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Environmental Noise Assessment - Mulga Downs Mining Operations

Mulga Downs, WA

Reference: 23058085-03 MDIOM

Prepared for:
Hancock Prospecting Pty Ltd

Reference: 23058085-03 MDIOM

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1. INTRODUCTION

1.1. Background

Lloyd George Acoustics was engaged by JBS&G, on behalf of the Proponent, Hancock Prospecting Pty Ltd (HPPL) to undertake an assessment of the potential noise and vibration impacts from the proposed 10Mtpa Mulga Downs Iron Ore Mine (MDIOM, the Proposal) on surrounding noise sensitive receptors including the Youngaleena and Wirrilimarra communities, heritage sites and bat caves. The Proposal is located approximately 210 km south of Port Hedland and 180 km northwest of Newman - refer *Figure 1-1.*

An overview of the mine site layout showing the homesteads and communities identified as noise sensitive receptors is provided as *Figure 1-2.* The overall mine layout (each proposed mine pit) is presented as *Figure 1-3*. Bat caves within the vicinity of the development envelope are shown on *Figure 1-4*.

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

1.2. Cumulative noise

This assessment also includes cumulative noise, considering noise from mining operations as a result of the Proposal, as well as the noise from the adjacent Mulga Downs Hub and Rail Spur Project and the proposed associated Haulage Road.

The Mulga Downs Hub and Rail Spur is a standalone project proposed by Roy Hill Infrastructure Pty Ltd (RHI), located adjacent to the proposed MDIOM. The Mulga Downs Hub and Rail Spur is a new asset which will contribute to supplying iron ore product for HPPL customers through the port facilities located at Port Hedland.

The Mulga Downs Hub and Rail Spur will service third party iron ore mines in the region as well as the future proposed MDIOM. Two rail alignment options are currently under consideration (Option 1B and 8B), these branch off from each other in a location that is relatively distant from the nearest noise sensitive receiver (being the Wirrilimarra Community, approximately 13.8 km south). The conceptual footprint for either option is the same in the vicinity of the hub (which is the source of most noise). As such, noise modelling for Option 8B was deemed to be the worst case for noise modelling purposes. This is discussed and assessed in detail in the Rail Spur Project report (LGA Ref 23058085-02B).

The proposed Haulage Road will allow the transport of ore to the Mulga Downs Hub and Rail Spur stockpile and loading facilities. It is anticipated that trucks consisting of three payload trailers of 100 tonnes each will be delivering material to the Mulga Downs Hub and Rail Spur approximately every 10 minutes.

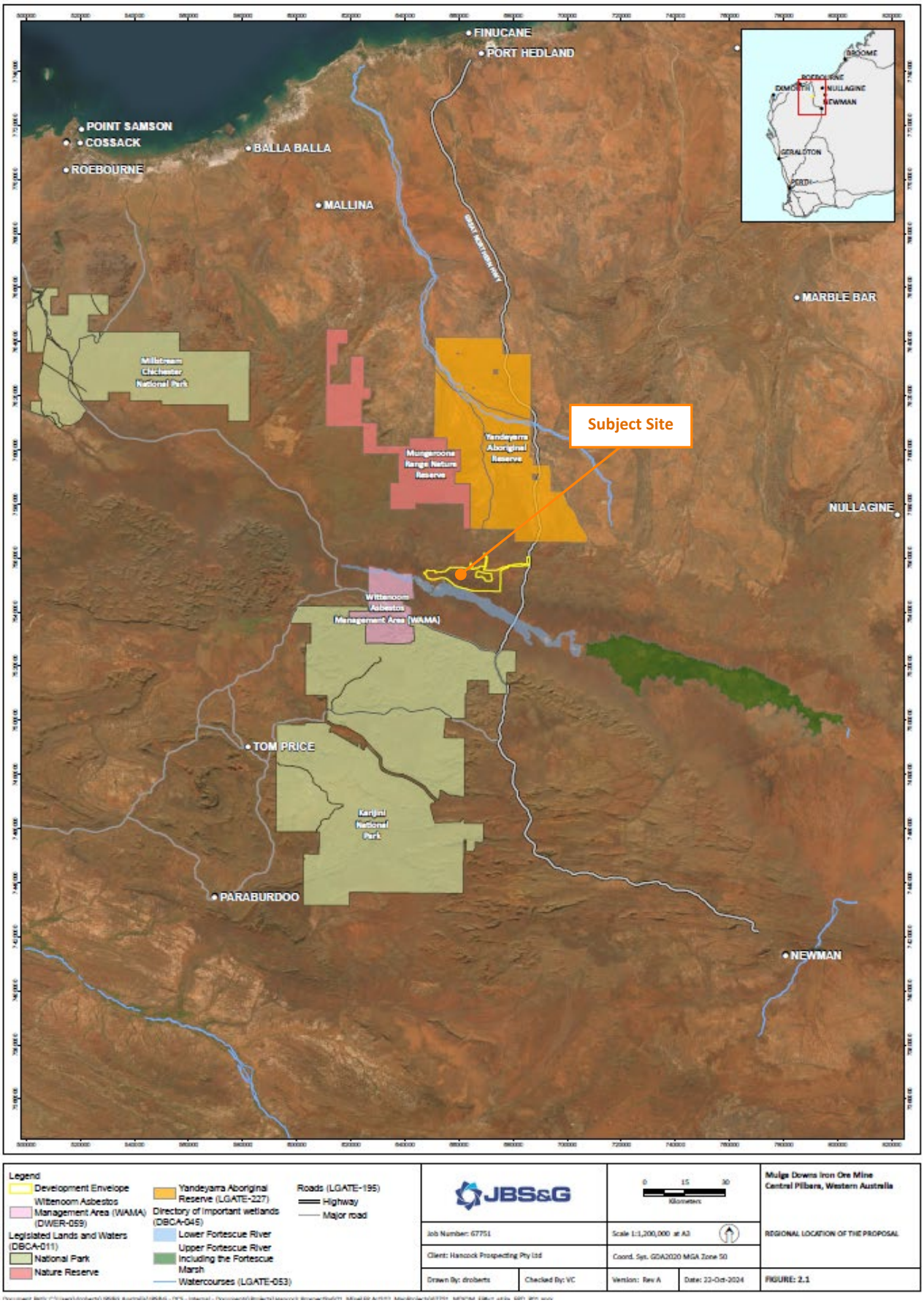
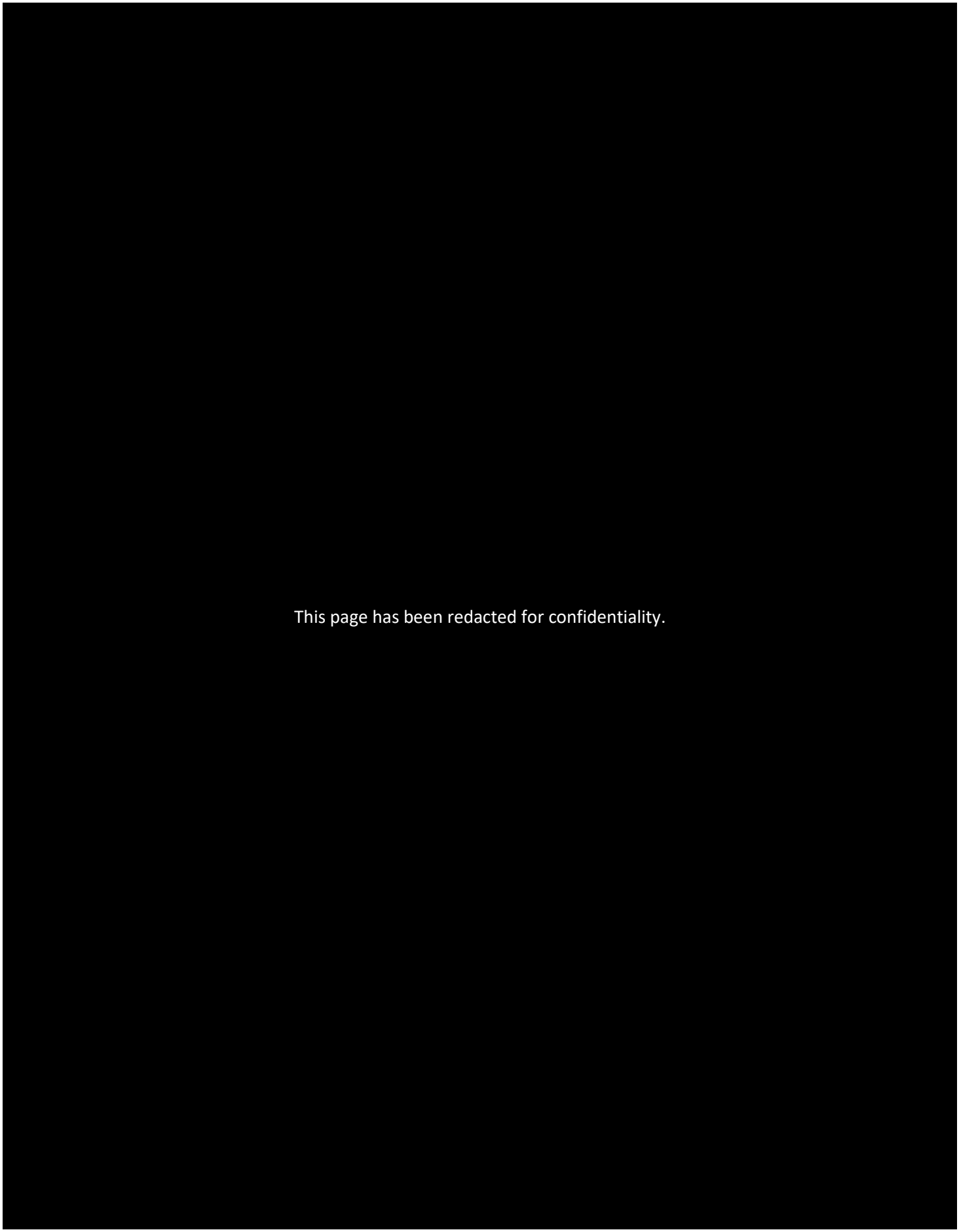


Figure 1-1: Subject Site Location (Source: JBS&G)

Figure 1-2: Nearest Sensitive Receptors (Source: JBS&G)



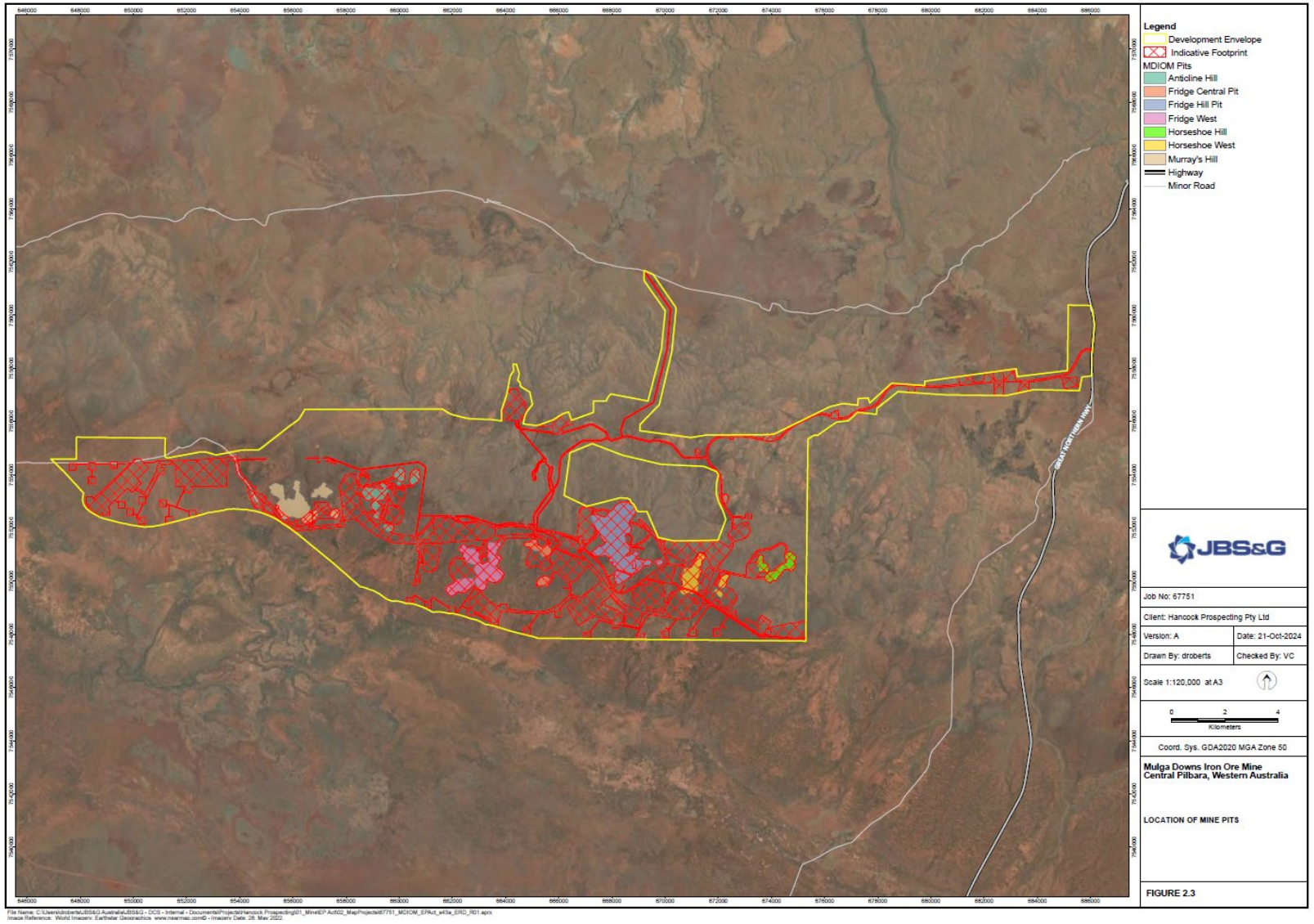


Figure 1-3: Mine Site Layout (Source: JBS&G)

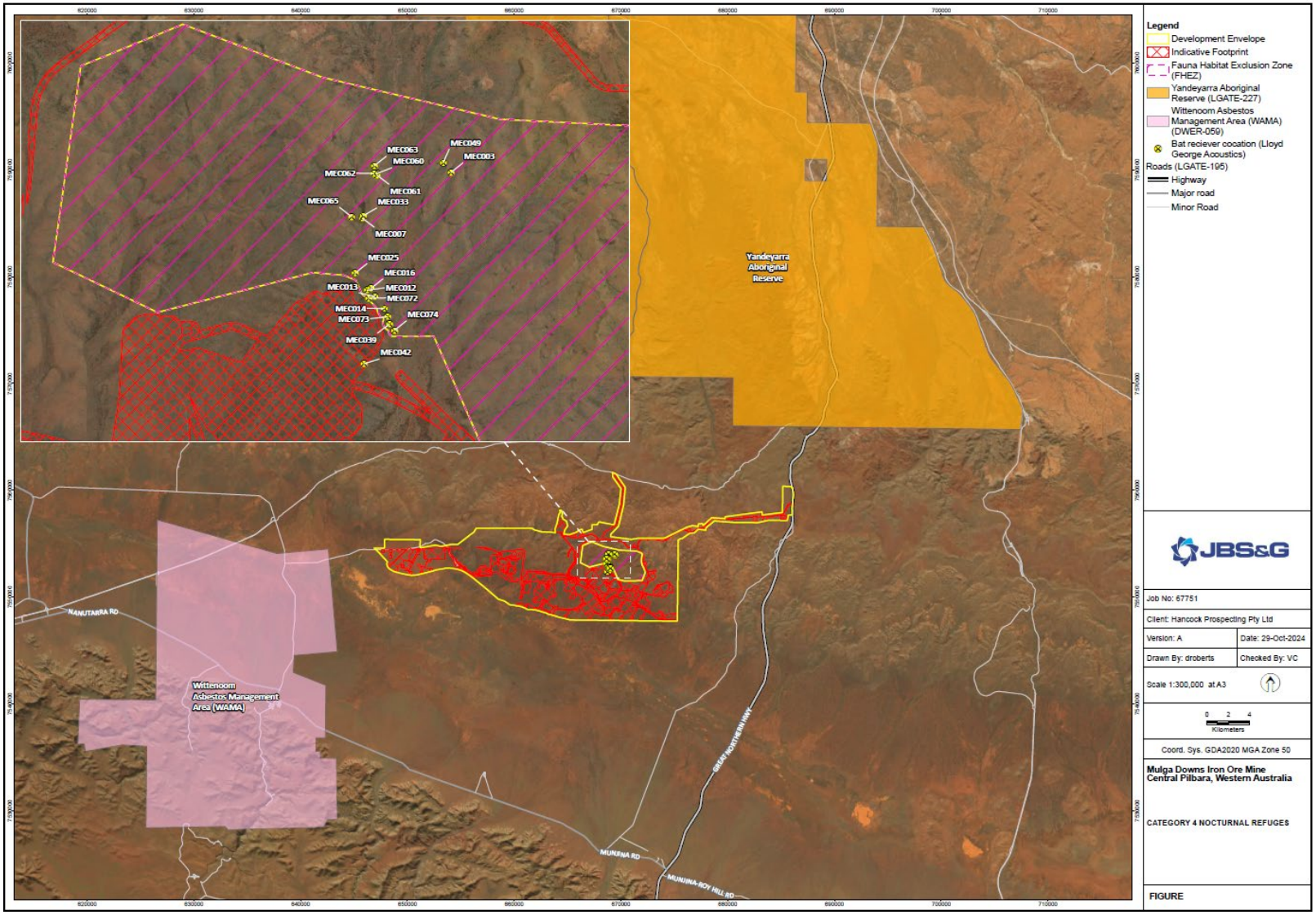


Figure 1-4: Bat Cave (category 4 refuges) locations (Source: JBS&G)

2. CRITERIA

Environmental noise in Western Australia is governed by the *Environmental Protection Act 1986* (EP Act) and through the *Environmental Protection (Noise) Regulations 1997* (the Regulations). The Regulations are applied to noise received by occupied human inhabited areas only. There are some noise sources related to the Proposal that not assessable under these regulations, and are covered under separate Policies and criteria and are discussed in the following subsections.

2.1. Regulations 7, 8 & 9

This group of regulations provide the prescribed standard for noise as follows:

*"**7. Prescribed standard for noise emissions***

(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; and

(ii) impulsiveness; and

(iii) modulation,

when assessed under regulation 9.

(2) For the purposes of subregulation (1)(a), 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 at the point of reception."

Tonality, impulsiveness and modulation are defined in regulation 9 (refer *Appendix A*). Under regulation 9(3), *"Noise is taken to be free of the characteristics of tonality, impulsiveness and modulation 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(1)(a) after the adjustments in the table [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

* These adjustments are cumulative to a maximum of 15 dB.

The assigned levels (prescribed standards) for all premises receiving noise are specified in regulation 8(3) and are shown in *Table 2-2*. The L_{A10} assigned level is applicable to noises present for more than 10% of a representative assessment period, generally applicable to "steady-state" noise sources. The L_{A1} is for short-

term noise sources present for less than 10% and more than 1% of the time. The L_{Amax} assigned level is applicable for incidental noise sources, present for less than 1% of the time.

Table 2-2 Baseline Assigned Outdoor 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
Commercial Premises	All hours	60	75	80
Industrial and Utility Premises	All hours	65	80	90

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 influencing factor (IF), in relation to noise received at noise sensitive premises in a remote area (such as surrounding the MDIOM) is generally 0 dB. As such, it is the baseline assigned levels of *Table 2-2* that are applicable for general noise sensitive receivers in this area, being homesteads, communities and heritage sites, which are presented in *Table 2-3* and all other premises types are no longer considered.

The assigned levels are statistical levels and therefore the period over which they are determined is important. The Regulations define the Representative Assessment Period (RAP) as "*a period of time of not less than 15 minutes, and not exceeding 4 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*". An inspector or authorised person is a person appointed under Sections 87 & 88 of the EP Act and include Local Government Environmental Health Officers and Officers from the Department of Water and Environmental Regulation. Acoustic consultants or other environmental consultants are not appointed as an inspector or authorised person. Therefore, whilst this assessment is based on a 4-hour RAP, which is assumed to be appropriate given the nature of the operations, this is to be used for guidance only.

Table 2-3 Assigned Levels

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

2.2. Regulation 3

"3. Regulations do not apply to certain noise emissions

(1) Nothing in these regulations applies to the following noise emissions –

c. Noise emissions from trains or aircraft (other than model aircraft and trains operating on railways with a gauge of less than 70cm;"

The noise from the freight trains aspect of the Hub and Rail Spur Project are therefore not assessable under The Regulations, instead being assessed against *State Planning Policy 5.4 Road and Rail Noise*. The Hub and associated plant within are still assessable and can be included in cumulative studies in accordance with the Regulations.

The aircraft noise associated with the proposed airport is also not assessable against The Regulations but instead considered under Australian Standard *AS2021 Acoustics – Aircraft Noise Intrusion - Building Siting and Construction.* This is address in more detail in Section 2.5.

2.3. Noise and Vibration to Fauna – Bats

Caves which are used by bats, including category 4 refuges for the listed Pilbara Leaf-nosed Bat and Ghost bats have been mapped within and immediately adjacent to the Proposal. While there are no legislated noise criteria for bats, the noise levels will be assessed based on relevant studies on the impact of noise on these animals. While the response to noise and vibration vary among vertebrate fauna species according to a number of factors (Busnel and Fletcher[1]), a study undertaken by Bullen and Creese [2] suggested that sound levels up to 70 dB(A) are unlikely to result in bats leaving their roost (specifically the Ghost Bat and the Pilbara Leaf-nosed Bat). Therefore, this criterion will be applied to the bat caves when assessing the operational noise (non-blasting) from the mine site.

Relating the airblast criteria of the Regulations to the bats is similarly undefined, such that there is no known airblast level for which disruption to their habitat or behaviour might occur. As such the noise level will be calculated for a range of blast cases and provided as guidance only.

There are no legislated criteria regarding ground vibration levels at biological sensitive receivers, however Appendix J of *AS 2187.2-2006 Explosives – Storage and use – Use of explosives* provides guidance on the possibility of cosmetic damage to buildings from transient vibration sources. This guidance is reproduced below and has been used a guide when assessing the vibration levels from the mine site:

TABLE J4.4.2.1

TRANSIENT VIBRATION GUIDE VALUES FOR COSMETIC DAMAGE (BS 7385-2)

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structure. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

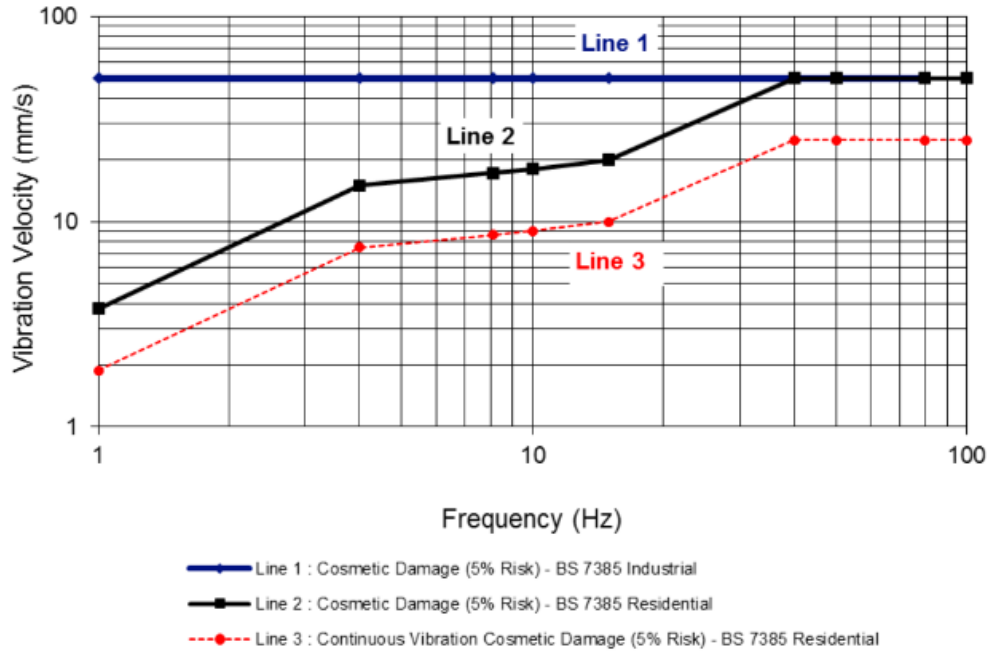
NOTES:

1 Values referred to are at the base of the building.

2 For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.

[1] *Busnel, R.G. and Fletcher, J.L. (Eds.) (1978). Effects of Noise on Wildlife. Academic Press, New York.*

[2] Bullen, R. and Creese, S. (2014). A note on the impact on Pilbara leaf-nosed and Ghost Bat activity from cave sound and vibration levels during drilling operations. *The Western Australian Naturalist* 29: 145-154.



Peak ground vibration levels can be calculated using the following algorithm (assuming free face -average Rock):

$$PPV = 1140\left(\frac{\sqrt{m}}{D}\right)^{1.6}$$

Where:
PPV = Peak particle velocity (mm/s)
m = Charge mass per hole or per delay (kg)
D = Distance from blast (m)

There are no legislated criteria regarding ground vibration levels at sensitive receivers. However, Australian Standard *AS 2187.2-2006 Explosives - Storage and use - Use of explosives* [Appendix J Table J4.5(A)] states that for a sensitive site with blasting lasting longer than 12 months or 20 blasts, a level of 5 mm/s for 95% of blasts and a maximum level of 10 mm/s is acceptable.

The structural integrity of the nearest bat cave is not easily assessed, and the effects of vibration both transient and constant are difficult to predict. Therefore, guidance levels have been provided within this report and conservative strategies can be adopted from these as needed.

2.4. Noise and Vibration to Heritage Sites

A large number of heritage sites exist within the MDIOM. It is understood that sites within the conceptual footprint may be impacted and negotiation with the Traditional Owners who are the custodians of these areas is in process. While many sites are not likely to be inhabited for long periods by people, some may be sensitive to vibration levels caused by mining activity. For noise, the criteria levels are defined in *Table 2-3* as “areas other than highly sensitive”. With regard to vibration, the structural integrity and therefore safe vibration limits, of a given site should be appraised and assessed by geotechnicians.

2.5. Regulation 11

With regard to airblast level, regulation 11 of the Regulations prescribes that:

(4) Subject to subregulation (5), no airblast level resulting from blasting on any premises or public place, when received at any other premises between 0700 hours and 1800 hours on any day, may exceed —

(a) for an airblast level received at noise sensitive premises —

(i) when received at a sensitive site — 120 dB $L_{Z\,peak}$; or

(ii) when received at a location other than a sensitive site — 125 dB $L_{Z\,peak}$;

or

(b) for an airblast level received at any other premises — 125 dB $L_{Z\,peak}$.

(5) The levels specified in subregulation (4) do not apply in respect of an airblast level when received at premises, or a part of premises, on which the blaster believes on reasonable grounds no person is present at the time of the blast.

(6) Despite subregulation (4), airblast levels for 9 in any 10 consecutive blasts (regardless of the interval between each blast), when received at any other single premises between 0700 hours and 1800 hours on any day, must not exceed —

(a) for airblast levels received at noise sensitive premises —

(i) when received at a sensitive site — 115 dB $L_{Z\,peak}$; or

(ii) when received at a location other than a sensitive site — 120 dB $L_{Z\,peak}$;

or

(b) for airblast levels received at any other premises — 120 dB $L_{Z\,peak}$.

(7) For the purposes of subregulation (6), an airblast level for a blast that would, but for this subregulation, exceed a level specified in subregulation (6)(a)(i) or (ii) or (b) is taken not to exceed that level when received at premises, or a part of premises, on which the blaster believes on reasonable grounds no person is present at the time of the blast.

(8) Subject to subregulation (9), no airblast level resulting from blasting on any premises or public place, when received at other premises outside the periods between 0700 hours and 1800 hours on any day, may exceed 90 dB $L_{Z\,peak}$ except where that blasting is carried out —

(a) as part of surface mining operations for the purposes of removing obstructions in crushers, or making workings safe, or for firing misfired holes; and

(b) with the consent in each case of the mine operator.

(9) The level specified in subregulation (8) does not apply in respect of an airblast level when received at premises, or a part of premises, on which the blaster believes on reasonable grounds no person is present at the time of the blast.

(10) Where blasting is carried out as described in subregulation (8)(a) and (b) outside the periods between 0700 hours and 1800 hours on any day —

(a) the blasting is taken to be carried out between 0700 hours and 1800 hours; and

(b) subregulations (4), (5), (6) and (7) apply accordingly.

(11) For the purposes of this regulation, an airblast level may be determined by —

(a) measurement at its point of reception when, to the extent practicable, other noises that would contribute to the measured airblast level are not present; or

(b) calculation of the airblast level at its point of reception based on measurement of the airblast level at a reference point determined by the inspector or authorised person to be a point where the relationship between the airblast level as measured at the reference point and at the point of reception can be established.

2.6. Aircraft Noise

Noise from aircraft is not assessable under The Regulations, per Regulation 3, part (1)(c). However, acceptable noise levels as a result of aircraft movements and methodology for calculating the noise for various aircraft types are provided in Australian Standard *AS2021 Acoustics – Aircraft Noise Intrusion - Building Siting and Construction*. This standard can be used for the assessment of suitability of airport location and orientation. *Table 2-4* sets out the indoor design sound levels from AS2021.

Table 2-4: Indoor Design Sound Levels for Determination of Aircraft Noise Reduction

Building type and Activity	Indoor Design Sound Level, dB L_{Amax}
Houses, home units, flats, caravan parks	
Sleeping areas, dedicated lounges	50
Other habitable spaces	55
Bathrooms, toilets, laundries	60

While the above would apply to any homestead or community nearby, the receptors nearest to the conceptual footprint are the bat caves due to being elevated (relative to the runway) and nearest to the airport runways. The noise level limit for bats is once again 70 dB L_{Amax}, and for heritage sites adopting the baseline outdoor assigned noise level of 80 dB L_{Amax}.

2.7. Cumulative Noise

This report also provides a cumulative noise study, considering noise from mining operations as a result of the Proposal, as well as the noise from the adjacent Mulga Downs Hub and Rail Spur Project and the proposed associated Haulage Road.

This is appropriate where noise levels are assessed under the same criteria and are from constant or frequent noise sources and events such as fixed or high-use mobile plant. Infrequent activity such as blasting, aircraft movements (no more than one per day in this case), train shunting and freight train pass-bys are not combined in the cumulative noise study as each one is instead assessable separately as an L_{Amax} noise event. Furthermore, noise from the freight rail is assessable separately under *State Planning Policy 5.4 Road and Rail Noise* which considers the $L_{Aeq(day)}$ and $L_{Aeq(night)}$ parameters which differ from those assessed under the Regulations and therefore cannot be combined cumulatively. However, noise from the Hub remains included in the cumulative study with respect to assessment against The Regulations.

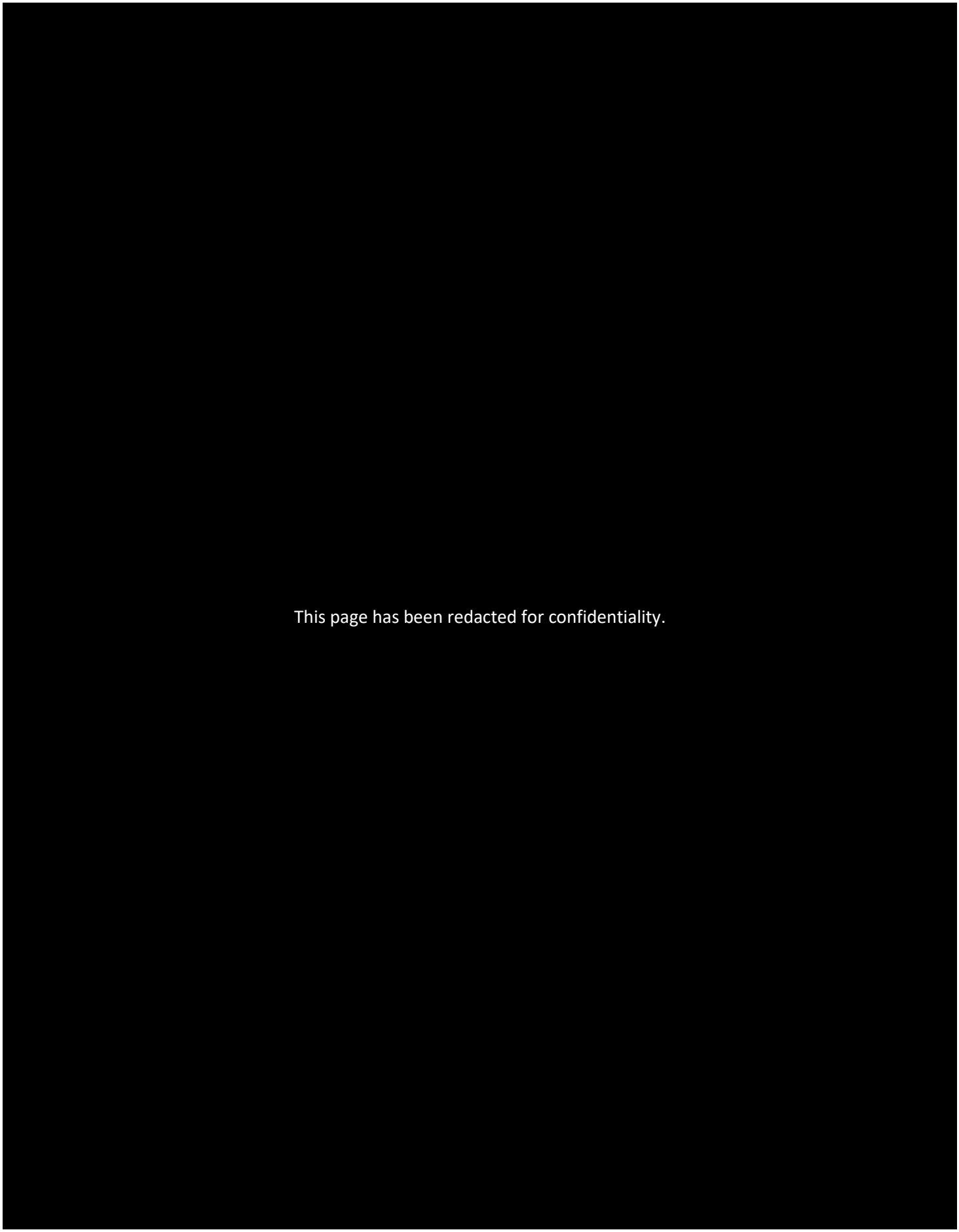
Table 2-5 provides a summary of source groups which can be included for cumulative noise assessment against these regulations or other policies.

Table 2-5: Source Groups and Applicable Criteria

Applicable Criteria	Source Group	Cumulatively Assessable
Environmental Protection (Noise) Regulations	Hub Plant	Yes
	Mobile Mining Plant	Yes
	Fixed Plant	Yes
	Conveyors	Yes
	Haul Trucks	Yes
	Trucks on Private Roads	Yes
AS2021	Aircraft	No
State Planning Policy 5.4	Freight Trains / Rail	No

When considering the cumulative noise impacts to nearest sensitive receptors, all aspects of the mine and haulage routes are considered as shown in *Figure 2-1* and *Figure 2-2*. Note that rail Option 8B is shown on these figures being the most stringent modelling case.

Figure 2-1: Noise Sensitive Receiver Locations (Cumulative Study)



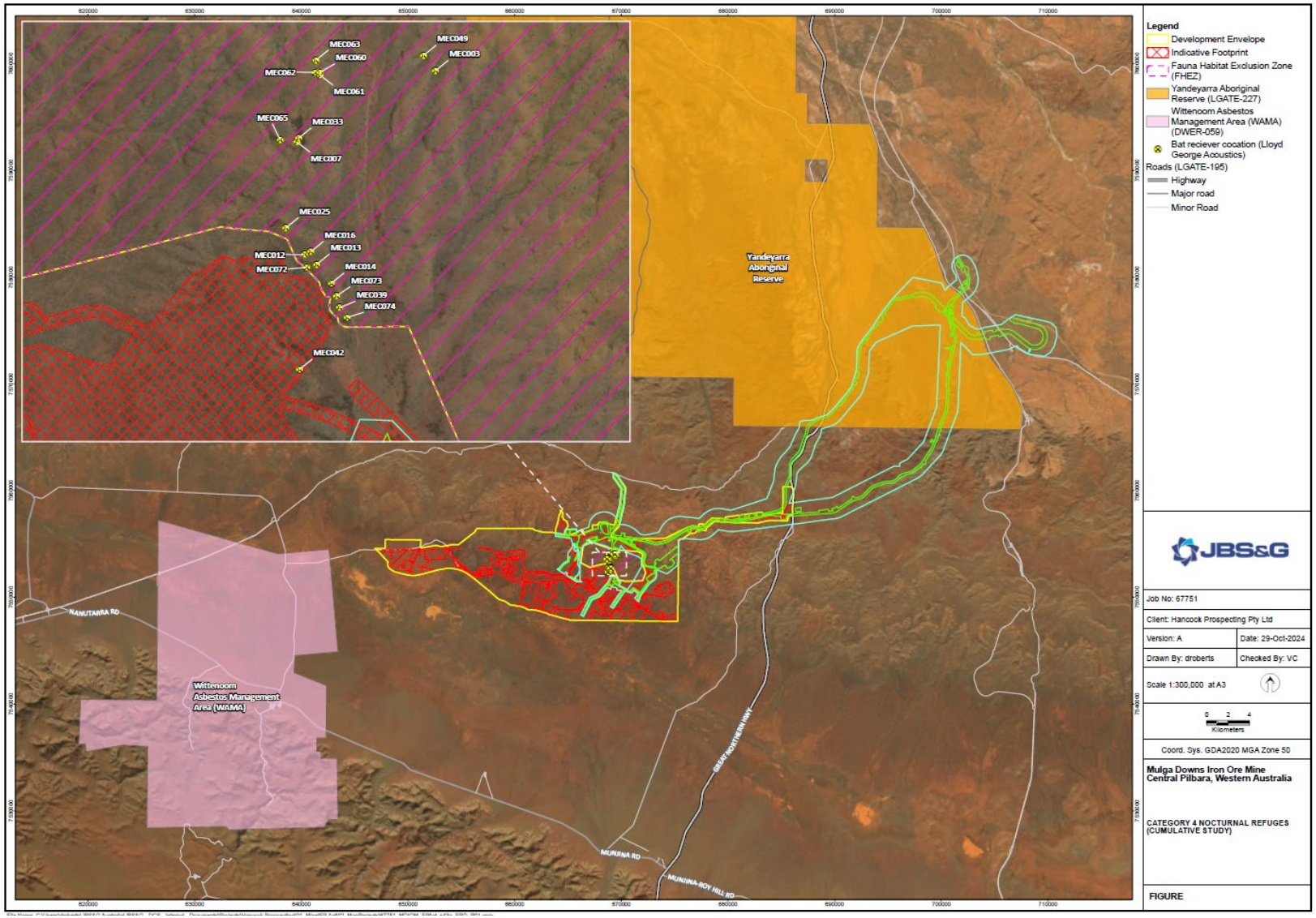


Figure 2-2: Bat Cave locations (Cumulative Study)

3. METHODOLOGY

Various methodologies are used for the various noise sources associated with the mine operation as described in the following sections.

3.1. Mining Operational Noise Modelling

Computer modelling has been used to predict the noise emissions from the development of the MDIOM to all nearby receivers. The software used was *SoundPLAN 9.0* with the CONCAWE (ISO 17534-3 improved method) selected, as they include the influence of meteorological conditions. Input data required in the model of the MDIOM are listed below and discussed in *Section 3.1.1* to *Section 3.1.4*:

- Meteorological information;
- Topographical data;
- Ground absorption; and
- Source sound power levels.

3.1.1. Meteorological Conditions

Meteorological information utilised in the software 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.

Table 3-1: Modelling Meteorological Conditions

Parameter	Day (7.00am to 7.00pm)[2]	Night (7.00pm to 7.00am)[2]
Temperature (°C)	20	15
Humidity (%)	50	50
Wind Speed (m/s)	4	3
Wind Direction[1]	All	All
Pasquil Stability Factor	E	F

Notes:
1. The modelling package allows for all wind directions to be modelled simultaneously.
2. The conditions above are as defined in *Guideline: Assessment of Environmental Noise Emissions*; May 2021

Alternatives to the above default conditions can be used where one year of weather data is available and the analysis considers the worst 2% of the day and night for the month of the year in which the worst-case weather conditions prevail (source: *Draft Guideline on Environmental Noise for Prescribed Premises*, May 2016). In most cases, the default conditions occur for more than 2% of the time and therefore must be satisfied. Noting the ambient noise study carried out by SLR Consulting, the weather conditions in *Table 3-1* are considered appropriate.

3.1.2. Topographical Data

Topographical data was adapted from a mixture of publicly available information (e.g. *Google Earth*) and information provided by HanRoy for the MDIOM development in the form of spot heights and combined with the site plan. Digital ground models were developed for the 5 year mining stage which incorporates deep steps. Earlier mining stages are not considered representative of full operations (maximum number of plant operating), and later stages will result in deeper steps and consequently lower noise from plant within the pit areas.

Receivers were incorporated into the noise model at 1.4 metres above ground at the location of identified noise sensitive sites, including the bat caves. This height is chosen as it as it aligns with minimum requirements of the noise regulations (at least 1.2m above ground plane) and is at a height equivalent to most standing people.

Figure 3-1 shows a 3D screenshot of the noise model for the operation phase at the northern end of Fridge Hill, highlighting the Category 4 bat caves as viewed from the north.

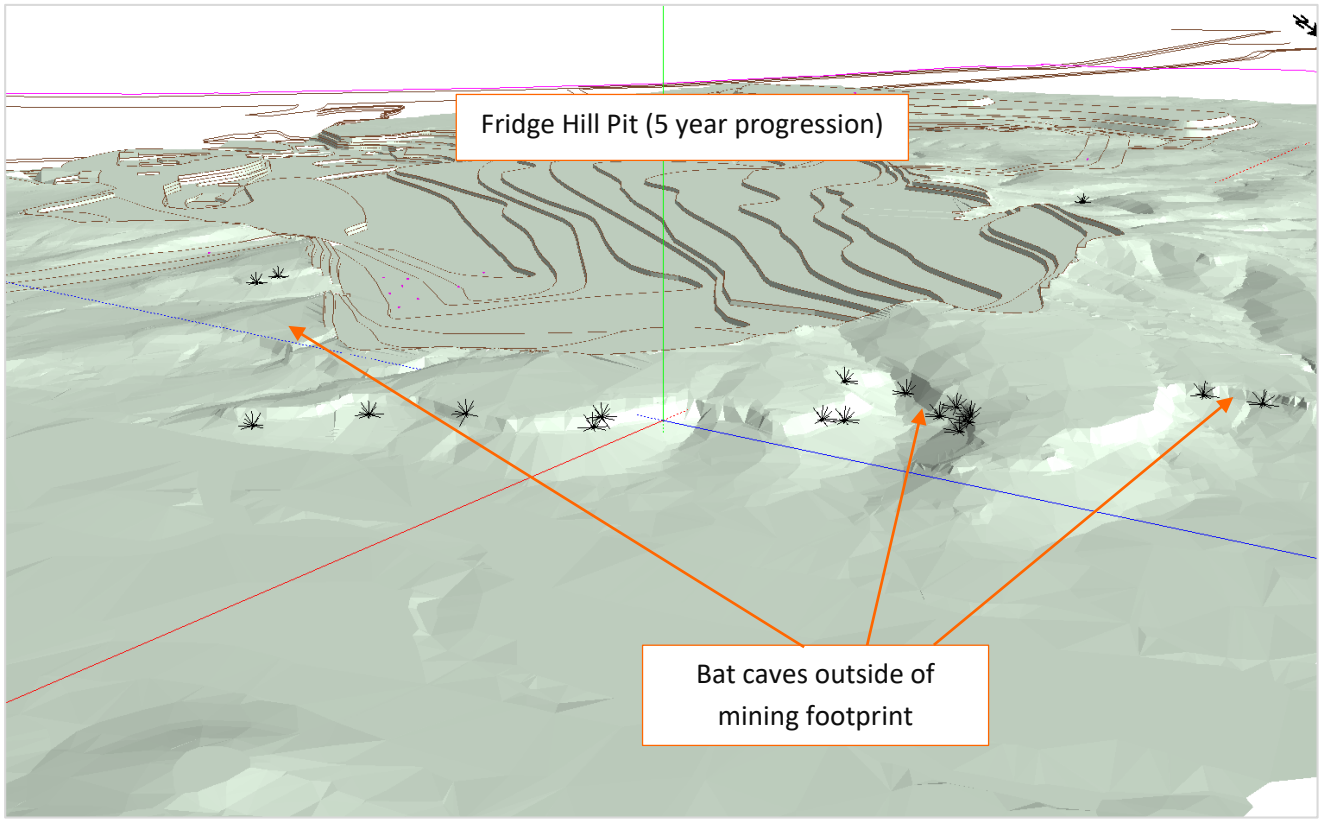


Figure 3-1: 3D Screenshot of Noise Model (Northern Fridge Hill Area Looking South)

3.1.3. Ground Absorption

To allow for a combination of low-lying bush and some cleared areas, a value of 0.6 has been used as an average value to represent the ground cover expected in the MDIOM, noting that 0.0 represents hard reflective surfaces such as water and 1.0 represents absorptive surfaces such as grass. Within the pits themselves, the ground absorption has been set to 0.3 assuming both tamped and disturbed ground.

3.1.4. Source Sound Levels

The source sound power levels for mining operations used in the modelling are provided in *Table 3-3*. The table is populated with a mixture of project provided data and Lloyd George Acoustics measured database levels. It should be noted that for the cumulative noise study (combined with hub-rail spur operations) additional sources are included in the model.

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	
CAT 982 Front End Loader (Crushing Pads)	102	119	108	109	106	101	95	85	**108**
CAT 777 Haul Truck	114	114	114	117	112	111	104	104	**117**
CAT 777 Water Cart	111	113	110	110	111	109	99	97	**115**
CAT 16H Grader	101	102	111	104	109	110	105	100	**113**
Excavator Komatsu PC1250	97	104	112	111	112	105	99	94	**111**
CAT D10 Tracked Dozer	104	106	111	109	109	107	105	98	**112**
Rock Breaker (Crushing Pads)	111	118	115	110	112	112	108	103	**116**
Primary Crusher (Crushing Pads)	104	104	116	113	111	108	105	99	**113**
Drilling Rig	107	106	107	104	106	107	112	112	**116**
Screening Modules (Crushing Pads)	113	108	106	108	108	111	111	106	**117**
Crusher (Crushing Pads)	110	111	112	114	111	104	99	93	**115**
Conveyor Line	82	97	103	111	107	106	98	90	**113**
Cummins Quad-trailer Prime Mover	110	113	116	114	111	110	106	108	**117**
3-trailer Road Train	107	109	112	109	106	105	101	103	**112**

The following is noted in relation to *Table 3-2*:

- All noise sources are assumed to be L_{A10} unless noted otherwise;
- Levels are based on file data retained by Lloyd George Acoustics from similar scale projects and is a mixture of site measured data and manufacturers specifications.
- Sources are generally modelled as point sources at 2.5m above ground level (AGL). All Screening and crushing modules are elevated with assumed acoustic centres of 4.0m AGL. These are considered in line with standard practice and similar previous assessments by Lloyd George Acoustics.
- All sources are modelled as omni-directional point sources, apart from the conveyors which are line sources.

3.2. Noise Modelling Scenarios

The MDIOM footprint consists of multiple pit locations - refer to *Figure 1-3*. Therefore, a number of worst-case scenarios are modelled to consolidate predictive calculation runs. These scenarios were developed in consultation with HanRoy to provide for representative and conservative projections.

Sources are grouped to account for different teams of mobile plant working at various locations in the pit. Modelling scenarios are described in detail in *Section 4* (**Results**).

For the cumulative noise study, the worst-case scenario occurs when mining is operating in the northern Fridge Hill and Eastern pit areas, where sources of the process plant, hub and haulage routes contribute the most to noise levels. Furthermore, the option of Prime Mover Quad-Trailer haulage between crushing pads and operating on the route out to Great Norther Highway is relatively noisier than operating conveyor networks.

3.3. Airblast Assessment

Confined blasting has been considered in the assessment of airblast levels at the nearest bat caves and the Youngaleena and Wirrilimarra communities. The size of the blast is influenced by many factors including the mass of explosive detonating within a given timeframe (MIC) and a site constant. Noting that some information has been provided by HanRoy, the maximum amount of explosive per delay to ensure compliance with the Regulations is determined, assuming a conservative site constant (K_a) of 10. This allows for the determination of a range (tabled data) of vibration and noise outcomes to suit varying structural disturbance outcomes.

For this assessment, airblast is calculated using equations provided in *Australian Standard AS 2187.2-2006 Explosives - Storage and use - Use of explosives* and equations developed by Orica Explosives Australia (Orica).

Confined Charge (AS 2187 Equation)

$$P = K_a \left(\frac{R}{Q^{1/3}} \right)^a$$

where

P = pressure, in kilopascals
Q = explosives charge mass, in kilograms
R = distance from charge, in metres
K_a = site constant
a = site exponent

Confined Charge (Orica Equation)

$$Airblast\ Level\ dB\ L_{Linear\ peak} = 20 \log \left(\frac{P_B}{P_0} \right)$$

where:

$$P_B = 3.3 \left(\frac{R}{W^{\frac{1}{3}}} \right)^{-1.2}$$

$P_0 = 2x10^{-8}$
R = *distance from blast*
W = *maximum charge mass per delay*

Unconfined blasting is not proposed except for unusual situations such as large rock removal from machinery or access paths after blasting. It is assumed that these blasts will be managed appropriately.

3.4. Ground Vibration Assessment

For ground vibration, it is assumed that the blasting conditions are for 'free-face average rock' formation. In the absence of specific blast vibration measurements at this site, the following scaled distance site law is adopted from the AS 2187.2-2006:

$$PPV = 1140\left(\frac{\sqrt{m}}{D}\right)^{1.6}$$

Where:

PPV = Peak particle velocity (mm/s)
m = Charge mass per hole or per delay (kg)
D = Distance from blast (m)

3.5. Aircraft Noise Assessment

AS2021: Acoustics—Aircraft noise intrusion - Building siting and construction, provides a number of look-up tables for various aircraft types based on a sites' proximity to Airport runway. With reference to *Figure 3-2* and assuming a straight approach, the various distances used in the look-up tables relevant to this site are provided in *Table 3-3*. The aircraft used at the MDIOM will likely be Airbus A320 or Boeing B737, at 8-10 flights per week.

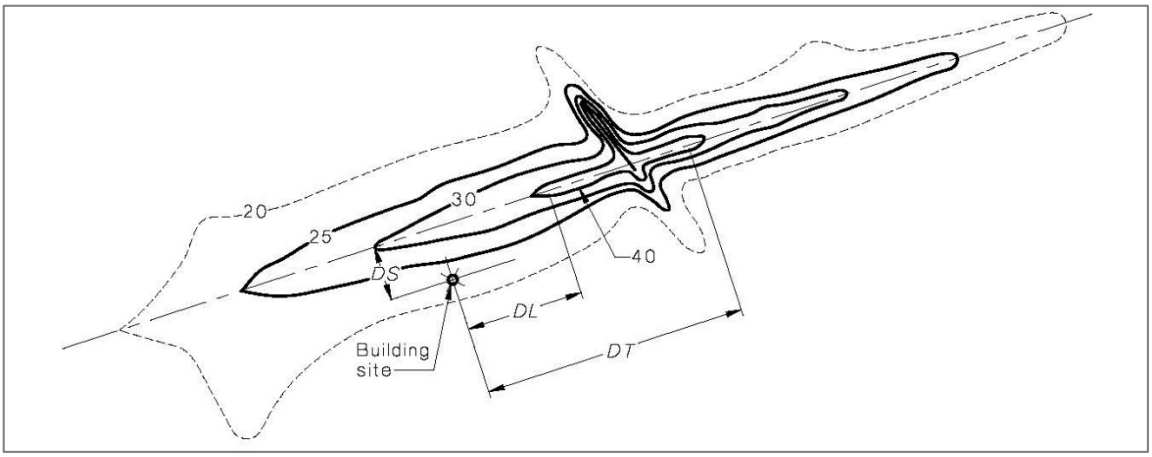


Figure 3-2: Determination of Distance Parameters (Source: AS2021)

3.6. Ambient Noise levels

A survey of ambient noise levels was conducted at the site in 2019-2021 by SLR Consulting[3]. Further detail of results and methodology undertaken can be found within the report. While the *Environmental Protection (Noise) Regulations 1997* do not specifically assess background noise levels, the data is valuable in providing the following inputs:

[3] *SLR Consulting Pty Ltd (March 2021) Phase 2 Mulga East Iron Ore Project – Noise Monitoring Program May 2019-February 2021. SLR Ref 675.11414-R03*

- A study of annual wind and other meteorological conditions.
- Background noise levels such that intrusive characteristics can be observed or dismissed.
- Overall impact to amenity by comparing to assigned noise levels.

Our review of the ambient noise study yields the following summary of information:

- Typical Noise levels of 35 to 40 dB $L_{Aeq,15min}$ between 11am to 6pm, then reducing to 23 dB (Minima) and 29 dB (Median) at Night.
- Key contributors to ambient sound levels are wind behaviour and distant road traffic from Great Northern Highway, and local fauna (insects). A wind rose is shown in *Figure 3-3*, extracted from the SLR Report.
- Ambient noise levels broadly increase in warmer months of the year:
    - December to March inclusive, L_{Aeq} 30-35 dB at night, and 35-40 dB during the day.
    - April to November inclusive, L_{Aeq} 20 dB at night, and 33-39 during the day.
- Under specific weather conditions such as high wind or rain, ambient sounds levels often exceeded night time Assigned Noise Levels.

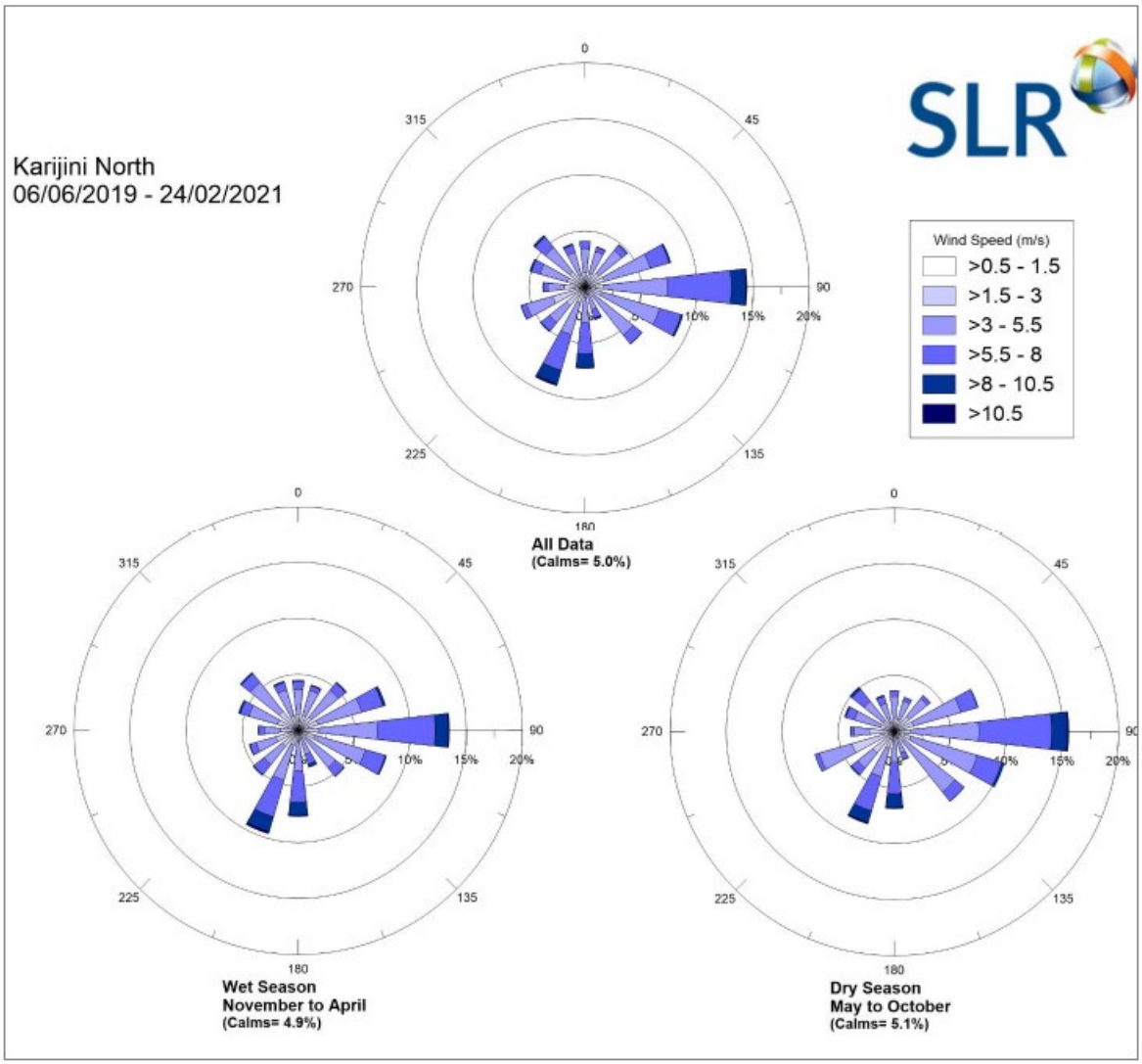


Figure 3-3: Karijini North Wind Rose Jun 2019 to Feb 2021 (Source: SLR Report, Figure C-8)

4. RESULTS

4.1. Operations Noise Modelling

Mining noise levels were predicted for various scenarios, developed with input from HanRoy. These scenarios were considered to be 'worst-case' to ensure a conservative approach to modelling:

1. Scenario 1A: East-Central Areas with Conveyors
   - Mining Fleet in Fridge Hill and Fridge West areas. Central and East Crushing Pads operating and conveyors linking pads to Hub. Haulage Trucks moving between mine areas and crushing pads.
2. Scenario 1B: East-West Areas with Conveyors
   - Mining Fleet in Fridge Hill and Murray Hill areas. West and East Crushing Pads operating and conveyors linking pads to Hub. Haulage Trucks moving between mine areas and crushing pads.
3. Scenario 2A: East-Central Areas with Road Trains
   - Mining Fleet in Fridge Hill and Fridge West areas. Central and East Crushing Pads operating Haulage and Road Trains linking pads to GNH. Haulage Trucks moving between mine areas and crushing pads.
4. Scenario 2B: East-West Areas with Road Trains
   - Mining Fleet in Fridge Hill and Murray Hill areas. West and East Crushing Pads operating and Road Trains linking pads to GNH. Haulage Trucks moving between mine areas and crushing pads.

Each operating crusher pad is assumed to have a team of 3x Front-end Loaders, screening and crushing plant and a rock breaker.

All scenarios include teams of mobile mining fleet: 1x Haul truck, 2x Drill rigs, 1xDozer, 2x Excavators. As well as 5 to 6 haul trucks in transit between the pit teams and each crusher pad along with a grader and water carts.

Note that while the model includes multiple bat caves as receiver points, only those nearest to operations are included in the tabulated results, these can be interpreted as the worst-case levels of each grouped set of receptors. This approach is also taken with the many heritage sites near the conceptual footprint.

Heritage sites and bat caves located within the conceptual footprint (proposed pits) were excluded from the assessment as these may be removed under the appropriate approvals upon implementation of the Proposal.

Figure 2-1 and *Figure 2-2* present the locations of specific receptors in vicinity of the project, and these can be cross-referenced to each calculation result table in the sections following.

4.1.1. Scenario 1A: East-Central Areas with Conveyors

The results for the mining operations while teams of plant are working at the far north extents of the Fridge Hill Pit as well as in the central pits (Fridge West) are provided in *Table 4-1*. This scenario includes a conveyor network to transport the crushed ore from crusher pads to the hub. A noise contour plot is also provided in *Figure 4-1 and Figure 4-2* showing noise levels at wide extents of the greater area and at close proximity to bat caves, respectively.

Table 4-1: Scenario 1A Predicted Levels, L_{10} dB(A)

Receiver	Conveyor Line	Haul Trucks	Crusher Pad East	Crusher Pad Central	Pit Team	Overall
Heritage MD24-021	<5	<5	5	4	11	**13**
Heritage Site - BCT	<5	<5	<5	0	11	**11**
Heritage Site - HK4	<5	<5	<5	<5	7	**7**
Heritage Site MD2022_045	39	30	20	24	31	**41**
Heritage Site MD2023-001	23	42	23	18	34	**43**
Heritage Site MD2023-021	<5	<5	<5	<5	11	**12**
Heritage Site MD2023-022	<5	<5	<5	<5	14	**15**
Heritage Site MD-2022-035	<5	<5	6	5	11	**13**
Heritage Site MD-2023-025	26	20	15	20	25	**30**
Heritage Site MD-2023-026	12	5	<5	<5	19	**20**
Heritage Site MD-2023-54	27	21	15	19	24	**30**
Heritage Site MD-2023-56	27	21	14	19	24	**30**
Heritage Site MIB-M13-050	5	33	12	10	40	**41**
Heritage Site MIB-MD12-038	12	25	10	10	32	**33**
Heritage Site MIB-MD12-039	21	25	11	13	29	**31**
Heritage Site MIB-MD13-015	6	28	12	9	32	**33**
Heritage Site MIB-MD13-016	8	34	28	8	35	**38**
Heritage Site MIB-MD13-024	7	28	14	11	34	**35**
Heritage Site MIB-MD13-025	7	28	15	11	35	**36**
Heritage Site MIB-MD13-027	9	29	16	12	34	**36**
Heritage Site MIB-MD13-036	27	42	41	34	37	**46**
Heritage Site MIB-MD13-039	26	52	18	28	51	**55**

Receiver	Conveyor Line	Haul Trucks	Crusher Pad East	Crusher Pad Central	Pit Team	Overall
Heritage Site MIB-MD13-042	16	53	32	18	67	**67**
Heritage Site MIB-MD13-043	11	33	19	15	41	**41**
Heritage Site MIB-MD13-044	5	32	12	10	40	**40**
Heritage Site MIB-MD13-048	8	30	15	9	39	**39**
Heritage Site MIB-MD13-049	11	33	21	14	41	**42**
Heritage Site MIB-MD13-051	9	32	13	9	39	**40**
Heritage Site MIB-MD13-052	18	37	21	15	46	**46**
Heritage Site MIB-MD13-063	17	43	41	19	33	**45**
Heritage Site MIB-MD13-070	21	46	44	20	26	**48**
Heritage Site MIB-MD13-071	23	46	44	32	25	**49**
Heritage Site MIB-MDowns12-07	15	23	12	18	31	**32**
Heritage Site MIB-MDowns12-10	17	23	11	16	32	**33**
Heritage Site MIB-MDowns12-35	26	40	26	34	38	**43**
Homestead (Mulga Downs) South	-	-	-	-	-	**-**
R1 Bat Fridge Hill (East) – MEC042	17	55	31	19	68	**68**
R2 Bat Cave Fridge Hill – MEC074	15	44	31	20	48	**50**
R3 Bat Cave Fridge Hill (north) – MEC072	19	34	17	14	43	**44**
R4 Bat Cave Hub – MEC063	16	35	25	22	36	**38**
R5 Fig Tree Crossing	-	-	-	-	-	**-**
R6 Private Property	<5	<5	7	6	18	**19**
R7 Hooley Station Homestead	-	-	-	-	-	**-**
R8 Auski Village	-	-	-	-	-	**-**
R9 Wirrilimarra Community	<5	<5	7	5	18	**18**
R10 Youngaleena Community	<5	<5	<5	5	<5	**5**
R11 Munjina East Gorge	-	-	-	-	-	**-**
R12 Karajini Eco Retreat	-	-	-	-	-	**-**
R13 Private Mining Camp	-	-	-	-	-	**-**

It should be noted that the predictive model does not calculate to locations farther than 20km from a given noise source. These locations are shown in the table with a blank ("-") result.

The results demonstrate that the Hooley Station homestead, Fig Tree Crossing, Auski Village and other sensitive receptors (Receivers 11 through 13) are not likely to be exposed to detectable noise levels from the MDIOM when operating in this location.

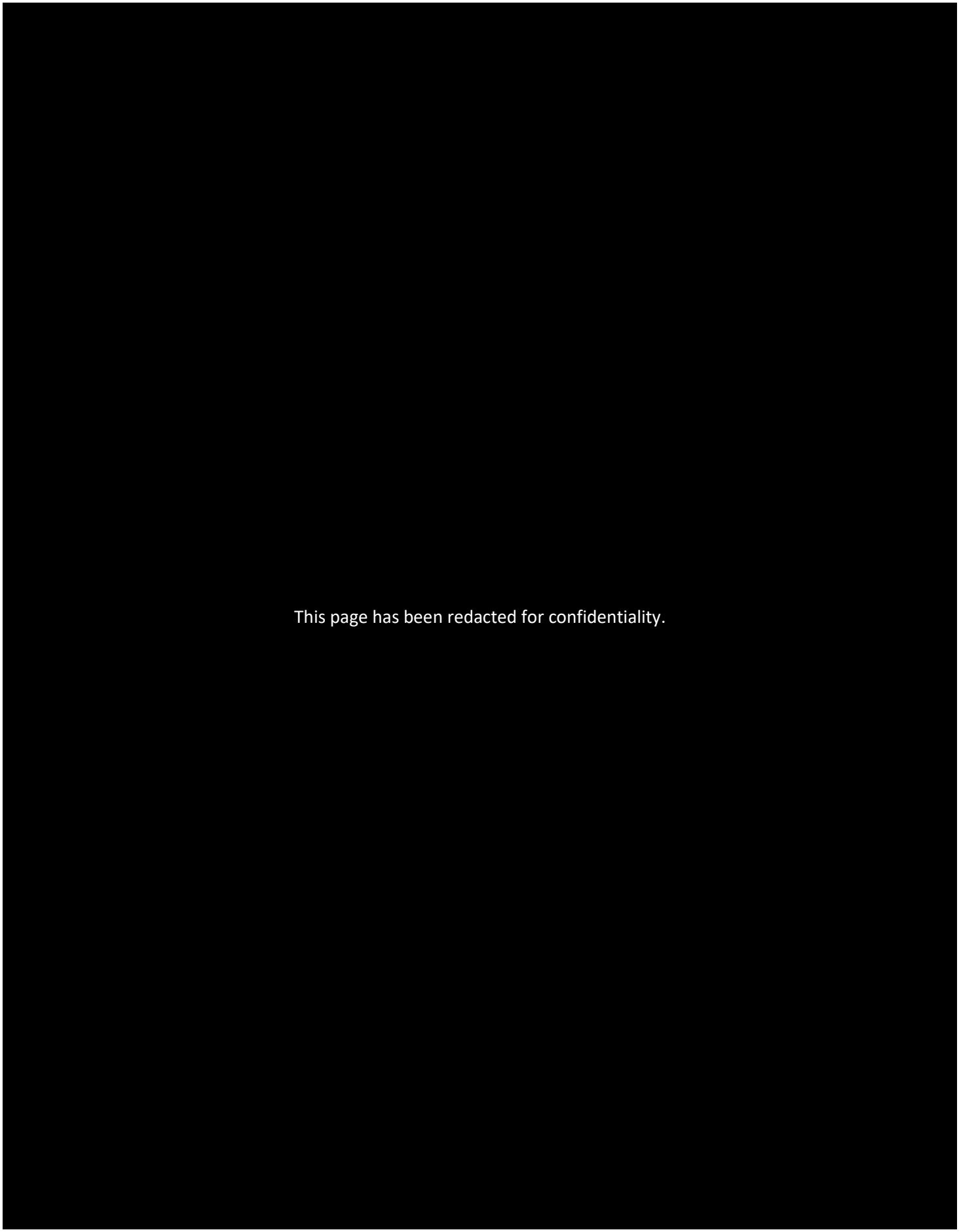
Wirrilimarra and Youngaleena communities are predicted to receive no greater than 18 dB L_{A10} which is compliant with the 35 dB L_{A10} criteria level.

With regard to heritage sites, the highest predicted level is at site MIB-MD13-042 with a level of 67 dB L_{A10}, noting that the site is 40m from the Fridge Hill Pit area. This exceeds a 60 dB L_{A10} criteria level of *Table 2-3* by a margin of 7 dB criteria and is a result of mining teams working as close as 200m. This site should be reviewed and strategies may be required to manage noise when working nearby, as deemed appropriate.

Bat caves are exposed to a worst case noise level of 68 dB L_{A10} at cave ref MEC042 when considering greatest contributions from pit teams working in the northern areas of Fridge Hill with noise from the Haul Trucks also contributing. These levels are compliant with the 70 dB(A) criteria level.

Figure 4-1: Scenario 1A East-Central Area with Conveyors - Greater Area

Figure 4-2: Scenario 1A East-Central Area with Conveyors - Zoomed Areas



4.1.2. Scenario 1B: East-West Areas with Conveyors

The results for the mining operations while teams of plant are working at the far west extents of the Murray's Hill Pits and at Fridge Hill are provided in *Table 4-2*. This scenario includes a conveyor network to transport the crushed ore from crusher pads to the hub. A noise contour plot is also provided in *Figure 4-3 and Figure 4-4* showing noise levels at wide extents of the greater area and at close proximity to bat caves, respectively.

Table 4-2: Scenario 1B Predicted Levels, L_{10} dB(A)

Receiver	Conveyor Line	Haul Trucks	Crusher Pad East	Crusher Pad West	Pit Team	Overall
Heritage MD24-021	<5	<5	5	<5	<5	**7**
Heritage Site - BCT	<5	50	<5	24	52	**54**
Heritage Site - HK4	<5	47	<5	23	47	**50**
Heritage Site MD2022_045	39	29	20	12	31	**40**
Heritage Site MD2023-001	20	42	23	9	34	**43**
Heritage Site MD2023-021	<5	25	<5	21	27	**29**
Heritage Site MD2023-022	<5	21	<5	21	25	**28**
Heritage Site MD-2022-035	<5	<5	6	<5	7	**10**
Heritage Site MD-2023-025	26	20	15	8	24	**29**
Heritage Site MD-2023-026	15	21	2	28	16	**29**
Heritage Site MD-2023-54	27	21	15	<5	23	**29**
Heritage Site MD-2023-56	27	21	14	<5	24	**30**
Heritage Site MIB-M13-050	<5	33	12	<5	40	**41**
Heritage Site MIB-MD12-038	12	25	10	<5	32	**33**
Heritage Site MIB-MD12-039	21	25	11	<5	29	**31**
Heritage Site MIB-MD13-015	5	28	12	<5	32	**33**
Heritage Site MIB-MD13-016	7	34	28	<5	35	**38**
Heritage Site MIB-MD13-024	7	28	14	<5	34	**35**
Heritage Site MIB-MD13-025	7	28	15	<5	35	**36**
Heritage Site MIB-MD13-027	9	29	16	<5	34	**36**
Heritage Site MIB-MD13-036	23	42	41	8	37	**45**
Heritage Site MIB-MD13-039	24	52	18	10	51	**55**

Receiver	Conveyor Line	Haul Trucks	Crusher Pad East	Crusher Pad West	Pit Team	Overall
Heritage Site MIB-MD13-042	15	53	32	<5	67	**67**
Heritage Site MIB-MD13-043	9	33	19	<5	41	**41**
Heritage Site MIB-MD13-044	4	32	12	<5	40	**40**
Heritage Site MIB-MD13-048	8	30	15	<5	39	**39**
Heritage Site MIB-MD13-049	10	33	21	<5	41	**42**
Heritage Site MIB-MD13-051	9	32	13	<5	39	**40**
Heritage Site MIB-MD13-052	18	37	21	<5	46	**46**
Heritage Site MIB-MD13-063	15	43	41	<5	33	**45**
Heritage Site MIB-MD13-070	18	46	44	<5	24	**48**
Heritage Site MIB-MD13-071	20	46	44	<5	22	**48**
Heritage Site MIB-MDowns12-07	27	12	12	12	14	**27**
Heritage Site MIB-MDowns12-10	28	20	11	27	20	**31**
Heritage Site MIB-MDowns12-35	23	40	26	8	38	**42**
Homestead (Mulga Downs) South	-	-	-	-	-	**-**
R1 Bat Fridge Hill (East) – MEC042	16	55	31	<5	68	**68**
R2 Bat Cave Fridge Hill – MEC074	13	44	31	<5	48	**50**
R3 Bat Cave Fridge Hill (north) – MEC072	19	34	17	<5	43	**44**
R4 Bat Cave Hub – MEC063	14	35	25	<5	36	**38**
R5 Fig Tree Crossing	-	-	-	-	-	**-**
R6 Private Property	<5	<5	7	0	<5	**8**
R7 Hooley Station Homestead	-	-	-	-	-	**-**
R8 Auski Village	-	-	-	-	-	**-**
R9 Wirrilimarra Community	<5	<5	7	0	<5	**8**
R10 Youngaleena Community	<5	<5	<5	<5	0	**<5**
R11 Munjina East Gorge	-	-	-	-	-	**-**
R12 Karajini Eco Retreat	-	-	-	-	-	**-**
R13 Private Mining Camp	-	-	-	-	-	**-**

It should be noted that the predictive model does not calculate to locations farther than 20km from a given noise source. These locations are shown in the table with a blank ("-") result.

The results demonstrate that the Hooley Station homestead, Fig Tree Crossing, Auski Village and other sensitive receptors (Receivers 11 through 13) are not likely to be exposed to detectable noise levels from the MDIOM when operating in this location.

The results for Scenario 1B demonstrate that when mining operations move to the westernmost pits of Murray's Hill, the levels will be at most 68 dB L_{A10} at the closest bat cave primarily due to the pit teams still working in Fridge Hill. This remains compliant with the prescribed criteria of 70 dB(A). At the nearest heritage sites, noise levels are up to 67 dB L_{A10} due to the Pit teams in Fridge Hill.

With regard to heritage sites, the highest predicted level is at site MIB-MD13-042 with a level of 67 dB L_{A10}, noting that the site is 40m from the Fridge Hill Pit area. This exceeds a 60 dB L_{A10} criteria level of *Table 2-3* by a margin of 7 dB criteria and is a result of mining teams working as close as 200m. This site should be reviewed and strategies may be required to manage noise when working nearby, as deemed appropriate.

Noise is predicted to be readily compliant at all other sensitive receptors noting the assigned level of 35 dB L_{A10}.

Figure 4-3: Scenario 1B East-West Area with Conveyors - Greater Area

Figure 4-4: Scenario 1B East-West Area with Conveyors - Zoomed Areas

4.1.3. Scenario 2A: East-Central Areas with Road Trains

The results for the mining operations while teams of plant are working at the far north extents of the Fridge Hill Pit as well as in the central pits (Fridge West) are provided in *Table 4-3*. This scenario includes a Road Train Haulage to transport the processed ore from crusher pads to Great Northern Highway via a private road. A noise contour plot is also provided in *Figure 4-5 and Figure 4-6* showing noise levels at wide extents of the greater area and at close proximity, respectively.

Table 4-3: Scenario 2A Predicted Levels, L_{10} dB(A)

Receiver	Road Trains	Haul Trucks	Crusher Pad East	Crusher Pad Central	Pit Team	Overall
Heritage MD24-021	50	<5	5	5	11	**50**
Heritage Site - BCT	<5	<5	<5	<5	11	**11**
Heritage Site - HK4	<5	<5	<5	<5	7	**7**
Heritage Site MD2022_045	12	30	20	24	31	**34**
Heritage Site MD2023-001	18	42	23	18	34	**43**
Heritage Site MD2023-021	<5	<5	<5	<5	11	**12**
Heritage Site MD2023-022	<5	<5	<5	<5	14	**15**
Heritage Site MD-2022-035	42	<5	6	5	11	**42**
Heritage Site MD-2023-025	6	20	15	20	25	**27**
Heritage Site MD-2023-026	<5	5	<5	<5	19	**19**
Heritage Site MD-2023-54	5	21	15	19	24	**27**
Heritage Site MD-2023-56	6	21	14	19	24	**27**
Heritage Site MIB-M13-050	11	33	12	10	40	**41**
Heritage Site MIB-MD12-038	<5	25	10	10	32	**33**
Heritage Site MIB-MD12-039	<5	25	11	13	29	**31**
Heritage Site MIB-MD13-015	9	28	12	9	32	**33**
Heritage Site MIB-MD13-016	13	34	28	8	35	**38**
Heritage Site MIB-MD13-024	12	28	14	11	34	**35**
Heritage Site MIB-MD13-025	11	28	15	11	35	**36**
Heritage Site MIB-MD13-027	10	29	16	12	34	**36**
Heritage Site MIB-MD13-036	23	42	41	34	37	**46**
Heritage Site MIB-MD13-039	17	52	18	28	51	**55**

Receiver	Road Trains	Haul Trucks	Crusher Pad East	Crusher Pad Central	Pit Team	Overall
Heritage Site MIB-MD13-042	15	53	32	18	67	**67**
Heritage Site MIB-MD13-043	13	33	19	15	41	**41**
Heritage Site MIB-MD13-044	13	32	12	10	40	**40**
Heritage Site MIB-MD13-048	11	30	15	9	39	**39**
Heritage Site MIB-MD13-049	14	33	21	14	41	**42**
Heritage Site MIB-MD13-051	11	32	13	9	39	**40**
Heritage Site MIB-MD13-052	14	37	21	15	46	**46**
Heritage Site MIB-MD13-063	17	43	41	19	33	**45**
Heritage Site MIB-MD13-070	22	46	44	20	26	**48**
Heritage Site MIB-MD13-071	23	46	44	32	25	**49**
Heritage Site MIB-MDowns12-07	<5	23	12	18	31	**32**
Heritage Site MIB-MDowns12-10	<5	23	11	16	32	**33**
Heritage Site MIB-MDowns12-35	22	40	26	34	38	**43**
Homestead (Mulga Downs) South	-	-	-	-	-	**-**
R1 Bat Fridge Hill (East) – MEC042	14	55	31	<5	68	**68**
R2 Bat Cave Fridge Hill – MEC074	16	44	31	20	48	**50**
R3 Bat Cave Fridge Hill (north) – MEC072	8	34	17	14	43	**44**
R4 Bat Cave Hub – MEC063	9	35	25	22	36	**38**
R5 Fig Tree Crossing	0	0	0	0	0	**0**
R6 Private Property	<5	<5	7	6	18	**19**
R7 Hooley Station Homestead	-	-	-	-	-	**-**
R8 Auski Village	-	-	-	-	-	**-**
R9 Wirrilimarra Community	<5	<5	7	5	18	**18**
R10 Youngaleena Community	<5	<5	<5	<5	<5	**5**
R11 Munjina East Gorge	-	-	-	-	-	**-**
R12 Karajini Eco Retreat	-	-	-	-	-	**-**
R13 Private Mining Camp	-	-	-	-	-	**-**

It should be noted that the predictive model does not calculate to locations farther than 20km from a given noise source. These locations are shown in the table with a blank ("-") result.

The results demonstrate that the Hooley Station homestead, Fig Tree Crossing, Auski Village and other sensitive receptors (Receivers 11 through 13) are not likely to be exposed to detectable noise levels from the MDIOM when operating in this location.

Wirrilimarra and Youngaleena communities are predicted to receive no greater than 18 dB L_{A10} which is compliant with the 35 dB L_{A10} criteria level.

Road trains generally cause greater levels at heritage sites in the north east, those within 200m from the proposed route to GNH, with the highest level predicted to be 50 dB L_{A10}.

Bat caves are exposed to a worst case noise level of 68 dB L_{A10} when considering greatest contributions from pit teams working in the northern areas of Fridge Hill with noise from the Haul Trucks also contributing. These levels are compliant with the 70 dB(A) criteria level.

With regard to heritage sites, the highest predicted level is at site MIB-MD13-042 with a level of 67 dB L_{A10}, noting that the site is 40m from the Fridge Hill Pit area. This exceeds a 60 dB L_{A10} criteria level of *Table 2-3* by a margin of 7 dB criteria and is a result of mining teams working as close as 200m. This site should be reviewed and strategies may be required to manage noise when working nearby, as deemed appropriate.

Figure 4-5: Scenario 2A East-Central Area with Road Trains - Greater Area

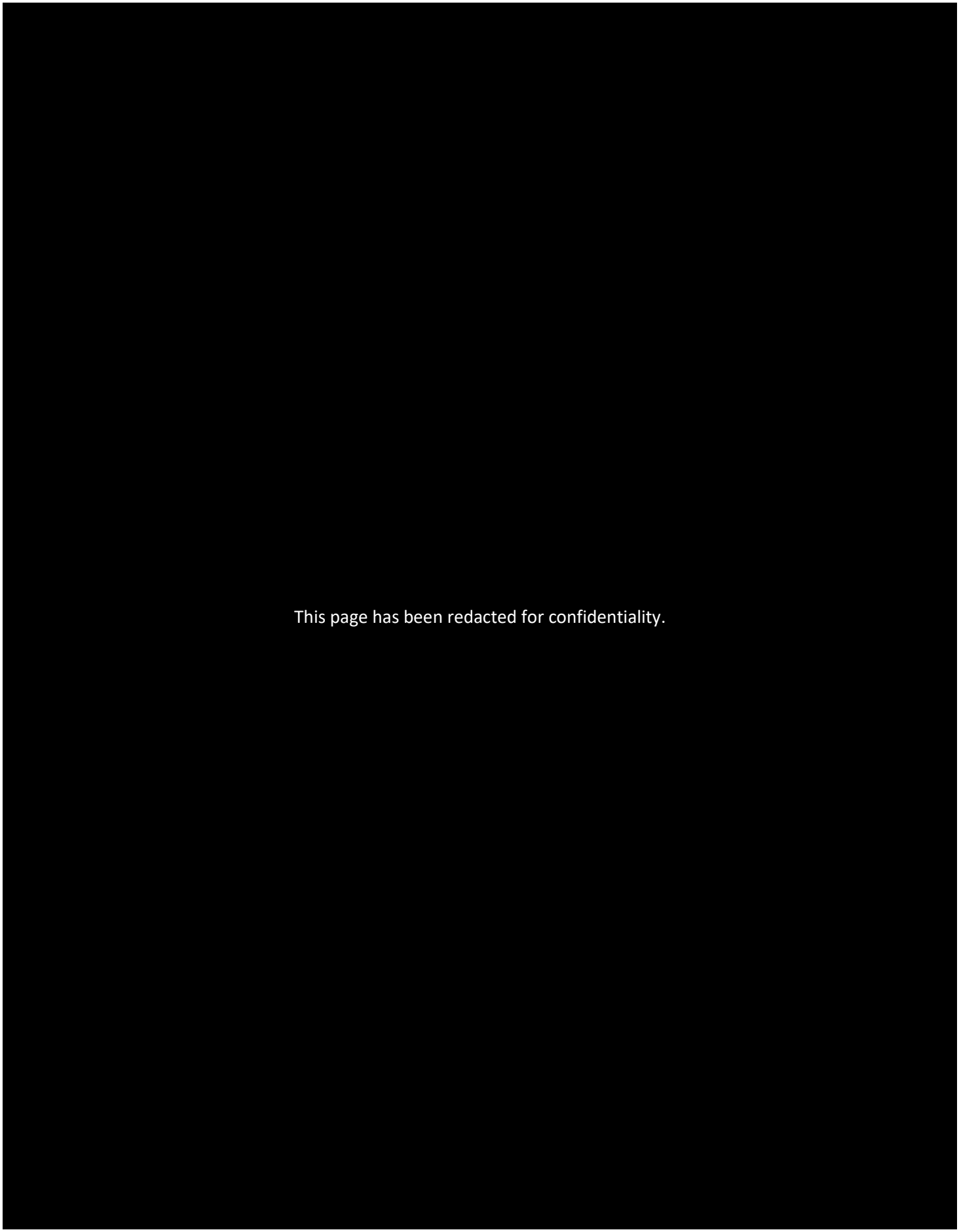
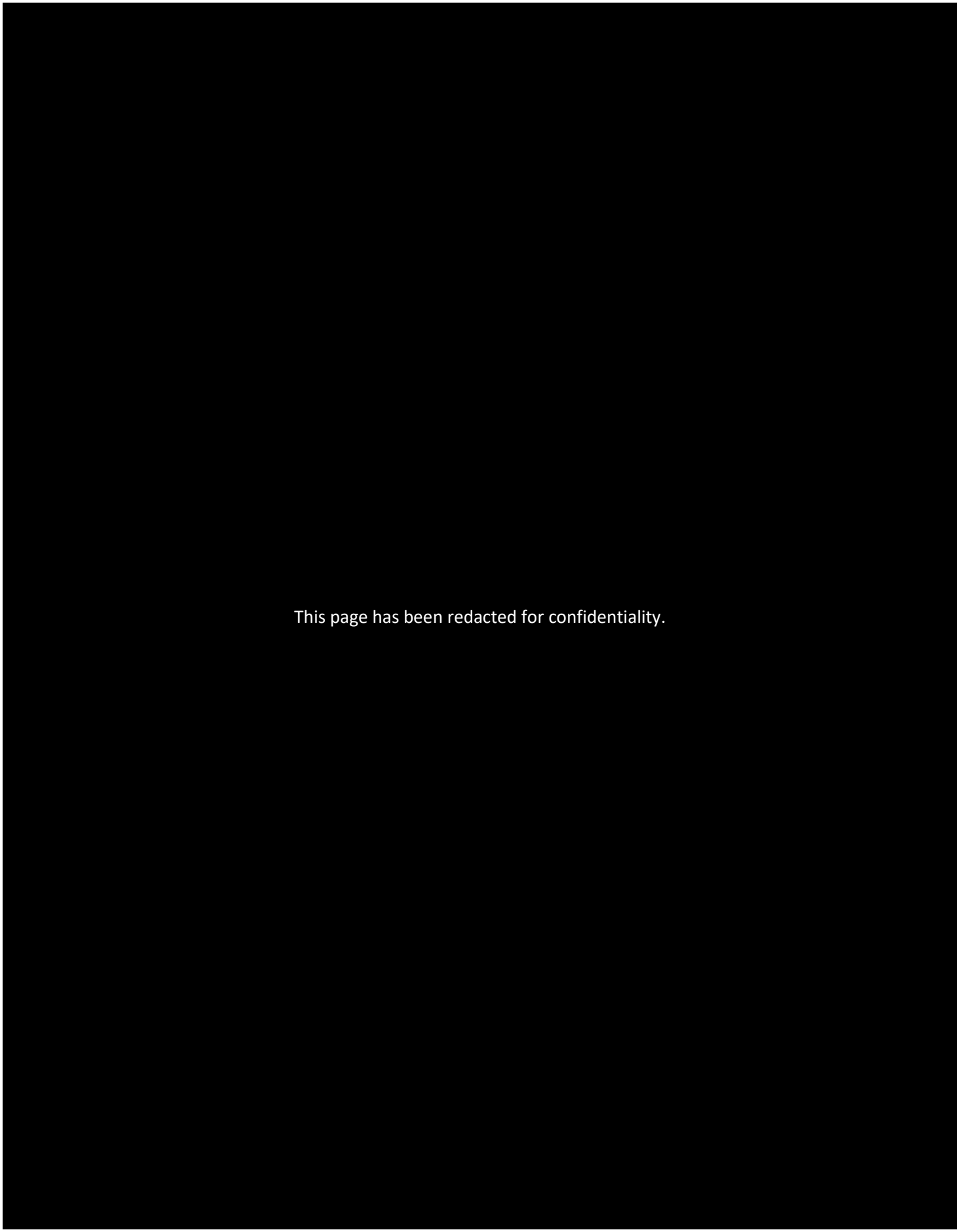


Figure 4-6: Scenario 2A East-Central Area with Road Trains - Zoomed Areas



4.1.4. Scenario 2B: East-West Areas with Road Trains

The results for the mining operations while teams of plant are working at the far west extents of the Murray's Hill Pits and at Fridge Hill are provided in *Table 4-4*. This scenario includes a Road Train Haulage to transport the processed ore from crusher pads to Great Northern Highway via a private road. A noise contour plot is also provided in *Figure 4-7 and Figure 4-8* showing noise levels at wide extents of the greater area and at close proximity, respectively.

Table 4-4: Scenario 2B Predicted Levels, L_{10} dB(A)

Receiver	Road Trains	Haul Trucks	Crusher Pad East	Crusher Pad Central	Pit Team	Overall
Heritage MD24-021	49	<5	5	<5	<5	**49**
Heritage Site - BCT	<5	50	<5	24	52	**54**
Heritage Site - HK4	<5	47	<5	23	47	**50**
Heritage Site MD2022_045	21	29	20	12	31	**34**
Heritage Site MD2023-001	18	42	23	9	34	**43**
Heritage Site MD2023-021	<5	25	<5	21	27	**29**
Heritage Site MD2023-022	<5	21	<5	21	25	**28**
Heritage Site MD-2022-035	41	-6	6	<5	7	**41**
Heritage Site MD-2023-025	15	20	15	8	24	**27**
Heritage Site MD-2023-026	11	21	<5	28	16	**29**
Heritage Site MD-2023-54	16	21	15	<5	23	**26**
Heritage Site MD-2023-56	16	21	14	<5	24	**26**
Heritage Site MIB-M13-050	9	33	12	<5	40	**41**
Heritage Site MIB-MD12-038	<5	25	10	<5	32	**33**
Heritage Site MIB-MD12-039	<5	25	11	<5	29	**30**
Heritage Site MIB-MD13-015	8	28	12	<5	32	**33**
Heritage Site MIB-MD13-016	11	34	28	<5	35	**38**
Heritage Site MIB-MD13-024	11	28	14	<5	34	**35**
Heritage Site MIB-MD13-025	10	28	15	<5	35	**36**
Heritage Site MIB-MD13-027	9	29	16	<5	34	**36**
Heritage Site MIB-MD13-036	22	42	41	8	37	**45**
Heritage Site MIB-MD13-039	18	52	18	10	51	**55**

Receiver	Road Trains	Haul Trucks	Crusher Pad East	Crusher Pad Central	Pit Team	Overall
Heritage Site MIB-MD13-042	14	53	32	<5	67	**67**
Heritage Site MIB-MD13-043	12	33	19	<5	41	**41**
Heritage Site MIB-MD13-044	11	32	12	<5	40	**40**
Heritage Site MIB-MD13-048	10	30	15	<5	39	**39**
Heritage Site MIB-MD13-049	13	33	21	<5	41	**42**
Heritage Site MIB-MD13-051	10	32	13	<5	39	**40**
Heritage Site MIB-MD13-052	13	37	21	<5	46	**46**
Heritage Site MIB-MD13-063	15	43	41	<5	33	**45**
Heritage Site MIB-MD13-070	21	46	44	<5	24	**48**
Heritage Site MIB-MD13-071	21	46	44	<5	22	**48**
Heritage Site MIB-MDowns12-07	26	12	12	12	14	**27**
Heritage Site MIB-MDowns12-10	28	20	11	27	20	**31**
Heritage Site MIB-MDowns12-35	21	40	26	8	38	**42**
Homestead (Mulga Downs) South	-	-	-	-	-	**-**
R1 Bat Fridge Hill (East) – MEC042	14	55	31	<5	68	**68**
R2 Bat Cave Fridge Hill – MEC074	14	44	31	<5	48	**50**
R3 Bat Cave Fridge Hill (north) – MEC072	8	34	17	<5	43	**44**
R4 Bat Cave Hub – MEC063	10	35	25	<5	36	**38**
R5 Fig Tree Crossing	-	-	-	-	-	**-**
R6 Private Property	<5	<5	7	0	<5	**8**
R7 Hooley Station Homestead	-	-	-	-	-	**-**
R8 Auski Village	-	-	-	-	-	**-**
R9 Wirrilimarra Community	<5	<5	7	0	0	**8**
R10 Youngaleena Community	<5	<5	<5	<5	0	<5
R11 Munjina East Gorge	-	-	-	-	-	**-**
R12 Karajini Eco Retreat	-	-	-	-	-	**-**
R13 Private Mining Camp	-	-	-	-	-	**-**

It should be noted that the predictive model does not calculate to locations farther than 20km from a given noise source. These locations are shown in the table with a blank ("-") result.

The results demonstrate that the Hooley Station homestead, Fig Tree Crossing, Auski Village and other sensitive receptors (Receivers 11 through 13) are not likely to be exposed to detectable noise levels from the MDIOM when operating in this location.

Wirrilimarra and Youngaleena communities are predicted to receive no greater than 8 dB L_{A10} which is compliant with the 35 dB L_{A10} criteria level.

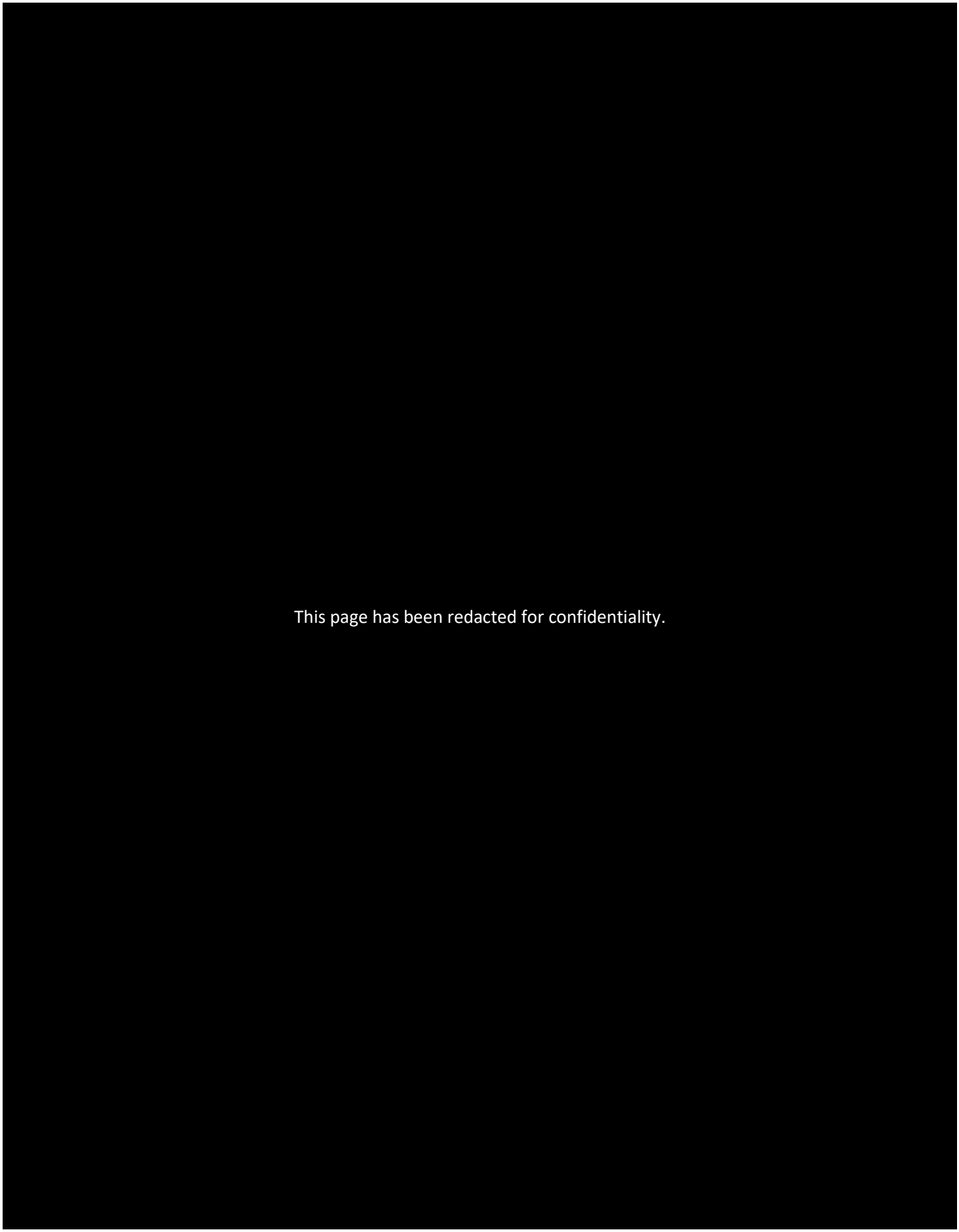
Road trains generally cause greater levels at heritage sites in the north east, those within 200m from the proposed route to GNH, with the highest level predicted to be 50 dB L_{A10}.

Bat caves are exposed to a worst case noise level of 68 dB L_{A10} when considering greatest contributions from pit teams working in the northern areas of Fridge Hill with noise from the Haul Trucks also contributing. These levels are compliant with the 70 dB(A) criteria level.

With regard to heritage sites, the highest predicted level is at site MIB-MD13-042 with a level of 67 dB L_{A10}, noting that the site is 40m from the Fridge Hill Pit area. This exceeds a 60 dB L_{A10} criteria level of *Table 2-3* by a margin of 7 dB criteria and is a result of mining teams working as close as 200m. This site should be reviewed and strategies may be required to manage noise when working nearby, as deemed appropriate.

Figure 4-7: Scenario 2B East-Central Area with Road Trains - Greater Area

Figure 4-8: Scenario 2B East-Central Area with Road Trains - Zoomed Area



4.2. Airblast Noise and Vibration Prediction

Airblast noise and vibration levels have been predicted to the nearest bat caves and heritage sites, being the closest receptors. The Wirrilimarra Community is 8.5km from the nearest pit and has been considered. *Table 4-5* presents the charge mass per hole (kg) for a given target peak ground vibration velocity (mm/s). This can be used as guidance when planning blasting within 100m to 200m of a given bat cave or heritage site, noting that the type of rock and/or location influences the outcome considerably.

Advice from HanRoy is that blast size may be up to 530kg in some cases – this value has been highlighted in the table for reference. The outcome is that such a blast may be suitable if a vibration velocity of 25mm/s is deemed acceptable to preserve structures (caves or heritage sites) at least 150m away. Where caves or heritage sites are closer than 150m away, the charge mass per hole should be reduced to no more than 240kg.

As always the recommendation is to adopt an iterative strategy combined with vibration monitoring on site.

Table 4-5: Permitted Charge Mass Per Delay (kg) for Various Vibration Velocities

Distance to Receptor	Charge Mass per Hole (kg) to Achieve Peak Ground Vibration Velocity Level (mm/s)								
	Free Face – Hard/Highly Structured Rock			Free Face – Average Rock			Heavily Confined		
	25 mm/s	50 mm/s	75 mm/s	25 mm/s	50 mm/s	75 mm/s	25 mm/s	50 mm/s	75 mm/s
100m	240	565	940	85	204	335	14	32	53
150m	530	1280	3000	190	460	1080	30	72	170
200m	950	2270	3750	340	810	1350	54	126	210

Table 4-6 presents the noise levels of an airblast predicted for a given charge mass-per-hole (kg). This can be used as a guideline when planning the blasting at known distances from a nearby bat cave or heritage site. The table highlights complying with a 125 $dB_{Lin\ Peak}$ limit level, though this is not necessarily to be taken as a limit for bats which is as yet not established.

A blast of 530kg mass would produce 92 $dB_{Lin\ Peak}$ and 0.9mm/s at Wirrilimarra, both results are readily below compliance levels. A nominally lower airblast level is expected at the Hooley Station homestead and Auski Village being some 33km and 23km away, respectively.

Table 4-6: Calculated Airblast Noise Levels (Confined blast)

Charge Mass per Hole (kg)	Airblast Level (dB $L_{Linear\ peak}$) at Distance (metres)				
	50m	100m	200m	300m	500m
1	124	116	107	102	96
5	130	123	114	109	102
10	134	126	119	112	105
20	137	129	120	114	108
30	139	130	122	116	110
40	140	131	123	117	111
50	141	132	124	118	112
60	142	133	124	119	113
70	143	134	125	120	114
80	143	134	126	120	114
90	144	135	126	121	115
100	144	135	127	121	115
110	144	136	127	121	115
120	145	136	127	122	116

4.3. Airport Noise

Table 4-7 provides the expected aircraft noise levels of a departing and arriving Airbus A320 or Boeing 737. The range of levels depends on which direction the aircraft will approach the runway. The runway distances are determined by perpendicular distances to the proposed runway (See *Figure 3-2*), noting that the air strip is an indicative envelope at this stage. These distances are determined in accordance with the methodology outlined in AS2021-2015.

Table 4-7: Nearest Site Locality Relative to Runway

Location Type	Parameter	Runway Horizontal Distances	Adjusted for Height
Bat Cave	DS	13000m	13000
	DL	11500m	11200m
	DT	14200m	13900m
Community	DS	>20000m	>20000m
	DL	7600m	7600m
	DT	10500m	10500m
Homestead	DS	>20000m	>20000m
	DL	>20000m	>20000m
	DT	>20000m	>20000m
Heritage Site	DS	3300m	3300m
	DL	5000m	4700m
	DT	7700m	7400m

Table 4-8: AS2021 Expected Noise Levels: Boeing 737

Location	Departures, dB L_{Amax}	Arrivals, dB L_{Amax}
Bat Cave	<10	<12
Community	<5	<10
Homestead	-	-
Heritage Site	25	30

As such, the worst-case maximum noise level for design purposes at a bat cave is **12 dB L_{Amax}**. For the Communities and homestead, the sideline distances exceed the maximums in the Standard's look up tables, therefore noise levels will be well below requirements. This should be noted when assessing any receiver greater than 11km away from the airport envelope. For the nearest heritage site to the airport's location, maximum noise levels are up to **30 dB L_{Amax}** which is below the assigned level of 80 dB L_{Amax}.

4.4. Cumulative Noise

The worst case cumulative scenario is when mobile mining teams are working in the northernmost pit (Fridge Hill) combined with modelled process plant and Mulga Downs Hub and Rail proposed operations. The results are summarised in *Table 4-9*. A noise contour plot is also provided in *Figure 4-9 and Figure 4-10* showing cumulative noise levels at wide extents of the greater area and at close proximity, respectively.

Table 4-9: Cumulative Predicted Levels, L_{10} dB(A)

Receiver	Mining Ops	Hub-Rail	Truck Haulage	Overall
Homestead (Mulga Downs) South	-	-	-	-
R1 Bat Fridge Hill (East) – MEC042	68	36	25	**68**
R2 Bat Cave Fridge Hill – MEC074	50	37	33	**50**
R3 Bat Cave Fridge Hill (north) – MEC072	44	37	27	**46**
R4 Bat Cave Hub – MEC063	38	27	33	**40**
R5 Fig Tree Crossing	-	-	-	-
R6 Private Property	19	17	-	-
R7 Hooley Station Homestead	-	-	-	-
R8 Auski Village	-	-	-	-
R9 Wirrilimarra Community	18	17	-	**20**
R10 Youngaleena Community	5	-	-	-
R11 Munjina East Gorge	-	-	-	-
R12 Karajini Eco Retreat	-	-	-	**<5**
R13 Private Mining Camp	-	-	-	-
Nearest Heritage Sites to Hub Haul Road	50	18	72	**72**
Other Worst Case Heritage Sites	55	35	29	**55**

The nearest heritage site (MD24-021) is within 40m of the Hub haul road, therefore receives a high level of noise at 72 dB(A) therefore exceeding the assigned level of 60 dB L_{A10} at this site. The next closest site is 200m away from the road and receives 65 dB(A). All other heritage sites receive no more than 40 dB(A), noting these levels are still compliant with the prescribed maximum of 80 dB L_{Max} but exceed the L_{A10} assigned levels of 60 dB(A). The nearest Bat cave is predicted to receive up to 68 dB(A) which complies with the 70 dB(A) maximum criteria level.

It should be noted that the predictive model does not calculate to locations farther than 20km from a given noise source. These locations are shown in the table with a blank ("-") result.

The results demonstrate that the Hooley Station homestead, Fig Tree Crossing, Auski Village and other sensitive receptors (Receivers 11 through 13) are not likely to be exposed to detectable noise levels from the MDIOM when operating in this location.

Figure 4-9: Cumulative Noise Contour Plot - Greater Area

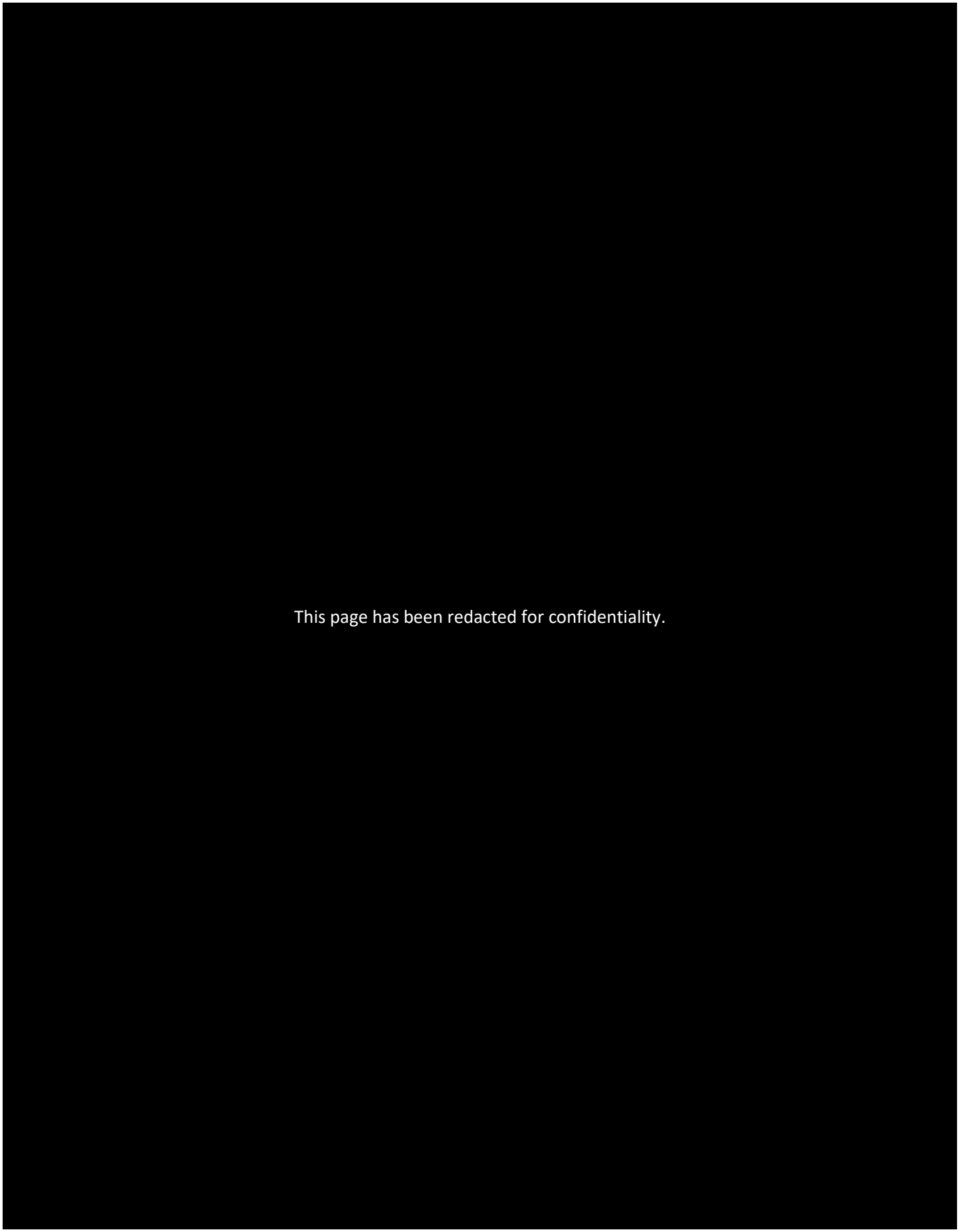


Figure 4-10: Cumulative Noise Contour Plot - Zoomed Areas

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5. ASSESSMENT

5.1. Noise Modelling

Table 5-1 assesses the worst-case noise levels predicted for all four modelled scenarios as a result of the Proposal. During night time, with less background noise, the emissions may be considered tonal and have therefore been adjusted by + 5 dB when assessing to human receptor sites.

Table 5-1: All Scenarios Assessment, dB_{LA10}

Receiver	Approximate Nearest Distance to Site	Predicted	Adjusted*	Criteria Level	Assessment
Bat Sites	60-150 metres	38-68	68	**70**	*Complies*
Homesteads	33 km	-	-	**35**	*Complies*
Auski Village	23 km	-	-	**35**	*Complies*
Karajini Eco Retreat	37 km	-	-	**35**	*Complies*
Munjina East Gorge	36 km	-	-	**35**	*Complies*
Communities	8.5 km	18	23	**35**	*Complies*
Heritage Sites	40 metres	67	67	**60**	*+7*

Notes:

- *Adjusted by + 5 dB for tonality when assessing to human receptors.

- Cells denoted with a "-" result are greater than 20km away and not predicted by the computer model.

The dominant noise source group is generally the mobile haul trucks and Crusher plant (all plant combined). It should be noted that all homesteads are far enough away from the mine (over 30km) that they are not expected to experience an impact from day to day mining operations. Noise levels at Communities is predicted to be low, and below background noise. The closest Heritage site (MIB-MD13-042) is 40 metres from the pit edge and therefore receives the highest noise level where mining teams work nearby. This site should be reviewed and strategies may be required to manage noise when working nearby, as deemed appropriate.

5.2. Airblast Noise

For confined blasting, the airblast levels are not predicted to exceed a value of $L_{Linear\ peak}$ 125 dB unless within 200m of a bat cave assuming a maximum charge mass per delay of 530kg. Occupied non-fauna receptors closest to the mine are at least 10km from a given mining pit, and therefore would not experience a blast above the 125 $dB_{Linear\ peak}$. It is understood that the more critical receptors for blasts would be the worker's accommodation village, which is the subject of a separate impact study.

5.3. Ground Vibration

Ground vibration levels at the closest bat caves and heritage sites, within 100m are most critical and guidance has been provided to suggest that when approaching these distances, blasts should be closely monitored with lower charge mass per delays used until the vibration levels and site constants can be determined.

With regard to communities and homesteads, the nearest community is Wirrilimarra at 8.5km from Fridge Hill East. The nearest homestead is over 30km away. The supplied blast of 530kg mass would produce 92 $dB_{Lin\ Peak}$ and 0.9mm/s at Wirrilimarra, which is well below compliance levels. The noise and vibration levels would be 78 $dB_{Lin\ Peak}$ and 0.01mm/s, at Hooley Station homestead and Karajini Eco Retreat, being some 30km from site. These levels are considered imperceptible.

5.4. Airport Noise

Noise levels expected from the airport position are based on look up tables with reference to spatial data for the nearest sensitive sites. The results are summarised an assessed in *Table 5-2*. Note that the levels are assessable against the assigned noise levels. Note that where a receptor is greater than 20km away the noise levels are sufficiently low as to not be calculable according to the Standard.

Table 5-2: Aircraft Noise Assessment, dB_{LAmax}

Receiver	Nearest Distance to Runway	Departures, dB L_{Amax}	Arrivals, dB L_{Amax}	Criteria Level	Assessment
Bat Sites	18 km	<12	<10	70	*Complies*
Homesteads	33 km	-	-	80	*Complies*
Auski Village	38 km	-	-	80	*Complies*
Karajini Eco Retreat	33 km	-	-	80	*Complies*
Communities	21 km	<10	<5	80	*Complies*
Heritage Sites	5 km	30	25	80	*Complies*

The outcome of the aircraft departure and arrival predictive noise calculations is compliance at all nearest receptors. This is based on a Boeing 737 or Airbus A320 aircraft and the assumed runway position and orientation. According to AS2021 the airport location would therefore be considered suitable against the metrics in the standard.

5.5. Cumulative Noise Modelling Assessment

Table 5-3 assesses the worst-case noise levels predicted for the cumulative site model inclusive of Mining, ROM, Process Plant, Hub -Rail and associated Haulage Road. During night-time, with less background noise, the emissions may be considered tonal and have therefore been adjusted by + 5 dB when assessing to human receptor sites. Note that noise sources such as train pass-bys, shunting, blasting, trains and aircraft noise are not included in the cumulative study as they use different acoustic parameters and are assessed against different criteria (refer to Section 2.7).

Table 5-3: Cumulative Site Noise Assessment, dB_{LA10}

Receiver	Approximate Nearest Distance to Mine	Predicted	Adjusted*	Criteria Level	Assessment
Bat Caves	100 metres	68	68	70	*Complies*
Homesteads	33 km	-	-	35	*Complies*
Auski Village	23 km	-	-	35	*Complies*
Karajini Eco Retreat	37 km	-	-	35	*Complies*
Munjina East Gorge	36 km	-	-	35	*Complies*
Communities	8.5 km	20	25	35	*Complies*
Heritage Sites	150 metres	55	60	60	*Complies*
Private Mining Camp	21 km	-	-	35	*Complies*

Notes:

- *Adjusted by + 5 dB for tonality when assessing to human receptors.

- Cells denoted with a "-" result are greater than 20km away and not predicted by the computer model.

The cumulative noise assessment demonstrates that noise levels are compliant at all receptors, apart from those heritage sites within 100m of the Haul Roads. The nature of these sites should be investigated and discussion may be warranted if they are to be frequented by people during the life of the mine. Once established, noise levels from the process plant could be measured on site, and mitigation measures potentially employed to effectively reduce noise levels by 1 dB if necessary.

Based on the cumulative modelling results, the noise sources contributing the most to the noise levels at Bat caves is Mining teams in the pits, and for heritage sites it is the Haulage Trucks.

6. CONCLUSION

Operational mining noise from the proposed MDIOM received at the nearest sensitive receptors, is predicted to comply with the criterion provided in the *Environmental Protection (Noise) Regulations 1997* at all times and in worst case scenarios. The sensitive receptors considered in accordance with the Regulations were Communities, accommodation villages and tourism sites. As an extension, Heritage sites were also assessed in this manner. It is understood that these Heritage sites are not areas which have occupancies, however the nearest site is within 40m of the pit edge and is expected to receive high levels above the 60 dB L_{A10} criteria as a result of mining teams working as close as 200m. . This site should be reviewed and strategies may be required to manage noise when working nearby, as deemed appropriate.

The operational noise to the nearby bat caves is predicted to comply with the criterion of 70 dB(A), at which level it is considered unlikely for noise to result in bats leaving their caves (Bullen and Creese[4]).

Guidance on airblast noise and vibration levels to address the nearest bat caves and heritage sites (within 200m of pit area) has been provided in this report. There is no known airblast criteria for bats. Therefore, it is recommended that blasting strategies take into account this information, in conjunction with geotechnical surveys and monitoring to minimise impact on the fauna and sensitive heritage sites.

Impacts from blast noise and vibration to homesteads, accommodation villages, tourism sites and communities in the vicinity of the Proposal are demonstrated to be compliant with relevant criteria noting the distances to these receptors exceeds 8.5km.

Noise impacts from the proposed airport are expected to be greatest for the nearest bat caves and heritage sites, with the levels at the homesteads, accommodation villages, tourism sites and communities also assessed. Compliance is predicted following the methodology outlined in *AS2021 Acoustics – Aircraft Noise Intrusion - Building Siting and Construction,* noting that the level at a bat cave is to be no more than 12 dB L_{Amax} for a given aircraft arrival or departure. Furthermore, aircraft noise levels are not expected to exceed 80 dB L_{Amax} at the nearest heritage site, homestead, accommodation village, tourism site or community. The proposed layout and orientation is therefore considered suitable for the site.

[4] Bullen, R. and Creese, S. (2014). A note on the impact on Pilbara leaf-nosed and Ghost Bat activity from cave sound and vibration levels during drilling operations. *The Western Australian Naturalist* 29: 145-154.

Appendix A – Terminology & Abbreviations

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

- **Decibel (dB)**

The decibel is the unit that describes the sound pressure 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 level 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. 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. This is used when assessing the presence of modulation.

- **L_{APeak}**

This is the greatest absolute instantaneous sound pressure level in decibels using the A-frequency weighting.

- **L_{Amax}**

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

- **L_{A1}**

The L_{A1} level is the A-weighted noise level exceeded for 1 percent of the measurement period and is considered to represent the average of the maximum noise levels measured.

- **L_{A10}**

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

- **L_{A90}**

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

- **One-Third-Octave Band**

Means a band of frequencies spanning one-third of an octave and having a centre frequency between 25 Hz and 20000 Hz inclusive.

- **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.

- **L_{Amax} assigned level**

Means an assigned level, which, measured as a L_{ASlow} value, is not to be exceeded at any time.

- **L_{A1} assigned level**

Means an assigned level, which, measured as a L_{ASlow} value, is not to be exceeded for more than 1 percent of the representative assessment period.

- **L_{A10} assigned level**

Means an assigned level, which, measured as a L_{ASlow} value, is not to be exceeded for more than 10 percent 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; and

(b) is present for at least 10% of the representative assessment period; and

(c) is regular, cyclic and audible.

- **Impulsive Noise**

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

– a variation in the emission of a noise where the difference between L_{Apeak} and L_{Amax} is more than 15 dB when determined for a single representative event.

- **Peak Component Particle Velocity (PCPV)**

The maximum instantaneous velocity in mm/s of a particle at a point during a given time interval and in one of the three orthogonal directions (x,y or z) measured as a peak response. Peak velocity is normally used for the assessment of structural damage from vibration.

- **Peak Particle Velocity (PPV)**

The maximum instantaneous velocity in mm/s of a particle at a point during a given time interval and is the vector sum of the PCPV for the x, y and z directions measured as a peak response. Peak velocity is normally used for the assessment of structural damage from vibration.

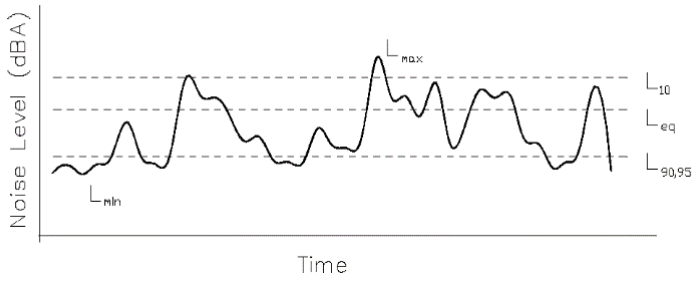
- **RMS Component Particle Velocity (PCPV)**

The maximum instantaneous velocity in mm/s of a particle at a point during a given time interval and in one of the three orthogonal directions (x, y or z) measured as a root mean square (rms) response. RMS velocity is normally used for the assessment of human annoyance from vibration.

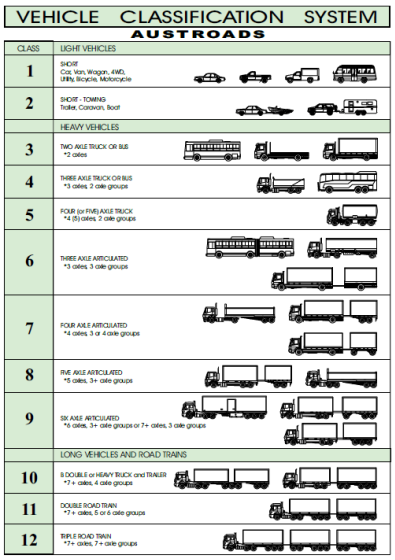
- **RMS Peak Particle Velocity (PPV)**

The maximum instantaneous velocity in mm/s of a particle at a point during a given time interval and is the vector sum of the PCPV for the x, y and z directions measured as a root mean square (rms) response. RMS velocity is normally used for the assessment of human annoyance from vibration.

- **Chart of Noise Level Descriptors**



- **Austroads Vehicle Class**



- **Typical Noise Levels**