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Environmental Noise Assessment

Warrawoona Gold Project, Marble Bar

Reference: 19034896-01 R3.docx

Prepared for:
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Report: 19034896-01 R3.docx

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Date:	Rev	Description	Prepared By	Verified
08-May-19	0	Issued to Client	Olivier Mallié	Terry George
29-May-19	1	Minor edits	Olivier Mallié	-
21-Jun-19	2	Night shift mining operations added	Olivier Mallié	-
14-Oct-19	3	KQ Cave Noise Levels Estimated	Olivier Mallié	-

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1 INTRODUCTION

The Warrawoona Gold Project is located 20 kilometres southeast of Marble Bar – refer *Figure 1-1*.

The project is centred around two deposits:

- Copenhagen – M45/240, M45/682;
- Klondyke – M45/547, M45/552, M45/669, M45/671, E45/3381; and E45/3381, E45/4906.

The Klondyke site will have a CIL plant with approximately 2 million tonnes per annum throughput, as well as other facilities (e.g. TSF, waste rock dumps, camp, etc.).

It is understood that Calidus seeks to understand the noise impact from the site at nearby receivers, including known roost sites for two bat species.

Lloyd George Acoustics was commissioned to model and assess the noise emissions from the site proposed process plant and associated power plant, and night-time mining operations at the Klondyke pit at the following locations:

- Prospector on tenements M45/004 and M45/646, and located approximately 2.5 kilometres to the south-west of the plant area, and
- Numerous roost sites for the Pilbara Leaf-nose and Ghost bats, with the closest site located approximately 1.3 kilometres north-west of the plant area.

The above receivers and the location of the process and power plants are shown on *Figure 1-2*.

Appendix A contains a description of some of the terminology used throughout this report.

Figure 1-1 Project Locality

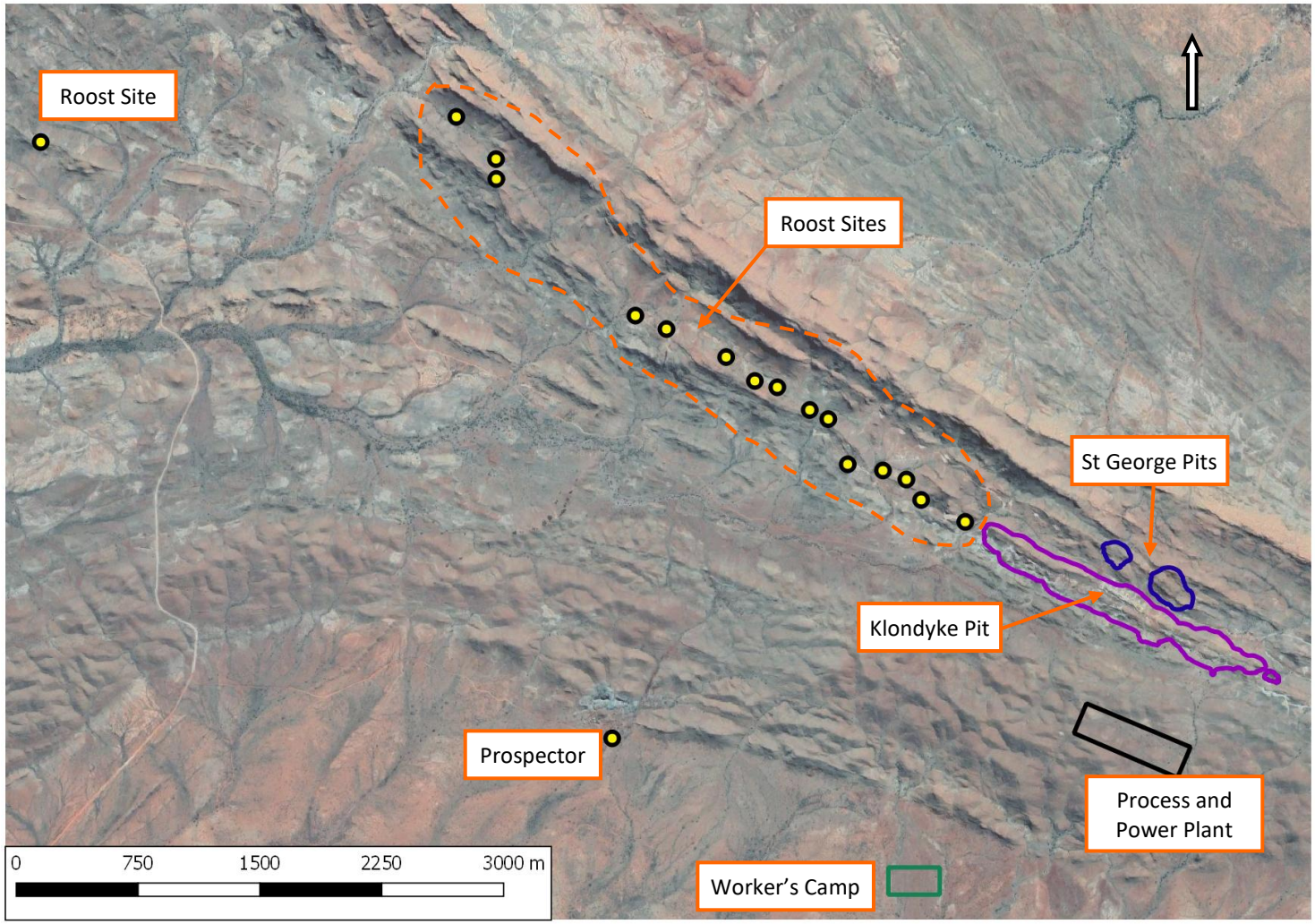


Figure 1-2 Site Layout

2 CRITERIA

Environmental noise in Western Australia is governed by the *Environmental Protection Act 1986*, through the *Environmental Protection (Noise) Regulations 1997* (the Regulations).

Regulation 7 defines the prescribed standard for noise emissions as follows:

"7. (1) Noise emitted from any premises or public place when received at other premises –

(a) Must not cause or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind; and

(b) Must be free of –

i. tonality;

ii. impulsiveness; and

iii. modulation,

when assessed under regulation 9"

A "…noise emission is taken to significantly contribute to a level of noise if the noise emission … exceeds a value which is 5 dB below the assigned level…"

Tonality, impulsiveness and modulation are defined in Regulation 9. Noise is to be taken to be free of these characteristics if:

(a) The characteristics cannot be reasonably and practicably removed by techniques other than attenuating the overall level of noise emission; and

(b) The noise emission complies with the standard prescribed under regulation 7 after the adjustments of *Table 2-1* are made to the noise emission as measured at the point of reception.

Table 2-1 Adjustments Where Characteristics Cannot Be Removed

Where Noise Emission is Not Music			Where Noise Emission is Music	
Tonality	Modulation	Impulsiveness	No Impulsiveness	Impulsiveness
+ 5 dB	+ 5 dB	+ 10 dB	+ 10 dB	+ 15 dB

Note: The above are cumulative to a maximum of 15dB.

The baseline assigned levels (prescribed standards) are specified in Regulation 8 and are shown in *Table 2-2*.

Table 2-2 Baseline Assigned Noise Levels

Premises Receiving Noise	Time Of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises: highly sensitive area[1]	0700 to 1900 hours Monday to Saturday (Day)	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays (Sunday)	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days (Evening)	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays (Night)	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise sensitive premises: any area other than highly sensitive area	All hours	60	75	80

1. ***highly sensitive area*** means that area (if any) of noise sensitive premises comprising —
   (a) a building, or a part of a building, on the premises that is used for a noise sensitive purpose; and
   (b) any other part of the premises within 15 metres of that building or that part of the building.

The project is located in a remote area and the closest sensitive receiver, the prospector, is located approximately 2.5 kilometres from the site. Therefore the influencing factor at that receiver would be 0 dB. As the process and power plants are assumed to operate 24/7, based on *Table 2-2* above the most stringent assigned noise level is therefore the **night-time L_{A10} of 35 dB** at that receiver.

With regard to the bats roosting sites, it is noted that the Regulations do not apply to fauna, however the land the roosting sites are on would be considered 'sensitive' but with no building associated with a sensitive use. Therefore the most stringent assigned noise level is the **L_{A10} of 60 dB at all hours**. Interestingly, a study by R.D. Bullen and S. Cresse (2014) indicated that noise levels up to 70 dB(A) from drilling activities did not appear to 'disturb' bats roosting at the time. As such the criterion of 60 dB L_{A10} would be considered conservative with regard to potential disturbance to bats.

The assigned noise levels above were predicted and assessed at a point located 1.5 metres above local ground level.

3 METHODOLOGY

Computer modelling has been used to predict noise levels at the various receiver locations.

The software used was *SoundPLAN 8.1* with the CONCAWE (ISO 171534-3 improved method) algorithms selected. These algorithms have been selected as they include the influence of wind and atmospheric stability. Input data required in the model are:

- Meteorological Information;
- Topographical data;
- Ground Absorption; and
- Source sound power levels.

3.1 Meteorological Information

Meteorological information utilised is provided in *Table 3-1* and is considered to represent worst-case conditions for noise propagation. At wind speeds greater than those shown, sound propagation may be further enhanced, however background noise from the wind itself and from local vegetation is likely to be elevated and dominate the ambient noise levels.

Given the continuous nature of the operations, only the night period was considered as the night weather conditions always result in higher noise levels than the day time.

Table 3-1 Modelling Meteorological Conditions

Parameter	Night (1900-0700)
Temperature (^{o}C)	15
Humidity (%)	50
Wind Speed (m/s)	3
Wind Direction*	All
Pasquil Stability Factor	F

* Note that the modelling package used allows for all wind directions to be modelled simultaneously.

It is generally considered that compliance with the assigned noise levels needs to be demonstrated for 98% of the time, during the day and night periods, for the month of the year in which the worst-case weather conditions prevail. In most cases, the above conditions occur for more than 2% of the time and therefore must be satisfied.

3.2 Topographical Data

Topographical data was based on that provided by the project in the form of 1 m elevation contours. The pit depth was taken to be the 12 months EOM surface as provided by the project team.

3.3 Ground Absorption

Ground absorption varies from a value of 0 to 1, with 0 being for an acoustically reflective ground (e.g. water or bitumen) and 1 for acoustically absorbent ground (e.g. grass). In this instance, a value of 0.5 e.g. compacted earth, has been used as an average across the study area.

3.4 Source Sound Levels

The sound power levels used in the modelling are provided in *Table 3-2*. These were derived from data already on file for gold processing plant of similar capacity i.e. up to 2 Mtpa and 8 MW power requirement.

Both the power station and processing plant were modelled as a point source located 6 metres above local ground.

The mining operations in the Klondyke pit were modelled based on the 12 months pit depth and the mobile plant as shown in *Table 3-2*.

Table 3-2 Source Sound Power Levels, dB

Description	Octave Band Centre Frequency (Hz)								Overall dB(A)
	63	125	250	500	1k	2k	4k	8k	
Power Plant	117	120	121	115	112	111	119	118	**123**
Processing Plant	128	121	120	117	115	110	107	101	**120**
Mining Operations (Klondyke Pit)									
Drill rigs, 2 of (each)	119	120	122	120	116	113	107	103	**122**
Haul trucks (CAT 785), 4 of (each)	107	123	113	123	114	110	105	98	**122**
190t excavator, 2 of (each)	113	119	116	111	111	108	104	100	**116**
D11 Dozer (on waste dump), 1 of	109	115	109	110	108	106	99	92	**113**

With regards to the above, please note the following:

- The generators at the power station are assumed to be fitted with 'entry level' generic silencers on the exhaust. Such silencers are generally provided to achieve adequate levels near the power station i.e. 85 dB(A) as per OHS. The generators are housed within a sheet metal building with some openings to allow for natural ventilation.
- The process plant includes crushers, screens and mills and is considered relatively 'open' i.e. plant is not mostly not enclosed.
- All mobile plant were modelled as point sources located 2.5 metres above the pit or waste dump surface. The waste dump was taken to be at approximately 290m RL.

4 RESULTS

The combined noise levels from the process plant and associated power plant, and the mining operations at Klondyke pit were predicted at the various receivers identified, and are summarised in *Table 4-1*.

Figure 4-1 also shows the predicted noise levels as a contours map at ground level as well as the location of each receiver.

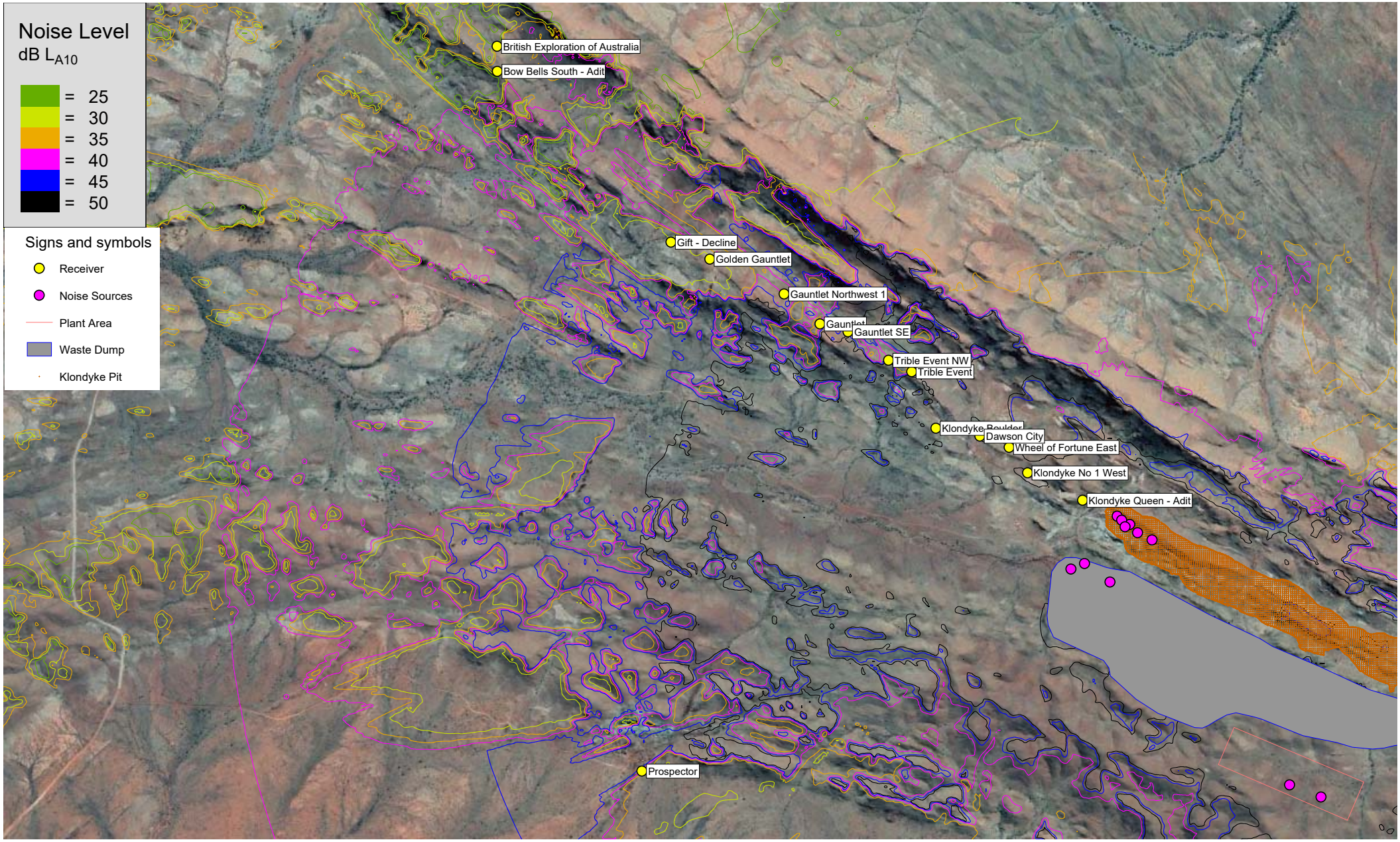
Table 4-1 Predicted Noise Levels (Night Worst-Case Weather Conditions)

Receiver (1.5 m above ground)	Predicted Noise Levels, dB L_{A10}		
	Process + Power Plant	Mining Operations	Overall
Prospector	18	38	**38**
Roosting Sites Name or ID			
Bow Bells Block No 1	25	36	**37**
Bow Bells South (Adit)	24	37	**38**
British Exploration of Australia	23	33	**33**
Dawson City	27	44	**44**
Gauntlet	19	35	**35**
Gauntlet Northwest 1	17	41	**41**
Gauntlet SE	31	44	**45**
Gift - Decline	14	28	**28**
Golden Gauntlet	14	29	**29**
Klondyke Boulder	37	58	**58**
Klondyke No 1 West	29	50	**50**
Klondyke Queen (Adit)	44	71	**71**
Trible Event	28	41	**41**
Trible Event NW	31	47	**47**
Trump	20	30	**30**
Wheel of Fortune East	41	58	**58**

From the above it can be seen that noise from the mining operations dominate the overall noise levels at all the receivers. The highest overall noise levels are predicted at the roosting sites at Klondyke Queen, Klondyke Boulder and Wheel of Fortune East.

Warrawoona Gold Project - Process Plant, Power Station and Mining Operations Noise Emissions
'Worst-case' meteorological conditions for night period

Figure 4-1



Length Scale 1:24750
0 100 200 400 600 m

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21-Jun-19

5 DISCUSSIONS

5.1 Receiver 'The Prospector'

For this project, the most critical sensitive receptor is considered to be the prospector location, as it is understood to be inhabited. From our experience on similar projects, the combined noise emissions from process and power plants can exhibit annoying characteristics such as tonality, even at distances in the order of 2 kilometres. However, in this case noise emissions from the mining operations are predicted to dominate the overall noise emissions at this receiver. Noise emissions from mining operations are not considered to contain annoying characteristics themselves, and therefore any annoying characteristics from the power plant e.g. tonality, will be masked by mining operations. This results in an assessable noise level of 38 dB L_{A10} and therefore a 3 dB exceedence of the night-time assigned noise level of 35 dB L_{A10} is predicted at this receiver.

At that receiver, the noise emissions are dominated by mining operations, in particular the drill rigs and haul trucks operating at, or near the surface. No single noise source is significantly contributing, that is the noise contribution from each the drill rigs and haul trucks are similar in the order of 31-33 dB L_{A10}. The noise contributions of the excavators and dozer are below 25 dB(A) each and therefore do not significantly affect the overall noise levels.

It is expected for the noise levels to decrease as the pit depth increases, however this gain will be offset as the number of haul trucks increases from 4 to 7 over the life of the project. Therefore, to achieve the night-time assigned noise level of 35 dB L_{A10}, it is required that at least the drills and haul trucks have a sound power level no greater than 119 dB(A).

5.2 Bats Roosting Sites

At the roosting sites, the applicable assigned noise level is 60 dB L_{A10}. The noise emissions from mining operations are not considered to contain annoying characteristics and therefore no adjustment is required.

The highest predicted noise level is 71 dB L_{A10} at the Klondyke Queen site, therefore exceeding the assigned noise level by 11 dB. By applying the noise controls above to the drill rigs and haul trucks, the predicted noise level decreases to 69 dB L_{A10}, which results in a 9 dB exceedence. It is noted the above applies when considering the noise levels at the surface however, it is understood the roosting site is located approximately 10 metres below ground and well away from the adit's entrance. As such, the noise levels within the cave are expected to be lower than on the surface. A simplified model of the adit and cave system was built in *SoundPlan*, with the adit approximately 70 metres long and with an average cross-section of 4 m^2, and both the adit and cave assumed to be relatively reverberant i.e. solid rock with minimal soft ground/vegetation within. The noise levels within the cave were predicted to be below 55 dB(A) using the VDI 3760 algorithms as implemented by *SoundPlan*.

In addition to the above, based on the limited information available on the impact of noise on bats' roosting sites, the predicted noise levels of 69-71 dB(A) at the surface and 55 dB(A) within the cave may not adversely impact on the local bat population. It is noted that the 'A' frequency weighting is used to imitate the frequency response of the human ear, and attenuates low frequency signals (i.e. below 250 Hz) more than the higher frequency sound. Hence, without the 'A' frequency weighting

applied, the predicted noise levels are 60 dB and 77 dB within the cave and on the surface respectively. Given the large separation distances involved, the noise levels are dominated by low frequency sound and therefore not likely to interfere with the bat's calls signals, which are understood to be near 2 kHz and above.

Figure 5-1 shows the predicted octave band data (with reduced drill rigs and haul trucks sound power levels) outside and within the cave for reference.

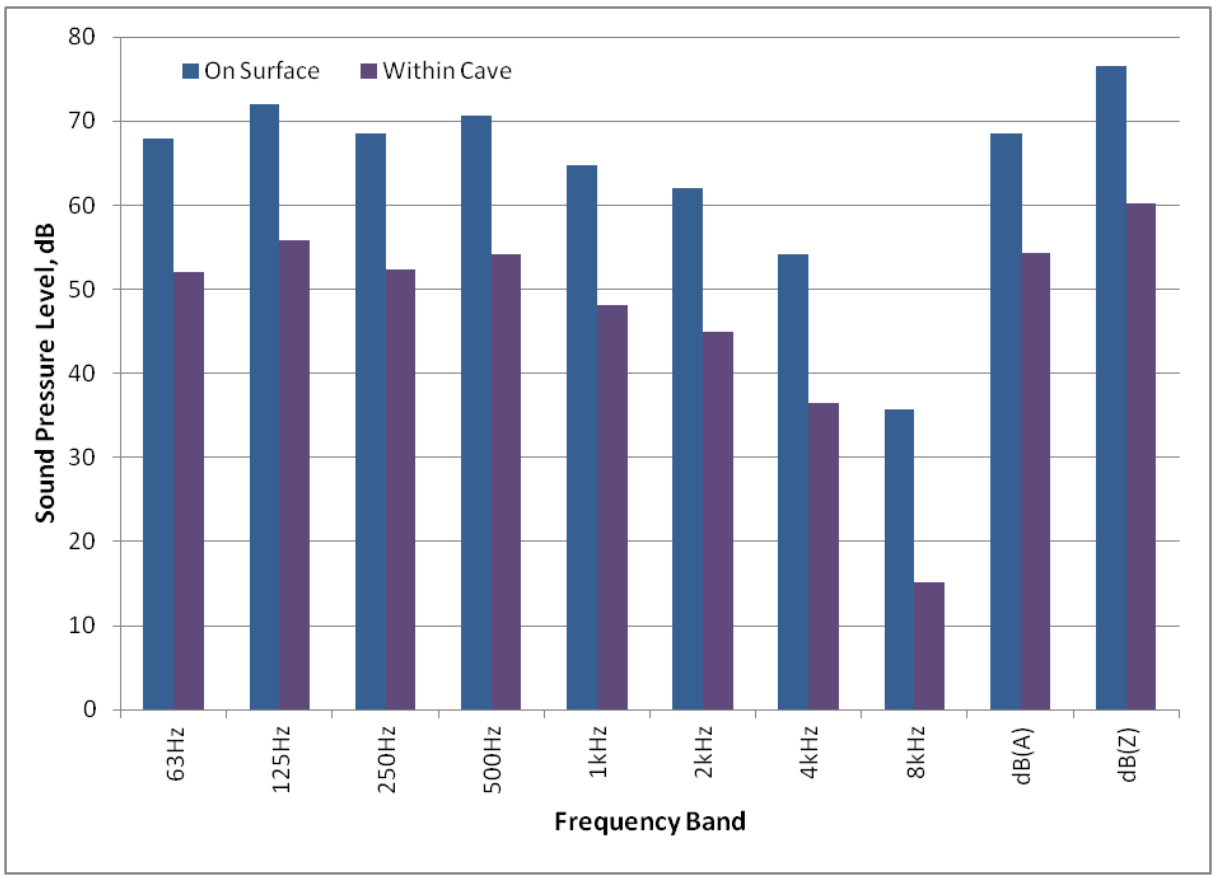


Figure 5-1 Predicted Octave Band Noise Levels

Further monitoring, both of noise levels and bat behaviour, could be undertaken to better quantify any threshold noise level above which bats may become affected.

Appendix A

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

Sound Power Level (L_w)
Under normal conditions, a given sound source will radiate the same amount of energy, irrespective of its surroundings, being the sound power level. This is similar to a 1kW electric heater always radiating 1kW of heat. The sound power level of a noise source cannot be directly measured using a sound level meter but is calculated based on measured sound pressure levels at known distances. Noise modelling incorporates source sound power levels as part of the input data.

Sound Pressure Level (L_p)
The sound pressure level of a noise source is dependent upon its surroundings, being influenced by distance, ground absorption, topography, meteorological conditions etc and is what the human ear actually hears. Using the electric heater analogy above, the heat will vary depending upon where the heater is located, just as the sound pressure level will vary depending on the surroundings. Noise modelling predicts the sound pressure level from the sound power levels taking into account ground absorption, barrier effects, distance etc.

L_{ASlow}
This is the noise level in decibels, obtained using the A frequency weighting and the S (Slow) time weighting as specified in IEC 61672-1:2002. Unless assessing modulation, all measurements use the slow time weighting characteristic.

L_{AFast}
This is the noise level in decibels, obtained using the A frequency weighting and the F (Fast) time weighting as specified in IEC 61672-1:2002. This is used when assessing the presence of modulation only.

L_{APeak}
This is the greatest absolute instantaneous sound pressure in decibels using the A frequency weighting as specified in IEC 61672-1:2002.

L_{Amax}
An L_{Amax} level is the maximum A-weighted noise level during a particular measurement.

L_{A1}
An L_{A1} level is the A-weighted noise level which is exceeded for one percent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{A10}
An L_{A10} level is the A-weighted noise level which is exceeded for 10 percent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{Aeq}
The equivalent steady state A-weighted sound level ("equal energy") in decibels which, in a specified time period, contains the same acoustic energy as the time-varying level during the same period. It is considered to represent the "average" noise level.

L_{A90}
An L_{A90} level is the A-weighted noise level which is exceeded for 90 percent of the measurement period and is considered to represent the "*background*" noise level.

One-Third-Octave Band
Means a band of frequencies spanning one-third of an octave and having a centre frequency between 25 Hz and 20 000 Hz inclusive.

L_{Amax} assigned level
Means an assigned level which, measured as a $L_{A\ Slow}$ value, is not to be exceeded at any time.

L_{A1} assigned level
Means an assigned level which, measured as a $L_{A\ Slow}$ value, is not to be exceeded for more than 1% of the representative assessment period.

L_{A10} assigned level
Means an assigned level which, measured as a $L_{A\ Slow}$ value, is not to be exceeded for more than 10% of the representative assessment period.

Tonal Noise
A tonal noise source can be described as a source that has a distinctive noise emission in one or more frequencies. An example would be whining or droning. The quantitative definition of tonality is:

the presence in the noise emission of tonal characteristics where the difference between -

(a) the A-weighted sound pressure level in any one-third octave band; and

(b) the arithmetic average of the A-weighted sound pressure levels in the 2 adjacent one-third octave bands,

is greater than 3 dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\ Slow}$ levels.

This is relatively common in most noise sources.

Modulating Noise
A modulating source is regular, cyclic and audible and is present for at least 10% of the measurement period. The quantitative definition of modulation is:

a variation in the emission of noise that —

(a) is more than 3 dB $L_{A\ Fast}$ or is more than 3 dB $L_{A\ Fast}$ in any one-third octave band;

(b) is present for at least 10% of the representative.

Impulsive Noise
An impulsive noise source has a short-term banging, clunking or explosive sound. The quantitative definition of impulsiveness is:

a variation in the emission of a noise where the difference between $L_{A\ peak}$ and $L_{A\ Max\ slow}$ is more than 15 dB when determined for a single representative event;

Major Road
Is a road with an estimated average daily traffic count of more than 15,000 vehicles.

Secondary / Minor Road
Is a road with an estimated average daily traffic count of between 6,000 and 15,000 vehicles.

Influencing Factor (IF)

$$= \frac{1}{10}(\%\ \text{Type A}_{100} + \%\ \text{Type A}_{450}) + \frac{1}{20}(\%\ \text{Type B}_{100} + \%\ \text{Type B}_{450})$$

where :

$\%\ \text{Type A}_{100}$ = the percentage of industrial land within a100m radius of the premises receiving the noise

$\%\text{TypeA}_{450}$ = the percentage of industrial land within a 450m radius of the premises receiving the noise

$\%\ \text{Type B}_{100}$ = the percentage of commercial land within a100m radius of the premises receiving the noise

$\%\text{TypeB}_{450}$ = the percentage of commercial land within a 450m radius of the premises receiving the noise

+ Traffic Factor (maximum of 6 dB)

= 2 for each secondary road within 100m

= 2 for each major road within 450m

= 6 for each major road within 100m

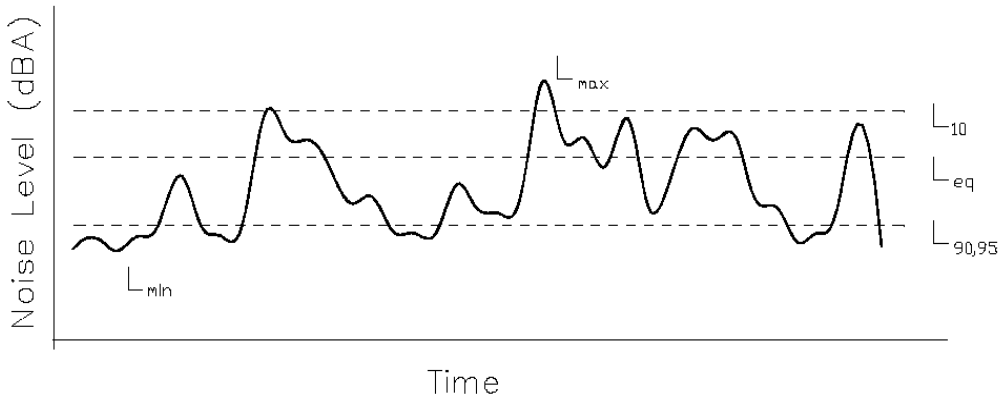
Representative Assessment Period
Means a period of time not less than 15 minutes, and not exceeding four hours, determined by an inspector or authorised person to be appropriate for the assessment of a noise emission, having regard to the type and nature of the noise emission.

Background Noise
Background noise or residual noise is the noise level from sources other than the source of concern. When measuring environmental noise, residual sound is often a problem. One reason is that regulations often require that the noise from different types of sources be dealt with separately. This separation, e.g. of traffic noise from industrial noise, is often difficult to accomplish in practice. Another reason is that the measurements are normally carried out outdoors. Wind-induced noise, directly on the microphone and indirectly on trees, buildings, etc., may also affect the result. The character of these noise sources can make it difficult or even impossible to carry out any corrections.

Ambient Noise
Means the level of noise from all sources, including background noise from near and far and the source of interest.

Specific Noise
Relates to the component of the ambient noise that is of interest. This can be referred to as the noise of concern or the noise of interest.

Chart of Noise Level Descriptors



Typical Noise Levels