partners 2021; OceanaGold NZ Limited 2022). At the Coromandel sites, geophones were placed between 1.8–5 m from the edge of the carriageway (i.e., the solid white line on the outer edge of the road) and a range of vibration amplitude values between 0.8–1.9 mm/s were recorded during daylight hours (Heilig & Partners 2021). In the Brynderwyn Ranges, the geophones were placed between 0.5–5.6 m from the edge of the carriageway and maximum vibration amplitude values of 0.7–2.1 mm/s were recorded during daylight hours (OceanaGold NZ Limited 2022).

Archey's frogs have historically been reported at 10 m or greater from the road edge (DOC Herpetofauna database, accessed April 2022), but more recent surveys of Coromandel sites recorded frogs at 4 m from the road edge (Boffa Miskell, unpub. data) and Hochstetter's frogs were recorded 10 m from road edge in the Brynderwyn Ranges (Bioresearches, unpub. data). At these distances, frogs may be subject to vibration values of <2 mm/s based on the current vibration data. While surveys did not detect frogs any closer to the road edge this was most likely an artifact of habitat quality (i.e., lower quality habitat and habitat subject to edge effects, e.g., increased light penetration, higher temperatures, and lower humidity) on road edges rather than avoidance of traffic vibration. However, this presumption has not been scientifically demonstrated. Since the road vibration data was not collected from sites where frogs were specifically found, this work should be considered a preliminary investigation into road vibration effects on frogs.

5.5.3 Archey's frog reproduction and captive breeding at the Auckland Zoo

The breeding biology of Archey's frog, described in detail by Bell (1985), involves a period after egg-laying whereby the male guards (broods) the eggs for several weeks until they hatch. Egg brooding in Archey's frog is characterised by a male sitting high over the eggs with body raised and both fore- and hind-limbs outstretched. Once the eggs hatch, the tiny, tailed froglets climb onto the back of the male

who carries them for several weeks while they complete their development (dorsal brooding). It is still unclear what function the male brooding and dorsal brooding is, but it has been postulated that these behaviours are possibly related to maintaining a moist micro-environment for the eggs and tadpoles in a 'dryer' terrestrial environment (Stephenson 1961; Salthe & Mecham 1974; Bell 1985). In the absence of sufficient moisture, eggs fail to develop successfully (Bell 1985). Brooding may also be a strategy to reduce the incidence of fungal and bacterial infection, and/ or protect the eggs/ froglets from predators. Notwithstanding the importance of male brooding, successful larval development from eggs to froglets in the absence of a male has been demonstrated in captivity, providing eggs and larvae are kept moist (Bell 1985; Auckland Zoo, unpub. data).

Irrespective of the function of brooding, this stage of the breeding cycle is clearly a sensitive time in the lifecycle of Archey's frog and is important for the successful recruitment of viable young in the wild. Moreover, the K-selected reproductive strategy of Archey's frog (i.e., a reproductive strategy characterised by slow maturation, low reproductive output, and living for a long time) means it is in the best interest for the male to protect 'his' eggs and progeny through to metamorphosis.

The key question is whether disturbance to brooding males leads to egg abandonment, and if so, what type and level of disturbance can a male frog tolerate before abandoning his eggs? Additionally, if abandonment occurs, does the male possess an innate behavioural drive to return to his eggs? While these specific questions have not been directly addressed in research studies, anecdotal evidence from both field observations and a captive Archey's frog facility suggests that brooding males may be tolerant to some low-level disturbance. Revealing brooding males by lifting natural refuge structures in the field to observe egg development, as well as zoo staff moving around the captive Archey's frog facility and lifting artificial refuges to closely monitor egg development in captivity will have frequently disturbed frogs. In captivity, despite these frequent disturbances, successful natural brooding through to metamorphosis was consistently observed (Auckland Zoo, unpub. data). In the field, Bell (1985) reported that two male Archey's frogs maintained their brooding posture for up to 17 days, even when gently "prodded", after being collected off egg clusters just before their eggs hatched. These observations suggest that male frogs exhibit a strong innate behavioural predisposition to continue brooding, even when subjected to disturbance.

In captivity, unfertilised eggs and egg abandonment was recorded on several occasions (Auckland Zoo, unpub. data). Several potential explanations for these recruitment failures have been considered, including the possible impact of anthropogenic vibrations within the custom-designed shipping container housing Archey's frogs at Auckland Zoo. It was reported that a broken floor support and movement in the floor panels, caused by keepers moving around inside the facility, led to frequent vibrational disturbances (R. Gibson, pers. comm., January 2022). While these vibrations may have contributed to the increased rates of egg clutch abandonment observed, this hypothesis remains largely speculative, and no measurements were taken to determine the extent of any increased vibration experienced by the frogs.

The effects of anthropogenic vibrations on captive animals have been documented in the literature. Garner *et al*. (2018) reported behavioural responses in laboratory rodents to vibration caused by

routine husbandry procedures and Felt *et al.* (2012) demonstrated morbidity and mortality in aquatic African clawed toads in a laboratory setting in response to adjacent construction vibration. As such, potential vibration effects on Archey's frogs at Auckland Zoo cannot be completely dismissed but it is more likely that other influences such as unnaturally high stocking densities (i.e., multiple frogs per m^2) may have been a larger contributing factor to lowered breeding success in the captive frogs (Auckland Zoo, unpub. data).

Although there is limited information on the behaviour and movements of male Archey's frogs while brooding eggs, it is likely that some movement occurs, as egg-brooding frogs have been observed to defecate, indicating they have fed despite their brood care responsibilities (Bell 1985). If frogs can temporarily move away from their eggs to feed and then return, it seems plausible that a male frog might respond to an extraneous disturbance, such as vibration, by briefly leaving the egg cluster. Given their significant investment in caring for their eggs and ensuring successful recruitment, it is likely they would return to brooding shortly after the disturbance subsides. Moreover, disturbance effects—such as startle responses or intentional movement—during the dorsal brooding phase may be less consequential, as males are more mobile and can carry the froglets on their backs during this period.

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6 DEWATERING EFFECTS ON NATIVE FROGS

6.1 DEWATERING AND POTENTIAL EFFECTS ASSOCIATED WITH THE PROPOSED WHAREKIRAUPONGA UNDERGROUND MINE

The Wharekirauponga Underground Mine associated with the Waihi North Project (WNP) proposes to mine a deep vein system in the Wharekirauponga catchment, which would result in deep groundwater dewatering. Potential drainage of the shallow groundwater system (groundwater drawdown) could reduce surface water discharges to streams and have a range of ecological effects, some of which may include:

- Surface water impacts – dewatering can affect surface water bodies by lowering water levels or altering flow patterns that can disrupt aquatic habitats and species that rely on these habitats (e.g., aquatic or amphibious taxa).
- Groundwater depletion – dewatering can lower the water table, leading to decreased groundwater availability for nearby forests. This can stress forest ecosystems, particularly during periods of drought, potentially leading to reduced tree growth, altered soil moisture levels, and changes in terrestrial species composition.
- Soil disturbance – the extraction of water can lead to soil compaction and erosion. Soil disturbance can negatively affect the health of forest ecosystems by reducing soil fertility, disrupting nutrient cycling, and increasing susceptibility to erosion and landslides.
- Loss of biodiversity – the cumulative impacts of dewatering on forest ecosystems could result in the loss of biodiversity. Species that are particularly sensitive to changes in hydrology, water quality, or habitat availability may decline or disappear from affected areas, leading to decreased overall biodiversity and ecosystem resilience.

Hochstetter's frog populations are known occupy the watercourses and riparian margins in the Wharekirauponga catchment and Archey's frog populations are known to occupy the surrounding forested areas. Dewatering as part of the Wharekirauponga Underground Mine could potentially impact frog populations if changes to stream or forest characteristics are realised. Changes to soil moisture levels, the drying of nearby wetlands or ground-fed streams, potential changes to forest composition and type (e.g., reduced moisture leading to altered or less preferable forest types for frogs), and reduced water flow and/ or wetted width could potentially affect frog habitat availability.

To assess the potential effects of dewatering on native frog populations, a variety of hydrological reports were reviewed[15] and interpreted alongside ecological and behavioural information available for Leiopelmatid frogs. Technical reports reviewed as part of the frog assessment included:

[15] Information associated with potential surface water impacts stemmed from a water balance model (WBM) developed by GHD, that captures the current continuous flow monitoring locations within the Wharekirauponga catchment. This information was used in the frog assessment, and thus the limitations and assumptions outlined by GHD 2025 are also relevant to the frog assessment.

- Flo Solutions (2024a, 2024b) – Conceptual groundwater model and numerical modelling.
- Intera (2024) – Model calibration and sensitivity analysis.
- GHD (2025) – Hydrology modelling.
- WWLA (2025a, 2025b, 2025c) – Regional hydrogeologic setting, wetland delineation and drainage effects.
- NIWA (2024) – Instream habitat (for aquatic fauna) of the Wharekirauponga Streams and tributaries.
- Boffa Miskell (2016, 2018, 2019a, 2019b, 2020, 2021, 2022, 2024, 2025a) – Ecological and Freshwater environment effects.
- Bioresearches (2025) – Wetland delineation and dewatering effects assessment.

The frog assessment focusses primarily on semi-aquatic Hochstetter's frogs, which are largely reliant on streams and flowing water to complete their lifecycle. However, the potential effects of dewatering on terrestrial Archey's frogs are also discussed.

6.1.1 Dewatering and surface water effects

Several aspects of dewatering have been identified as potentially impacting frogs, including reductions in stream flow, decreased wetted width, potential effects on forest and riparian vegetation, impacts on spring-fed watercourses, and changes to instream habitats that support invertebrate prey. Although these factors are interrelated, they have been separated for the purpose of this assessment, with the potential effects of each on frog populations evaluated individually.

6.1.1.1 Flow reduction

Water flow is a key factor in determining habitat availability in streams and rivers, which directly impacts the composition and distribution of aquatic life. Aquatic and semi-aquatic species have evolved life history strategies that are closely tied to the natural flow regime. Any disturbance to this flow such as reduced water velocity or change in water depth can reduce habitat availability, disrupt the life cycles of organisms, and negatively affect the structure (e.g., diversity and abundance of organisms) and health of aquatic ecosystems (Lake 2003; Power *et al*. 2013; Kaylor *et al.* 2019; Szałkiewicz *et al*. 2022).

Furthermore, reduced water velocity can lead to increased fine sediment deposition, which can clog interstitial spaces between substrates thereby reducing habitat quality. Indeed, Hochstetter's frogs occur much less frequently in silted, compared to unsilted, streams. Reduced flow may slow the downstream movement ('flushing') of organic debris and food resources, reducing refuge habitat and food availability for a variety of organisms, including Hochstetter's frog.

Significantly reduced flow can also affect the physicochemical properties of water by altering contaminant concentrations and water temperature. Water temperatures may increase due to faster

warming in summer or decrease as a result of substantial groundwater recharge to the watercourse. These temperature fluctuations, in turn, affect dissolved oxygen levels, to which certain taxonomic groups are particularly sensitive (Szałkiewicz *et al.* 2022).

Hochstetter's frogs show a strong preference for cool, shaded, unsilted streams with relatively fast-flowing water. Reductions in flow that lead to elevated water temperatures and increased siltation could degrade the quality of their habitat. The impact of physical habitat changes on stream organisms depends on the species' specific responses to such changes, the severity and duration of reduced flows, and the availability of thermal and habitat refugia (Walters 2016; Kaylor *et al.* 2019) (see *Section 6.1.2: Instream habitat assessment and implications for frogs*).

6.1.1.1.1 Predicted baseflow reduction in surface water in Wharekirauponga

Groundwater modelling suggests that mine dewatering could potentially affect surface water through baseflow losses from streams (GHD 2025). The modelling indicates the following:

- The post-mining scenario could influence the flow regime to varying degrees in different sub-catchments, with the percentage reduction between the pre-mining and post-mining scenarios greatest during low flow conditions at all sites (e.g., MALF[16], 7-day MALF[17]) (GHD 2025).
- Model results predict the 7-day mean annual low flow (7-day MALF) could be reduced by between 2 to 13%, and this would be largely restricted to areas immediately above the Wharekirauponga Underground Mine and down catchment of this area (Figures 6.1 and 6.2).
- Modelled reductions would only be realised for short time periods (during prolonged dry spells).
- The modelled reductions in MALF do not significantly depart from the current calculated MALF and are unlikely to significantly affect the flow variability currently observed from year to year, which exhibits significant variation in annual low flow (ALF) (i.e., reduced flows are within the current natural variation observed). The exception to this is within the Thompsons sub-catchment and to a lesser extent Edmonds sub-catchment where the modelled reductions in MALF (as a result of the Wharekirauponga Underground Mine development) approach the lower end of the estimated ALF variability (GHD 2025). That is, the Thompsons and Edmonds sub-catchments will experience the largest reductions in 7-day MALF because they represent smaller tributaries located above the proposed Wharekirauponga Underground Mine area (Figure 6.2).
- The modelled results are conservative for reasons outlined by GHD (2025) (and summarised by WWLA 2025b).

[16] Mean annual low flow (MALF) = where the lowest flow for each (hydrological) year is averaged over the data record available.
[17] 7-day Mean annual low flow (7-day MALF) = the lowest flow over a 7-day rolling average for each (hydrological) year, averaged over the data record available.

- Groundwater level recovery, as predicted by the numerical groundwater model has indicated it would take 10 years after the cessation of pumping associated with mining for the groundwater levels to recover to 90% of the preexisting levels, with full recovery expected within 20 to 30 years.
- Since the predicted reductions in surface water flow are within the range of natural seasonal variation, potential effects on surface water (not accounting for ecological processes or effects) are considered low.

Of the nine stream sub-catchments, the Edmonds and Thompsons are predicted to potentially experience the largest reductions in flow. 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 2025). Hochstetter's frogs are known to occur widely in both the upper and lower stream reaches of the Edmonds sub-catchment, and while there are no existing Hochstetter's frog records from the Thompsons sub-catchment, it is conservatively assumed that frog populations are present.

While reductions in the 7-day MALF of up to 12.4% could be seen as having measurable impacts on Hochstetter's frogs (e.g., due to siltation and reduced habitat quality), it's important to note that these predicted reductions remain within the range of natural variation observed in ALF—recognising that the modelled reductions for Edmonds and Thompsons approach the lower end of estimated ALF variability (GHD 2025). Additionally, these flow reductions are expected to occur only during brief periods, such as extended dry spells. Hochstetter's frogs will be naturally familiar with seasonal variation in stream flows and will have adapted behavioural strategies to cope with low flow (e.g., selecting refuges close to the lowered waterline). Because the predicted reductions remain within the range of natural variation observed in ALF, impacts of flow reductions on Hochstetter's frogs in streams above the proposed Wharekirauponga Underground Mine and within the wider Wharekirauponga catchment area are not anticipated.

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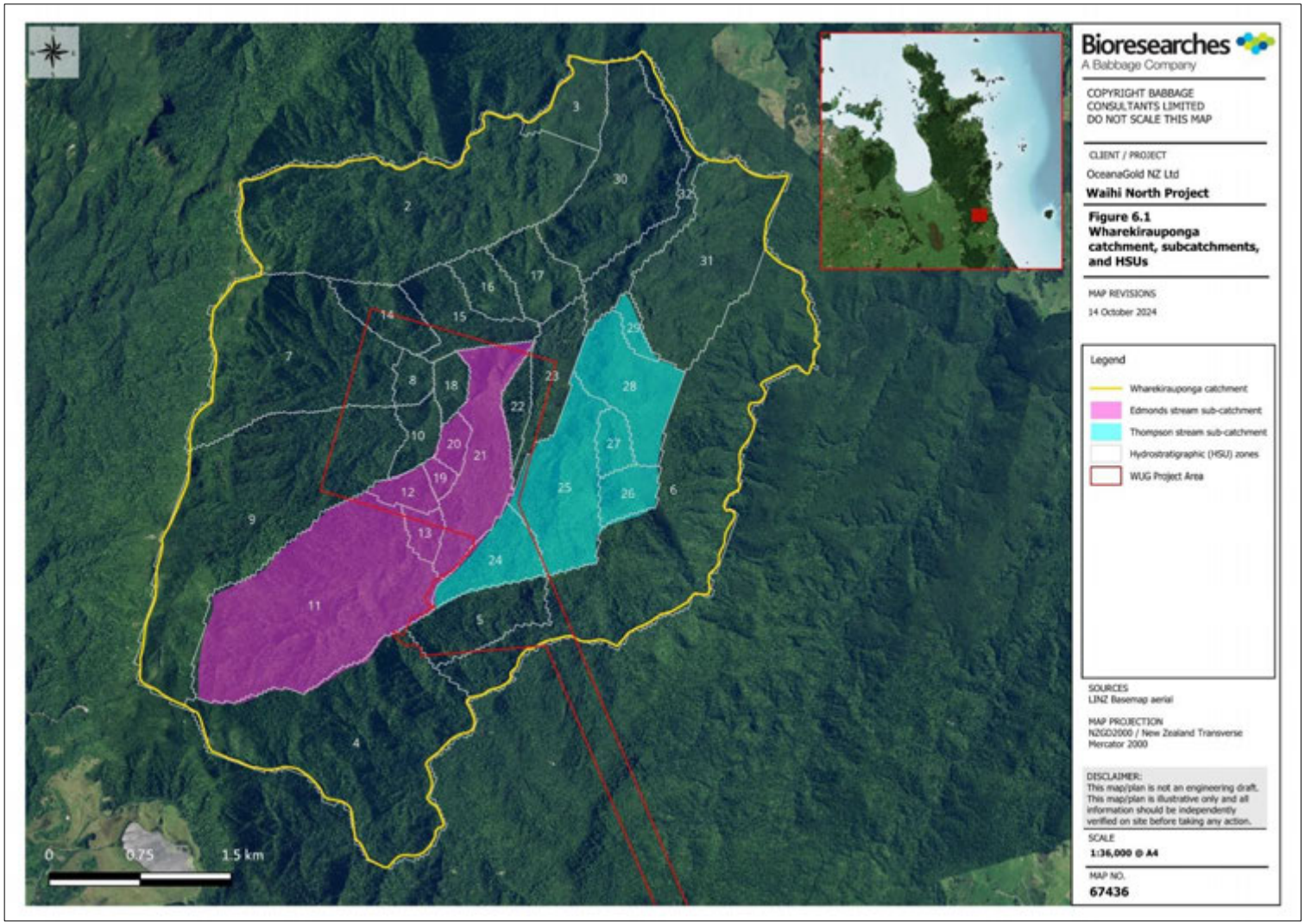


Figure 6.1. Location of the Wharekirauponga Underground Mine in relation to the Wharekirauponga catchment and the Thompson and Edmonds sub-catchments referred to in the text above.

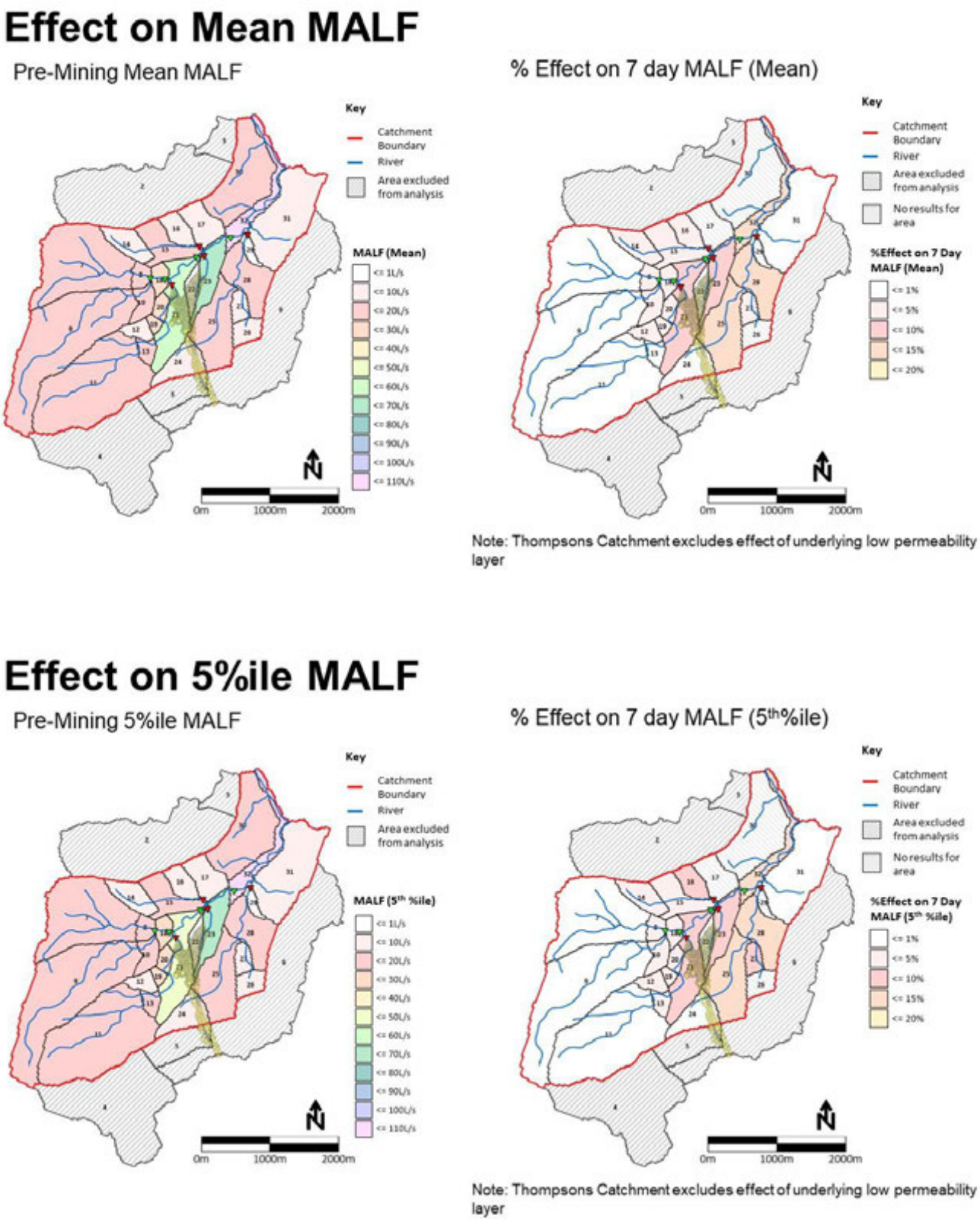


Figure 6.2. Dewatering effects on mean MALF (expected scenario) and 5th% MALF (worst case scenario) for pre- and mining situations. Sourced from GHD (2025).

6.1.1.2 Wetted width reduction

The wetted width of a stream or river is defined as the distance between the sides of the channel at the point where substrates are no longer surrounded by surface water. Wetted width is directly important to biological conditions as it controls the total area available for bottom-living organisms. That is, it is an important measurement in understanding the physical and ecological habitat availability for a variety of aquatic taxa (e.g., periphyton, macroinvertebrate and fish) (NIWA 2024). For semi-aquatic taxa such as Hochstetter's frog that move freely along the edge of the waterline, it is expected that changes to wetted width will have much less influence on habitat availability compared to the influence on aquatic species.

6.1.1.2.1 Predicted wetted width reduction in Wharekirauponga

Changes in wetted width predominantly occur as a result of changes in flow (MfE 1998), and based on the current mine design, potential wetted width reductions under the worst case (unlikely) scenario may be realised due to baseflow losses in streams (GHD 2025).

The modelled reductions in wetted width are outlined in detail by GHD (2025). The models predict potential reductions in wetted width of 0–5% of the 7-day MALF across the affected sub-catchments during periods of low flow, with the Edmonds and Thompson Stream sub-catchments predicted to be most affected (Figure 6.3). Table 6.1 shows wetted width reductions predicted for the nine affected sub-catchments and Table 6.2 shows wetted width reductions predicted for the five worst affected HSUs. It is important to emphasise that reductions in wetted width will not be realised in the environment often. During periods of normal (average), medium and higher flows, much smaller or no such wetted width reduction is modelled to occur. The modelled reductions in wetted width are considerably smaller than the relative reduction in flow based on the flow/ wetted width relationship, which only sees significant reductions in wetted width (for reduction in flow) as the flow approaches zero (GHD 2025).

To conceptually demonstrate the potential effects of reduced wetted width at low flow on Hochstetter's frogs, a worse-cast 5% reduction was applied to a 2-metre-wide stream. This resulted in a 100 mm decrease in wetted width (Figure 6.4). Since Hochstetter's frogs typically inhabit a broad streamside margin—up to a metre or more on either side of the waterline—this small decrease in wetted width represents only a minimal reduction in available habitat. In fact, in streams with gently sloping banks, the decrease in wetted width may expose additional damp substrate, potentially providing more areas for foraging and refuge for the frogs.

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 Wharekirauponga Underground Mine will result from potential reductions in wetted 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.

Table 6.1. Sub-catchment level wetted width reduction percentage pre- vs post mining. Sourced from GHD (2025).

Percentage reduction (wetted width) between pre mining and mining - Probabilistic Scenario (5th %ile and average results)																		
	TStreamW		TStream E		Edmonds		Trib R		Adams		WKP 03		WKP 02		Thompson		WKP 01	
	5%ile	Mean	5%ile	Mean	5%ile	Mean	5%ile	Mean	5%ile	Mean	5%ile	Mean	5%ile	Mean	5%ile	Mean	5%ile	Mean
Average flow	0.1%	0.1%	0.2%	0.2%	0.7%	0.7%	0.2%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.9%	0.7%	0.4%	0.3%
MALF	0.5%	0.4%	1.1%	0.9%	3.4%	3.2%	1.3%	1.6%	1.4%	1.3%	2.1%	1.9%	2.1%	1.9%	3.6%	3.3%	1.9%	1.7%
7day-MALF	0.4%	0.4%	1.0%	0.8%	3.0%	2.9%	1.1%	1.5%	1.3%	1.2%	1.8%	1.7%	1.8%	1.7%	3.3%	3.1%	1.7%	1.6%

Table 6.2. HSU level wetted width. Five HSUs with largest potential wetted width reductions. Sourced from GHD (2025).

Percentage reduction (wetted width) between pre mining and mining - Probabilistic Scenario (5th %ile and average results)										
	HSU20		HSU21		HSU22		HSU25		HSU28	
	5%ile	Mean	5%ile	Mean	5%ile	Mean	5%ile	Mean	5%ile	Mean
Average flow	?	?	0.4%	0.4%	?	?	1.2%	1.0%	0.9%	0.8%
MALF	?	?	2.1%	1.9%	?	?	4.1%	3.8%	3.8%	3.5%
7day-MALF	?	?	1.8%	1.7%	?	?	3.9%	3.6%	3.5%	3.2%

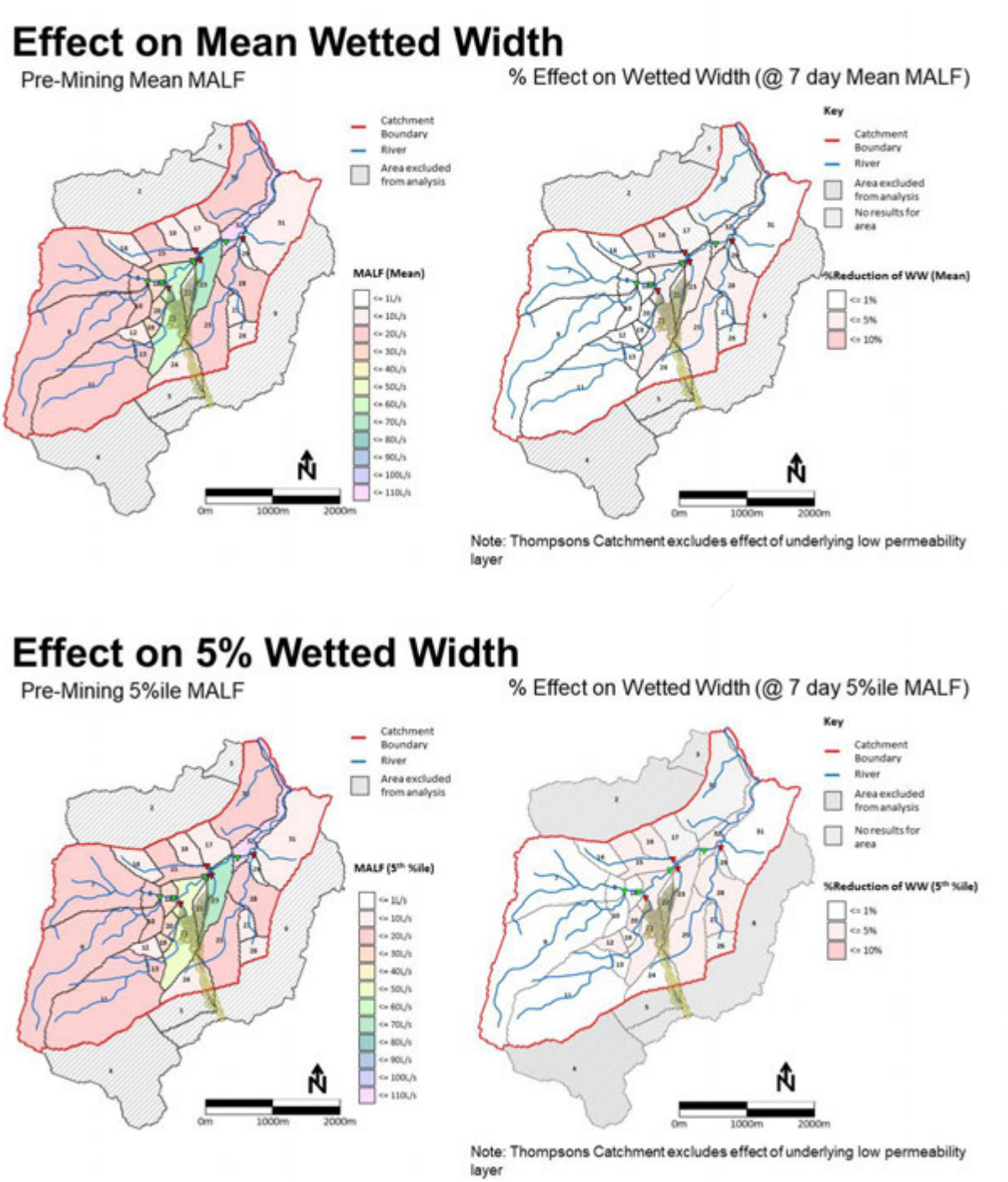


Figure 6.3. Dewatering effects on mean wetted width (expected scenario) and 5th%ile wetted width (worst case scenario) for pre- and mining situations. Sourced from GHD (2025).

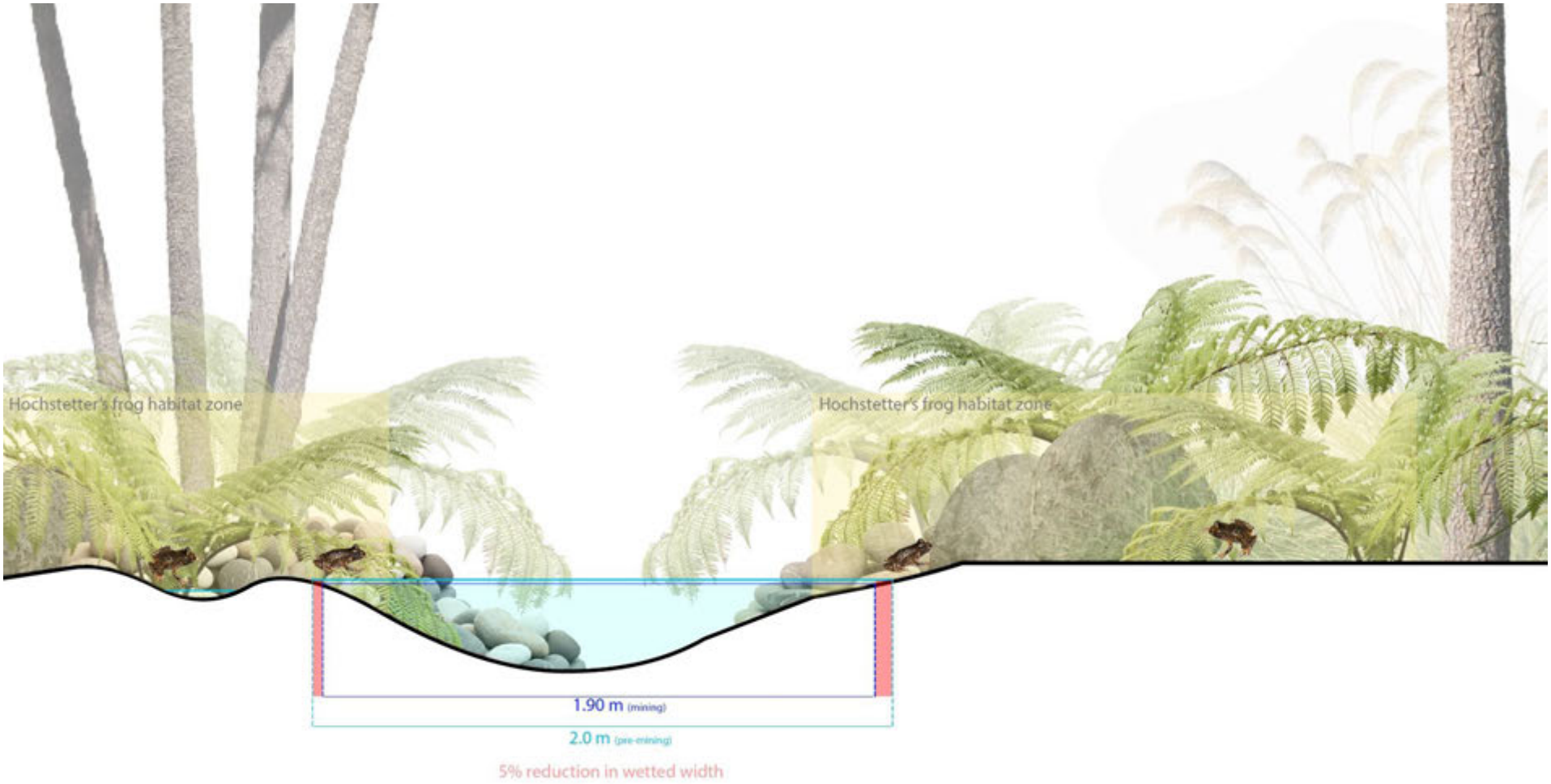


Figure 6.4. Cross section of forest stream showing the influence of a worst-case 5% reduction in wetted width at low flow, due to potential baseflow reduction during mining, on Hochstetter's frog habitat.

6.1.1.3 Forest vegetation effects

When dewatering lowers groundwater levels in the shallow aquifer system, it can reduce groundwater availability for forest, riparian, or wetland ecosystems. In extreme cases, where groundwater depletion persists over extended periods and coincides with low rainfall (e.g., during droughts), vegetation communities may experience stress, potentially leading to altered soil moisture levels, reduced plant growth, and changes in species composition and behaviour.

Vegetation cover plays a crucial role in shading forest floors and streams, helping to maintain lower temperatures and high relative humidity (Sugimoto *et al*. 1997). Riparian vegetation also provides significant organic matter inputs that sustain stream food webs, where species like Hochstetter's frogs occupy an intermediate trophic level (Nájera-Hillman *et al*. 2009a, b). Any reduction in riparian vegetation within catchments where Hochstetter's frogs occur may negatively impact their populations. Similarly, decreased soil moisture and reductions in forest vegetation or relative humidity could degrade the quality of forest habitats for terrestrial species such as Archey's frog.

6.1.1.3.1 Anticipated effects of dewatering on forest vegetation in Wharekirauponga

Groundwater modelling predicts that the extraction of deep groundwater for mine dewatering is expected to have minor or negligible effects on groundwater levels in the shallow aquifer system (WWLA 2025b). This is because the deep ("EG Vein") aquifer is considered to be disconnected or very weakly connected to the shallow aquifer (Flo Solutions 2024a, b; WWLA 2025b). Accordingly, soil moisture that supports surface vegetation and frog habitat is predominantly rainfall derived and is not expected to be adversely affected by deep groundwater changes. As a result, adverse effects on the habitat quality and quantity, and populations of Hochstetter's and Archey's frogs due to dewatering are not anticipated.

6.1.1.4 Effects on springs and rainfall fed seeps/ streams

Hochstetter's frogs favour lower-order (first and second) streams and seepages in headwater catchments as their primary habitat (Nájera-Hillman *et al.* 2009b). These upper catchment streams and seeps are typically fed by rainfall or springs. Springs form when the water table intersects the earth's surface or when groundwater rises through rock faults, fractures, or depressions (Death *et al*. 2004). A unique feature of springs is their role as a three-way interaction zone between groundwater, surface water, and terrestrial ecosystems (Scarsbrook *et al*. 2007), often creating groundwater-dependent ecosystems (Hatton & Evans 1998). Springs that discharge into small seeps, which may turn into springbrooks (small overland flow paths created by a spring), provide the moist conditions essential for species like Hochstetter's frog.

If dewatering affects groundwater levels in the shallow aquifer system, it could lead to reduced or ceased water flow from springs, thereby altering springbrook and small stream flows. This reduction in flow could diminish the availability of suitably damp habitats required by Hochstetter's frogs.

6.1.1.4.1 Predicted effects on springs in Wharekirauponga

Hydrological assessments conclude that interflow and contact springs will not be impacted by the proposed mine dewatering, as they are fed by shallow water movement sourced from rainfall (WWLA 2025b). Therefore, the spring-fed seeps, springbrooks, and streams throughout Wharekirauponga, which currently provide habitat for Hochstetter's frogs, will remain unaffected by the dewatering. This conclusion also applies to most non-spring-fed streams, where water is primarily sourced from rainfall rather than shallow groundwater. As a result, these streams—and the resident Hochstetter's frogs and their habitats—will not be impacted by the dewatering.

There are two exceptions where spring flows are expected to decrease due to dewatering effects. At a single downstream reach discharge location, a temporary reduction of 5 L/s in fracture-controlled discharge is anticipated for the duration of the mine dewatering. This spring feeds into a larger downstream reach of the Wharekirauponga Stream, and while Hochstetter's frogs may be present downstream, a 5 L/s reduction in flow is unlikely to adversely affect the frogs or their habitat, as sufficient water flow will remain in the stream despite reduced flow. As noted earlier, this reduction in discharge will be temporary, with flow levels expected to return to normal discharge levels as the mine rewaters to its natural state (WWLA 2025b).

Another spring, known as "Warm Spring," has been identified as being affected by dewatering. At this discharge point, approximately 3.5 L/s of flow is conservatively expected to cease for the duration of the mine dewatering. This flow is unlikely to return once the mine rewaters, as the pathway from deep groundwater to the surface is expected to be disrupted by mining activities (WWLA 2025b). However, it is possible that a cold spring may emerge at the same location once rewatering occurs. Despite the likely permanent—or potentially temporary—reduction in discharge at this site, the impact on Hochstetter's frogs is considered negligible. The Warm Spring currently discharges directly into the main channel of the Wharekirauponga Stream and therefore, does not sustain stream flow or provide critical frog habitat.

6.1.2 Instream habitat assessment and implications for frogs

National Institute of Water and Atmospheric Research/ Taihoro Nukurangi (NIWA) was engaged by OGNZL to determine the effect of dewatering on instream habitat for aquatic organisms (assessed taxonomic groups included periphyton, invertebrates, and fish) in the Wharekirauponga Stream and its tributaries above the proposed Wharekirauponga Underground Mine. An interpreted summary of their findings is provided here but the reader should refer to the NIWA (2024) for a detailed description of the methods, assessment results, and expert interpretation.

This section of the report outlines the summary findings of the instream habitat assessment, carried out by NIWA (2024), as they relate to the Edmonds and Thompson Streams[18] and potential effects on semi-aquatic Hochstetter's frogs.

[18] Edmonds and Thompson Streams are the focus because this is where the greatest predicted surface water effects would be realised, according to modelled mine dewatering scenarios and flows provided by Flo Solutions and GHD.

NIWA used instream habitat modelling to determine the available instream physical habitat for a range of aquatic species/ classes and how the available habitat for these species would respond to potential changes in flow in Wharekirauponga Stream and its tributaries. This was predicted by calculating the change in 'habitat suitability' ("Area Weighted Suitability"[19]). NIWA focused results on the 'worst case' post-mining 7-day MALF as this would cause the largest reductions to instream habitat. However, they also included results of the 'average case' (i.e., most likely scenario) post-mining 7-day MALF, and the median flows (which are representative of the average annual flow conditions). The results of the predicted change of AWS for invertebrates are summarised below and in Table 6.3.

- For the average-case (most likely scenario) changes to suitable instream habitat for aquatic invertebrates between the pre-mining 7-day MALF and the predicted post-mining 7-day MALF ranged from -1.04% to -3.91% in Edmonds, Adams, and Thompson Stream sub-catchments. The average reduction of suitable instream habitat for invertebrates for the three sites was -2.55%.
- For the worst-case (unlikely scenario) changes to suitable instream habitat for aquatic invertebrates between the pre-mining 7-day MALF and the predicted post-mining 7-day MALF ranged from -1.64% to -5.28% in Edmonds, Adams, and Thompson Stream sub-catchments. The average reduction of suitable instream habitat for invertebrates for the three sites was -3.58%.
- At median flow, which is representative of average annual flow conditions, changes in flow due to mining scenarios having much less impact on suitable instream habitat than those at the 7-day MALF.
- Even for the improbable worst-case scenario of the groundwater and surface water modelling there are very small changes to suitable instream habitat for flow reductions relative to the median flow.

Since Hochstetter's frogs are semi-aquatic (they do not spend all their lives in the water column), the methods used by NIWA to calculate instream habitat change in response to potential flow changes could not be directly applied to frogs or their habitat. However, aquatic invertebrates, which likely provide a food resource for frogs, may provide a proxy for habitat quality. Changes in invertebrate communities or abundance resulting from changes in available habitat could affect frog habitat quality. That is, if potential food resources are impacted by flow and habitat reductions, then this could indirectly impact frogs living in the streams.

The results of the instream habitat modelling suggest that changes to aquatic invertebrate habitat would be minimal, even under the worst-case scenario (7-day MALF). Consequently, it is likely that aquatic invertebrate diversity or abundance would not be significantly impacted (Boffa Miskell 2024).

[19] Area Weighted Suitability (m^2/ m) is the average wetted area of a stream (per unit length) that is suitable for use by an aquatic species, or class of aquatic species.

Since Hochstetter's frogs primarily feed on terrestrial invertebrates (Stephenson & Stephenson 1957; Sharell 1966; Kane 1980; Chapman & Alexander 2006; Nájera-Hillman *et al.* 2009a; Shaw *et al.* 2012), with much less reliance on aquatic invertebrate prey, it is highly improbable that frogs living and foraging along stream edges above the Wharekirauponga Underground Mine would be affected.

Table 6.3. Percentage change of Area Weighted Suitability (AWS) for all invertebrates (showing taxa where at least 5% of available AWS is suitable at 7-day MALF) in three stream sub-catchments (Edmonds, Adams, Thompson) under post-mining scenarios.

	Percentage change from Pre-mining Median flow		Percentage change from Pre-mining 7-day MALF	
Sub-catchment	**Post-mining Median flow [Average case]**	**Post-mining Median flow [Worst case]**	**Post-mining 7-day MALF [Average case]**	**Post-mining 7-day MALF [Worst case]**
Edmonds Stream	-0.62	-1.39	-2.70	-3.82
Adams Stream	-0.42	-0.97	-1.04	-1.64
Thompson Stream	-0.95	-1.73	-3.91	-5.28

Changes to suitable instream habitat for flows around the median (more representative of annual flow conditions) are typically much less significant than those around the 7-day MALF for all study reaches and all species/classes.

7 ASSESSMENT OF ECOLOGICAL VALUES AND EFFECTS

The Ecological Impact Assessment Guidelines (EcIAG) published by Environment Institute of Australia and New Zealand (EIANZ) (Roper-Lindsay *et al.* 2018) were used to guide the ecological values and effects assessment process. The framework is based on guidelines developed by the Institute of Ecology and Environmental Management (Regini 2000; 2002). The EcIAGs provide a standardised matrix framework that provides a transparent and consistent approach to ecological effects assessments. The EcIAG framework is generally used in impact assessments in New Zealand as good practice.

The approach involves three main steps:

Step 1: Assign an ecological **value** on a scale of 'Negligible' to 'Very High' to ecosystems/ habitats and species identified within the Project area (see Table 5 and Table 6 in Appendix A).

Step 2: Determine the **magnitude** of effect each value (see Table 8 in Appendix A). This step also includes consideration of the timescale and permanence of the effect.

Step 3: Evaluate the overall severity or **level of effect** using a matrix of the ecological value and magnitude of effect (see Table 10 in Appendix A).

The EcIAG ecological value assignment process uses attributes that are broadly consistent with those commonly used for RMA s6(c) significance assessment. That is, a level of effect 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 is usually considered to correspond to a 'minor ecological effect' or 'less than minor ecological effect' under the RMA. It is generally accepted that 'Very High' levels of effect trigger avoidance or re-design.

7.1 ASSIGNMENT OF ECOLOGICAL VALUE

In assigning ecological values to Archey's and Hochstetter's frogs that occur in the potentially affected area, each frog species' New Zealand Threat Classification System listing (Townsend *et al.* 2008; Rolfe *et al.* 2022; Burns *et al.* 2025) has been considered. Since both species are listed as 'At Risk – Declining' and both occur permanently in the zone of influence (ZOI)[20], a 'High' ecological value has been assigned in accordance with criteria listed in Table 5 of EIANZ guidelines.

7.2 MAGNITUDE OF EFFECTS ASSIGNMENT

The potential effects of the Wharekirauponga Underground Mine activities on native frogs occupying the streams and forests above the mine are identified and described below, under the general themes of 'distribution and abundance', 'vibration', and 'dewatering' effects. In assigning a magnitude of

[20] Zone of influence (ZOI): area in which an activity or pressure could directly or indirectly impact part of the environment.

effect, duration and timescale (permanence) of the effects have been considered, as well as the anticipated risk and uncertainty of the effects.

A summary of the identified potential effects and magnitude of effects assignments are provided in Table 7.1.

While there is a level of confidence that the potential vibration and dewatering impacts on frogs will be very low (possibly negligible) (i.e., a slight change from existing baseline condition/ negligible effect on the known frog population or range; Roper-Lindsay *et al*. 2008), it is acknowledged that some uncertainty remains regarding the scale and magnitude of possible outcomes for frogs. Furthermore, a zero-risk assumption is not supported by the available evidence. Accordingly, a precautionary approach has been taken when assigning magnitude of effect—assuming an exacerbated scenario—, whereby vibration and dewatering effects may result in potential indirect effects (though not direct mortality) on breeding success, movement, and/ or predation vulnerability.

7.2.1 Distribution and abundance of frogs inside the potentially affected area

Historical records and more recent surveys demonstrate that populations of Archey's and Hochstetter's frog occupy the forested habitats above the proposed Wharekirauponga Underground Mine site in Wharekirauponga catchment.

Available data shows that Archey's frog populations are densest in undisturbed native forests at mid to high altitudes (>400 m a.s.l.) throughout the Coromandel. In contrast, the area expected to be impacted by the Wharekirauponga Underground Mine, offers lower-quality habitat for Archey's frog, with altitudes ranging from 90 to 330 m a.s.l., and half the area consisting of historically disturbed and now regenerating forest. Indeed, the Wharekirauponga Underground Mine's affected area footprint represents only 0.61% of Archey's frogs inferred 52,000 ha distribution range in the Coromandel (Lloyd 2025a). If frog densities are similar across the entire range, about 0.61% of the population would reside within the vibration footprint. However, the actual proportion is likely much lower due to the poorer habitat quality in the footprint area. In terms of the size of the population that occupies the 315 ha area of forest above the Wharekirauponga Underground Mine, it is estimated to range between 48,888 and 152,774 adult frogs (61,406–278,785 for all age frogs). This represents a small proportion of the likely very large population of adult Archey's frogs occurring in the Coromandel Range (Lloyd 2025a).

Hochstetter's frogs are common in seepages, creeks, and streams in the Wharekirauponga catchment, and were also found in the lower elevation, wider, and faster flowing streams contrary to previously thought (Boffa Miskell 2020). When examining the detection probability and abundance of Hochstetter's frogs inside versus outside the area affected by the Wharekirauponga Underground Mine, the data indicates that frog encounter rates and frog abundance were significantly lower inside the affected Edmonds sub-catchment compared to areas outside of the affected area (Lloyd 2025b). Furthermore, a lower proportion of juvenile frogs and a higher proportion of mature female frogs were found in the affected area compared to outside the affected area. This may suggest an aging population of frogs, with relatively low juvenile recruitment, in the affected area compared to outside.

The estimated number of Hochstetter's frogs occupying the 12.1 km length of stream in the affected Edmonds sub-catchment ranges between 238 and 1,597 frogs (i.e., density of 0.4–2.6 frogs/ 20 m length of stream) (Lloyd 2025b). These data may suggest that the Hochstetter's frog populations outside the affected area may be faring better than those inside the affected area, though the data is limited.

Overall, the Archey's and Hochstetter's frog populations in the affected Wharekirauponga catchment are largely representative of the wider Coromandel populations in terms of distribution and abundance. However, the presence of lower-quality regenerating forest, which covers approximately half of the affected area, along with possible evidence of an aging population of Hochstetter's frogs, suggests that the populations within the impacted area may be less robust compared to those in the surrounding landscape.

7.2.2 Potential effects of vibration on frogs

The role of anthropogenic substrate vibrations in disrupting animal behaviour is poorly understood and the field is largely under researched. Theoretically, Leiopelmatid frogs do have the anatomical apparatus to detect vibration and the influence of extraneous vibration stimuli on some of the Archey's frogs' more sensitive behaviours such as male egg-brooding remains a possibility. However, to date there is no evidence to verify vibration sensation or perception in leiopelmatid frogs, let alone the positive or negative responses of these frogs to natural or anthropogenic generated vibrations.

The modelled vibration contours for the Wharekirauponga Underground Mine show levels of vibration like those experienced during the historical Golden Cross mining activities. Blast vibrations typically <5 mm/s and infrequently up 10 mm/s were experienced in the areas immediately surrounding Golden Cross Mine, where abundant Archey's and Hochstetter's frog populations were present over the life of the mine (Lane 2021; Heilig & Partners 2024).

In Archey's frog, the high level of investment in egg care by males does suggest that this species can tolerate some level of disturbance 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 some levels of vibration despite differences in biology and ecology. Indeed, the Golden Cross vibration modelling provides the best circumstantial evidence that Leiopelmatid frogs can tolerate blast vibrations (i.e., between 2–10 mm/s tolerated by Hochstetter's frog and 2 mm/s, maybe up to 4 mm/s, tolerated by Archey's frog). Nevertheless, it is important to recognise that the Golden Cross data does not provide evidence of a vibration threshold (both in terms of vibration acceleration and duration) above which a response that is meaningful in an ecological sense could be expected.
Vibrations from the proposed mine will occur intermittently during an eleven-year period and only be noticeable within a 315 ha area of forest, which represents 0.61% of the Archey's frog Coromandel range (Lloyd 2025a) and even less of the Hochstetter's frog Coromandel range.

7.2.3 Potential effects of dewatering on frogs

Dewatering as part of the Wharekirauponga Underground Mine could potentially impact frog populations if changes to stream or forest characteristics are realised. Any potential impacts on surface water through baseflow losses from streams would not be the same for Archey's and Hochstetter's frogs because of their different ecologies and habitat preferences (i.e., Archey's being terrestrial and Hochstetter's semi-aquatic).

Away from streams, the groundwater modelling predicts that there will be minor or negligible impacts of mine dewatering on groundwater in the shallow aquifers (WWLA 2025a, b). Because the ground water supply to the forest vegetation in the Wharekirauponga catchment that supports Archey's frog populations is not expected to be influenced by mine dewatering, no adverse impacts on terrestrial Archey's frogs nor their habitat are anticipated.

In some streams, surface water baseflows have the potential to temporarily decrease due to deep groundwater extraction for mine dewatering (WWLA 2025a, b). Hochstetter's frogs inhabiting the edges of these streams may experience reductions in the 7-day MALF ranging from 2% to 13%, along with decreases in wetted width of 0–5% across affected sub-catchments during low flow. These effects would be temporary (during mining) and would occur only during periods of lowest flow, primarily impacting areas directly above the Wharekirauponga Underground Mine and downstream (GHD 2025; WWLA 2025b).

Although reductions in flow and wetted width may be noticeable in the most affected sub-catchments, such as Edmonds and Thompson streams, the ecological impacts on the aquatic system are likely to be minor, if not negligible (Boffa Miskell 2024). Even under the unlikely worst-case scenario predicted by groundwater and surface water models, the change in suitable instream habitat for aquatic invertebrates (potential prey for Hochstetter's frog) relative to the median flow would be minimal (less than 6%) when comparing pre-mining conditions with the predicted post-mining situation (NIWA 2024). This minor reduction is unlikely to alter aquatic invertebrate diversity and abundance (Boffa Miskell 2024), and therefore, not affect aquatic food availability for frogs. Hochstetter's frogs are much more reliant on terrestrial (cf. aquatic) invertebrates for food (Stephenson & Stephenson 1957; Sharell 1966; Kane 1980; Chapman & Alexander 2006; Nájera-Hillman *et al*. 2009a; Shaw *et al*. 2012) and any potential alterations to aquatic invertebrate habitat as a result of mine dewatering are not expected to have measurable effects on Hochstetter's frog food availability. Similarly, any small changes to instream habitat for aquatic invertebrates would not have any reaching effects on Archey's frog populations in the surrounding forests because the frogs feed exclusively on terrestrial invertebrates.

Hochstetter's frogs, which are mobile and adapted to living on the banks of dynamic streams with naturally fluctuating water levels, are unlikely to be adversely affected by any small, predicted reductions in flow, wetted width, and instream habitat. The relatively wide streamside margins they inhabit, along with their ability to freely move to more favourable conditions along a stream, suggest they are likely to be unaffected by any minor reductions in baseflow.

Hydrological assessments conclude that most springs, and therefore spring-fed seeps, springbrooks, and small-order streams, will not be impacted by the proposed mine dewatering, as they are fed by shallow water movement sourced from rainfall (WWLA 2025b). Therefore, Hochstetter's frog populations occupying these habitats will not be impacted by the mine dewatering.

The presence and abundance of egg-laying sites and shallow pools necessary to support tadpoles through their development are not expected to reduce as a result baseflow reductions because the predicted reductions to flow and wetted width are so minor. Indeed, in streams with shallow sloping banks and accumulations of rocks/ boulders and leaf litter, lowering of the waterline (reduced wetted width) due to lower flow could plausibly result in additional areas of shallow, pooled or slow flowing water, creating further suitable breeding habitat for Hochstetter's frog.

Table 7.2. Summary of the ecological value and magnitude of effects assignments for native frogs occupying the streams and forests above the proposed Wharekirauponga Underground Mine.

Ecological attribute	Ecological value	Potential effect	Magnitude of effect
Archey's & Hochstetter's frogs	High	**Impacts on frog distribution & abundance** • The Wharekirauponga Underground Mine's ZOI covers a very small proportion of the total area occupied by native frogs in Wharekirauponga catchment and the Coromandel Peninsula.	Low
		Vibration Blast vibrations could potentially cause heightened stress, avoidance behaviours, reduced/ failed reproductive output, and/ or changes in species distribution and species composition. However, measurable effects on frogs are considered unlikely because: • Vibration footprints cover a small proportion of the total area occupied by native frogs in Wharekirauponga and the Coromandel. • Vibrations will be intermittent and are at levels unlikely to result in biological responses that negatively impact frogs and their reproduction, though some uncertainty remains. • Frog populations (both Archey's and Hochstetter's frog) persisted in the vicinity of the historical Golden Cross mine, where similar vibrations from blasts would have been experienced. Some uncertainty remains surrounding frog responses to vibration levels >2 mm/s.	Low
		Dewatering Potential drainage of the shallow groundwater system (groundwater drawdown) could reduce surface water discharges to streams and have a range of ecological effects, some of which could impact frogs (especially stream dwelling Hochstetter's frogs). However, measurable effects on frogs are considered unlikely because: • Reductions in flow and wetted width are unlikely to negatively impact semi-aquatic Hochstetter's frog habitat quantity or quality (i.e., food resources, refuges, breeding habitat) in lower stream catchments, and would not affect higher order catchments where most of the Hochstetter's frog population occurs. • Potential dewatering will have no impact on terrestrial Archey's frogs as their habitat is maintained by surface water, which is not expected to be affected by the mining activities. • Groundwater level recovery expected. E.g., 9% recovery 10 years following cessation of pumping, and full recovery at 20–30 years. Groundwater recovery would occur within the lifespan of a Leiopelmatid frog.	Low

7.3 LEVEL OF EFFECT

The level of effect was assessed using the risk matrix approach that considers ecological value(s) and magnitude of effect(s), as per Table 10 of the EIANZ guidance (Appendix A). Level of effect was initially assessed before measures to avoid, remedy, or mitigate potential adverse effects were applied (Table 7.2). Recognising a level of uncertainty exists surrounding the scale and magnitude of possible outcomes for native frogs, a project-wide mitigation package has been proposed to manage the potential for residual adverse effects associated with the Wharekirauponga Underground Mine.

An outline of the proposed mitigation package for native frogs is provided by RMA Ecology (2025) and detailed further in other technical reports (Boffa Miskell 2025a, b), but in general, the package will include:

1. 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;
2. Offset – 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 level of effect was then assessed after the application of the measures to reduce potential adverse effects listed above, and this is also presented in Table 7.3.

It is also important to highlight that OGNZL's technical experts consider that the management response proposed for native frogs (as per RMA Ecology 2025) will provide a demonstrable net benefit for these species (RMA Ecology 2025; Boffa Miskell 2025b and references sited with), and as such the (low) overall level of effect on native frogs is likely conservative.

Table 7.3. Level of effect before and after mitigation measures.

Ecological attribute	Ecological value	Potential effect	Magnitude of effect	Level of effect (before mitigation)	Level of effect (after mitigation)
Archey's & Hochstetter's frog	High	Distribution & abundance	Low	Moderate	Very low
		Vibration	Low	Moderate	Low (acknowledging uncertainty of effects above 2 mm/s vibration)
		Dewatering	Low	Moderate	Very low

8 SUMMARY OF POTENTIAL MINING EFFECTS ON LEIOPELMATID FROGS

Based on the information presented in this report, it is considered highly unlikely that measurable adverse effects on Leiopelmatid frogs inhabiting the forests and stream habitats above the Wharekirauponga Underground Mine would result from mine-associated blast vibrations or dewatering. While the potential overall level of effect is considered low, some uncertainty remains regarding the scale and magnitude of possible outcomes, and a zero-risk assumption is not supported by the available evidence.

As a precautionary measure, OGNZL has proposed a comprehensive habitat enhancement programme across the project area and its surroundings (including areas of high value frog habitat) to address uncertainties regarding potential effects on native frogs. This habitat enhancement programme will include elements of mitigation (i.e., intensive pest control within 314 ha of the WUG surface footprint, offset (i.e., intensive pest control within 318 ha of habitat for native frogs to the east and west of WUG), and compensation (i.e., financial support for researcher programmes). The enhancement programme will also address other potential impacts on frogs—such as those associated with light, noise, water quality, air pollution, and biotic factors (e.g., vegetation changes)—that have been identified and assessed in detail by other experts (Boffa Miskell 2025a). Overall, it is considered that the management response proposed for native frogs (see RMA Ecology 2025) will provide a demonstrable net benefit for both Archey's and Hochstetter's frogs (RMA Ecology 2025; Boffa Miskell 2025b).

9 ONGOING MONITORING

It is recommended that ongoing monitoring of activities such as blasting, dewatering, and potential affected biological communities be carried out over the life of the mine as good practice. Data collected from rigorous monitoring will help validate the expected project outcomes for frogs.

9.1 VIBRATION MONITORING WUG

Vibration monitoring for blasting will be carried out over the life of the Wharekirauponga Underground Mine. A description of the proposed monitoring programme is provided by Heilig & Partners (2024) and further details will be outlined in a Vibration Management Plan that will be developed to guide actions around monitoring vibration levels, including comparing vibrations to permissible criteria, adaptive modelling, and adjusting monitoring site locations to achieve accurate modelling of surface vibration levels.

9.2 FROG MONITORING

It is recommended that a monitoring programme for both Archey's and Hochstetter's frogs be established and implemented following a Before-After Control-Impact (BACI) design. The monitoring programmes should aim to measure frog occupancy and/ or abundance both within the Wharekirauponga catchment and outside ('control' areas) prior to, during, and post-mining activities associated with the Wharekirauponga Underground Mine. The monitoring programmes should be designed by a biometrician(s) in consultation with a herpetologist(s) to ensure the programme can be feasibly implemented in the field and has statistical rigour.

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12 APPENDICES

12.1 APPENDIX A. 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

Auckland

Address | Level 4, 68 Beach Road, Auckland 1010

Post | PO Box 2027, Shortland Street, Auckland 1140, New Zealand

Ph | 64 9 379 9980

Fax | +64 9 377 1170

Email | contact-us@babbage.co.nz

Hamilton

Address | Unit 1, 85 Church Road, Pukete, Hamilton 3200

Post | PO Box 20068, Te Rapa, Hamilton 3241, New Zealand

Ph | +64 7 850 7010

Fax | +64 9 377 1170

Email | contact-us@babbage.co.nz

Christchurch

Address | 128 Montreal Street, Sydenham, Christchurch 8023

Post | PO Box 2373, Christchurch 8140, New Zealand

Ph | +64 3 379 2734

Fax | +64 3 379 1642

Email | solutions@babbage.co.nz

Babbage Consultants Australia Pty Ltd – Australia

Address | Suite 4, Level 2, 1 Yarra Street, Geelong,

Victoria 3220, Australia

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ATTACHMENT 5

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Preliminary Investigation of Dust Generation in Granite Quarry

Mumini Babatunde Saka[a], Mohd Hazizan Mohd Hashim[b*]

[a b] *School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia, Penang,14300, Malaysia.*

Abstract

Dust dispersion from granite surface quarries substantially influences the health of workers and nearby neighbourhoods. A preliminary study was conducted at a granite quarry to investigate the factors that contribute to the emission of dust in granite surface quarries and to develop effective dust control measures. The particulate matter from areas within the site was measured using a Handheld Laser Particle Counter Model 3887. The preliminary results revealed the presence of PM0.3, PM0.5, and PM5.0 at their least value of 4.85×107µm/m^3, 1.18×107µm/m^3, and 2.83×104µm/m^3 respectively. While, the highest value ranges of 6.22×107µm/m^3, 7.68×106µm/m^3, and 9.89×103µm/m^3 respectively, and is considered to be beyond hazardous. The preliminary readings indicate that the air quality is extremely poor and that there is a high risk of health problems, even for healthy people. The initial results of this study suggest that dust generation in granite surface quarries is a complex process influenced by various factors, including the type of rock being quarried, the blasting methods used, and the prevailing meteorological conditions. To better understand the factors that contribute to dust generation and to devise effective dust control measures, additional research is required.

Keywords: Particulate Matter, Environment, Health

1. Introduction

The intricate composition of gases in the Earth's atmosphere has recently been significantly altered [1]–[3]. This unfavourable status of atmospheric elements due to the accumulation of pollutants is primarily attributable to human activities ranging from domestic energy utilization to large-scale industrial operations. A serious worldwide environmental problem that affects both industrialized and developing countries is air pollution [4]–[6]. As a result of the variety of sources, the influence of air pollution on human health and safety is highly complicated, resulting in a wide range of effects.

The emission of particulate matter (PM) from quarries is notable, notwithstanding the identification of power stations, cement factories, refineries, petrochemical facilities, and mines as significant producers of air pollution [7]–[11]. The impacts of dust emissions originating from quarries encompass local and regional scales. Meanwhile, [12] opined that the detrimental effects of air pollution and ground vibration resulting from blasting, crushing, and releasing harmful gases have adverse consequences on human health and overall welfare.

However, the importance of granite quarrying cannot be overemphasized due to its highly valued for its durability, aesthetic appeal, and versatility in architectural and infrastructural applications. Its use extends to various construction projects, from residential countertops and flooring to massive infrastructure developments like bridges and buildings. As the demand for granite continues to rise globally, so does the scale of granite quarrying operations. Consequently, Saka and Hashim [13] said the environmental and health impacts of dust generation in granite quarries have gained increasing attention from researchers, environmental agencies, and communities near these operations. If these emissions are not handled properly, has the potential to have major public health and toxicological, environmental, operational, and safety consequences for quarry workers and the surrounding community [14], [15]. Dust from surface mining is generated by the applied force to materials during cost-effective extraction, handling, processing, storage, and transportation operations[16]–[18].

Dust emissions from quarrying can have far-reaching effects, affecting the quarry site, the nearby environment, and public health. PM of varying sizes, from fine to coarse, constitutes a significant portion of quarry dust emissions. When dispersed in the air, these particles can be transported over substantial distances, impacting air quality and posing hazards to the respiratory health of nearby communities.

Dust generation and dispersion are critical concerns in atmospheric quality modelling for surface mines. This necessitates the monitoring, safeguarding, and managing of air pollution to ensure the mining sector's long-term sustainability [19].

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In a recent study conducted by [20], it was found that the inhalation of airborne dust particles might lead to respiratory complications. These complications encompass chronic lung ailments, such as silicosis, and acute symptoms like coughing and wheezing. Similarly, Requena-Mullor and colleagues [21] have stated that silicosis represents a significant occupational health risk. This condition arises from prolonged exposure to the inhalable crystalline silica present in granite dust. The research aimed to preliminarily investigate the correlation of dust generated during quarry activity with meteorological data.

2. Material and Method

The two types of granite found in the studied area are A-type and S-type granite. The A-type comprises Alkaline granite rich in alkali feldspar, quartz, and sometimes minerals like muscovite. It often has a pink, reddish, or greyish colour. The S-Type has Slightly peraluminous granite containing significant amounts of muscovite, biotite, and aluminium-rich minerals. It tends to be light-coloured. The PM at the blasting operations was monitored using a Handheld Laser Particle Counter Model 3887 (KANOMAX), and the area's meteorological information was considered.
The measuring device was stationed 100 meters away from the blasting area. This device can measure three PM diameter sizes of 0.3, 0.5, and 5.0 in micrometers at the same time and log their readings against their sizes separately. The measured PM sizes were correlated and used to establish the existence of PM5.0µm using MATLAB (a simple econometric analysis).

3. Results and Discussions

The device used to monitor PM revealed the presence of three different PM diameters such as PM0.3µm, PM0.5µm, and PM5.0µm.

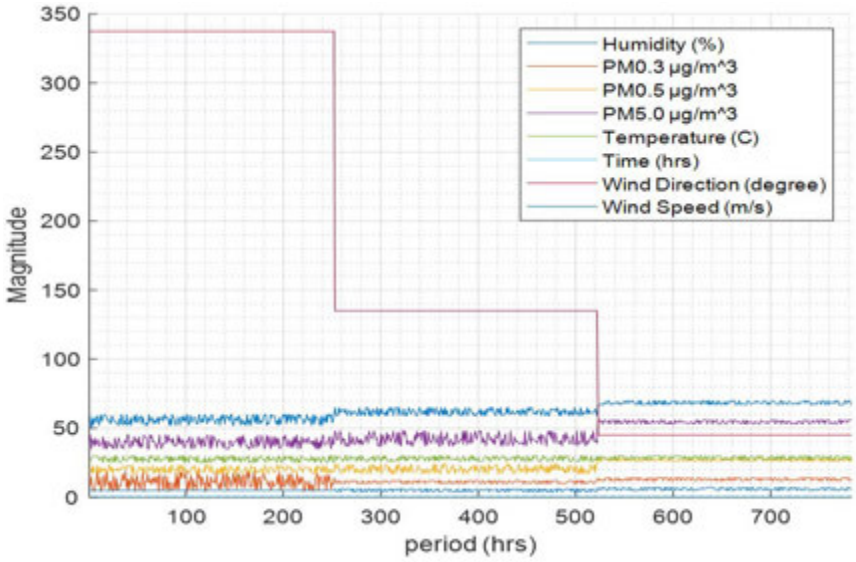


Fig. 1. Time series plot.

As shown in Fig. 1, the impact of humidity on the generation of PM is of considerable importance. Elevated levels of humidity have the potential to cause the condensation of water vapour onto PM particles. The phenomenon under discussion is commonly referred to as hygroscopic growth. When water vapour undergoes condensation onto PM particles, it increases its size and mass. This phenomenon can potentially augment their mass and dimensions, reducing their propensity to remain in a state of suspension within the atmosphere. The transportation of PM is also influenced by humidity which corroborates the assertions made by [22]–[26]. When PM particles undergo hygroscopic

development, their size increases, which may enhance their propensity to settle due to the augmented weight and this was supported by Izzotti et al. [27]. As a result, elevated humidity levels can play a role in eliminating PM from the atmosphere by gravity settling and rainout. Conversely, elevated humidity levels can induce the agglomeration of PM particles, resulting in bigger aggregates that may pose greater difficulty in their removal from the atmosphere, particularly in the absence of rainfall to facilitate their washout as observed by [28]. Temperature significantly influences the dispersion and containment of particulate matter (PM). During periods of low temperature, the atmospheric air has a higher density than in periods of high temperature. The presence of cold air tends to confine PM particles closer to the earth's surface.

On the other hand, elevated temperatures have the potential to generate thermal updrafts, resulting in the upward movement of air. The upward movement of updrafts can facilitate the vertical transport of PM particles, enabling their dispersion into higher layers of the atmosphere. Under such circumstances, PM can disperse over greater distances before deposition and this conforms with the affirmation of some groups of researchers [29]–[33].

Therefore, wind speed, which greatly affects the dispersion of particulate matter (PM), was measured using a HOBO system. However, [34] opined that in situations characterized by low wind speeds, the accumulation of PM particles near their emission sources is observed due to the insufficient kinetic energy the wind possesses to disperse these particles adequately. This phenomenon has the potential to result in localized areas with elevated levels of PM, especially in metropolitan regions characterized by restricted air circulation. Wind-induced resuspension can also dislodge PM particles that have previously settled on various surfaces. Powerful winds can agitate PM and dust from many sources, such as highways, construction sites, and other exposed surfaces, causing their re-entry into the atmosphere. PM transportation can be facilitated by increased wind velocities, resulting in the particles being transported over greater distances. The significance of this issue is especially evident in the context of the long-distance transportation of PM pollution between different geographical areas.

It is imperative to acknowledge that the interplay among these components exhibits considerable intricacy and is subject to variation contingent upon geographical location, local meteorological circumstances, and the precise origins of PM. Furthermore, the dimensions and constituents of PM particles also influence their behaviour in response to humidity, temperature, and wind velocity disparities, this was supported by [35]–[38]. A thorough understanding of these interconnections is essential in effectively controlling air quality and addressing the PM pollution's adverse health and environmental consequences.

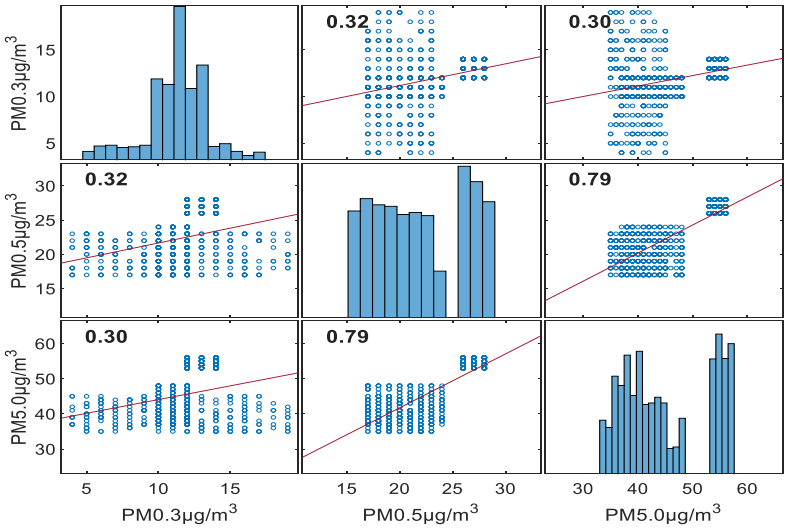


Fig. 2. Correlation matrix.

It can be seen in Fig. 2 that the line depicted in red illustrates the average correlation between PM0.5µg/m^3 and PM5.0µg/m^3 concentrations. This implies a broad pattern or reference point for the correlation between the two variables. The data points depicted in Fig. 2 correspond to the empirically observed measurements of PM0.5µg/m^3 and PM5.0µg/m^3 concentrations at various times. The presented data points demonstrate the empirical variety

observed in the association between the two variables in real-world scenarios. Shown in Fig. 2 illustrates a positive association between the PM0.5µg/m3 levels and PM5.0µg/m^3. This implies that an elevated PM0.5µg/m3 concentration is associated with a correspondingly increased PM5.0µg/m3 concentration. The two variables have a positive correlation of 79%.

The Fig. 2 also demonstrates a notable degree of variability in the correlation between PM0.5µg/m^3 and PM5.0µg/m^3. The observed fluctuation implies that there are additional factors that exert an influence on PM concentrations. Several factors that could potentially influence PM levels include the particular sources of PM, prevailing weather conditions, and the time of year. Summarily, Fig. 2 presents evidence of a positive connection between PM0.5µg/m^3 and PM5.0µg/m^3, suggesting that an increase in the other typically accompanies an increase in one variable. Nevertheless, the observed variability in the correlation underscores the intricate nature of the variables that impact PM concentrations in the atmosphere. Comprehending and addressing the health consequences of PM necessitates the comprehensive examination of these variables and their interrelationships, alongside implementing strategies aimed at curtailing PM emissions originating from diverse sources.

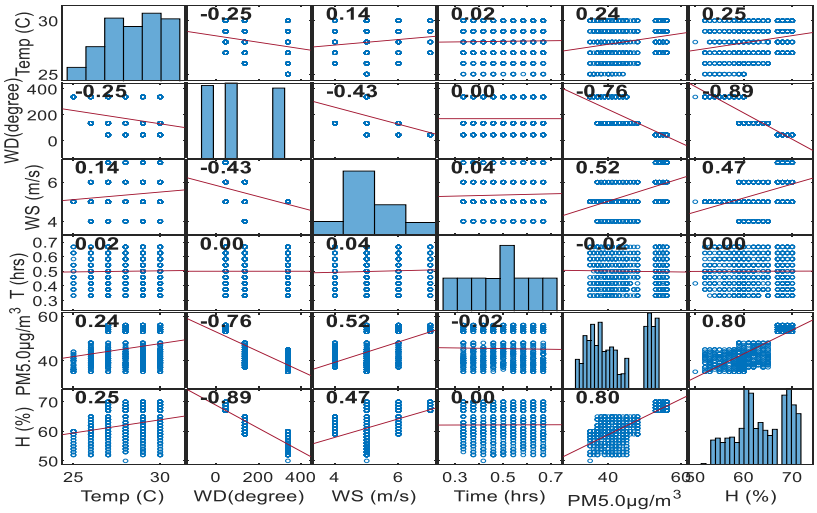


Fig. 3. Correlation with meteorological data.

As seen in Fig. 3, it is evident that there is a correlation between the targeted PM5.0µg/m^3 and wind speed (WS) of approximately 52% and a correlation relationship of 47% between humidity (H) and wind speed (WS). Hence, there is an 80% correlation between the PM5.0µg/m^3 and humidity. Given this, it could be deduced from Fig. 3 that humidity and wind speed influence the existence of PM5.0µg/m^3. Alternatively, a significant negative correlation of -76% was observed between wind direction (WD) and the presence of PM5.0µg/m^3.

4. Conclusion and Recommendation

This preliminary study underscores the instrumental role of wind dynamics and humidity in shaping PM5.0µg/m^3 concentrations in our environment. The relationship showcases notable variations, shedding light on the multifaceted influences on PM atmospheric concentrations. To effectively grasp the health ramifications of PM, it's imperative to study these influences and their interconnected dynamics holistically. Such insights pave the way for devising efficacious approaches to reduce PM emissions from an array of sources.

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EXHIBIT C

7 October 2026

Carmen Borg
Shute, Mihaly & Weinberger LLP
396 Hayes Street
San Francisco, CA 94102
borg@smwlaw.com

Subject: CEMEX Rockfield Modification Project, Fresno County, CA
Acoustical Comments on Final Environmental Impact Report Response to Comments
Salter Project 25-0038

Dear Carmen:

As requested, we reviewed responses to comments provided with the final environmental impact report (FEIR) for the subject Project. We focused on the responses to our 7 March 2025 comment letter. In summary, the responses do not adequately address the concerns we raised regarding the protection of nearby people and wildlife from future noise and vibration. The FEIR made minimal changes to the noise analysis and our prior comments remain applicable. Further detail is provided below.

RESPONSES 58C-3 THROUGH 58C-12

Our related comments focused on the blasting impact analysis thresholds that fail to adequately address human disturbance at nearby sensitive receptors. The analysis in the DEIR focused solely on damage criteria instead. Therefore, nearby residences and recreational areas could be exposed to excessive vibration that could be startling and disruptive, resulting in complaints, and result in a significant impact under CEQA. We provided several references indicating that vibration thresholds for human response and comfort/disruption should be more strict than vibration thresholds for building damage.

In responses to comments, the FEIR largely aims to dismiss the references that we provided in our comments. Even so, an updated "Technical Note on Threshold of Significance for Human Response" (Vibra-Tech Report)[1] was provided to develop a new vibration analysis threshold. This new study identified a peak particle velocity of 0.6 as a threshold of significance for blast-induced ground vibrations, as referenced below.

[1] Dated 29 April 2026, by Vibra-Tech

"The peak vibration tolerated by humans in a residence or office is 0.50 or 0.71 in/sec respectively. Comparing the research described in the preceding section with the 2004 Caltrans study and the ANSI standards, an appropriate significance threshold for human response to blast-induced ground vibrations from the proposed Rockfield Quarry is a peak particle velocity of 0.60 inches/second. This threshold falls between the two ANSI standards and is at the lower end of the "strongly perceptible to mildly unpleasant."

This threshold is only slightly below the original DEIR significance threshold related to building damage. This new threshold is provided as a compromise or an average level between the ANSI standards of 0.5 and 0.71 for human response to impulsive vibration for residences and offices, respectively. However, the Vibra-Tech report provides no justification why an office standard is being considered here. The nearby receptors are residences and a residential standard should apply.

At a minimum, the blasting-induced vibration significance threshold should be reduced to 0.5 PPV in/sec to align with the ANSI standard for impulsive vibration in residences during daytime hours. An office standard is not applicable to residences. This would also move the threshold below the "strongly perceptible to mildly unpleasant" human response category listed in the 2004 Caltrans study. Based on our previous comments, blast induced vibration should be limited to a threshold within the "distinctly perceptible to strongly perceptible" human response category, ranging from 0.1 to 0.5 PPV in/sec, per the 2005 Caltrans study. With a more appropriate human response threshold between 0.5 PPV in/sec and 0.1 PPV in/sec, the project would result in a significant impact and further mitigation would be applicable.

RESPONSES 58C-13 THROUGH 58C-16

Our related comments focused on processing operations that were projected to exceed noise impact thresholds. The proposed operational noise mitigation in the FEIR is inadequate because it fails to require specific noise reduction measures prior to commencing operations. The proposed mitigation would only be required if operational noise was shown to exceed the thresholds, via monitoring or complaints. The Project must not take a "wait-and-see" approach with a lengthy retrofit process that would follow complaints. The FEIR Response 58C-13 claims that this is not a deferred mitigation strategy, as excerpted below:

"Rather than deferring mitigation, as stated in the comment, the Draft EIR mitigation measures are tied to performance standards that would ensure that appropriate noise mitigation measures are implemented for the project to reduce the project sites' noise levels to a less than significant impact."

However, this simply isn't true. If adequate mitigation is not required if the FEIR, if it is optional pending a future comparison to the performance standard, then it is a deferral of mitigation. I am not able to evaluate or comment on the effectiveness of the deferred mitigation because the FEIR fails to identify the reduction in noise that would be achieved with each of the options listed. I see no reason why the EIR cannot identify, discuss, and select a mitigation measure for noise impacts prior to project approval.

RESPONSES 58C-17 THROUGH 58C-18

Our comments focused on the DEIR's failure to fully analyze the noise and vibration impact of the Project on wildlife. Beyond the impact analysis for fish, the DEIR includes no noise or vibration thresholds, analysis, or mitigation for other wildlife in nearby areas. In particular, an analysis of blasting noise, vibration, and "airblast" should be included.

In Response 58C-17 and 58C-18, the FEIR states that "The duration of a blast is one second. As such, a blasting event is not anticipated to be disruptive for wildlife." This claim that the short duration of blast noise and vibration justifies a claim of no significant impact is completely unjustified and untrue. It indefensibly aims to disregard our comments, and as such, our comments remain unaddressed.

* * *

Should you have any questions, please call.

Best,

SALTER



Jeremy L. Decker, PE
Vice President

P/2026-10-07 Acoustical FEIR Comments 25-0038 Cemex

EXHIBIT D

ENVIRONMENTAL PERMITTING SPECIALISTS
Air Quality • Permitting • OHSA • RMP/PSM

TECHNICAL MEMORANDUM

To: Carmen J. Borg
Urban Planner
Shute, Mihaly & Weinberger, LLP

Date: October 06, 2026

From: Ray Kapahi RK
Tel: 916-806-8333
E-Mail: ray.kapahi@gmail.com

Subject: Review of Air Quality Section of the Final Environmental Report (FEIR)
CEMEX Rockfield Quarry, Fresno County, California

Per your request, I have reviewed the FEIR for the proposed CEMEX Rockfield Quarry expansion with a focus on impacts to air quality and public health. Specifically, I reviewed Appendix D-3 (Air Quality, Health Risk, and Climate Change[1]) and Appendix D-4 (Rev. Section 4.3 Air Quality ERRATA[2]).

My review focused on the accuracy, completeness, assumptions and conclusions related to air quality that appear in these documents.

[1] SESPE (2026):" Air Quality, Health Risk, and Climate Change" Revised May 13, 2026. Available at: https://www.fresnocountyca.gov/files/sharedassets/county/v/1/public-works-and-planning/development-services/environmental-impact-reports/cemex-rockfield-expansion/feir/rmp-7736-feir-vol.-ii-appendix-d-3-revised-aqhrccia.pdf

[2] SESPE (2026): "4.3 Air Quality". Available at: https://www.fresnocountyca.gov/files/sharedassets/county/v/1/public-works-and-planning/development-services/environmental-impact-reports/cemex-rockfield-expansion/feir/rmp-7736-feir-vol.-ii-appendix-d-4-rev.-section-4.3-air-quality_errata.pdf

My findings are as follows:

Significance Criteria for Air Quality Impacts

The document references the thresholds of significance that appear in the San Joaquin Valley Air Pollution Control District's (SJVAPCD) Guidance for Assessing and Mitigating Air Quality Impacts (GAMAQI) as the basis for determining the significance of impacts to air quality.

The SJVAPCD guidance is not the only criteria for determining the significance of air quality impacts. If the project violates an ambient air quality standard or causes new violations that interfere with the attainment of a standard, then impacts are also considered significant.

As discussed below, the project would lead to new violations and would violate the 1-hour ambient air quality standard for oxides of nitrogen (NOx). Under the federal Clean Air Act[3], any project emissions that lead to an exceedance of the ambient air quality standards is considered a violation and therefore, is considered a significant impact.

Understated Project Impacts

The revised air quality analysis (FEIR Appendix D-3) distinguishes between sources that are subject to SJVAPCD permits and sources that are permit exempt. The analysis references GAMAQI thresholds as a basis for determining project impacts separately for these two categories of emissions. See for example, Table ES1 from Appendix D-3 shown below.

Table ES1. Annual Project Emissions and Comparison to APCD Significance Criteria

Criteria Pollutant	Permit – Required Sources (tons/yr)			Permit - Exempt Sources (tons/yr)		
	Project	Significance Criteria	Project Exceeds?	Project	Significance Criteria	Project Exceeds?
ROG	6.2	10	No	-0.1	10	No
CO	34.3	100	No	49.4	100	No
NO_X	3.4	10	No	5.2	10	No
PM_{10}	9.8	15	No	-25.4	15	No
$PM_{2.5}$	2.9	15	No	-6.3	15	No
SO_X	0.9	27	No	1.4	27	No

Source: Appendix G.

Note: Negative values represent emissions reductions due to newer technology and lower emission equipment as would be expected from phase in of existing engine regulations.

GAMAQI thresholds apply to total emissions from all sources. The GAMAQI does not distinguish between permitted or non-permitted sources. This means that emissions from both permitted and non-permitted should be added and the sum total and should be compared with the thresholds of significance. By separating emissions from permitted v. non-permitted sources, the FEIR understates actual project impacts.

[3] CAA (1970): 42 USC Section 7401 et seq. Available at: https://www.epa.gov/laws-regulations/summary-clean-air-act

Ambient 1-Hour Federal NO_2 Standard Violated for Operational Phase

The maximum hourly NOx emissions reported in Table 4.3-15 (Appendix D-4) would violate the 1-hour federal NO_2 standard of 188 ug/m^3. See Table 1 for a copy of the ambient air quality standards.

Table 4.3-15 reported 7 lbs/hr NOx emissions from stationary sources and 28.2 lbs/hr from permit exempt sources or a total of 35.2 lbs/hr.

I used the AERMOD dispersion model with 5 years of weather data from Fresno airport to calculate the 1-hour concentration of NOx to determine if the ambient standards would be violated. Emissions were modeled as a single area source (Figure 1) and is based on review of Appendix D-3 (Figure 9). Figure 2 depicts the modeling area used in my calculations. The resulting 1-hour NOx concentration is shown in Figure 3. Overall, the 1-hour NOx standard would be violated by a substantial margin over a wide area around the project site. This exceedance of the ambient air quality standards is a violation of the Clean Air Act and is considered a significant impact under CEQA.

A modeling analysis of 1-hour NOx emissions was included in Appendix D-4. However, this was limited to stationary (permitted) sources. Those results (Table 4.3-23) indicated a maximum impact of 79.93 ug/m^3. These results are not based on the total NOx emissions (permitted + permit exempt sources) and therefore understate the actual impacts.

Exposure to nitrogen dioxide harms the lungs causing irritation, coughing and worsening of asthma. Children, the elderly and those with respiratory issues are most at risk. In addition, NO_2 forms harmful secondary air pollutants such as ozone (smog) and fine particulate that worsen respiratory and cardiovascular problems.

It should also be noted that project level NOx emissions are the main contributor to the formation of smog (ozone). Fresno County has been classified as “Severe Non-Attainment for the federal 8-hour ozone standard. High concentrations of ozone lead to increased levels of asthma and other respiratory diseases. The very young and the elderly are most at risk from these air pollutants. operational phase. Therefore, the project would result in undisclosed significant impacts related to a significant increase in a criteria pollutant for which the project region is in non-attainment.

Table 1
Ambient Air Quality Standards

Ambient Air Quality Standards						
Pollutant	Averaging Time	California Standards [1]		National Standards [2]		
		Concentration [3]	Method [4]	Primary [3,5]	Secondary [3,6]	Method [7]
Ozone (O_3)[8]	1 Hour	0.09 ppm (180 µg/m^3)	Ultraviolet Photometry	—	Same as Primary Standard	Ultraviolet Photometry
	8 Hour	0.070 ppm (137 µg/m^3)		0.070 ppm (137 µg/m^3)		
Respirable Particulate Matter (PM10)[9]	24 Hour	50 µg/m^3	Gravimetric or Beta Attenuation	150 µg/m^3	Same as Primary Standard	Inertial Separation and Gravimetric Analysis
	Annual Arithmetic Mean	20 µg/m^3		—		
Fine Particulate Matter (PM2.5)[9]	24 Hour	—	—	35 µg/m^3	Same as Primary Standard	Inertial Separation and Gravimetric Analysis
	Annual Arithmetic Mean	12 µg/m^3	Gravimetric or Beta Attenuation	12.0 µg/m^3	15 µg/m^3	
Carbon Monoxide (CO)	1 Hour	20 ppm (23 mg/m^3)	Non-Dispersive Infrared Photometry (NDIR)	35 ppm (40 mg/m^3)	—	Non-Dispersive Infrared Photometry (NDIR)
	8 Hour	9.0 ppm (10 mg/m^3)		9 ppm (10 mg/m^3)	—	
	8 Hour (Lake Tahoe)	6 ppm (7 mg/m^3)		—	—	
Nitrogen Dioxide (NO_2)[10]	1 Hour	0.18 ppm (339 µg/m^3)	Gas Phase Chemiluminescence	100 ppb (188 µg/m^3)	—	Gas Phase Chemiluminescence
	Annual Arithmetic Mean	0.030 ppm (57 µg/m^3)		0.053 ppm (100 µg/m^3)	Same as Primary Standard	
Sulfur Dioxide (SO_2)[11]	1 Hour	0.25 ppm (655 µg/m^3)	Ultraviolet Fluorescence	75 ppb (196 µg/m^3)	—	Ultraviolet Flourescence; Spectrophotometry (Pararosaniline Method)
	3 Hour	—		—	0.5 ppm (1300 µg/m^3)	
	24 Hour	0.04 ppm (105 µg/m^3)		0.14 ppm (for certain areas)[11]	—	
	Annual Arithmetic Mean	—		0.030 ppm (for certain areas)[11]	—	
Lead[12,13]	30 Day Average	1.5 µg/m^3	Atomic Absorption	—	—	High Volume Sampler and Atomic Absorption
	Calendar Quarter	—		1.5 µg/m^3 (for certain areas)[12]	Same as Primary Standard	
	Rolling 3-Month Average	—		0.15 µg/m^3		
Visibility Reducing Particles[14]	8 Hour	See footnote 14	Beta Attenuation and Transmittance through Filter Tape	No National Standards		
Sulfates	24 Hour	25 µg/m^3	Ion Chromatography			
Hydrogen Sulfide	1 Hour	0.03 ppm (42 µg/m^3)	Ultraviolet Fluorescence			
Vinyl Chloride[12]	24 Hour	0.01 ppm (26 µg/m^3)	Gas Chromatography			

See footnotes on next page ...

Table 1
Ambient Air Quality Standards
(cont.)

1. California standards for ozone, carbon monoxide (except 8-hour Lake Tahoe), sulfur dioxide (1 and 24 hour), nitrogen dioxide, and particulate matter (PM10, PM2.5, and visibility reducing particles), are values that are not to be exceeded. All others are not to be equaled or exceeded. California ambient air quality standards are listed in the Table of Standards in Section 70200 of Title 17 of the California Code of Regulations.

2. National standards (other than ozone, particulate matter, and those based on annual arithmetic mean) are not to be exceeded more than once a year. The ozone standard is attained when the fourth highest 8-hour concentration measured at each site in a year, averaged over three years, is equal to or less than the standard. For PM10, the 24 hour standard is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 $\mu g/m^3$ is equal to or less than one. For PM2.5, the 24 hour standard is attained when 98 percent of the daily concentrations, averaged over three years, are equal to or less than the standard. Contact the U.S. EPA for further clarification and current national policies.

3. Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based upon a reference temperature of 25°C and a reference pressure of 760 torr. Most measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 torr; ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

4. Any equivalent measurement method which can be shown to the satisfaction of the ARB to give equivalent results at or near the level of the air quality standard may be used.

5. National Primary Standards: The levels of air quality necessary, with an adequate margin of safety to protect the public health.

6. National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

7. Reference method as described by the U.S. EPA. An "equivalent method" of measurement may be used but must have a "consistent relationship to the reference method" and must be approved by the U.S. EPA.

8. On October 1, 2015, the national 8-hour ozone primary and secondary standards were lowered from 0.075 to 0.070 ppm.

9. On December 14, 2012, the national annual PM2.5 primary standard was lowered from 15 $\mu g/m^3$ to 12.0 $\mu g/m^3$. The existing national 24-hour PM2.5 standards (primary and secondary) were retained at 35 $\mu g/m^3$, as was the annual secondary standard of 15 $\mu g/m^3$. The existing 24-hour PM10 standards (primary and secondary) of 150 $\mu g/m^3$ also were retained. The form of the annual primary and secondary standards is the annual mean, averaged over 3 years.

10. To attain the 1-hour national standard, the 3-year average of the annual 98th percentile of the 1-hour daily maximum concentrations at each site must not exceed 100 ppb. Note that the national 1-hour standard is in units of parts per billion (ppb). California standards are in units of parts per million (ppm). To directly compare the national 1-hour standard to the California standards the units can be converted from ppb to ppm. In this case, the national standard of 100 ppb is identical to 0.100 ppm.

11. On June 2, 2010, a new 1-hour SO_2 standard was established and the existing 24-hour and annual primary standards were revoked. To attain the 1-hour national standard, the 3-year average of the annual 99th percentile of the 1-hour daily maximum concentrations at each site must not exceed 75 ppb. The 1971 SO_2 national standards (24-hour and annual) remain in effect until one year after an area is designated for the 2010 standard, except that in areas designated nonattainment for the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.

    Note that the 1-hour national standard is in units of parts per billion (ppb). California standards are in units of parts per million (ppm). To directly compare the 1-hour national standard to the California standard the units can be converted to ppm. In this case, the national standard of 75 ppb is identical to 0.075 ppm.

12. The ARB has identified lead and vinyl chloride as 'toxic air contaminants' with no threshold level of exposure for adverse health effects determined. These actions allow for the implementation of control measures at levels below the ambient concentrations specified for these pollutants.

13. The national standard for lead was revised on October 15, 2008 to a rolling 3-month average. The 1978 lead standard (1.5 $\mu g/m^3$ as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

14. In 1989, the ARB converted both the general statewide 10-mile visibility standard and the Lake Tahoe 30-mile visibility standard to instrumental equivalents, which are "extinction of 0.23 per kilometer" and "extinction of 0.07 per kilometer" for the statewide and Lake Tahoe Air Basin standards, respectively.

Figure 1

Area Sources Used for Modeling NOx Emissions

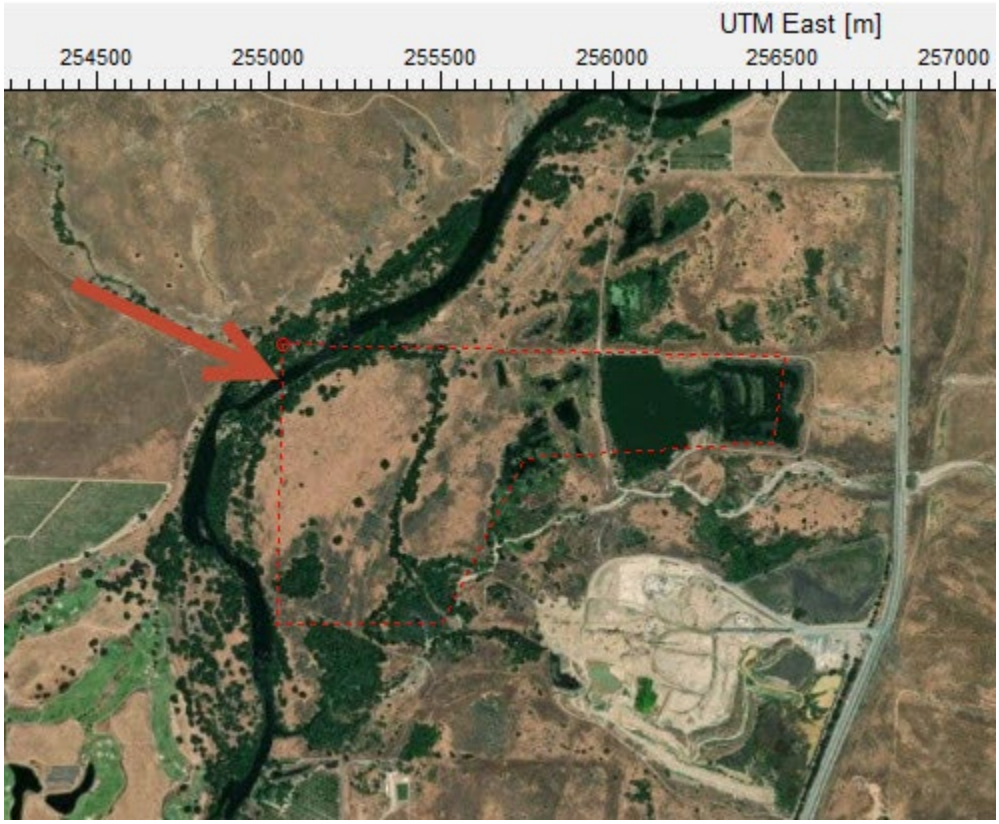


Figure 2

Modeling Grid Used to Calculate NOx Concentrations

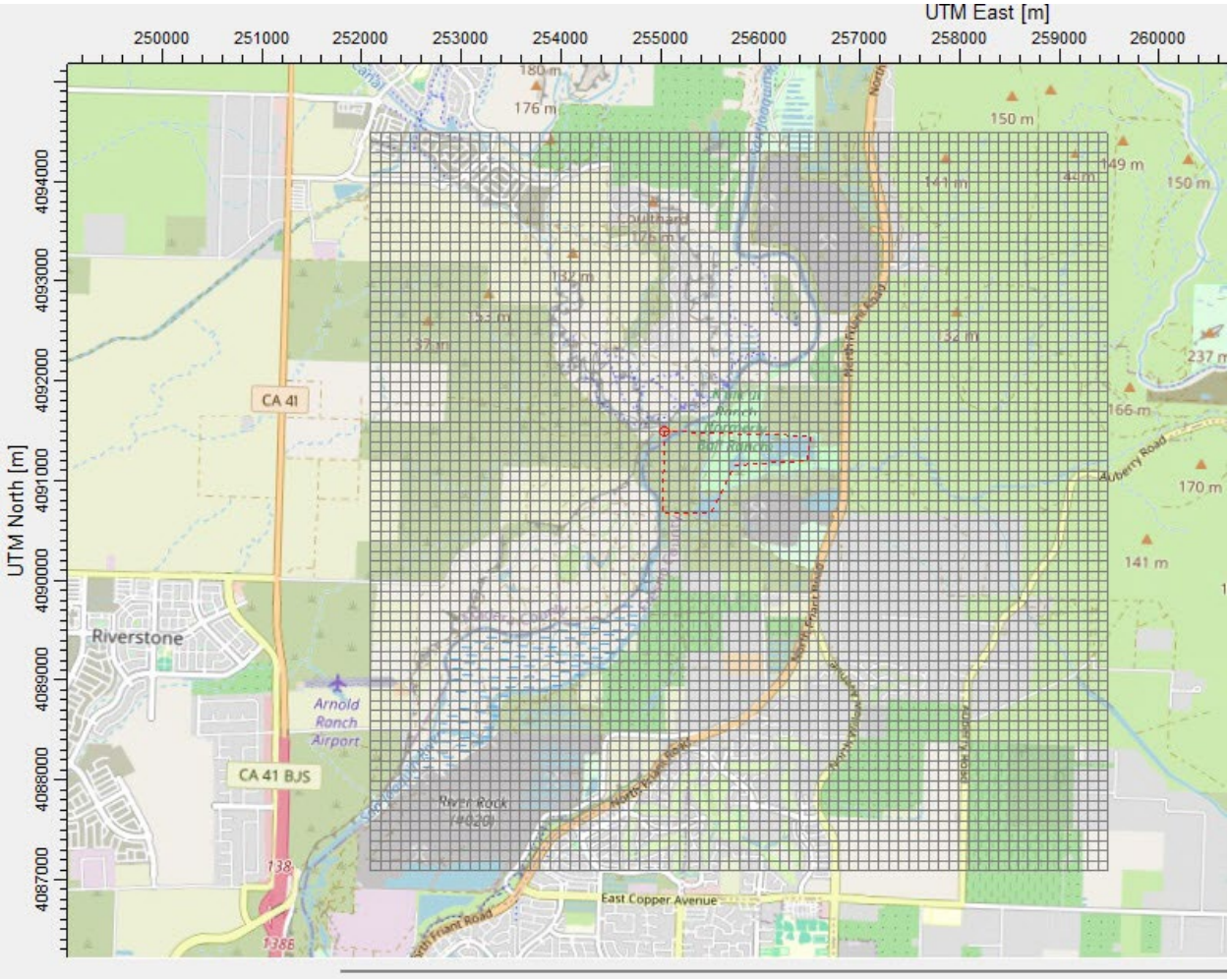
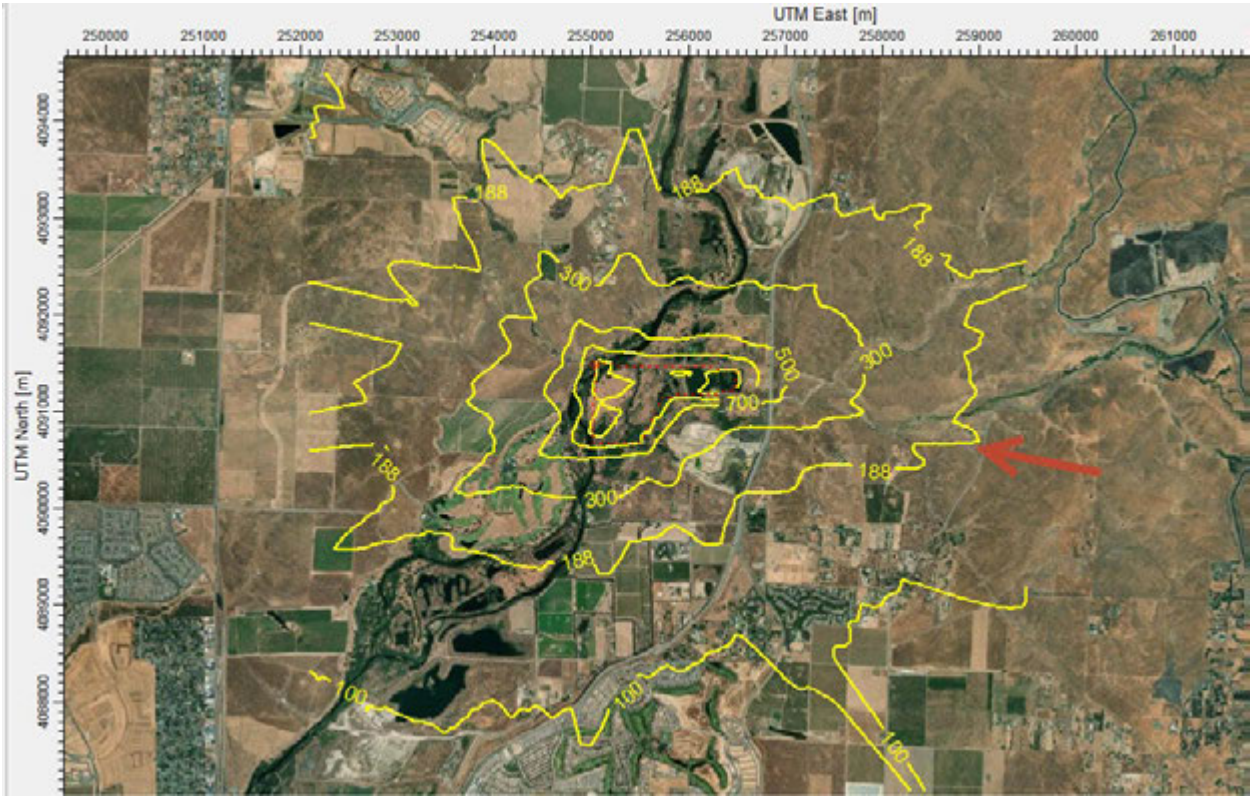


Figure 3

Spatial Distribution of 1-Hour NOx Concentration
(in micrograms per cubic Meter)



Note: Area enclosed by the "188" contour would exceed the 1-hour NOx standard.