

EA APPLICATION SUPPORTING REPORT

SAVANNAH GOLDFIELDS LTD

Appendix 18 Noise Assessment (SEG, 2023)



Simpson Engineering Group

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1 Introduction

Wulguru Technical Services (WTS) on behalf of Laneway Resources Pty Ltd, engaged Simpson Engineering Group (SEG) to prepare a noise and vibration assessment for a proposed metals mining project, Agate Creek Mine Expansion (the Project), 40km south of Forsayth in north Queensland.

The objective of this assessment is to inform the relevant aspects of Department of Environment and Science Guideline ESR/2015/1838 – Application requirements for activities with noise impacts.

This noise and vibration assessment addresses the following issues:

- likely change in noise environment following development of the mine;
- development of appropriate noise and vibration goals;
- assessment of noise at sensitive receptors and comparison to the noise and vibration goals; and,
- recommendations for relevant impact mitigation measures.

1.1 Project Description

The proposed mine is an expansion of the existing open pit and has a 3 year life of mine. Ongoing exploration may identify suitable future developments and the life of the mine will likely extend beyond three years. The mining will involve conventional excavator and haul trucks to create a pit and external waste dump. The mining fleet comprises 4 trucks, a 30 tonne excavators and associated plant. Road trains take the ROM ore directly to an off-site processing facility. The average production of ore is 0.25Mt. The mass of waste moved is approximately 1.25Mt per annum.

1.2 Locality Description

The project is situated in a well-established grazing and mining region. The region is undulating, generally comprising open grazing and native scrublands. The location of the Project is shown on Figure 1. The closest community is Forsayth, situated to the NE of the site. Forsayth is service centre for the farming, mining and tourist industry. The area to the west of the site comprises the Rungulla Resources Reserve and the Rungulla National park. The national park comprises a wide range of sandstone formations, including outcrops of large, sculpted caves and pagoda-like sandstone features. The Agate Creek fossicking area is southwest of the site.

There is one dwelling 8 km NE of the project and another dwelling approximately 25 km NW of the site. It is understood the proponent has reached an agreement with the nearby campground landowner to relocate the campground.

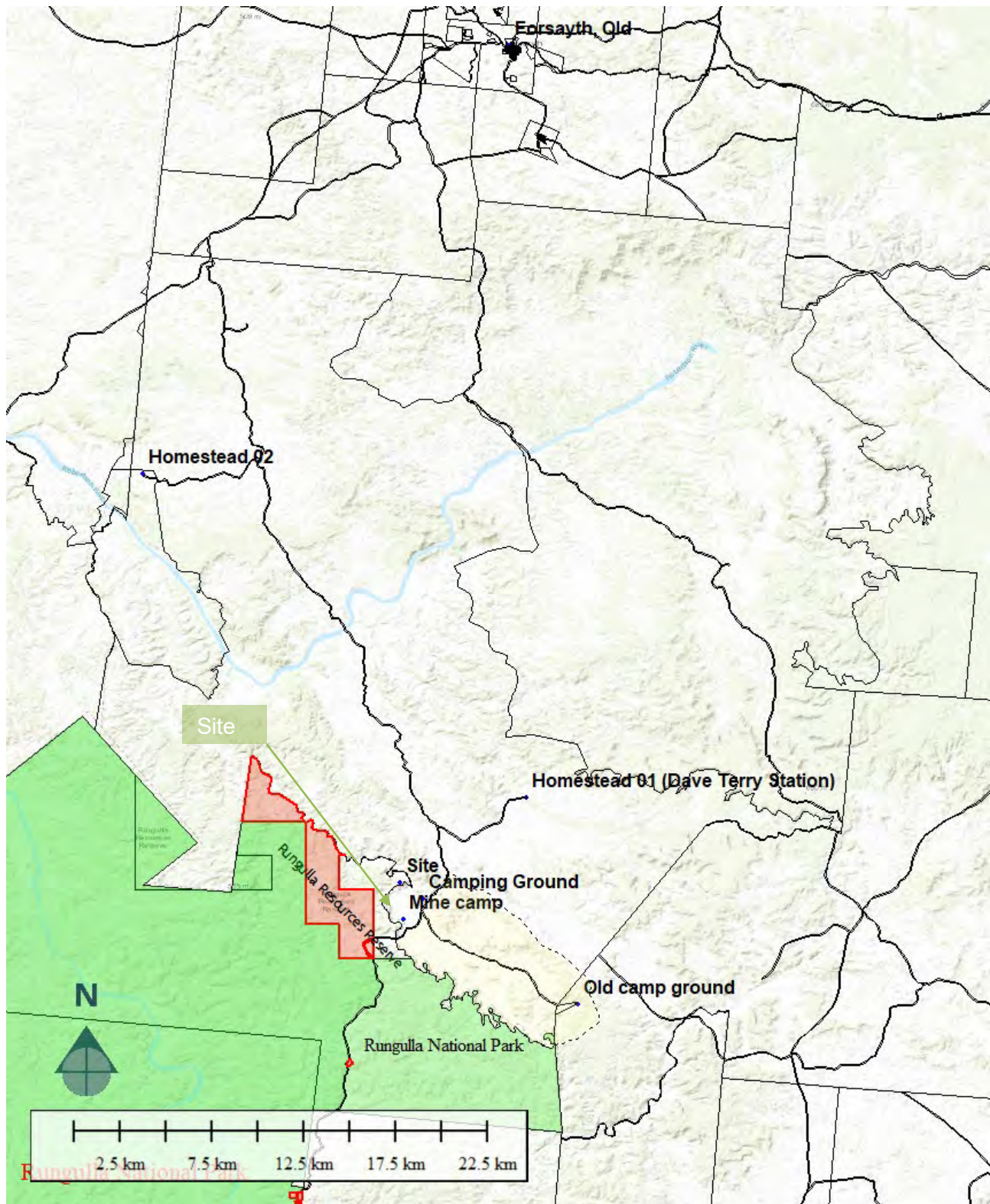


Figure 1: Regional View Showing the Project Area

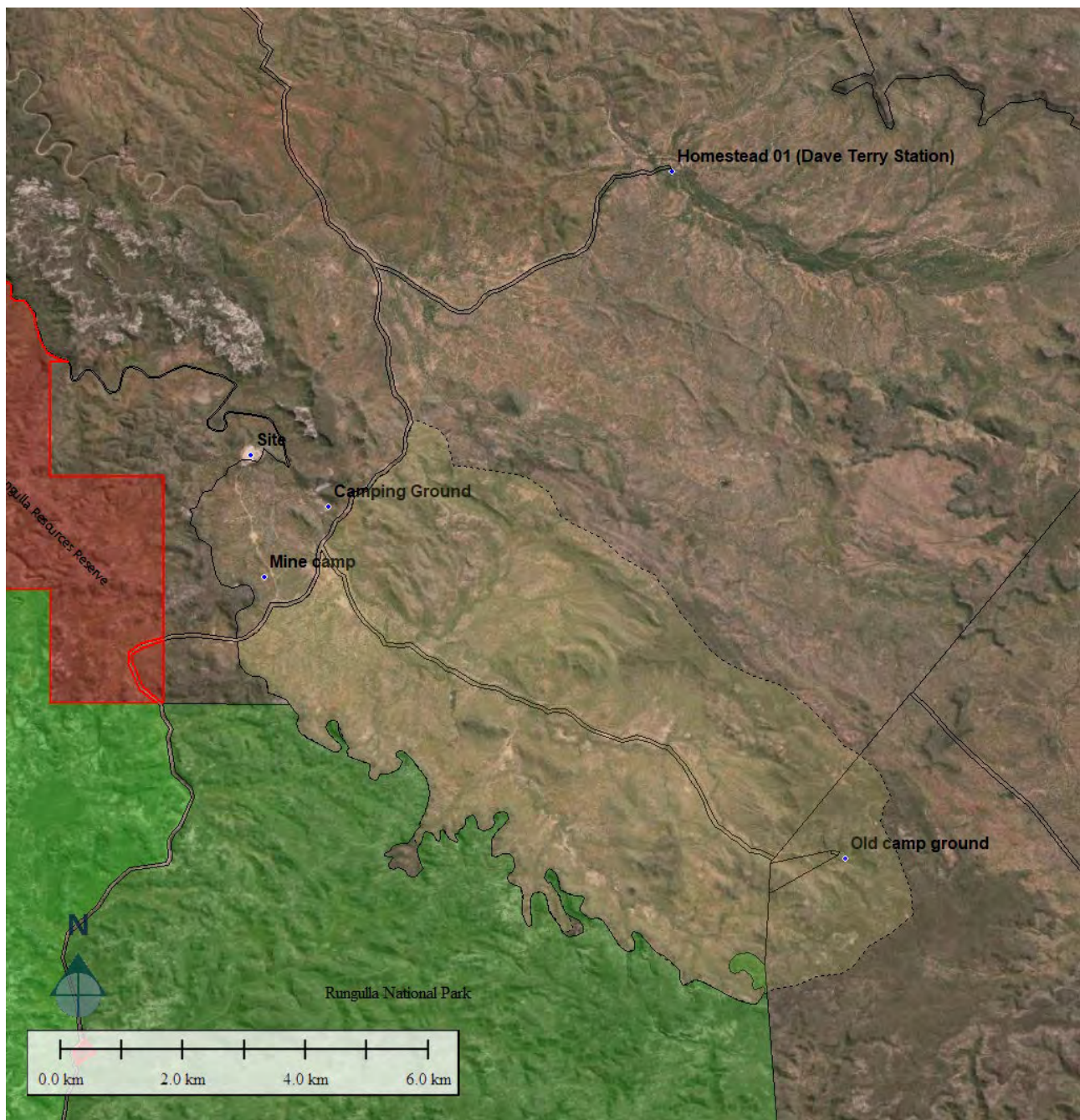


Figure 2: Site and Surroundings

2 Existing Noise Environment

The distance and bearing from the mine to identified sensitive receptors are contained in Table 1. Homestead 01 is identified as prime receptors due to its proximity to the mine. The remaining receptors are secondary due to the large separation distances. The campground provides convenient camping location for people accessing the Agate Creek fossicking area. However, it is understood the owner has been compensated to relocate the camping ground to a more distant location.

Table 1: Sensitive Receptors Surrounding the Mine

Receptors	Distance [km]	Bearing (degrees)
Homesteads		
Mine camp	1.9	175
Camping ground	1.5	120
Old Camp Ground	11	125
Homestead 01 (Dave Terry station)	8	55
Homestead 02	25	330
Forsayth	45	7
Protected area or critical area		
Rungulla National Park	4.0	180
Rungulla Resource Reserve	1.4	260

2.1 Existing Environment

A noise survey of the existing noise levels was carried out at the nearby campground, i.e. 1.5km from the mine. Mining was not taking place during the monitoring period. Based on the Bureau of Meteorology Georgetown Airport weather station, the period to 8 March 2023 was cloudy with occasional scattered rain. When monitoring recommenced on 11 March 2023, the rain was less prevalent, minor to no cloud cover and increasing temperatures. During this later period wind speeds was low, typically less than 3.6m/s.

The noise measurements included occasional distant heavy machinery noise on a neighbouring property and not associated with mining, natural environment, including birds, insects, animals etc.

The gap in the data (9 March and 10 March) was due to low-battery and the equipment was collected and recharged, then redeployed at the same location.

The measurements were obtained using a Rion NL42 sound level meter. The instrument was configured to record 'A' weighted noise levels in 15-minute periods. Refer to Table 2 and Figure 3 being a summary and chart of the noise measurements. The sound level meter was not configured to record the L_{A01} . However, the sound level meter records the L_{A05} which would be slightly below the L_{A01} .

The measured Rating Background Noise (RBN) noise level for each time period comprised:

- Day 37 dB(A)
- Evening 33 dB(A)
- Night 36 dB(A)

Table 2: Measured Ambient Noise Levels at Campground

Date	LA05			LA10			LAeq			LA90		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
6/03/2023	62	49	47	48	47	46	47	43	43	36	34	39
7/03/2023	47	45	45	45	43	45	40	39	42	36	33	35
8/03/2023	49	47	41	46	43	39	43	40	37	37	34	35
11/03/2023	45	43	40	42	43	40	40	41	39	37	33	38
12/03/2023	47	44	39	44	42	38	41	38	38	37	33	37
13/03/2023	47	46	38	43	43	38	39	40	36	35	33	35
14/03/2023	48	45	39	45	42	39	41	38	38	37	34	36
Median/RBN	47	45	40	45	43	39	41	40	38	37	33	36
Week Day	47	46	40	45	43	39	41	39	38	37	33	36

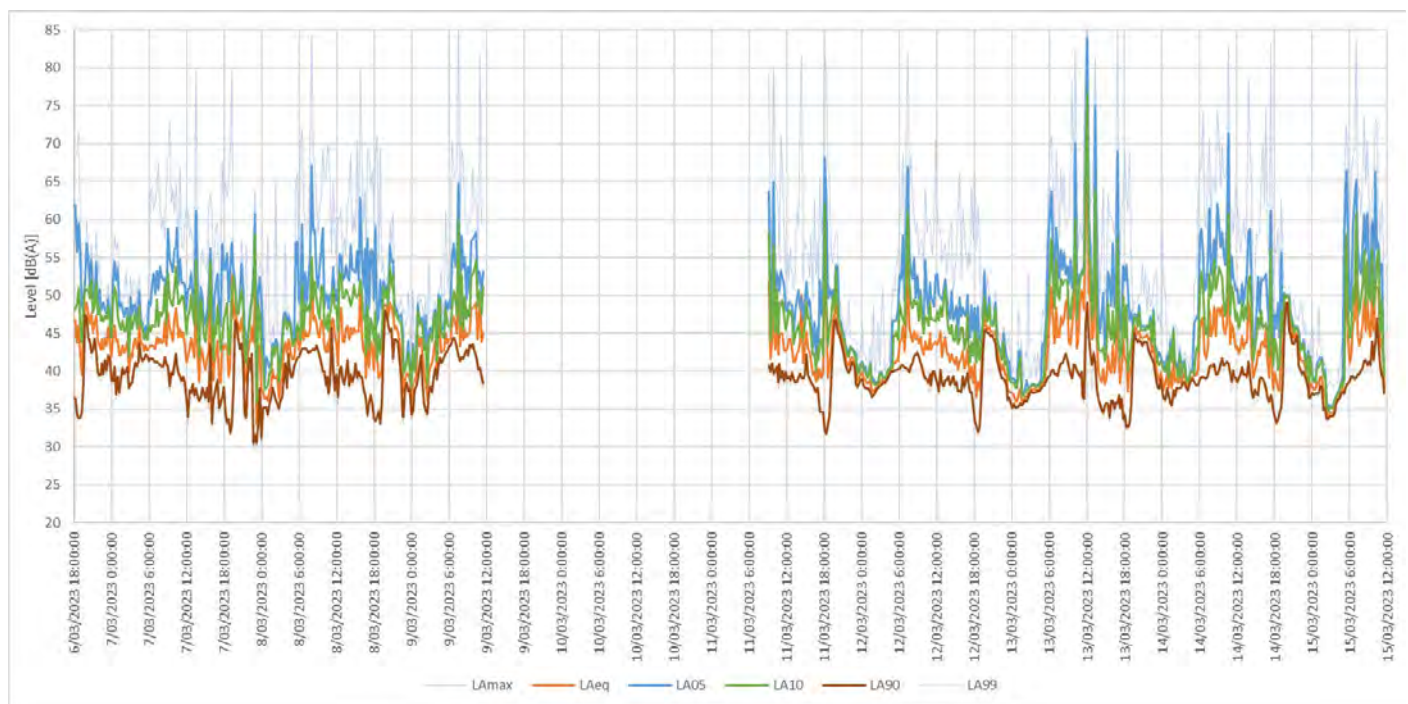


Figure 3: Measured Noise Levels at Campground

Table 3: Weather at Georgetown (Source: BoM)

Date	Min Temp (°C)	Max Temp (°C)	Rain (mm)	9am Temp (°C)	9am relative humidity (%)	9am cloud amount (oktas)	9am wind direction	9am wind speed (km/h)	3pm Temp (°C)	3pm relative humidity (%)	3pm cloud amount (oktas)	3pm wind direction	3pm wind speed (km/h)
6/03/2023	24.4	30.9	0	25.7	75	8	ENE	19	30.1	65	8	NE	17
7/03/2023	22.6	31.2	9.2	26.8	82	8	ENE	19	29.8	69	6	NE	17
8/03/2023	23.8		6.2	27	83		NNE	24	31.9	54		NNE	20
9/03/2023	23.2	29		25.1	86	8	NNE	22	27.6	82	8	N	17
10/03/2023	22.1	28.6	3.4	24.1	84	8	NNE	20	25.3	87	8	N	17
11/03/2023	20.5	31.6	2.8	25.6	78	1	NNE	11	31.1	54	7	N	7
12/03/2023	20.9	32.4	0.2	27.2	68		ENE	9	32	57	1	WNW	13
13/03/2023	21.4	33.1	0	28.4	70		NE	9	32.7	52	3	WNW	13
14/03/2023	22.1	32.1	0	25	80		NE	7	31.1	50		N	9
15/03/2023	22.2	34.7	0	28.7	69		NNE	13	33.7	52	1	WNW	11

3 Noise and Vibration Criteria

3.1 ERS/2015/1838

The Guideline ESR/2015/1838 describes types of impacts that environmentally relevant activities can have in relation to noise, and outlines the information to be provided to the department as part of the ERA application process.

There are three key areas to be identified and addressed through the ERA application process:

- Identify the environmental values of the receiving acoustic environment including the identification of any nearby sensitive places.
- Identify the possible impacts due to the proposed activity and all associated risks to environmental values.
- Identify the strategies to mitigate the identified risks to the environmental values

It is necessary to identify the environmental values of the site including but not limited to:

1. Identify sensitive places
2. Provide a site description.
3. Provide details of a background noise survey.

The department seeks to determine possible impacts to identified environmental values. To assist with this the following information is sought:

1. Identify all noise, vibration, and air blast overpressure sources, including stationary and mobile sources, associated with the activity. Also provide a scaled map which shows the source of all noise emissions in relation to any existing noise sensitive places
2. Describe in detail, the characteristics of the noise emissions produced.
3. Describe how noise, vibration or airblast overpressure emissions will be avoided, minimised or otherwise managed in accordance with the noise management hierarchy provided in the EPP (Noise).

If it is not possible to mitigate the impacts associated with the noise emission, applicants are to provide a noise impact assessment, which identifies the likely effect of noise from the activity on nearby sensitive places and include:

- Noise modelling contour maps to show predicted noise levels at all potential noise source locations.
- Analysis on whether noise emissions associated with the activity will adversely affect the environmental values of the receiving environment (including noise sensitive places).
- Description of controls (e.g. noise emission limits or operational controls such as operating hours) which are appropriate to protect environmental values.
- A vibration risk assessment for blasting activities, if applicable.
- If blasting is to occur, that blasting activities will be managed in accordance with AS 2187: Explosives.

Due to the rapid growth and increasing density of noise-producing activities in Queensland, the consideration of cumulative noise impacts and background creep is particularly important. For applications where background creep is likely, applicants are encouraged to use modelling to demonstrate that the activity will, to the extent it is reasonable to do so, ensure that background creep in an area or place is prevented or minimised. If the acoustic quality objectives for an area or place are not being achieved or maintained, the noise experienced in the area or place must, to the extent it is reasonable to do so, be dealt with in a way that progressively improves the acoustic environment of the area or place.

3.2 Model mining conditions

The model mining conditions may be used as a basis for proposing environmental protection commitments in the application documents. They may also be used to expedite the process of developing appropriate conditions for an environmental authority for a mining project in consultation with the administering authority. The noise level limits are not linked to specific meteorological conditions; hence the limits apply for all meteorology.

Table D1 – Noise Limits

Sensitive Place						
Noise Level dB(A) measured as:	Monday to Saturday			Sundays and Public Holidays		
	7 am to 6 pm	6 pm to 10 pm	10 pm to 7 am	7 am to 6 pm	6 pm to 10 pm	10 pm to 7 am
$L_{Aeq, adj, 15m}$	CV=50 AV=5	CV=45 AV=5	CV=40 AV=0	CV=45 AV=5	CV=40 AV=5	CV=35 AV=0
$LA_{01, adj, 15m}$	CV=55 AV=10	CV=50 AV=10	CV=45 AV=5	CV=50 AV=10	CV=45 AV=10	CV=40 AV=5
Commercial Place						
Noise Level dB(A) measured as:	Monday to Saturday			Sundays and Public Holidays		
	7 am to 6 pm	6 pm to 10 pm	10 pm to 7 am	7 am to 6 pm	6 pm to 10 pm	10 pm to 7 am
$L_{Aeq, adj, 15m}$	CV=55 AV=10	CV=50 AV=10	CV=45 AV=5	CV=50 AV=10	CV=45 AV=10	CV=40 AV=5

Table D1 – Noise limits notes:

1. CV = Critical Value
2. AV = Adjustment Value
3. To calculate noise limits in Table D1:
 - If $bg \leq (CV - AV)$:
Noise limit = $bg + AV$
 - If $(CV - AV) < bg \leq CV$:
Noise limit = CV
 - If $bg > CV$:
Noise limit = $bg + 0$
4. In the event that measured bg ($LA_{90, adj, 15 mins}$) is less than 30 dB(A), then 30 dB(A) can be substituted for the measured background level
5. bg = background noise level ($LA_{90, adj, 15 mins}$) measured over 3-5 days at the nearest sensitive receptor
6. If the project is unable to meet the noise limits as calculated above alternative limits may be calculated using the processes outlined in the "Planning for Noise Control" guideline.

Table 4: Limits Based on Measured Background Noise Level

Sensitive Place						
Noise Level dB(A) measured as:	Monday to Saturday			Sundays and Public Holidays		
	7 am to 6 pm	6 pm to 10 pm	10 pm to 7 am	7 am to 6 pm	6 pm to 10 pm	10 pm to 7 am
$L_{Aeq, adj, 15m}$	42	38	36	42	38	36
$L_{A01, adj, 15m}$	47	43	41	47	43	40
Commercial Place						
Noise Level dB(A) measured as:	Monday to Saturday			Sundays and Public Holidays		
	7 am to 6 pm	6 pm to 10 pm	10 pm to 7 am	7 am to 6 pm	6 pm to 10 pm	10 pm to 7 am
$L_{Aeq, adj, 15m}$	47	43	41	47	43	40

Airblast overpressure nuisance

The model mining conditions for blasting has limits for peak particle velocity and air blast overpressure, described in Table D2 - Blasting noise limits.

Table D2 – Blasting Noise Limits

Blasting noise limits	Sensitive or commercial place limits	
	Monday to Friday 6 am - 6 pm Saturday 6 am – 6 pm	Sundays and public holidays
Airblast overpressure	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB (Linear) Peak at any time	either no blasting or limits justified by proponent not less stringent than 7am – 6pm
Ground vibration peak particle velocity	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	either no blasting or limits justified by proponent not less stringent than 7am – 6pm

Typical conditions for Sunday and public holidays may include references such as “No blasting will occur on Sundays or Public Holidays without notification to sensitive receivers”.

3.3 Environmental Protection Act 1994

The objective of the EP Act is to protect Queensland’s environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.

The EP Act states a person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm. This is termed the 'general environmental duty'.

Environmental harm is defined as any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance.

The noise level goals for operations may be determined from the *Environmental Protection (Noise) Policy 2019* (EPP (Noise) 2019). The EPP (Noise) 2019 came into effect on 1 Sept 2019.

The purpose of the EPP(Noise) is to achieve the objects of the Act and achieved by:

- a) identifying and declaring the environmental values of the acoustic environment; and
- a) stating acoustic quality objectives that are directed at enhancing or protecting the environmental values; and
- b) providing a framework for making consistent, equitable and informed decisions that relate to the acoustic environment.

The environmental values to be enhanced or protected under the EPP(Noise) are:

- (a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and
- (b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following-
 - a. sleep;
 - b. study or learn;
 - c. be involved in recreation, including relaxation and conversation; and
- (c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

There are two main considerations namely:

- 1. Acoustic quality objective (noise levels that are conducive to human health and well-being, ensuring a suitable acoustic environment for individuals to sleep, study or learn, be involved in recreation, including relaxation and conversation; and preserve the qualities of the acoustic environment that are conducive to protecting the amenity of the community); and
- 2. Management Intent

3.3.1 Acoustic Quality Objectives

The 'Acoustic Quality Objectives' seek to protect the amenity of an acoustic environment. The indoor night-time goals effectively address sleep disturbance and sleep awakenings, while during the day it protects conversation. It should be noted that these are not strictly design limits for individual sources but objectives that are considered to provide acceptable health and wellbeing for the community.

The acoustic quality objectives are expressed as indoor noise level goals for dwellings at Night (10 pm to 7 am) and outdoor noise level goals during the Day (7 am to 6 pm) and Evening (6 pm to 10 pm). These objectives are all contained in Table 5.

The indoor noise quality objective for dwellings is converted to an outdoor noise level by conservatively assuming that the windows of the dwellings are wide open. The equivalent external noise levels (for the

dwelling indoor noise level goals in Table 5) measured at least 4 m from the dwelling would be 5 dB higher (to allow for the reduction of noise through the building envelope).

Table 5: Acoustic Quality Objectives for Dwellings and Other Receivers Relevant to the Project during the Day (7 am to 6 pm), Evening (6 pm to 10 pm) and Night (10 pm to 7 am).

Location	Time of Day	Acoustic Quality Objectives (Measured at the receptors) dB(A)			Environmental Value
		L _{Aeq} , adj, 1 hr	L _{A10} , adj, 1 hr	L _{A1} , adj, 1 hr	
Dwelling outdoors	Daytime & evening	50	55	65	Health and wellbeing
Dwelling indoors	Daytime & evening	35	40	45	Health and wellbeing
Dwelling indoors	Night-time	30	35	40	Health and wellbeing, in relation to the ability to sleep
School or playground outdoors	When the children usually play outside	55	-	-	Health and wellbeing, and community amenity
Protected area or critical area	anytime	The level of noise that preserves the amenity of the existing area or place			Health and biodiversity of ecosystems

Source: EPP (Noise) 2019

3.3.2 Managing Intent For Noise

It is intended that noise from an activity that affects or may affect an environmental value to be enhanced or protected under the EPP(Noise) be appropriately managed.

To the extent it is reasonable to do so, noise must be dealt with in a way that ensures-

- a) the noise does not have any adverse effect, or potential adverse effect, on an environmental value under this policy; and
- b) background creep in an area or place is prevented or minimised.

In the situation where existing noise levels exceed the Acoustic Quality objectives, to the extent it is reasonable to do so, noise at that sensitive place must be dealt with in a way that progressively improves the acoustic environment of the area or place.

Background creep, for noise in an area or place, is described as a gradual increase in the total amount of background noise in the area or place.

The EPP(Noise) does not provide any guidance nor limits regarding how to address background creep.

However, the guiding principles are:

- i. Background creep in an area is to be prevented or minimised
- ii. Any control requirements are to be reasonable

Background creep can be prevented by ensuring the noise from activity is always below the background noise level. However, this may be excessively onerous for many situations. The EPP(Noise) does not include any guidance regarding how to assess “reasonable” noise control. A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements. Selecting reasonable measures from those that are feasible involves making a judgement to determine whether the overall noise-reduction benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the noise abatement measure. To make such a judgement, consideration may be given to aspects such as noise level impacts, noise mitigation benefits, cost effectiveness and community views.

3.4 Sleep Disturbance WHO Guidelines

Research has shown that the ability to get to sleep and, when asleep, the probability of experiencing a change of sleep state or ultimately of awakening are related to both the ambient and maximum instantaneous noise levels at the ear of the sleeper and the number of events during the night time period (WHO 1999).

As a rule in planning for short-term or transient noise events, for good sleep over eight hours, the indoor sound pressure level measured as a maximum instantaneous value should not exceed approximately 45dBA maxLpA more than 10-15 times per night. According to Guideline Ecoaccess Planning for Noise Control (EPA 2004), the corresponding external noise level, assuming partially closed windows, is 52dBA maxLpA (L_{Amax}), measured in the free field.

For larger number of events per night, the noise level goal is reduced by $10 \cdot \log(\text{Number of events}/10)$. Hence if there are 100 events per night (over an 8 hour period) the external noise level goal would become 42 dB(A) free field.

3.5 DEHP Ecoaccess Guideline - Low Frequency Noise

The DEHP Ecoaccess Guideline "Assessment of Low Frequency Noise" identifies a number of industrial sources and processes having high noise levels and frequency content less than 200 Hz.

Industrial sources may exhibit a spectrum that characteristically shows a general increase in sound pressure level with decrease in frequency. Annoyance due to low frequency noise can be high, even though the dB(A) level measured is relatively low. Typically, annoyance is experienced in the otherwise quiet environs of residences, offices and factories adjacent to, or near, low frequency noise sources. Generally, low level/low frequency noises become annoying when the masking effect of higher frequencies is absent. This loss of high frequency components may occur as a result of transmission through the fabric of a building, or in propagation over long distances.

Where a noise emission occurs exhibiting an unbalanced frequency spectra, the overall sound pressure level inside residences should not exceed 50 dB(Linear) to avoid complaints of low frequency noise annoyance.

3.6 Blasting Criteria

Open cut coal mining procedures often include drilling and blasting of overburden material above the coal to make removal of that material easier.

According to the DEHP Ecoaccess Guideline "Noise and Vibration From Blasting" (DERM, 2004), blasting for the mining industry should generally be limited to the hours of 7:00 am to 6:00 pm.

Blasting outside these recommended times should be approved only where:

- a) blasting during the preferred times is clearly impracticable (in such situations blasts should be limited in number and stricter airblast overpressure and ground vibration limits should apply); or
- b) there is no likelihood of persons in a noise-sensitive place being affected because of the remote location of the blast site.

Blasting activities must be carried out in such a manner that if blasting noise should propagate to a noise-sensitive place, then:

- a) the airblast overpressure must be not more than 115 dB(linear) peak for 9 out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and
- b) the airblast overpressure must not exceed 120 dB(linear) peak for any blast.

Blasting operations must be carried out in such a manner that if ground vibration should propagate to a vibration-sensitive place:

- a) the ground-borne vibration must not exceed a peak particle velocity of 5 mm per second for nine out of any 10 consecutive blasts initiated, regardless of the interval between blasts; and,
- b) the ground-borne vibration must not exceed a peak particle velocity of 10 mm per second for any blast.

3.7 Road Traffic Noise Goals

Queensland Department of Transport and Main Roads (TMR) is responsible for setting noise level limits from road traffic on public roads in Queensland. There are no noise level goals in Queensland for assessing noise from a traffic producing development. However, TMR have guidelines for existing roads. For this category priority is given to noise control when there is a sudden increase in traffic volumes (at least double equal to a 3 dB increase) or there is a high percentage of heavy vehicles (greater than 20%) at night. TMR have a road traffic noise level goal of 68 dB(A) as an LA10(18 hour) at the facade of existing residences from existing roads.

However, if a new road is proposed TMR would apply a noise level goal at the residences of 63 dB(A) where the existing $L_{A10(18 \text{ hour})}$ is greater than 55 dB(A) and 60 dB(A) and where the existing $L_{A10(18 \text{ hour})}$ is 55 dB(A) or less. It is likely that the existing $L_{A10(18 \text{ hour})}$ along the public roads between the site and Georgetown processing plant would be less than 55 dB(A) hence a noise level goal of 60 dB(A) as an $L_{A10(18 \text{ hour})}$ would be appropriate.

Since Queensland doesn't have a noise level goal for traffic generating developments it is appropriate to consider goals developed elsewhere in Australia. The NSW EPA goals for land use developments with the potential to create additional traffic on local roads are in terms of the $L_{Aeq(1 \text{ hour})}$ and the day goal is 55 dB(A) and at night the goal is 50 dB(A) and existing noise levels should not increase road traffic noise levels by more than 2 dB(A). Along existing freeway/arterial/sub-arterial roads the noise level goals are in terms of the $L_{Aeq(15 \text{ hour})}$ 60 dB(A) during the day and the $L_{Aeq(9 \text{ hour})}$ 55 dB(A) during the night.

Where the route utilises existing sub-arterial roads the road traffic noise level goals would be less stringent, i.e. $L_{Aeq(15 \text{ hour})}$ 60 dB(A) during the day and the $L_{Aeq(9 \text{ hour})}$ 55 dB(A) during the night. Since it is beyond the scope of this assessment to provide a detailed model for the entire route, the more stringent local road noise level goal has been adopted for the entire route as a screening tool for additional investigations if required.

3.8 Summary of Noise Goals

Model License Conditions

The model license conditions are a composite of the two considerations contained (Acoustic quality objectives and background creep) of the *Environmental Protection (Noise) Policy 2019* (EPP (Noise) 2019), assuming a time varying noise source. The model license conditions also include reference to the Planning for Noise control document to develop alternate goals in the event that the project is unable to meet the model noise level goals. These goals apply to mining noise.

Application of Low Frequency Noise Goals

It is possible that, due to the propagation of noise over the large separation distances between the source of noise and the receiver, a loss of high frequency components may occur. Thus, the low frequency noise goal of 50 dB(Linear) applies at noise sensitive receptors. This goal applies to mining noise.

Application of Blasting Limits

The blasting goals apply and it is proposed to carry out the assessment with typical blasting charge weights.

Application of Sleep Disturbance Goals

The maximum noise level from mining during the night is an L_{Amax} of 42 dB(A) free field, on the assumption that the maximum noise levels occur approximately 100 occasions per 8 hour night.

Application of Road Traffic Goal

The noise level goals are in terms of the $L_{Aeq(1 \text{ hour})}$ and the day goal is 55 dB(A) and at night the goal is 50 dB(A) for dwellings adjacent to the haul route.

Noise Goals for Critical Areas

The Acoustic Quality Objectives describes the desired noise goals as “The level of noise that preserves the amenity of the existing area or place” to protect the “Health and biodiversity of ecosystems.” Rungulla National Park and Rungulla Resources Reserve contains spectacular rugged sandstone country, dissected by the Gilbert River and straddles two bioregions. Rungulla has significant natural values including springs and spring-fed watercourses, plateau lagoons, and varied refugia habitats. Woodlands with perennial grasses provide habitat for species of conservation significance such as the Gouldian finch and koala. Aboriginal Cultural sites are a significant value of the park.

It is considered appropriate to adopt a noise level of $L_{Aeq, adj, 1 \text{ hr}}$ of 60 dB(A), near the fringe of the Rungulla National Park and Rungulla Resources Reserve. i.e. 10 dB(A) higher than the acoustic quality objectives for dwellings.

A summary of the noise and vibration goals for this project is contained in Table 6.

Table 6: Summary of Noise and Vibration Goals (free-field)

Location	Time Period	Monday to Saturday Mining		Sundays and Public Holidays Mining		Low Frequency Noise Limit [dB]	Blasting to Avoid Annoyance at Sensitive Receptors	
		$L_{Aeq, adj, 1 hr}$ [dB(A)]	$L_{A01, adj, 1 hr}$ [dB(A)]	$L_{Aeq, adj, 1 hr}$ [dB(A)]	$L_{A01, adj, 1 hr}$ [dB(A)]		Noise [dB]Lin Peak]	Vibration PPV [mm/s]
All Residential Receptors	Day	42	47	42	47	50	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB(Linear) Peak at any time	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time
	Evening	38	43	38	43	50		
	Night	36	41	36	40	50		
Commercial Receptors	Day	47	-	47	-	-		
	Evening	43	-	43	-			
	Night	41	-	40	-			
National Park Fringe	All periods	60	-	60	-	-	-	-

Note: No blasting to occur on Sundays or Public Holidays without notification to sensitive receptors

4 Predicted Noise Levels

4.1 Modelling Methodology

A digital terrain noise model of the site and surroundings has been developed using PEN3D software. The PEN3D General Prediction Model (GPM) is based on the method contained in a book by Bies and Hansen (1988, pages 117, 127). The implementation is a more complex variation of the approach to sound propagation described in Concawe (1981). Concawe is one of the most commonly used methodologies to predict outdoor noise propagation from industrial sites. PEN3D also draws on aspects from ISO 9613-2. The PEN3D software was originally developed in 1993 and has been in constant development and review. The basic equation adopted by the GPM is:

$$L_p = L_w - 20 \log_{10}(r) - 10 \log_{10}(4\pi) + AE$$

Where:

L_p is the sound pressure level at an observer

L_w is the sound power level of the source, in octave bands from 63 Hz to 8 kHz

$20 \log_{10}(r) + 10 \log_{10}(4\pi)$ is the distance attenuation (spherical)

AE is the excess attenuation factors.

The excess attenuation factors AE comprise:

$$AE = A_a + A_g + A_m + A_b + A_f$$

Where:

A_a = Excess attenuation due to air absorption from Sutherland *et. al.* (1974)

A_g = Excess attenuation due to ground reflection

A_m = Excess attenuation due to meteorological effects

A_b = Excess attenuation due to barriers

A_f = Excess attenuation due to forests.

PEN3D is a sophisticated environmental noise model incorporating a 3D terrain model that permits accurate representation of the ground, ground cover, tree zones, mounds, barriers and weather conditions. PEN3D calculates a curved noise path based on surface friction, vertical temperature gradients and wind speed. All the noise calculations are based on this curved path. A finite differences approximation method is used to calculate the curved path. The curvature of the path determines the meteorology corrections. The meteorology corrections are frequency and distance dependent and are limited to +12 dB (downwind at night) and -7 dB (upwind and during the day) similar to the Concawe Category 1 and Category 6 meteorological corrections.

The excess attenuation due to ground reflection is obtained by combining the direct wave and the reflected wave incoherently, that is the energy from the ground wave is added to the direct wave. The ground reflection attenuation (or ground effects) will be between 0 and -3 dB (a negative value is an increase in noise levels) for all cases. This contrasts with the coherent reflection approach. The coherent approach is considered to be an “exact” method. For those situations where the source and receiver are located close to the same very hard reflecting plane and the path difference between the direct path and the reflected path is small, then the addition of the reflected wave and the direct wave will result in 6 dB increase rather than a 3 dB increase. However, at large distances the sound pressure level reduces at 12 dB per doubling with the coherent model (not 6 dB as per the incoherent model). This approach, while “exact”, is dubious as Digital Terrain Models (DTM) models are neither of sufficient accuracy nor can noise models truly account for the effects of atmospheric turbulence. Other methods such as the Nordic method or ISO 9613-2 divide the region between the source and receiver into three zones, and those zones closest to the source and to the receiver can potentially have higher absorption values. Consequently, if a noise source was measured say at a distance of 30 m and the sound power level is calculated by the commonly adopted formula $PWL = SPL + 10\log_{10}(2\pi r^2)$ then the calculations using the PEN3D methodology would remain conservatively high for all distances.

The ground reflection (or ground effects) is a complex calculation using the flow resistivity for the surface likely to provide the ground reflection and the likely angle of incidence of the reflected wave to the ground. In those instances where the ground is highly absorptive the excess correction will approach zero. For those surfaces which are highly reflective the correction will be - 3dB, i.e. will lead to an increase in noise levels of 3 dB(A) (simulates hemispherical propagation).

While there are numerous methods to calculate ground effects (some of which provide significant attenuation [reduction of noise levels]), the PEN3D implementation is one of the more conservative estimates of ground effect in the far field. Bies & Hansen (1988) indicate “as the distance from the source or frequency increases, the incoherent model will become more appropriate”.

The theoretical approach to meteorology implies that PEN3D is likely to provide more significant corrections than other models. Thus, at night or during downwind predictions, the PEN3D calculations are likely to result in conservatively high results, i.e. the modelled noise levels are likely to be higher than the measured levels.

The likely barrier attenuations are calculated for four possible curved paths, namely:

- source, to the top of barrier then to the receiver;
- source, reflection from ground (source side), top of barrier, receiver;
- source, top of barrier, reflection from ground (receiver side), receiver; and
- source, reflection from ground (source side), top of barrier, reflection from ground (receiver side), receiver.

These are combined to obtain effective barrier attenuation. In the situation where the source and receiver are well above the ground and the barrier just intercepts line-of-sight then the barrier effect will be 5 dB(A). However, if the source and receiver are close to the ground and the noise barrier just intercepts line of sight (a pebble) the barrier effect will tend to zero.

Once the most likely curved path has been calculated, the method determines if it intercepts any tree zones within the digital terrain model. If the curved noise path travels in the lower 75% of the tree zone then the full excess attenuation is applied for the distance travelled in the tree zone. If the curved noise path travels in the upper 25% of the tree zone then:

- a) the average propagation height is determined;
- b) the length in the zone is determined; and,
- c) the forest excess attenuation is taken to be linearly interpolated between zero at the top of the tree zone and full excess attenuation at 75% height.

Tree zones can potentially provide extremely high attenuation if the tree coverage is large. However, in practice, the curved path adopted in the PEN3D methodology usually results in the noise rays passing above tree zones (at night or during downwind conditions) and only intercepting tree zones if they exist on the tops of hills or whenever the noise ray approaches the ground. Tree zones can potentially provide higher than expected attenuation during calm neutral conditions.

4.2 Meteorology

The meteorology for the site has been analysed to address frequent wind speeds, wind directions and inversions. The meteorology was prepared for the Air Quality Assessment (SEG 2021) and is based on a 5-year modelling simulation, years 2016 to 2020.

4.2.1 Temperature Inversions

The total night-time period during winter (June, July and August) has been analysed to determine the frequency of inversions, as presented in Table 5. Temperature inversions generally occur during the night-time and early morning periods. The likelihood of inversions reduces with wind speed. It was determined that inversions are likely 51% of the time. This indicates that modelling during inversion conditions is appropriate. However, since the terrain is essentially flat without any dominant (katabatic) drainage flows it is not necessary to include a wind component. The wind direction analysis confirmed that the light winds at night are evenly distributed with direction.

It is proposed to model inversions with the following parameters:

- 3 degrees Celsius (°C)/100 m temperature inversion strength
- Zero wind speed
- Air temperature 10°C.

Table 7: Inversion Analysis June to August (6 pm to 7 am)

Wind speeds	Percentage of Time Occurring (%)
Calms	1
Winds less than 1m/s	2
Wind 1 to 2 m/s	12
Wind 2 to 3 m/s	23
Wind 3 to 4 m/s	32
Wind 4 to 5 m/s	22
Wind over 5 m/s	10

4.2.2 Wind Effects

Wind effects are typically assessed when wind is a feature of the area. Wind is a feature when source-to-receiver wind speeds (at 10 m height) of 3 m/s or below occur for 30 percent of the time or more in any assessment period (day, evening, night) in any season. This differs from the procedure used with temperature inversions, in that the 30 percent occurrence applies to all seasons and each assessment period—and not just the winter season and night/early morning assessment period.

The wind direction and wind speeds were analysed to determine whether wind effects need to be considered. For this analysis, the wind speed was limited to 3 m/s since higher wind speeds tend to increase the ambient noise. Each season and each time period (day, evening and night) was analysed and winds were not found to occur more than 30 percent of the time in any direction. It is noted however that easterly winds are common throughout the year and as a consequence a single wind case at night has been included in the noise model.

The modelling cases adopted in Table 8 are based on the wind distribution.

Table 8: Meteorology Modelling Cases Assessed

Case	Wind speed [m/s]	Wind Direction [degrees from North]	Vertical Temp Profile [°C/100 m]	Air Temp [°C]
Day	0	0	-3	25
Evening (Neutral)	0	0	0	15
Night (Inversion)	0	0	3	10
Night west wind	3	225	1	10

4.3 Noise Model Parameters

4.3.1 Noise Model For Mining

The DTM of the Project has been based on NASA Shuttle Radar telemetry and contoured at 5m intervals for a zone approximately 1.5km from the site. The remaining DTM is contoured at 20, intervals. The noise model has an adopted ground cover of 'thick grass' as a representation of the combination of the roughness provided by pasture and the taller vegetation that exists throughout the region. The model dose not incorporate excess attenuation factors associated with tree zones.

The operational noise sources comprise:

- loaders operation in the pit;
- dozers;
- rock drill;
- blasting;
- dump trucks (in-pit); and
- various surface earth working machines.

The $L_{Aeq(60 \text{ min})}$ equipment noise levels are contained in Table 9. The noise levels are expressed as a sound power level. The overall sound power levels are "A" weighted. The "A" weighting emulates the way the human ear responds to sound. These noise levels are based on measurements by SEG and published data. Refer to Table 9 for equipment for the modelling case.

All the noise sources have been placed in typical operating positions in the noise model. For instance, the route of the overburden trucks encompasses the haul roads as well as the waste rock emplacement. This are typically elevated positions and completely or partially unscreened by nearby terrain. In practice, an operational mine may choose to operate trucks at night in positions that are screened by stockpiles or waste rock emplacements, and consequently noise reductions are likely to be significantly improved compared with the modelled case.

Table 9: Sound Power Levels ($L_{Aeq(1\text{ hr})}$) in dB(A) for major fleet with source of data

Fleet Item	SWL $L_{Aeq(1\text{ hr})}$ dB(A)	Project	Source	Number of Plant
Mining Excavator				
Hitachi EX1800	115	Ensham central Mine	Bassett (2006)	1
Haul Truck				
CAT 789	115	Millenium Mine	Site measurements (2006)	4
Dozer				
CAT D10	111	Baralaba North (2013)	SEG (2012)	1
Grader				
CAT 16M	109	Baralaba North (2013)	SEG (2012)	1
Water Truck				
Komatsu HD785 Water Truck	114	Moolarben Coal Mine	Global Acoustics (2012)	1
Other				
Production Drill	116	Duralie Coal Mine	SLR Consulting (2014)	1
Diesel Generator	109	Estimated	Estimated from library data	1

The noise sources are positioned as follows:

- excavators 5 m above local terrain; and,
- haul trucks, dozers, graders, production drill and other mobile sources at 4 m above local terrain.

There are several items of minor mining plant not included in Table 9. Minor noise sources are comparatively quiet or operated infrequently. The exclusion of this plant from the noise model will not make a noticeable difference in the calculated noise levels at sensitive receptors. In addition, it has been found that the model is relatively insensitive to operating height of the equipment since the model calculates a curved path through the air and for downwind or inversion cases the curved path passes above most obstructions.

Blasting

PEN3D contains a blasting module that includes the effects of meteorology. The basic equations were originally developed and verified for Collinsville coal mine in central Queensland. The basic equation for blast overpressure is:

$$\text{dBL} = 20 \cdot \log(3557/0.00005) - 20 \cdot 1.26 \cdot \log(\text{Distance}) + 20 \cdot 1.268 \cdot \log(\text{MIC}) + 3$$

The proponent indicated the maximum instantaneous charge weight has been nominated to be 1700 kg. For a maximum instantaneous charge weight of 1700 kg, the blast overpressure at 1000 m is 120 dB Lin peak.

For vibration, the peak particle velocity in mm/s is:

$$V = 2000 \cdot (\text{Distance}/(\text{MIC})^{0.5})^{-1.6}$$

For a maximum instantaneous charge weight of 1700 kg, the peak vibration velocity at 1000 m is 12.2 mm/s. This assessment is based on a charge weight of 1700 kg.

4.3.2 Noise Model for Road Trains

SEG has previously conducted attended noise monitoring road trains transporting coal in central Queensland. The monitoring was carried out in compliance with Queensland Noise Measurement Manual 2000 (DERM, 2001) and AS 1055 Parts 1 & 2 Acoustics—Description and measurement of environmental noise. The measurements comprise the maximum noise level at 30m from the edge of the pavement occurring from the bypass of vehicles whilst traveling a straight road in a 100km/h zone. It was noticed the noise at 100km/h is mostly tyre noise. The test surface was chip seal. This road surface produces more noise than a dense graded road surface. The Department of Transport and Main Roads in their document Transport Noise Management Code of Practice states the correction factor for chip seal is increase of 4 to 5.0 dB(A) compared with +0 dB(A) for dense graded asphalt. However, as chip seal ages the surface becomes less noisy. Since the traffic densities on the rural roads is low, the roads surfaces do not wear or age quickly. For the purposes of this report it is assumed that chip seal is 5 dB(A) noisier than dense graded asphalt and gravel roads are 8 dB(A) noisier than dense graded asphalt. Additionally, it is assumed the noise levels are 3 dB(A) quieter at 50 km/h compared with 100km/h. This correction is determined from the methodologies contained Calculation of Road Traffic Noise (CoRTN88).

Table 10: Measured Noise Levels from Vehicles in Central Queensland - Chip Sealed Road and 100km/h Speed Zone

Vehicle Type	Average L_{Amax} at 30m [dB(A)]	Contribution to the $L_{Aeq(1 \text{ hour})}$ at 30m per vehicle [dB(A)]
Road train (Quad) laden	81.1	36.2
Road train (Quad) unladen	80.1	35.2
Truck	76.6	31.7
Light truck	71.8	26.9
4WD	70.3	25.4
4WD with caravan	72.4	27.5
Campervan	66.9	22.0
Cars	68.4	23.5

The route from the mine to the processing facility was inspected and seven noise sensitive locations were identified within approximately 1km of the route, refer to Figure 4. From aerial photographs¹, each location appears to be a residential receptor.

¹ Queensland Globe <https://qldglobe.information.qld.gov.au/> accessed 6 June 2023

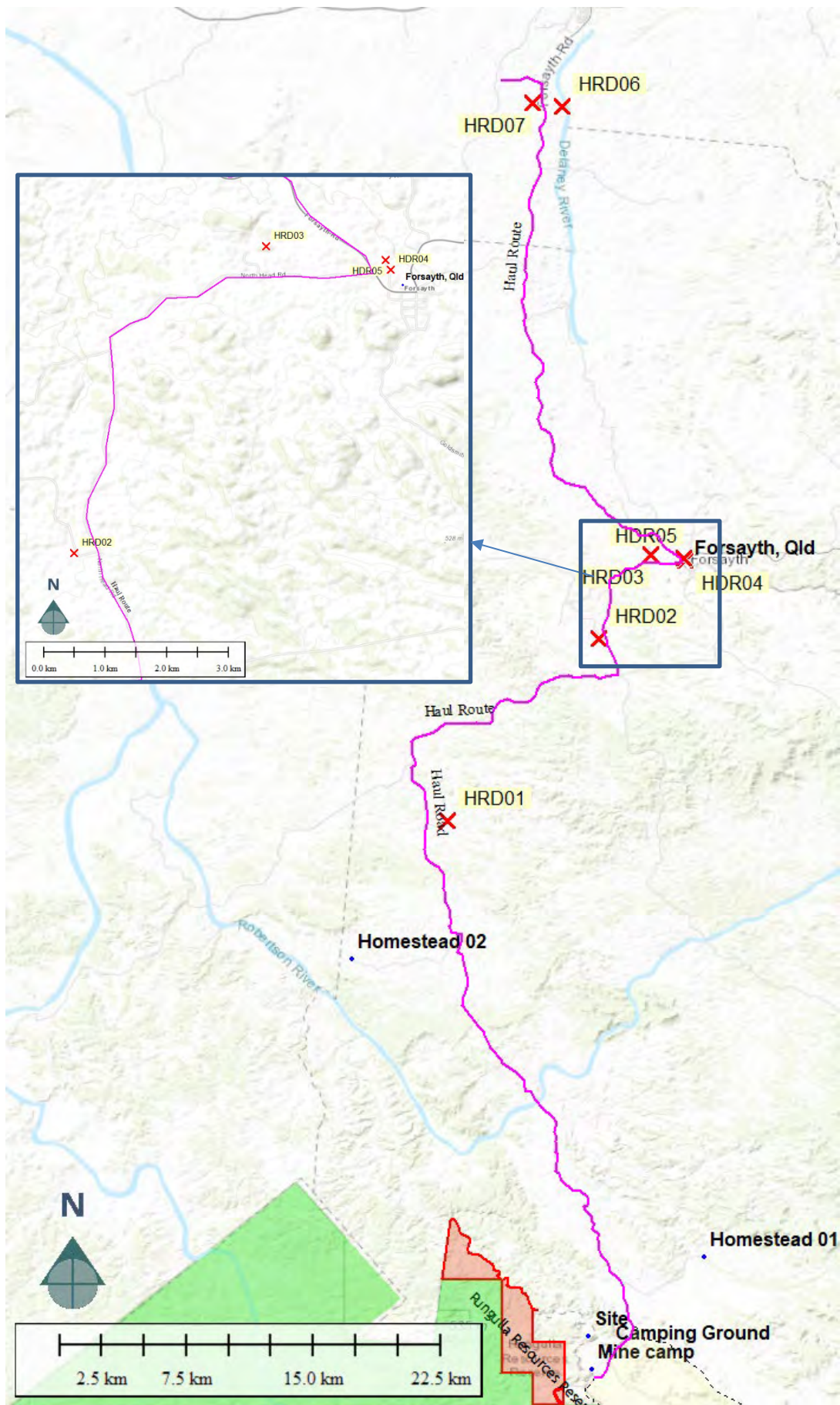


Figure 4: Haul Route Showing Sensitive Receptors

4.4 Noise Modelling Results

4.4.1 Mining Noise

A noise model has been developed for the one mining stages for the fully operational project representing the peak overburden production of the mine. All the noise models are to obtain the $L_{Aeq(1\text{ hr})}$. Each item of equipment goes through a repeating short duration cycle representative of operations. The L_{Aeq} noise model incorporates the fluctuating noise levels to obtain the L_{Aeq} at the receiver. This is a mathematically correct analysis as it is independent of the time the noise is generated. However, it is also a conservative methodology as it requires the meteorology to remain constant for the entire hour (i.e. it ignores the small variations in a turbulent atmosphere that lead to variations of actual noise level below the calculated noise level).

Table 11 contains the calculated $L_{Aeq(15\text{ min})}$ noise levels at the sensitive receptor for all modelling cases in tabular format, Appendix B contains the noise contour diagrams. The results are summarised for the day, evening and night periods. The $L_{eq(15\text{ min})linear}$ low frequency noise levels are contained in Appendix C. The L_{Amax} is calculated by the noise model and is taken to be the noisiest individual noise source logarithmically added to the calculated L_{Aeq} for all noise sources combined.

The shorter duration modelling period (15 min) can be readily applied to the longer (1 hour) averaging time period without loss of accuracy.

All noise level predictions are noise levels due to all mining activities combined, i.e. the noise under investigation, unaffected by extraneous noise, during the measurement period and this is commonly known as component noise levels. As described in the Queensland Noise Measurement Manual March 2020

“The influence of ambient noise must always be removed from the source noise level measurements for the purposes of comparison with noise limits. The source noise level with ambient noise removed is referred to as the component level.”

Thus, the noise modelling only provides component noise levels to facilitate comparison with limits.

Table 11: Predicted Noise Level at Sensitive Receptors (Component Noise Levels)

Location	Time Period	Monday to Saturday Mining Noise		Sundays and Public Holidays Mining Noise		Low Frequency Noise [dB]	Blasting to Avoid Annoyance at Sensitive Receptors	
		<i>L_{Aeq, adj, 1 hr}</i> [dB(A)]	<i>L_{A01, adj, 1 hr}</i> [dB(A)]	<i>L_{Aeq, adj, 1 hr}</i> [dB(A)]	<i>L_{A01, adj, 1 hr}</i> [dB(A)]		Noise [dBLin Peak]	Vibration PPV [mm/s]
All Residential Receptors	Day	42	47	42	47	50	115 dB (Linear) Peak for 9 out of 10 consecutive blasts initiated and not greater than 120 dB(Linear) Peak at any time	5mm/second peak particle velocity for 9 out of 10 consecutive blasts and not greater than 10 mm/second peak particle velocity at any time
	Evening	38	43	38	43	50		
	Night	36	41	36	40	50		
Homestead 01	Day	<thh	<thh	<thh	<thh	18	100	0.05
	Evening	8	12	8	12	20	-	-
	Night	18	23	18	23	36	-	-
	Night (with Wind)	21	26	21	26	38	-	-
Old camp ground (distant)	Day	<thh	<thh	<thh	<thh	16	98	0.05
	Evening	<thh	<thh	<thh	<thh	17	-	-
	Night	16	20	16	20	30	-	-
	Night (with Wind)	20	27	20	27	32	-	-
Camping ground with (nearby) compensation agreement	Day	34	36	34	36	42	118	0.8
	Evening	36	40	36	40	46	-	-
	Night	41	45	41	45	52	-	-
	Night (with Wind)	40	44	40	44	51	-	-
Rungulla	Day	20-30	-	20-30	-	-	-	-
	Evening	20-30	-	20-30	-	-	-	-
	Night	30-40	-	30-40	-	-	-	-
	Night (with Wind)	20-30	-	20-30	-	-	-	-

Note <thh represents a noise level below the threshold of human hearing

4.4.2 Road Train Noise

The calculated noise level at each sensitive receptor along the road train route is contained in Table 12. It is assumed the road trains operate 24 hours per day 7 days per week. It is understood the return trip is 5 hours, hence each road train is able to do 2 return trip per 10 hour shift. For conservatism it is assumed the maximum likely hourly traffic flow passing any of the sensitive receptors is two road trains, one empty and one full.

Table 12: Calculated Noise Levels at Each Sensitive Receptor Adjacent to The Road Train Route

Dwelling	Distance to Haul route [m]	Road Surface	Speed [km/h]	Predicted L_{Amax} from Road Train Passing Dwelling [dB(A)]	Predicted $L_{Aeq}(1 \text{ hour})$ from Road Train Passing Dwelling [dB(A)]
Noise Goal	-	-	-	-	Day 55 Night 50
Campground (nearby)	250	Unsealed	50	63.7	21.6
HRD01	1100	Unsealed	50	50.8	8.7
HRD02	350	Unsealed	50	60.8	18.7
HRD03	500	Unsealed	50	57.7	15.6
HRD04	280	Sealed	50	58.7	16.6
HRD05	280	Sealed	50	58.7	16.6
HRD06	1000	Sealed	50	47.6	5.6
HRD07	500	Sealed	50	53.7	11.6

5 Assessment of Modelled Noise Levels

Operational Noise Assessment

The noise from the operation of the mine is expected to readily comply with the proposed operational environmental goals (L_{Aeq} , L_{A01}) at all Homesteads and sensitive receptors for all time periods. The noise level goal at the nearby campground is expected to exceed noise level goals at night but comply with noise level goals during the day and evening. However, it is understood the proponent has a compensation agreement in place with the landholder to relocate the camping ground to a more distant location if requested.

EA Blasting Objectives

The blast over pressure and blast vibrations from the blasting at the min (MIC of 1700kg) mine is expected to readily comply with the proposed environmental goals at all Homesteads and sensitive receptors.

Low Frequency Noise Objectives

The low frequency noise from the operation of the mine is expected to comply with the proposed environmental goals at all Homesteads and noise sensitive receptors.

Road Train Noise

The noise from road trains on public roads is expected to readily comply with the proposed noise level goals.

5.1 Mitigation Measures

It is not necessary to provide any mitigation measures, other than the normal practices to maintain all equipment in good serviceable condition.

6 Conclusions and Recommendations

The assessment of the Project has been based on a conservative modelling methodology.

Initially the meteorology for the site was assessed in detail to determine whether inversions and/or winds were likely to be frequent for the site. It was determined that inversions are frequent in winter. Assessment of wind occurrence indicated that adverse winds occur during the evening and night. The likely noise levels from operating equipment has been robustly established based on measurements obtained by SEG and from numerous published sources in the public domain. The likely noise emissions were also compared with measurements from similar equipment from other manufacturers to ensure that noise levels were accurate and appropriate.

The DTM map for the site and surroundings was based on NASA shuttle radar mission. The adoption of these contours provides the major features without over emphasising possible noise screening effects of smaller landforms.

A noise survey was carried out at the campground and the background noise levels were determined. Mining was not taking place during the period of the noise survey. From this the noise level goals and environmental values to be preserved were determined. The goals for the Rungulla National Park and Rungulla Resources Reserve have been based on the Acoustic Quality Objectives for dwellings and increased by 10 dB(A). The goal applies near the fringe/boundary of the critical areas.

The model mining conditions were adopted as the appropriate noise level goals for the proposal. Since Queensland does not have a policy addressing traffic generating developments, the noise level goal for the road trains while on public roads has been drawn from NSW Industrial noise policy.

One modelling case was adopted representing the peak overburden production and this is conservative for the entire open pit mining phase.

Except for the nearby campground it was found that the noise and vibration goals are expected to be easily met at all sensitive receptors and at the Rungulla National Park and Rungulla Resources Reserve during the proposed mining phase. It is understood that the proponent has a compensation agreement in place with the campground owner to relocate the camping ground to a more distant location. Consequently, the site is not considered to be a sensitive receptor.

While the noise from passing road trains will be audible at the seven dwellings identified along the haul train route, the noise levels are expected to readily comply with noise level limits.

It is recommended that the site prepare a noise and vibration management plan which identifies the existing risks, specific triggers and management methodologies. The risks include exceeding noise level goals at the nearby Rungulla National Park and Rungulla Resources Reserve and noise from road trains while on public roads. To address mining noise it is recommended plant and equipment be maintained in good condition. Thae hauls roads (waste and ROM) are maintained in good condition. Finally, it is recommended the road trains be operated in a professional manner and speeds are kept low near all sensitive receptors along the route. The unsealed sections of the route near dwellings to be maintained in good condition. The road trains should avoid use of exhaust brakes in the vicinity of dwellings and the township of Forsayth.

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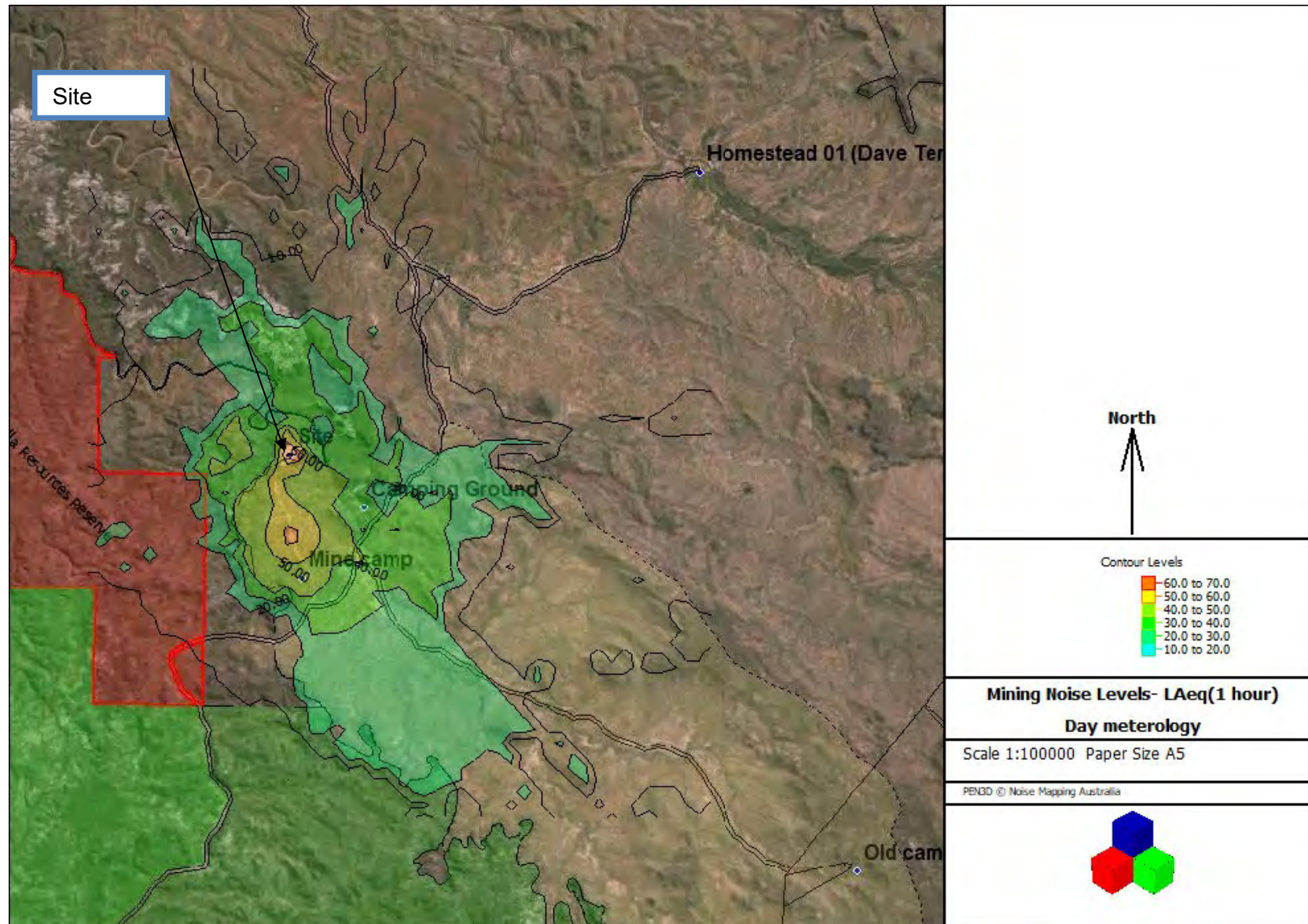
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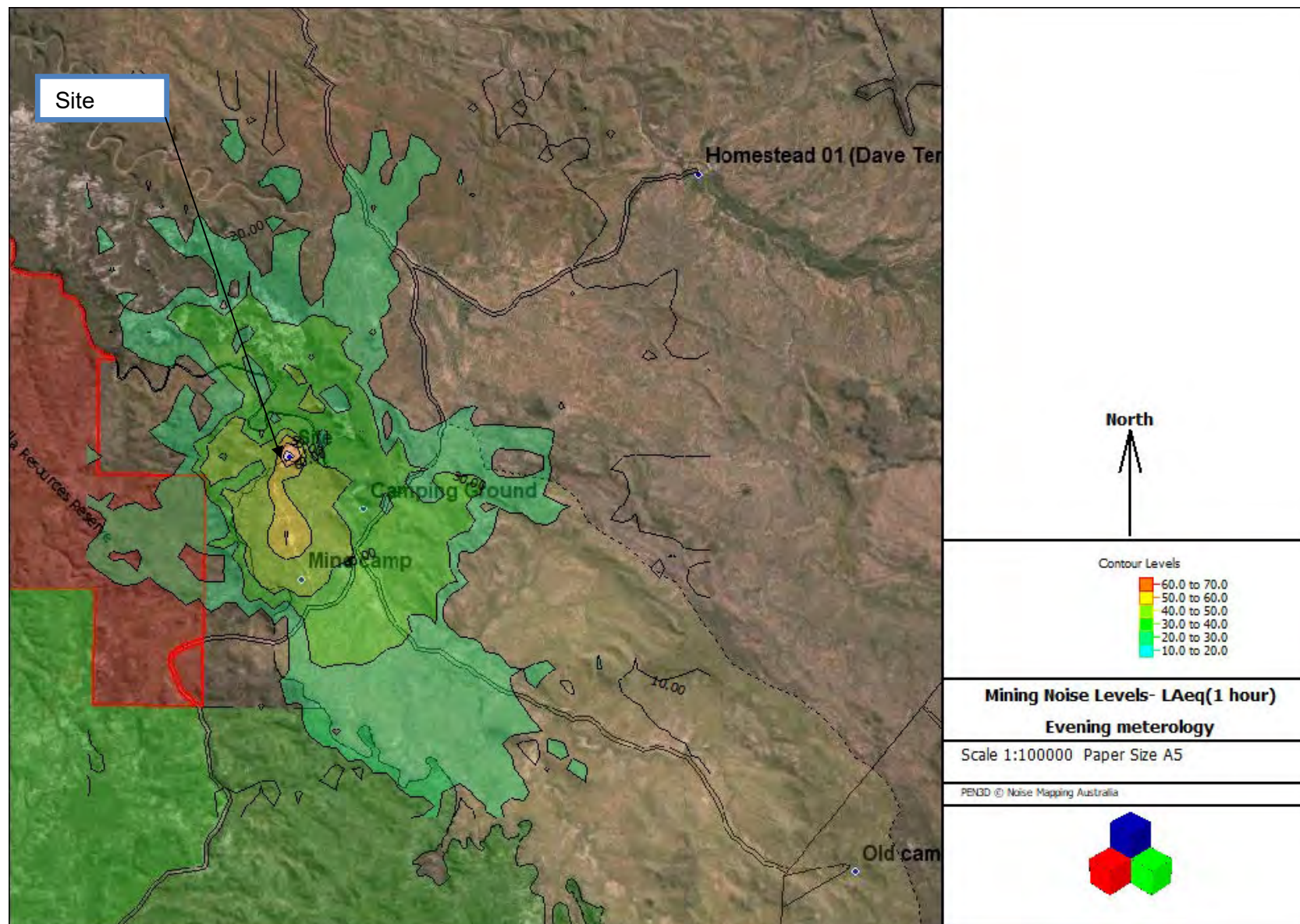
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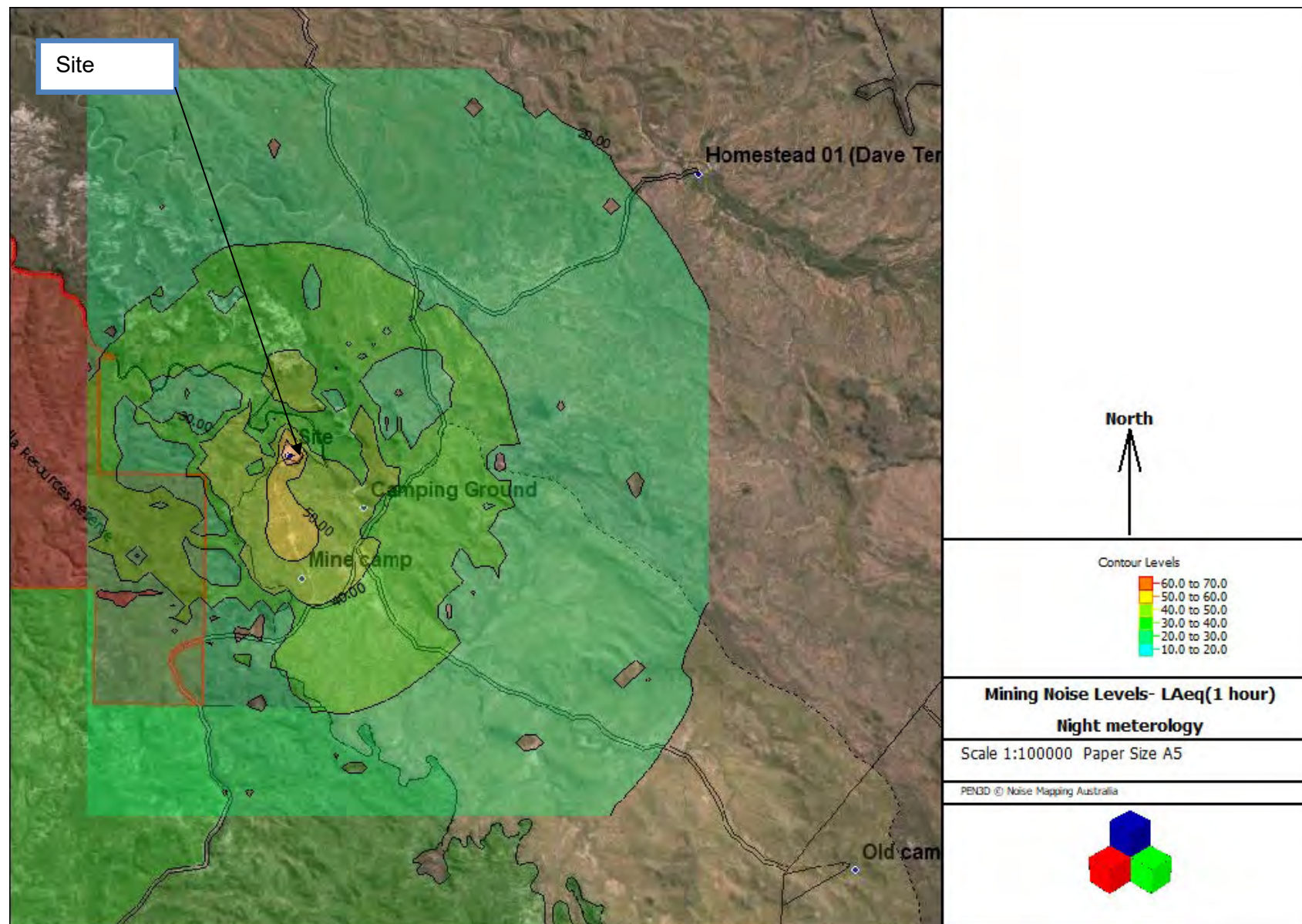
Appendix A: Sound Power Level Details

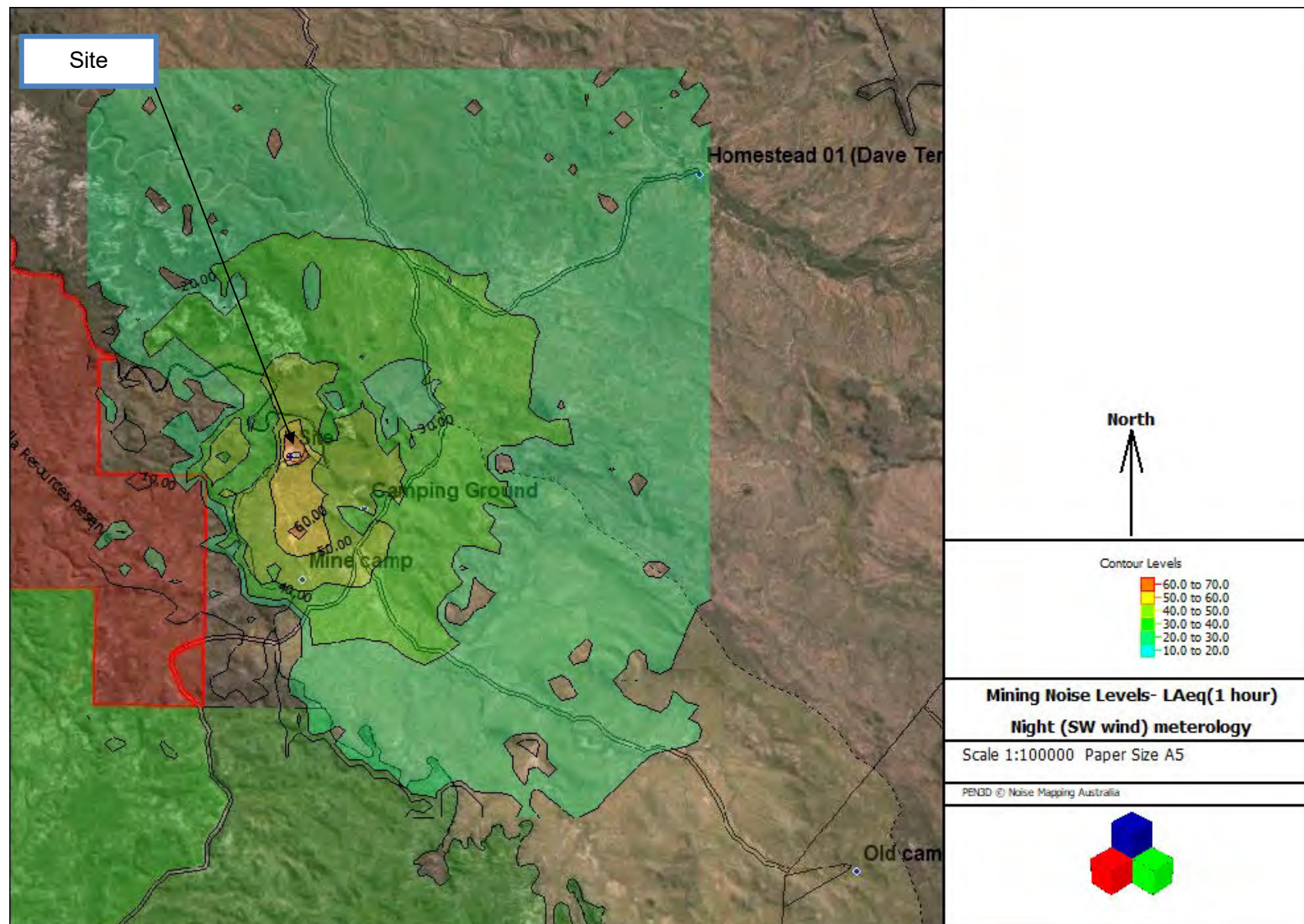
Plant	Octave dB Sound Power Levels in dB at Octave band Hz								Totals	
	63	125	250	500	1000	2000	4000	8000	dB(A)	dB(Z)
Mining Excavator										
Hitachi EX1200	96.8	103.9	109.9	112.6	111.9	113.6	107.3	100.8	118.7	118.9
Hitachi EX1800	116	117	110	113	111	106	102	99	115.0	121.0
30t Excavator	96.0	100.0	97.0	98.0	99.0	100.0	90.0	91.0	103.0	105.0
Haul Truck										
CAT 789	99.4	109.3	112.1	109.9	111.9	115.4	110.0	102.7	112.6	119.9
Dozer										
CAT D10	104.8	112.6	106.3	111.9	104.4	101.1	97.8	95.9	111.3	116.6
Grader										
CAT 16M	110.7	105.9	104.6	103.3	105.0	101.6	98.4	96.8	109.0	114.2
Water Cart										
Komatsu HD785 Water Truck	106.0	110.0	107.0	108.0	109.0	110.0	100.0	101.0	114.0	116.6
Other										
Production Drill	108.0	114.0	114.0	113.0	110.0	108.0	103.0	98.0	116.0	120.0
Diesel generator	87	94	100	102	102	104	97	91	109.0	110
B-Double road train	89.0	89.0	93.0	99.0	98.0	97.0	100.0	106.0	108.0	108.6

Appendix B: Calculated $L_{Aeq\ 1hr}$ Noise Levels Contour Diagrams









Appendix C: Low Frequency Noise $L_{Aeq(15\text{ min})}$ Linear – Based on Night Case

