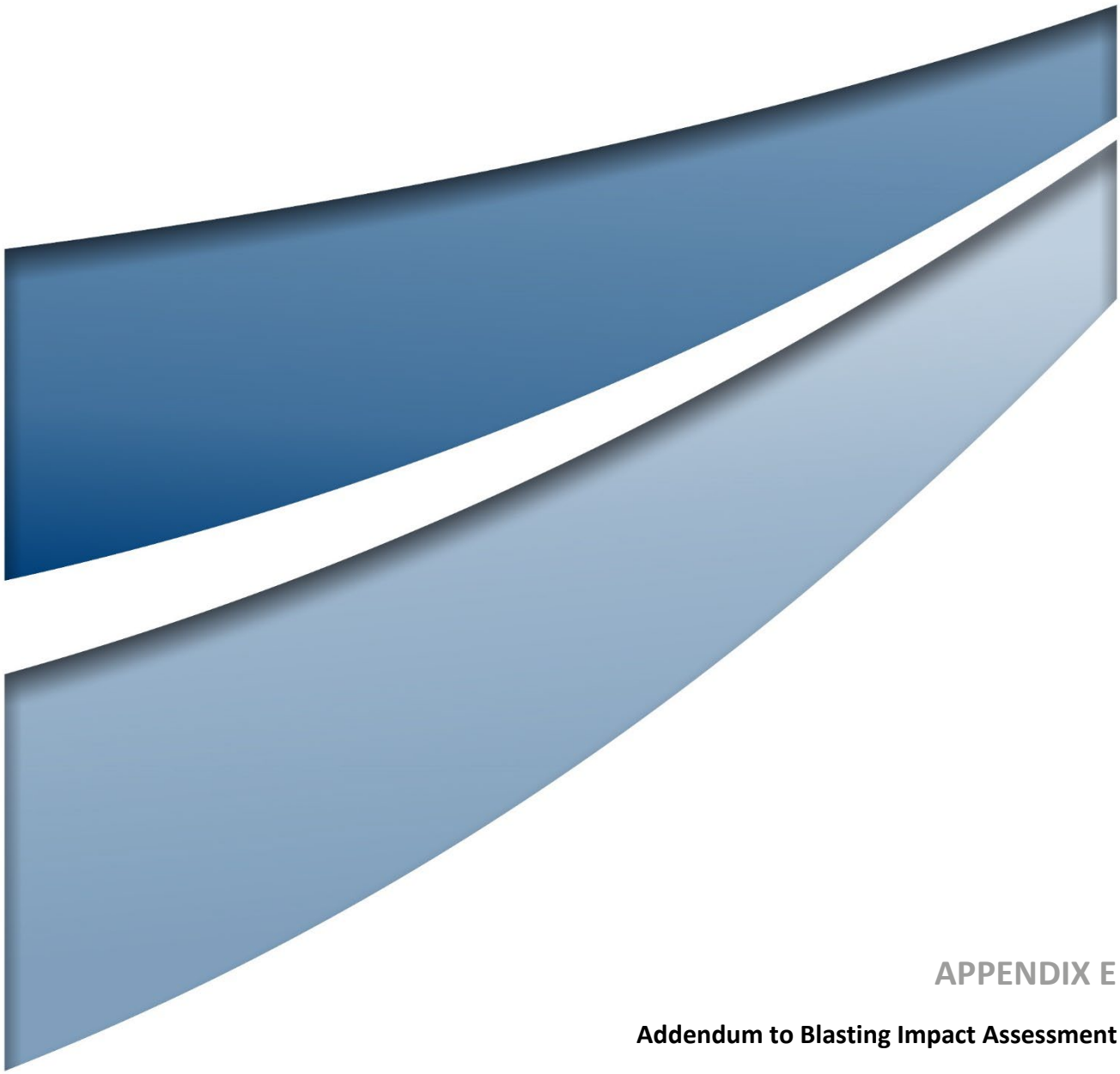

APPENDIX E

Addendum to Blasting Impact Assessment

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ADDENDUM

STONE RIDGE QUARRY (Amended Quarry Plans) – ADDENDUM TO BLASTING IMPACT ASSESSMENT

Prepared for Umwelt (Australia) Pty Ltd on behalf of Australian Resource Development Group Pty Ltd

Document No. UM-2312-201223

DRAFT 4

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20th December 2023

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ADDENDUM

1.0 INTRODUCTION

This is an addendum to the *'Stone Ridge Quarry - Blasting Impact Assessment'* (**ESC (2023a))** prepared by Enviro Strata Consulting Pty Limited (ESC) on behalf of Umwelt (Australia) Pty Limited as part of the Environmental Impact Statement (EIS) to assess the blasting impacts associated with the amended quarry design.

The addendum also addresses potential blast impacts associated with bat colonies located at Balickera Tunnel in response to issues raised during the public exhibition of the Project.

2.0 REVISED BLAST IMPACT ASSESSMENT RESULTS SUMMARY

The Project has been amended resulting in an overall reduction in the size of disturbance area from approximately 79 to approximately 68 hectares associated with a reduction in the quarry extraction area through removal of the North Pit. This amendment has been undertaken as a direct response to issues raised during the exhibition of the EIS and will assist with minimising the impact associated with the Project on the environment and biodiversity with minimal impacts on production.

The updated conceptual quarry layout, location of private residential receivers, infrastructure and heritage items are presented in **Figure 1**.

Based on the revised conceptual quarry layout, the minimum distances to the closest residential receiver (residence R18) and the closest infrastructure (i.e., Balickera Tunnel / Italia Road) have increased by 70 m each and are in the order of 490 and 340 m respectively.

Due to the changes in quarry and associated changes in separation distance to the assessed items, the predicted blast impacts on residential receivers, infrastructure facilities and heritage sites were re-assessed and compared with the applicable ground vibration and/or airblast overpressure criteria as indicated in the corresponding tables, in **Appendix 1**.

The methodology and assessment methods used are consistent with that applied in the original Blast Impact Assessment (**ESC 2023a**).

The result tables are presented in **Appendix 1**. The tables highlight maximum predicted ground vibration and airblast overpressure estimates (where applicable) for private residential receivers (see **Table 1**) and infrastructure and heritage items (see **Tables 2A-B**) based on the four different maximum instantaneous charge (MIC) scenarios considered in the original Blast Impact Assessment (**ESC 2023a**).

2.1 Residences

Based on the revised assessment it is concluded that potential blast impacts from the amended conceptual layout of the Stone Ridge Quarry will be lower than that associated with the original conceptual layout presented in the EIS for most residential receivers and particularly those which are located closer.

All residential receivers located within 1 km of the quarry are predicted to have lower vibration and overpressure levels under the Amended Quarry Design relative to the design assessed in the original BIA. The assessment indicates that only limited blast management measures (in the north western corner of the pit) will be required to satisfy the applicable ground vibration and airblast overpressure criteria with the predictions indicating that a higher MIC of up to 75 kg can now be used without exceeding vibration and overpressure criteria at the closest residence (R18). The assessment indicated that there will be minor increases in predicted vibration levels at receivers to the southeast along Nine Mile Creek Road (R5, R6, R7, R9, R10 and R22) associated with the extended extraction zone to the southeast, however predicted vibration levels at all of these residences remain well below relevant assessment criteria.

2.2 Infrastructure

With respect to infrastructure, modelling indicates that Predicted vibration and overpressure levels associated with the Amended Quarry Design all demonstrate adopted criteria for infrastructure and heritage items can be achieved under all assessed blast charge sizes. Importantly, this includes Hunter Water's Balickera Tunnel, where blast modelling estimated maximum vibration at the tunnel of 10.8 mm/s, which is well below the damage criteria for underground rock strata and concrete material, being in the order of a few hundred mm/s (>200 mm/s). Notwithstanding, a nominal criteria limit of 100 mm/s has been adopted for Balickera Tunnel, with a safety factor being > 10.

2.3 Animals

Within a 2 km radius of the Project, livestock were observed within property R19 and R13. The estimated ground vibration and airblast overpressure impacts for the R19 receptor are no higher than 1.5 mm/s and 106 dBL respectively, while for the R13 receptor are no higher than 1 mm/s and 103 dBL respectively (i.e., below the ANZECC guideline limits). Also, as there are a number of private rural residences in the area, the presence of pet animals on the premises may be expected.

ANZECC guideline limits (ANZECC 1990) which apply to private residences are designed to protect human comfort and, as such, it can be inferred that blasting impacts can be fully managed in relation to livestock and pets/animals within these properties. Studies undertaken to assess potential impacts from blasting on feedlots have identified that blasting impacts have little to no impact on domestic stock (Nelson, 2011). Similar effects would be expected for native fauna and, anecdotally, it is noted that many fauna species have been recorded adjacent to active mining operations where larger and more frequent blasts than those proposed for the Project are undertaken. Due to the periodic (weekly or fortnightly) and very short duration (1 – 2 s) nature of blasting proposed, blasting associated with the Project is not anticipated to have any significant impacts on livestock, domestic or native fauna.

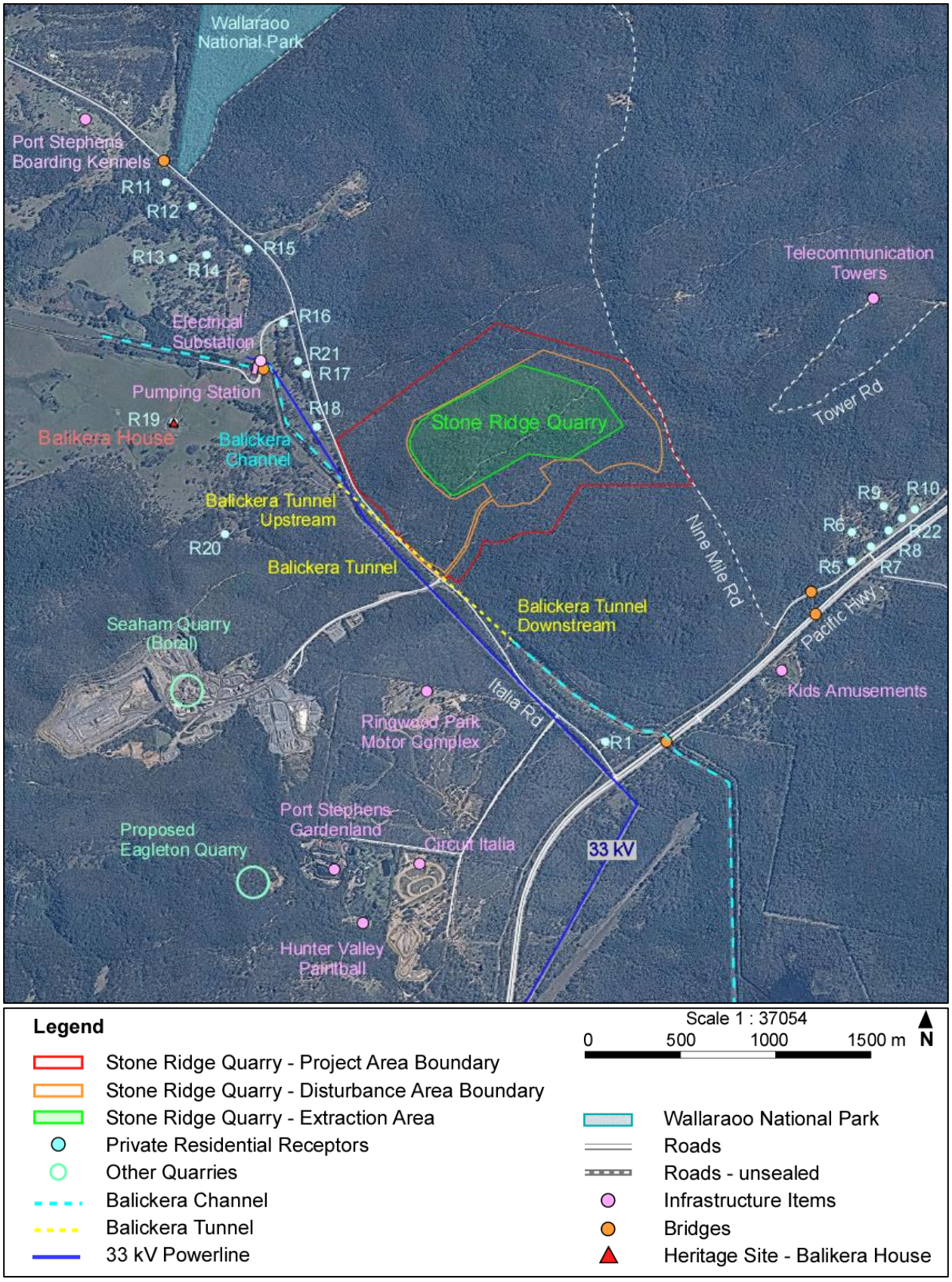

Figure 1 – Locations of Residential Receivers and Infrastructure with Respect to Stone Ridge Quarry

3.0 POTENTIAL IMPACTS ON BATS

The following section addresses comments raised by Biodiversity and Conservation Division (BCD), Hunter Water and Port Stephens Council in relation to potential blast impacts on bat colonies located within Balickera Tunnel.

3.1 Balickera Tunnel Environment

The Balickera Tunnel environment and relevant blasting considerations are outlined in the following sections to facilitate a better understanding of potential implications involved for the bat colonies.

Dynamics of Balickera Tunnel Environment

The Balickera Tunnel environment is an engineered tunnel specifically constructed for conveying water. In this regard, it differs from a sheltered dry cave environment where there is limited, or only occasional presence of sound. It can be postulated that animals living within the presence of ongoing noise, such as the water-transporting tunnel, have adapted to this acoustic environment and therefore their sensory arousal would have adjusted to these noise levels.

The water passing through Balickera Tunnel provides a dynamic and noisy environment because of water constantly bouncing against the tunnel walls inducing continuous noise as well as some wall vibration. Thus, bats inhabiting the tunnel are likely already accustomed to certain levels of sound and ground vibration.

Length and Relative Location of the Tunnel

Balickera Tunnel extends over a length of approximately 1,220 m. Balickera Tunnel is positioned parallel to the extraction area and at a lower reduced level (RL). Different parts of the tunnel will therefore experience different levels of vibration associated with a blast due to variation in separation distance from the point of the blast. To account for this variation, three locations were used for this amended assessment.

Due to the orientation and lower RL of the tunnel, the entries to the tunnel are well shielded from any direct overpressure impact that may result from the Project. No overpressure impacts are predicted within the tunnel due to this shielding. It is noted that overpressure, rather than vibration, is typically identified as the primary cause of animal disturbance, and the absence of this type of impact within Balickera Tunnel is likely to significantly mitigate potential impacts on bats associated with blasting.

The orientation of tunnel effectively precludes any risk of fly-rock entering the tunnel and this is therefore not identified as a potential risk for bats present within Balickera Tunnel.

Blast Frequency / Duration

The proposed blasting is to be undertaken during the daylight hours (i.e., between 9 am to 5 pm) with a maximum frequency of 1 blast per week or 1 blast per fortnight. Only on rare occasions (such as a misfire) would multiple blasts be required on a single day.

Typically, a quarry blast is of short duration, with induced vibrations usually lasting no longer than 1 – 2 seconds. By comparison, vibrations from coal mine blasts are of longer durations in the order of 3 – 8 seconds.

Therefore, potential impacts on bats as a result of blasting associated with the Project are considered to be infrequent and very limited.

3.2 Current and Previous Vibration Impacts

As noted, the Balickera Tunnel presents a dynamic environment, which differs significantly from a secluded dry cave environment. The bats living in the tunnel will have already experienced some exposure to different levels of vibration over a number of years including:

Seaham Quarry Blasting

Seaham Quarry (Boral) currently undertakes ongoing quarry blasting in the vicinity of the tunnel, although positioned at a distance further than the proposed Stone Ridge quarry, see **Figure 1**. Consequently, blast vibration and associated noise is occurring in the locality.

Passing Traffic at Italia Road

A previous vibration monitoring study in the vicinity of the Balickera Tunnel at Italia Road confirmed that passing cars and trucks induce some level of vibration (**ESC (2020)**), which is dependent on the size of passing cars or trucks. This study measured induced ground vibration using a portable monitoring apparatus that was located within approximately 2.5 metres from the side of the roadway. These measurements confirmed high variability in induced ground vibration (depending on the size of cars and loads carried) being in the order of 0.1 – 2.5 mm/s. As a result, some vibrational impact can be inferred from passing traffic for the section of the tunnel located underneath the road.

Balickera Tunnel Remediation Works

Hunter Water undertook a series of remediation works on the tunnel area in 2021-2022 (i.e., completed in May 2022) with the aim of improving long-term structural stability of the infrastructure.

Tunnel remediation work included the removal of loose rocks from the floor and walls (using machinery, picks and jackhammers) and reinforcement of the tunnel walls. As the proposed method was assessed to be invasive presenting potential impacts on bat species, microbats were progressively excluded from the tunnel for the duration of remediation works.

Following the remediation works, and a restoration program, an assessment was undertaken by **WSP Australia (2023**) on the bat species inhabiting Balickera Tunnel. The study was undertaken after the remediation works were completed with the aim of specifically assessing recovery of the bat species in the tunnel. This also includes a post construction monitoring program implemented through the Microbat Management Plan (MMP). Monitoring concluded that the program for bat exclusion and construction works was successful in minimising any detrimental impact to the bat colony. In addition, the study confirmed positive signs of the bats immediate return to the tunnel area after a period of five months of bat exclusion for the remediation works.

3.3 Comparative Tunnel Study

Summarised in detail in **Appendix 2** is a tunnel study on a bat colony in a mine in Western Australia (**Martin (2015**)). This included the site's field testing via exposing existing bat colony to various levels of vibration. The study was supported by vibration (using geophones) and biological monitoring (using high frequency microphones and data recorders) to detect the bats' behaviour.

Due to an absence of applicable vibration limits, the study opted to utilise vibration limits imposed for humans in houses (as specified in the **Australian Standard (AS2187.2-2006**)).

The study confirmed that the bat colony's exposure to the AS2187.2-2006 vibration limit of 10 mm/s did not negatively impact on the colony and moderate vibration impacts of up to 12.2 mm/s did not negatively impact on their long-term behaviour nor was any significant risk to the colony identified.

3.4 Assessment of Blast Impacts for Bats

The tunnel presents a long structure in the order of 1,220 m. Due to its length the vibration exposure will be highly variable with the closest point exposed to the highest levels of vibration and the farthest point exposed to the lowest level of vibration. The modelling takes into account various snapshots throughout the length of the tunnel (upstream, minimum distance and downstream points) to evaluate the impact for both the environment and the infrastructure.

Vibration Modelling

The vibration modelling results for Balickera Tunnel are highlighted in **Table 2A;** they correspond to vibration levels from blasting undertaken at the closest extent of the proposed quarry pit only i.e., worst case scenario**.** Blasting occurring in other parts of the pit will have results in lower vibration levels. The results are summarised as follows:

- Modelling confirmed high variation in vibration levels due to tunnel length and distance variation.
- Impact of vibration will be low in the initial stage of quarry excavation when operations are located further from the tunnel however will increase with time as quarrying progresses towards the west.
- Maximum vibration levels can be expected when blasting is conducted in the most western corner of the quarry (this is limited to only a few critical blasts during Quarry Stages 8 and 9). The modelling indicated that via reducing MIC to approximately 98 kg the 10 mm/s criterion (adopted from AS2187.2-2006) can be achieved for the whole length of the tunnel.
- The predicted vibration impacts for the tunnel from the Amended Quarry Design are lower than for the originally assessed design in the **Blast Impact Assessment** (**2023a**).
- Modelled vibration impacts under all MIC scenarios considered were below the 12.2 mm/s levels observed in the **Martin (2015)** suggesting predicted impacts, even at higher MIC sizes, are unlikely to have negative impacts on bats present.
- The controls relevant to meeting blast criteria at R18 will ensure that the 10 mm/s vibration criterion will be met for all blasts in the north western section of the pit and extending this to all blasts located withing the western 30 m of the pit will enable the 10 mm/s criterion to be satisfied through all sections of the tunnel.

3.5 Risk Analysis

The potential risks of harm to bats present within Balickera Tunnel can be summarised as follows:

- No risk of airblast overpressure impacts have been identified. The predominate airblast overpressure impact from the quarry will be emitted to the east direction (due to bench positioning). Some suppressed airblast emission will also be emitted behind the blasted benches (to the north-west, west and south-west directions). The path of overpressure wave impacts will not be directed towards the tunnel entry (due to the north-west tunnel positioning). Therefore, only distant noise (if any) will reach the tunnel's entries and overpressure levels associated with the Project's blasts will be negligible.

- No risk of strata movement or detachment of small rock debris within the tunnel have been identified at the estimated vibration levels (see ESC infrastructure report (**ESC (2023b**)). The recent Balickera Tunnell Remediation Works have also significantly reduced this risk. Dislodgement of dust or small rocks from the roof of the cave is unlikely to be more prevalent from blast vibration than disturbance from the bats themselves.
- No risk of fume impacts on the tunnel have been identified as any potential fumes from the quarry would travel upwards and the tunnel is positioned well below Italia Road (i.e., approximately 4 - 5 m below the road level).
- No risk of flyrock impact within the tunnel area due to the orientation of the pit and the tunnel entrances (**ESC (2023b**)).
- A vibration criterion of 10 mm/s is considered to be appropriate limit to manage potential impacts to bats present (i.e., based on **Martin (2015**) and adopting AS2184.2-2006 limit). It is noted, that the same limit was originally referenced in the **ANZECC Guidelines (1990)**. The assessment concluded that a 10 mm/s vibration criterion can be met within Balickera Tunnel through appropriate management of MIC levels. This will only apply to a few blasts in the most western section of the quarry in the final stages of the Project. No potential risks associated with blasting and no additional vibration management requirements were identified in the initial and mid stages of the Project.

4.0 CONCLUSIONS AND RECOMMENDATIONS

This report provides an addendum to the Blast Impact Assessment (**ESC 2023a**) in view of the amended conceptual layout for the Stone Ridge Quarry and feedback during the public exhibition of the Project. Based on this additional assessment the following conclusions have been reached:

COMMUNITY, INFRASTRUCTURE AND HERITAGE SITES

- The assessment concluded that the amended conceptual layout will result in reduced vibration levels at residences located closest to the quarry than that predicted from the original conceptual layout. As with the original Blast Impact Assessment, potential impacts can be managed through blast design (MIC charge size) and are required only for blasts in the north western parts of the pit in the later stages of the Project. While minor increases in vibration levels and overpressure are predicted at residences to the southeast of the quarry along Nine Mile Creek Road, these residences are all located further from proposed blasts than residences to the northwest and predicted vibration levels are well within adopted assessment criteria.

- Predicted vibration and overpressure levels associated with the Amended Quarry Design all demonstrate adopted criteria for heritage items and infrastructure can be achieved under all assessed blast charge sizes. This includes assessment of Hunter Water's Balickera Tunnel, where blast modelling estimated maximum vibration at the tunnel of 10.8 mm/s well below the damage criteria for underground rock strata and concrete material (several hundred mm/s).

ANIMALS

The assessment concluded that blasting impacts can be fully managed in relation to native fauna, livestock and pets/animals at properties within a 2 km radius. Due to the periodic (weekly or fortnightly) and very short duration (1 – 2 sec) nature of blasting proposed, blasting associated with the Project is not anticipated to have any significant impacts on livestock, domestic or native fauna.

BATS IN BALICKERA TUNNEL

The results of the blast impact analysis on bats roosting within Balickera Tunnel are summarised as follows:

- Risk assessment review confirmed absence of any significant airblast overpressure, flyrock, rock strata movement or fume threats likely impact on the tunnel and occupying bats.
- The quarry commences blasting at the farthest distance from Balickera Tunnel and advances towards the tunnel area. The distance closest to the tunnel area will occur in the final years of quarry life. Therefore, the vibration levels in the tunnel will be negligible in the initial stages of extraction and then gradually increase with time. The **Australian Standard AS2187.2-2006** and **ANZECC Guidelines** (**1990**) criterion of 10 mm/s was adopted as a threshold below which impacts on bats are not expected (based on blasting studies reported in **Martin (2015)**). The assessment indicates that the 10 mm/s criterion can be readily achieved through a reduction in MIC levels (i.e., by using MIC to 98 kg or lower) for blasts located in the western extent of the Amended Quarry Design. It is noted that MIC reductions are also required to meet vibration criteria at residence R18. No risks or vibration management requirements were identified for the initial and mid stages of the Project.
- The potential for blast vibrations to dislodge dust or small rock particles from the roof of the Tunnel is present however this risk has been mitigated through the recent Balickera Tunnel Remediation Works and risk of dislodgement from blasts is unlikely to be higher than dislodgement from the bats themselves.
- There are a number of mitigating factors which will limit blasting effects on bats roosting in Balickera Tunnel, which are discussed in sections 3.1 and 3.2, including but not limited to blast frequency, short blast duration, previous exposure of bats to vibrations in the tunnel area and the tunnel length (fading vibration levels with distance). The acoustic environment within the tunnel (dynamic water impacts) is also likely to screen noise impacts associated with blasts.
- A vibration monitoring program will be implemented near the tunnel entry during Stages 8 and 9, when blasting will be undertaken adjacent to the western quarry boundary.

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20th December 20023
Enviro Strata Consulting

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APPENDIX 1 – REVISED SUMMARY OF BLASTING IMPACTS

Table 1: Results of Ground Vibration and Airblast Overpressure Modelling for Residential Receptors – Maximum Vibration Estimates (worst-case scenario)

Residential Receptor ID	Min. Distance (1) (m)	Direction from Blasting Area	Estimated Max. Ground Vibration (mm/s)				Applicable Criteria	Estimated Max. Airblast Overpressure (dBL)				Applicable Criteria
			MIC (kg)					MIC (kg)				
			37.5 (2)	75	98.4	122		37.5 (2)	75	98.4	122	
R1	1,510	S	0.4	0.7	0.8	1.0	5 mm/s (for 95% of blasts), and 10 mm/s (not to be exceeded) over a 12-month period	98	101	102	103	115 dBL (for 95% of blasts), and 120 dBL (not to be exceeded) over a 12-month period
R5	1,390	SE	0.4	0.8	1.0	1.1		99	102	103	104	
R6	1,320	SE	0.5	0.8	1.0	1.2		100	102	104	104	
R7	1,450	SE	0.4	0.7	0.9	1.1		98	101	102	103	
R8	1,500	SE	0.4	0.7	0.8	1.0		98	101	102	103	
R9	1,430	SE	0.4	0.7	0.9	1.1		99	101	103	103	
R10	1,590	SE	0.4	0.6	0.8	0.9		97	100	101	102	
R11	1,820	NW	0.3	0.5	0.6	0.7		95	98	100	100	
R12	1,640	NW	0.3	0.6	0.7	0.9		97	100	101	102	
R13	1,550	NW	0.4	0.6	0.8	1.0		98	100	102	102	
R14	1,420	NW	0.4	0.7	0.9	1.1		99	102	103	104	
R15	1,270	NW	0.5	0.9	1.1	1.3		100	103	104	105	
R16	880	NW	0.9	1.6	2.0	2.4		105	108	109	110	
R17	640	NW	1.5	2.7	3.3	3.9		109	112	113	114	
R18	490	W	2.3	4.1	5.1	6.0		112	115	116	117	
R19	1,230	W	0.5	0.9	1.2	1.4		100	103	104	105	
R20	1,060	W	0.7	1.2	1.5	1.7		102	105	106	107	
R21	710	NW	1.3	2.2	2.8	3.3		107	110	111	112	
R22	1,540	SE	0.4	0.7	0.8	1.0		98	100	102	103	

1 – minimum distance over the lifetime of the Project, i.e., from the edge of the blasting boundary

2 – the MIC corresponds to a single deck when deck charges used

grey cells –estimate exceeding the applicable limit (5 mm/s or 115 dBL for 95% of blasts); however, compliance is achievable at all residences through the application of reduced charge masses

Table 2A: Results of Ground Vibration Modelling for Infrastructure and Historical Sites Maximum Vibration Estimates (worst-case scenario)

Receptor	Min. Distance[1] (m)	Estimated Max. Ground Vibration (mm/s) MIC (kg)				Applicable Vibration Criteria
		37.5 [2]	75	98.4	122	
PUBLIC / PRIVATE INFRASTRUCTURE						
Roads & Bridges						
Italia Road	340	4.2	7.3	9.1	10.8	100
Pacific Hwy (F3)	1,390	0.4	0.8	1.0	1.1	
Pacific Hwy Bridge over Balickera Canal	1,550	0.4	0.6	0.8	1.0	
Pacific Hwy Bridge over Nine Mile Creek	1,400	0.4	0.8	0.9	1.1	
Bridge on Nine Mile Rd	1,300	0.5	0.9	1.1	1.3	
Bridge on Italia Rd	1,910	0.3	0.5	0.6	0.7	
Hunter Water Infrastructure						
Balickera Tunnel: upstream point	410	3.1	5.4	6.7	8.0	100
minimum distance	340	4.2	7.3	9.1	10.8	
downstream point	810	1.0	1.8	2.3	2.7	
Balickera Channel	410	3.1	5.4	6.7	8.0	
Pumping Station	880	0.9	1.6	2.0	2.4	25
Bridge	850	1.0	1.7	2.1	2.5	100
Pipelines	860	0.9	1.7	2.1	2.4	
Electrical Sub-station	880	0.9	1.6	2.0	2.4	25
Powerlines						
33 kV Power poles (Hunter Water)	390	3.4	5.9	7.3	8.7	100
Telecommunication						
Telecommunication underground lines (along Italia Road)	340	4.2	7.3	9.1	10.8	100
Telecommunication towers	1,470	0.4	0.7	0.9	1.0	
Other Private Infrastructure						
Seaham Quarry (Boral)	800	1.1	1.9	2.3	2.7	25
Proposed Eagleton Quarry	2,200	0.2	0.4	0.5	0.5	
Port Stephens Gardenland (landscape supplies)	2,060	0.2	0.4	0.5	0.6	
Ringwood Park Motor Complex	1,030	0.7	1.2	1.5	1.8	
Circuit Italia	1,930	0.3	0.5	0.6	0.7	
Port Stephens Boarding Kennels [3]	2,360	0.2	0.3	0.4	0.5	5/10
Hunter Valley Paintball [3]	2,290	0.2	0.3	0.4	0.5	
Kids Amusements [3]	1,520	0.4	0.7	0.8	1.0	
HERITAGE SITES						
Balikera House (adjacent to R19)	1,240	0.5	0.9	1.1	1.4	5

1 – minimum distance over the lifetime of the Project, i.e., from the edge of the blasting boundary

2 – the MIC corresponds to a single deck when deck charges used

3 – assessed applying private residence criteria

Table 2B: Results of Airblast Overpressure Modelling for Infrastructure and Heritage Sites Maximum Vibration Estimates (worst-case scenario)

Receptor	Min. Distance[1] (m)	Estimated Max. Airblast Overpressure (dBL) MIC (kg) 37.5 [2]	75	98.4	122	Applicable Vibration Criteria
PRIVATE INFRASTRUCTURE						
Seaham Quarry (Boral)	800	106	109	110	111	125[3]
Proposed Eagleton Quarry	2,200	93	96	97	98	
Port Stephens Gardenland	2,060	94	97	98	99	
Ringwood Park Motor Complex	1,030	103	106	107	108	
Circuit Italia	1,930	95	98	99	100	
Port Stephens Boarding Kennels	2,360	92	95	96	97	
Hunter Valley Paintball	2,290	93	95	97	98	
Kids Amusements	1,520	98	101	102	103	
HERITAGE SITES						
Balikera House (adjacent to R19)	1,240	100	103	104	105	133

1 – minimum distance over the lifetime of the Project, i.e., from the edge of the blasting boundary

2 – the MIC corresponds to a single deck when deck charges used

3 – based on AS2187.2-2006 criteria for occupied non-sensitive sites, such as factories and commercial premises

APPENDIX 2 – Summary of Western Australia's Mine Study Titled "Scientific Evaluation of Fauna Sensitivity to Blasting" (Martin (2015))

Mount Bruce Mining Pty Ltd (part of the Rio Tinto group) proposed to undertake close-range, open cut blasting in the vicinity of an already-extracted, underground tunnel area. The area was occupied by a large colony of bats that included approximately 430 species of the Orange Leaf-nosed Bats (OLNB) (*Rhininicteris aurantius*) that were living in a previously mined tunnel area. The ONLB are classified as vulnerable and require protection under the *Western Australian Conservation Act 1950*.

A scientifically-designed, in-field test study was implemented to gauge bat behaviour when exposed to close-range blasting. It also included a detailed evaluation of blasting impacts on the colony of bats in using trial-sized seismic blasting in the vicinity of the tunnel with a gradual increase in blasting impacts (by increasing the charge mass and a gradual decrease of the distance from the blasting area). For that purpose, six, specifically-designed blastholes were discharged at varying distances commencing from the farthest to the closest. This gradual approach provided a comprehensive picture of the bat's response to different vibration levels.

The site's field testing also involved a detailed biological and vibration monitoring program conducted at different points (including the tunnel entry) using high frequency microphones and data recorders that monitored the bats responses to identify any disturbance because of vibrational impacts i.e., the microphones and recorders detected bat movements or any negative responses and therefore, quantified sensitivity to various induced vibration levels.

It is important to emphasize that initially the study opted to utilize vibration limits imposed for humans located in houses (as specified in the Australian Standard (AS2187.2-2006). The study acknowledged that there were no applicable vibration limits for bats so in the absence of such limits, an interim limit such as that used for humans was applied and deemed justifiable as a vibration limit of 10 mm/s, which are applied for house structures when humans are present.

Testing included the firing of each hole separately followed by a detailed assessment and review of the vibration levels along with the collated microphone data. These vibration monitoring results were also used to update a site analysis law and assisted with the blast design for subsequent blastholes (i.e., providing feedback in the choice of MIC). Following the execution of each blast, the reviewed microphone data served as final confirmation in detecting the bats behaviour towards induced vibrations from a given blasthole i.e., an assessment on movement after the blast. This same procedure was followed for the firing of each hole blasted.

The overall measure in ground vibration exposure ranged from 0.66 to 18.7 mm/s and as indicated by the authors, none of the executed blasts produced negative impact on the colony of bats, which were tested with the highest vibration level exposure of 12.2 mm/s (at the tunnel area where the colony was located).

In summary, the empirical assessment study including biological assessment served to assist the mine to better understand and manage blasting impacts on the bat colony located in the extracted tunnel area and allowed for improved confidence in managing and balancing environmental issues associated with blasting. Subsequently, the close-range open cut blasting progressed towards the tunnel area where bats were located without any long-term detriment to the colony.

Overall, the study confirmed that the bat colony's exposure to moderate vibration did not negatively impact on their long-term behaviour nor was any significant risk to the colony identified.