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Environmental Noise Impact Assessment

Worsley Mining Expansion - Revised Proposal
Boddington Bauxite Mine

Prepared for South32 Worsley Alumina Pty Ltd
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Information utilised and contained within this report was current at time of completion of the assessment in July 2020. It is acknowledged that some premise locations, tenures and agreements may have been updated since publication.

Executive Summary

Worsley is seeking environmental approvals for a revised Worsley Mining Development Envelope (WMDE) that replaces the previous development envelope known as the 'Pre-existing Approval Area' (or Primary Bauxite Area - PBA). The Proposal includes an expansion of the existing mining area and the development of a Bauxite Transport Corridor (BTC) at the Boddington Bauxite Mine (BBM).

An environmental noise impact assessment of the Proposal has been undertaken using predictive noise modelling to determine the noise impacts of mining operations on the surrounding community (i.e. sensitive receivers).

Overland conveyor extensions and construction work are not included in the assessment, as extensions to the overland conveyor fall under Worsley's State Agreement (see section 2.1.7) and construction work is covered under Regulation 13 of the Noise Regulations (see section 2.1.8). For construction activities Worsley will comply with the requirements of Regulation 13.

The approach taken in the assessment for noise from mining operations was to use both worst-case[1] and calm weather conditions combined with realistic worst-case operating conditions to predict possible impacts on sensitive receivers in the study area. The study area was divided into 19 operational areas chosen due to their proximity to sensitive receivers. Using the predicted levels from the modelling the sensitive receivers were then categorised into critical, major, moderate and minor risk depending on their predicted exceedance of the Regulatory assigned levels. The worst-case assessment study identified 4 critical and 24 major receivers (see section 5.3.1). The remaining 101 receivers were categorised as low, minor and moderate. A blast noise assessment performed under worst-case weather conditions identified 4 receivers which were categorised as major.

The categorisation of the receiver risk was then used to determine mitigation measures and recommendations for reducing the risk associated with each receiver to below the assigned levels.

The resulting noise mitigation strategies are as follows (see section 6 and section 8.4):

- Noise Mitigation Strategies for Mining Activities:
  - Long Term Planning and Scheduling.
  - Adaptive Management.
  - Engineering Noise Control.
  - Commercial arrangements.
- Noise Mitigation Strategies for Blasting Activities:
  - A predictive software program that uses forecast (and live) weather and blast parameters should be used to assist operations in determining favourable conditions for blasting.
  - Measure and assess blasting operations associated with the proposal.
  - Use of electronic or signal tube chord detonation and stemming.

Evidence has been provided in section 7 that demonstrates that Worsley is not only currently implementing the proposed strategies, but is also continuously looking for future improvements to their noise management practices.

[1] Draft Guideline on Environmental Noise for Prescribed Premises (May 2016)

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1 Introduction

1.1 Background

South32 Worsley Alumina Pty Ltd (South32) currently operates the Boddington Bauxite Mine, the Worsley Alumina Refinery and the Port Facility, which is pursuant to the *Alumina Refinery (Worsley) Agreement Act 1973* (Worsley State Agreement). The Boddington Bauxite Mine is primarily located on Mining Lease ML258SA, which was granted through the Worsley State Agreement.

The Boddington Bauxite Mine is located approximately 5 kilometres (km) west-south-west of Boddington, and the Worsley Alumina Refinery is located approximately 15 km north-west of Collie.

The existing bauxite mining activities are undertaken in what is referred to as the "Primary Bauxite Area" (PBA), which is comprised of the Saddleback, Marradong and Hotham North areas. The refinery is currently licensed to produce up to 4.7 million tonnes per annum (Mtpa) of alumina.

The current Worsley Bauxite-Alumina operation is a long-term operation with a current expected ore reserve life of 17 years (as at 30 June 2018) based on a total ore reserve of 298 Mt. The Worsley Bauxite-Alumina operation has a Mineral Resource of 1,170 Mt from which additional ore reserves may be estimated beyond the current ore reserves. The current mining and refinery operations are managed through conditions in Part A of Ministerial Statement No. 719 (MS 719) (Part IV of the Environmental Protection Act 1986), Licencing through the Environmental Protection Regulations 1987, and exemptions through the Commonwealth EPBC Act.

Worsley is seeking environmental approvals for the Worsley Mine Expansion – Revised Proposal (the proposal). The Proposal includes an expansion of the existing mining area, be known as the Worsley Mining Development Envelope (WMDE), and the development of a Bauxite Transport Corridor (BTC) at the Boddington Bauxite Mine (BBM). The WMDE and BTC allow for additional mining operations and development to occur at the BBM within the proposed broader mining envelope (as shown in Figure 1-1). This report provides the outcomes of the environmental noise impact assessment that is required as part of the approval process for the WMDE and BTC.

The Proposal also includes a development envelope for contingency mining within the Contingency Bauxite Mining Envelope (CBME). The CBME is located within the Refinery Lease Area at the Worsley Refinery. Impacts associated with mining and blasting within the CBME are provided as an addendum to this report.

1.2 Aim

The aim of this assessment is to assess and characterise noise impacts on sensitive receptors as a result of the Worsley Mine Expansion Revised Proposal.

1.3 Scope

The scope of this document includes:

- Section 2 – Summary of legislation, including applicable assigned levels for noise sensitive receivers.
- Section 3 – Noise Modelling Methodology.
- Section 4 – Noise model results and risk-based compliance assessment against the *Environmental Protection (Noise) Regulations 1997*.
- Section 5 – Receiver Risk Assessment.
- Section 6 – Noise Mitigation.
- Section 7– Ability to Implement Noise Mitigation Strategies.

- Section 8 – Blasting noise and vibration impacts.
- Section 9 – Conclusions and Recommendations.

1.4 Applicable Documents

The following are the applicable regulatory requirements and references used to conduct this impact assessment:

- [1] *Environmental Protection Act 1986.*
- [2] *Environmental Protection (Noise) Regulations 1997*.
- [3] Regulation 8 inserted in Gazette 5 Dec 2013 p. 5653-6; amended in Gazette 10 Jan 2017 p. 196.
- [4] Draft Guideline on Environmental Noise for Prescribed Premises (May 2016).
- [5] AS 2187.2-2006 Explosives - Storage and use - Use of explosives.
- [6] Newmont Boddington Goldmine - Extended Basement Operations.
- [7] Newmont Boddington Gold Life-of-Mine Extension Project (Reference 12022070-02 draft 5).
- [8] Worley Mine Expansion (EP ACT Revised Proposal / EPBC A Action) Referral Supporting Document May 2019.
- [9] EPA Environmental Scoping Document – Worsley Mine Expansion – Revised Proposal (2019/8437)
- [10] Worsley Excessive Mining Noise Withdrawal Policy (v5. Nov 2013)

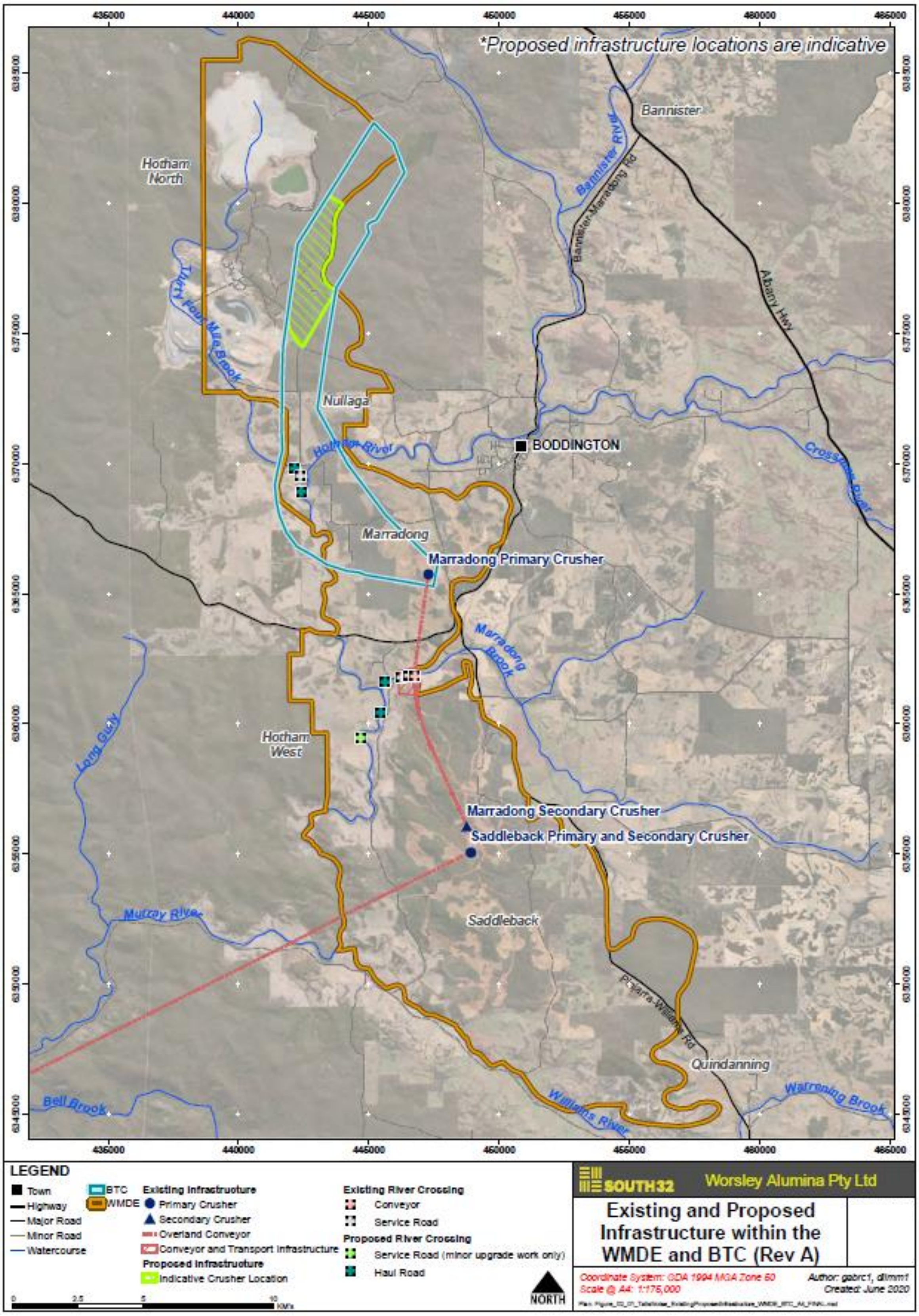


Figure 1-1 : Proposed Worsley Mining Development Envelope (WMDE) and Bauxite Transport Corridor (BTC) for the Boddington Bauxite Mine.

1.5 Overview

Worsley is located on the Darling Plateau, which forms the south-western margin of the great Plateau of Western Australia. The Worsley operation consists of bauxite mining and alumina refining activities with supporting infrastructure.

The proposed WMDE is located approximately 5 km west of Boddington and 130 km south-east of Perth, WA. The WMDE covers an area of 27,796 ha, which includes the 'Pre-existing Approval Area' as well as expanded mining areas. The indicative disturbance footprint of the WMDE not covered under existing approvals (i.e. the subject of the assessment under this Proposal) is 5,694 ha. The proposed mining within the WMDE will occur within the Hotham North, Nullaga, Marradong, Saddleback, Hotham West and Quindanning development areas.

Once bauxite is mined and crushed at BBM, it is transported 51 km by a two-flight cable belt conveyor system to the Worsley Refinery, ~20 km north-west of Collie. Alumina powder is then transported by rail to the Port of Bunbury, where it is shipped to smelters around the world.

In addition to the proposed revision of the WMDE, Worsley is also seeking approval for a Bauxite Transport Corridor (BTC) as shown in Figure 3-1. The BTC is a proposed corridor where long term transport routes are planned (potentially including but not limited to road truck transport and conveyors). The BTC will provide a route between Marradong and Hotham North mining areas with future linkage with the Mid Central mining area.

Table 1-1 details the requirement as stated in the EPA Environmental Scoping Document (2019/8437)[9] inclusive of the report sections referencing the requirements.

Table 1-1 : Environmental Scoping Document Worsley Mine Expansion – Revised Proposal (Social Surroundings - Noise[2])

Item	Reference	Requirement	Report Section
1	55	Characterise the surrounding land use and amenity values in, and adjacent to the Primary Assessment Area (WMDE, BTC and CBME), with a focus on the sensitive receptors and important areas for human use that could be affected by noise and dust emissions, visual amenity issues, and alterations to the land from mining. Include relevant maps to show the locations of the sensitive receptors likely to be affected by the proposal.	Section 2.1.5 Section 3.6 Section 3.7 Appendix A:
2	56	Characterise noise impacts on sensitive receptors via a noise assessment in accordance with EPA and contemporary guidance. Demonstrate that noise can be managed such that it complies the Environmental Protection (Noise) Regulations 1997 at sensitive receptor locations.	Section 6 Section 7 Section 8
3	57	Characterise impacts on sensitive receptors from ground vibration due to activities including but not limited to blasting	Section 8.5 Section 4

[2] The current assessment is limited to operational noise, over blast noise and vibration from the proposed mining operations for residential noise sensitive receivers.

4	63	Provide a detailed description of the cumulative impacts associated with this proposal on heritage, recreation and other important areas for human use in all approved areas in MS 719.	Section 2.1.2
5	64	Predict the residual amenity impacts from the proposal on the sensitive receptors and important areas for human use after considering and applying avoidance and minimisation measures. Impact predictions are to include, but not be limited to: Environmental Scoping Document Worsley Mine Expansion – Revised Proposal Page 23 of 29 Endorsed 23/01/2020 a. The likely extent, severity and duration of the impacts from noise, dust, light-spill, and alterations to the landscape, landform and to amenity; and b. Simulations/modelling of the predicted residual impacts from the proposal, including changes to the landscape from the agreed reference and vantage points.	Section 4 Section 5 Section 8.3
6	65	Identify management and mitigation measures for the proposal including closure and rehabilitation outcomes to ensure residual impacts are not greater than predicted. The ERD is to include: a) A description of the management and mitigation measures; b) Management zones and strategies for managing visual landscape character relative to each stage of the proposed operation; and c) Environmental management plans outlining the environmental outcomes/objectives, other key regulatory requirements; management actions, monitoring (including methodology, frequency, location and rational), trigger criteria, contingency actions, review, reporting and consultation.	Section 6 Section 8.4

Worsley currently operates in accordance with environmental approval instruments Ministerial Statement (MS) 719, MS751 and EPBC Approval 2004/1566.

2 Summary of Legislation

The applicable noise legislation for the assessment of the proposal is the Environmental Protection (Noise) Regulations 1997.

A brief summary of the assessment criteria is provided in the following sections (see Appendix A: for a more detailed overview).

2.1 Environmental Protection (Noise) Regulations 1997

Noise management in Western Australia is implemented through the Environmental Protection (Noise) Regulations 1997 (*The Regulations*) which operate under the *Environmental Protection Act 1986*. The Regulations specify maximum noise levels (assigned levels, set in regulations 7 and 8), which are the highest noise levels that can be received at noise-sensitive premises, commercial and industrial premises.

For the noise sensitive premises identified as per the *Regulations* (Appendix A:), the time of day also affects the assigned levels. The Regulations define three types of assigned noise levels:

- L_{Amax} assigned noise level means a noise level which is not to be exceeded at any time;
- L_{A1} assigned noise level which is not to be exceeded for more than 1% of the time; and
- L_{A10} assigned noise level which is not to be exceeded for more than 10% of the time.

The L_{A10} noise limit has been used for this study as it is representative of noise from continuous mining operations.

2.1.1 Adjustments and Influencing Factors

Noise levels determined at the receiver positions are subject to adjustments if the noise exhibits intrusive or dominant characteristics, i.e. if the noise is impulsive, tonal or modulating.

Influencing factors, as determined under Schedule 3 of the Noise Regulations, are adjustments applied to the base assigned level in relation to noise received at a highly sensitive area on a noise sensitive premise.

2.1.2 Significant Contributor

Regulation 7 states that noise emitted from any premises when received at a receiver must not cause, or significantly contribute to, a level of noise which exceeds the assigned level. If it does, then a noise emission is taken to ***significantly contribute*** if it exceeds a value which is 5 dB below the assigned level at the receiver.

The significant contributor adjustment is applied when the cumulative noise impacts from two or more industries at a sensitive receiver could potentially result in an exceedance of the regulatory assigned levels. For this study two industries (i.e. Worsley and Newmont Boddington Gold Mine (NBG)) have been considered when determining whether their combined noise levels could potentially contribute significantly at any of the receivers within the study area. If it was found that NBG's noise level could possibly be greater than 30 dB(A)[3] then a 5 dB reduction of the assigned level was applied.

[3] i.e. night-time assigned level 35 dB(A) – 5 dB = 30 dB(A)

As this assessment only considers Worsley's contribution, publicly available literature[4] was used to determine NBG's contribution at various receivers. Table 2-1 provides a summary of the outcomes of the assessment of the report for the Newmont Boddington Gold Life-of-Mine Extension Project. Sensitive receivers identified for the current proposal which were also included in NBG's Life-of-Mine Extension Project noise assessment are identified by including the NBG reference in the receiver name. As can be seen from this table R_151 and R_152 have been identified as receivers that the Significant Contributor adjustment of 5 dB was applied for this assessment.

Table 2-1 : Noise Sensitive Receivers Identified by NBG Life-of-Mine Extension Project that may be Subject to Significant Contributor Adjustment

Worsley Reference	Report Reference[5]	Comment	Maximum Noise Level dB(A) (excl. tonality adjustment)	Possible Significant Contributor Assessment
R_155	A		16	No
R_153	B		7	
R_132	C		5	
R_146	D		22	
R_111	E		22	
R_112	F		23	
R_154	G	Newmont Camp	21	
R_156	H		27	
R_089	I		26	
R_038	P		27	
R_151	Q		32	Yes
R_152	R		32	
R_159	Mnt Wells Camp		31	N/A (see Section 2.1.5)

2.1.3 Assigned Noise Levels

The applicable assigned noise levels are presented in Table 2-2. As mining is a continuous operation, the noise modelling results have been assessed against the most stringent L_{A10} night-time level of 35 dB(A).

[4]The 'Newmont Boddington Gold Life-of-Mine Extension Project (Reference 12022070-02 draft5' 2012) was found to be the most recent available noise assessment of NBG's impact on the Town of Boddington.

[5] Newmont Receivers with whom Worsley has a commercial arrangement are omitted.

Table 2-2 : Noise Criteria Applicable at the Sensitive Receivers

Time of Day	L_{A10} Assigned Noise Level in dB(A)	L_{A10} Assigned Noise Level in dB(A) for R_151 (Q) and R_152 (R) with non-significant contributor adjustment (5dB) Applied
0700 to 1900 hours Monday to Saturday	45	40
0900 to 1900 hours Sundays and Public Holidays	40	35
1900 to 2200 hours all days	40	35
2200 to 0700 hours all days	35	30

2.1.4 Air Blasting Assessment Criteria

Noise from blasting is also assessed under the Environmental Protection (Noise) Regulations 1997. Table 2-3 presents the applicable air blast noise limits defined in Regulation 11, applicable at the sensitive receivers. It should be noted that blasting noise is assessed as an L_{ZPeak} value, not a statistical value.

Table 2-3 : Blasting Limits

Time of Day	Single Blast Limit	9/10 Consecutive Blast Limit
Daytime (7am – 6pm)	120dB (L_{Zpeak})	115 dB (L_{Zpeak})
All other times	90 dB (L_{Zpeak})	90 dB (L_{Zpeak})

2.1.5 Blast Vibration Criteria

Blasting vibration impacts is assessed against AS2187.2[6] and can be categorised into criteria for structural damage and for human comfort. Table 2-4 presents the vibration levels defined in AS 2187.2.

[6] Blast Vibration Criteria for Building Damage EPA Guidance Note 8 states "Predictions of ground vibration levels should be carried out at the nearest adjacent premises for a typical blast of the size proposed, using Appendix J7 of Australian Standard AS 2187.2-2006".Appendix J of AS 2187.2-2006: Explosives - Storage Transport and Use states that "conventional blasting at normal distances is unlikely to create ground vibrations of a magnitude which causes damage".

Table 2-4 : Blasting Vibration Limits – Building Structural Integrity

	Peak Particle Velocity (mm/s)
Building structure - Houses and low-rise residential buildings and commercial buildings	15
95th percentile for human comfort	5

2.1.6 Tullis Bridge and Mount Wells Camp

An aspirational goal of 45 dB(A) has been used to determine reasonable and practicable noise levels for Tullis Bridge (R_160) and the Bibbulmun Track's Mount Wells Camp (R_159). The aspirational goal has been adopted from Hearson's Cove on the Burrup Peninsula where the EPA determined in Bulletin 1077 that: *"The principle of "all reasonable and practicable measures" under the Environmental Protection Act 1986 requires proponents to get impacts down as low as reasonably practicable within the definition in the Act. A cumulative level of 45dBA at the beach is recommended by the EPA as an aspirational goal to help maintain the amenity at Hearson Cove. While this aspirational goal is not mandatory, it provides some guidance on a target for all proponents to strive to achieve."* (EPA 2002).

2.1.7 State Agreement (Overland Conveyor)

Worsley operates their overland conveyor system under a State Agreement, which details allowable overland conveyor noise emissions. The allowable overland conveyor noise emissions are different to the assigned noise levels defined in *The Regulations*. The Agreement requires the emissions from the overland conveyor to be evaluated at pre-defined measurement locations that are defined in the State Agreement in order to ensure that the overland conveyor complies with the allowable levels.

Any extension to the existing overland conveyor system is also covered under the Agreement. The State Agreement's only requirement for an extension is that the equipment used in the extension of the overland conveyor be of a standard which emits noise at a level less than or equal to that of the existing overland conveyor.

As a result, the overland conveyor system is not subject to the Noise Regulations and, in the event that the overland conveyor is extended, South32 is required to demonstrate that the equipment used, emits noise at a level less than or equal to that of the existing conveyor. Overland conveyor extensions that may form part of the proposal are therefore not included in this assessment.

2.1.8 Construction Noise

Site preparation and construction activities, such as construction of conveyors, haul roads and bridges, fall under Regulation 13 of the Noise Regulations. Regulation 13 does not require noise from a construction site to comply with the prescribed standard for noise emissions set in Regulations 7[7].

Therefore, Regulation 7 does not apply to noise emitted from a construction site, provided the following requirements are met[8]:

1. Construction work is carried out in accordance with control of environmental noise practices set out in section 4 of AS2436-2010.
2. The equipment used on the premises is the quietest reasonably available.

Unless requested by the CEO of DWER[9], a construction noise management plan is only required for construction activities carried out between 19:00 and 07:00 hours on any day or on a Sunday or public holiday. The plan must be prepared in accordance with Regulation 13, subregulation 6 and be given to the CEO of DWER not later than 7 days before construction work commences. As a result, construction noise has not been included in this assessment.

[7] Note: Regulation 13 – Construction Sites, Noise Regulation Fact Sheet includes not only Regulation 7, but also Regulation 8 as an exclusion. The exclusion of Regulation 7 and 8 implies that the assigned levels are not applicable.

[8] If the requirements are not met, the noise must comply with the assigned levels.

[9] Chief Executive Officer (the CEO) of the Department of Water and Environment Regulation (DWER) or any employee of the Local Government under the LGA who is appointed as an authorised person under section 87 of the Environmental Protection Act 1986 (EP Act).

3 Noise Model Overview

3.1 Acoustic Model

An acoustic model was developed using the SoundPlan v8 program. This program calculates sound pressure levels at nominated receiver locations or produces noise contours over a defined area of interest around the noise sources. SoundPlan can be used to model different types of noise, such as industrial noise, traffic noise and aircraft noise. It is approved by the Department of Water and Environmental Regulation (DWER).

The software provides a range of prediction algorithms that can be selected by the user. The CONCAWE[10,11] prediction algorithms have been selected as most appropriate for this study.

The inputs required in SoundPlan are noise source, ground topographical, receiver and meteorological data.

The model does not include noise emissions from any sources other than the proposed mining operations. Therefore, noise emissions from neighbouring industrial sources, road traffic and other extraneous sources are excluded from the modelling.

3.2 Topography

Topographical data for the noise model was provided by Worsley. The 2018 data consisted of terrain contours in 5m increments over the study area.

3.3 Ground Absorption

The acoustic properties of the ground surface affect the absorption of noise. Flat non-porous surfaces such as concrete, asphalt, buildings, calm water are highly reflective to noise have a ground constant of G=0. Soft and porous surfaces such as foliage, loam, soft grass, etc. are highly absorptive to noise and have a ground constant of G=1.

In order to represent the bushland of the study area, the ground surface has been modelled using a ground constant of **0.8**.

3.4 Project Noise Sources

The noise source sound power levels (both fixed and mobile plant) used in the model were measured onsite at Marradong and Saddleback (see tables in Appendix B: for more detail). Sound Power Levels for all crushing facilities were based on the Marradong Primary Crusher or sound powers of similar equipment.

[10] CONCAWE (Conservation of Clean Air and Water in Europe) was established in 1963 by a group of oil companies to carry out research on environmental issues relevant to the oil industry.

[11] The propagation of noise from petroleum and petrochemical complexes to neighbouring communities, CONCAWE Report 4/81, 1981

3.5 Meteorological Conditions

SoundPlan (with the CONCAWE algorithm) calculates noise levels for defined meteorological conditions. Temperature, relative humidity, wind speed and direction data are required as input to the model. Two meteorological conditions, worst case and calm, have been considered in this assessment.

3.5.1 Worst Case Meteorological Conditions

For the noise modelling the meteorological conditions used (see Table 3-1) are taken from WA EPA Draft Guideline on Environmental noise for Prescribed Premises [4] for assessing noise impact from new developments.

Table 3-1 : Worst-case Meteorological Conditions for Noise Propagation

Time of day	Temperature	Relative Humidity	Wind Speed	Pasquil Stability Category (PSC)
Day (07:00 - 19:00)	20° Celsius	50%	4 m/s	E
Evening (19:00 - 22:00)	15° Celsius	50%	3 m/s	F
Night (22:00 - 07:00)	15° Celsius	50%	3 m/s	F

The L_{A10} night-time noise limit is the most stringent Regulatory level for compliance as a result the night time meteorological conditions in Table 3-1 have been used as worst case for modelling purposes. Additionally, the wind direction has been modelled as worst case, which assumes the wind direction is always in the direction from source to receiver.

3.5.2 Calm Meteorological Conditions

Table 3-2 shows the calm meteorological conditions used in the modelling

Table 3-2 : Calm Meteorological Conditions for Noise Propagation

Time of day	Temperature	Relative Humidity	Wind Speed	Pasquil Stability Category (PSC)
Evening (19:00 - 22:00)	15° Celsius	50%	0 m/s	D

3.6 Model Layout

The model area was divided up into 19 areas (i.e. *Area_01* to *Area_19)* spread out over the proposed Worsley Mining Development Envelope area (as shown in Figure 3-1). In general, these areas were purposely selected due to their proximity to nearby receivers. As shown in Figure 3-1, some of the areas included in this noise impact assessment are located within the existing approval area.

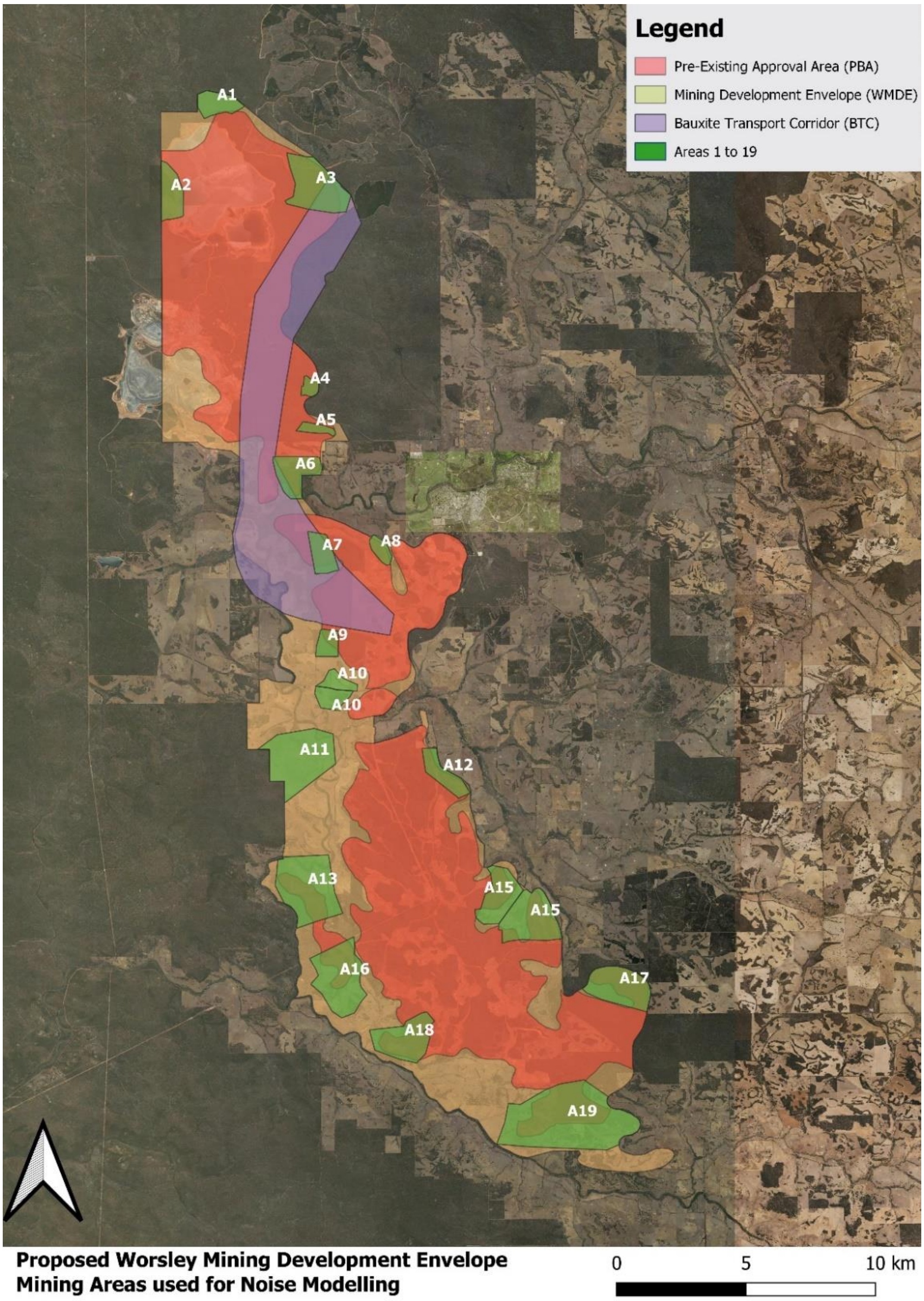
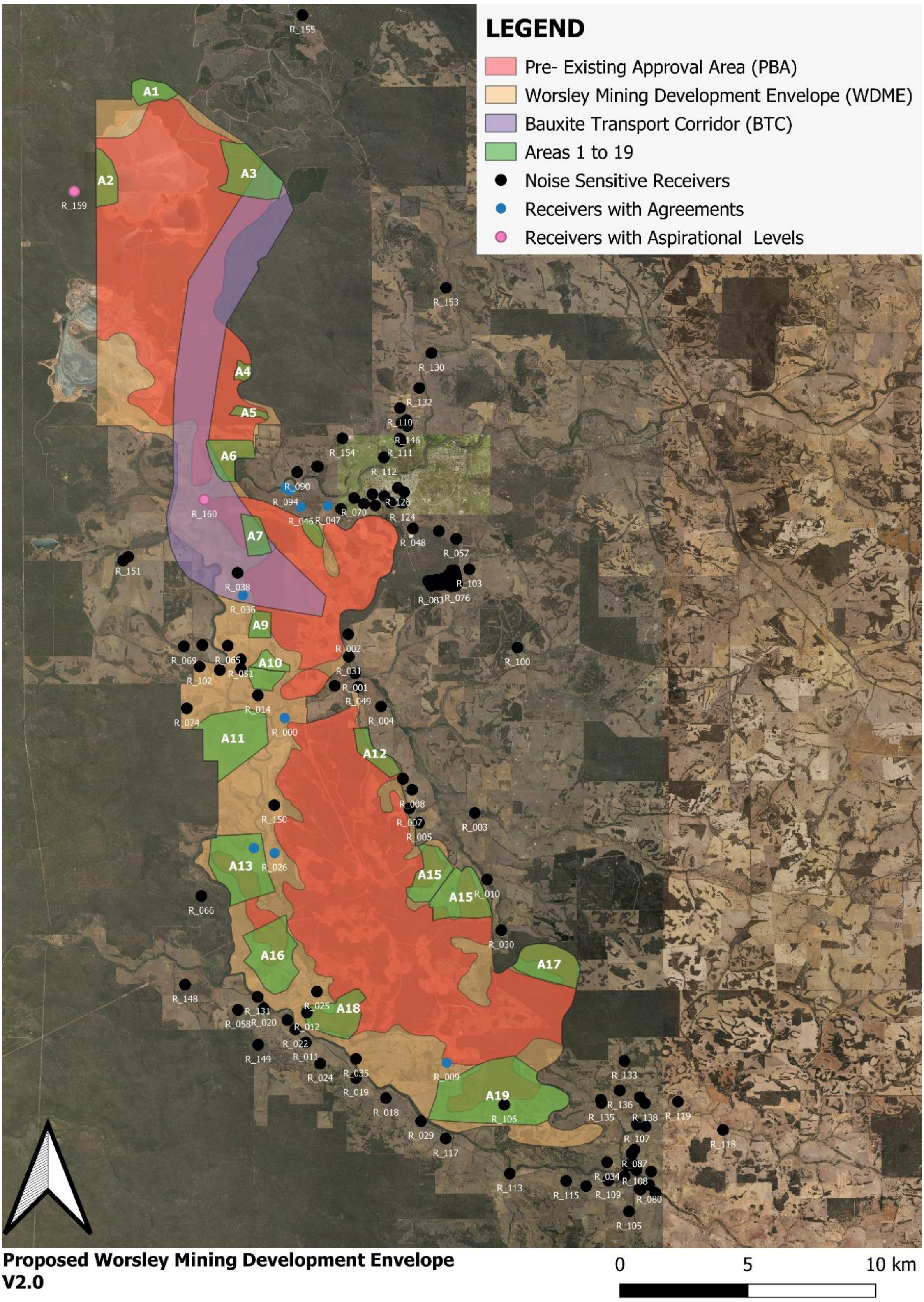


Figure 3-1 : Regional Location of the Proposed Mining Areas used in Noise Modelling Scenarios

3.7 Surrounding Community (Noise Sensitive Receivers)

The community relevant to this study consists of the Town of Boddington and the surrounding farming community. The receivers used in the modelling, as shown Figure 3-2, were provided by Worsley and are (apart from the Tullis Bridge and Mount Wells Camp) private residences. They represent the key sensitive receiver locations that are currently surrounding the current proposal (see Appendix B: and Appendix C: for more details).

Properties which are owned by the Worsley Joint Venture or which have existing commercial arrangements in place are marked with a blue circle in Figure 3-2. These receivers have been excluded from the analysis of results (Section 5) and risk mitigation assessment (Section 6).



Proposed Worsley Mining Development Envelope V2.0

0 5 10 km

Figure 3-2 : Image showing receiver locations[12] relative to Areas assessed.

[12] More details regarding receivers are included in Appendix B: and Appendix C:.

3.8 Modelled Scenarios

A total of 19 operational areas (as shown in Figure 3-1) were modelled under worst case weather conditions. The scenarios were based on typical Worsley mining activities and their associated equipment (see Appendix E: for details). The following scenarios were modelled in each area on their own:

- Blasting (note: blasting is modelled separately, see section 8).
- Development.
- Drilling.
- Mining and Haulage.
- Rehabilitation.
- Combined (i.e. Development, Drilling, Mining and Haulage and Rehabilitation).

In total 228[13] scenarios were modelled. All scenarios, excepting for blasting, included the existing (Saddleback and Marradong) and proposed (Nullaga) crusher infrastructure and ancillary equipment (e.g. graders, watercarts etc).

3.9 Blast Wave Noise Source

Blasting at Worsley normally follows a square blasting pattern (3m x 3.5m or 3.5m x 3.5m) or echelon pattern (3.5m x 4m) with a charge weight of 16.4kg to 30kg maximum by a single hole initiation. The majority of blasting only occurs once a day during the daytime, with very occasional days in which more than one blast occurs. All blast information was provided by Worsley.

"AS 2187.2-2006 Explosives - Storage and use - Use of explosives" [14]was used to calculate the blast wave peak pressure and derive the blast SWL. The SWL was entered into the model SoundPlan in order to predict the expected received levels at each receiver.

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[13] 19 operational areas x 6 scenarios per area x 2 meteorological conditions = 228 scenarios.

[14] For more information refer to Appendix G:

4 Noise Modelling Results (Mining)

This section provides the modelling results for the mining scenarios (as described in section 3.8). Results are provided separately for the two meteorological conditions (i.e. worst-case and calm) as defined in section 3.5. Vibration from mining activities, excluding blasting, has not been included as it is considered that it will have negligible impact on the sensitive receivers.

4.1 Overview

Figure 4-1 and Figure 4-2 show the range of night-time predicted noise levels at each receiver for the worst-case and calm meteorological conditions respectively. The following is a summary of the figures:

- The figures show the range of predicted received noise levels for each receiver within the study area. The vertical axis shows the predicted LA10 level while the horizontal axis shows the receivers.
- The colours on the graph are associated with the risk categories as defined in section 5.2.
- The maximum predicted noise level for each receiver shown in the figures is the highest predicted level at that receiver from all the operational areas modelled.
- The range of levels for each receiver was calculated using the highest predicted received level for that receiver under each operational activity type across all operational areas (i.e. a total of 5 values are included in each range). Each operational area was modelled for the following mining activities: combined, development, drilling, rehabilitation, mining and haulage.
- The green area indicates the night-time adjusted limit[15].
- The blue area indicates the daytime adjusted limit[15].
- The yellow area indicates the daytime unadjusted limit[15].

The following receivers are excluded from the figures:

- Receivers with commercial arrangements in place.
- Tullis Bridge and Mount Wells Camp as the aspirational received levels were not exceeded at these receivers.

As can be seen from the figures the range of predicted noise levels can extend between the coloured zones (e.g. a receiver for some scenarios could be in the red zone while for other scenarios the same receiver could have a predicted noise level that could fall in either the orange or yellow zone). This indicates that there is a reasonable amount of variation in noise level at the receivers depending on the activities that are taking place within the area.

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[15] **Adjusted Limit** is defined, for this report, as the assigned level – 5 dB (i.e. to compensate for either a significant contributor adjustment or for tonality – it is noted that the tonality is usually added to the predicted level. For the purposes of the risk assessment and this report it has rather been removed from the assigned level). **Note:** As mobile equipment is identified as the dominating noise source, tonality at receivers in close vicinity to the mining operations is assumed to be present. Daytime unadjusted LA10 limit is 45 dB(A).

4.2 Comparison

The effect of the weather on the predicted noise levels can be seen when Figure 4-1 (i.e. worst-case meteorological conditions) and Figure 4-2 (i.e. calm meteorological conditions) are compared. As can be seen from the figures there is a considerable difference (~10 dB) between the predicted levels.

If it is considered that this difference is between worst-case and calm meteorological conditions, then if more favourable meteorological conditions were applied (i.e. wind blowing from the receiver to the noise source) then the predicted noise levels would show an even larger difference.

This outcome not only demonstrates that received noise levels are highly dependent on meteorological conditions, but also that scheduling activities in areas, using forecast and observed weather, is a credible and effective mitigation approach.

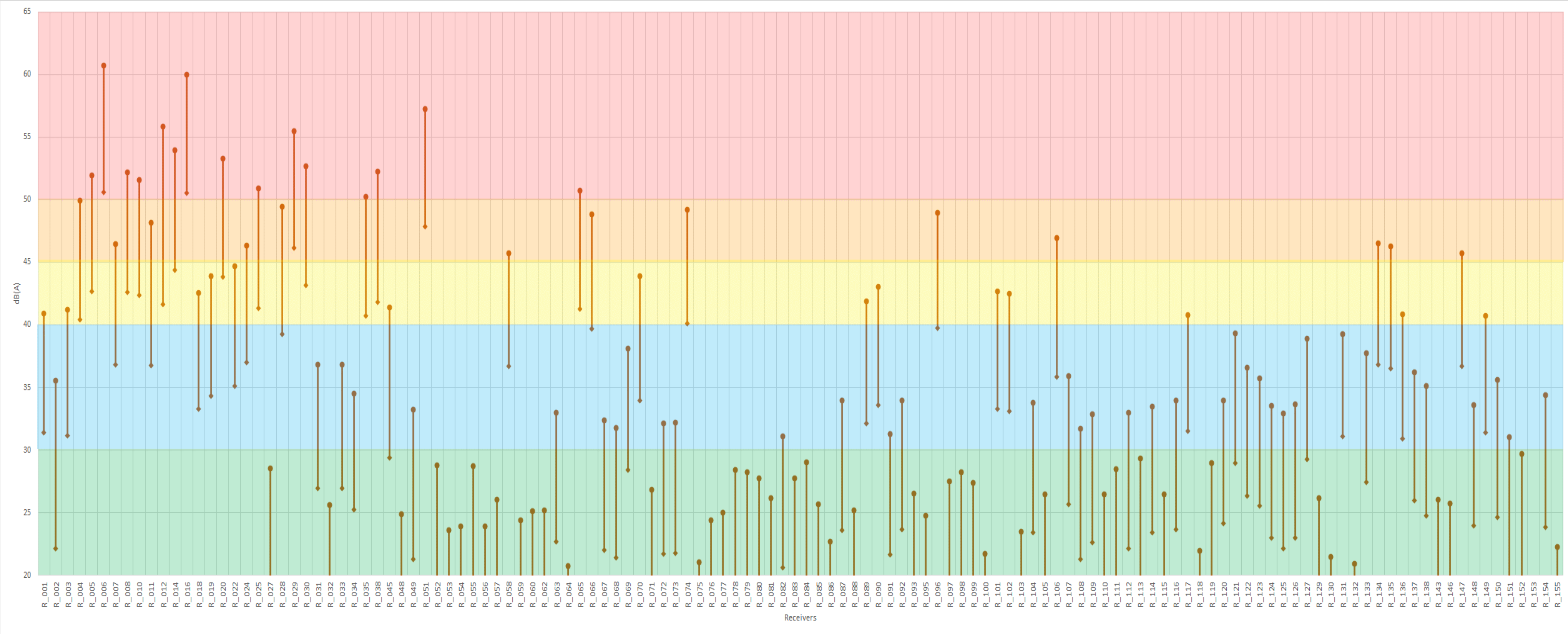

Figure 4-1 : Night Time Predicted Receiver Noise Levels for Worst Case Metrological Conditions

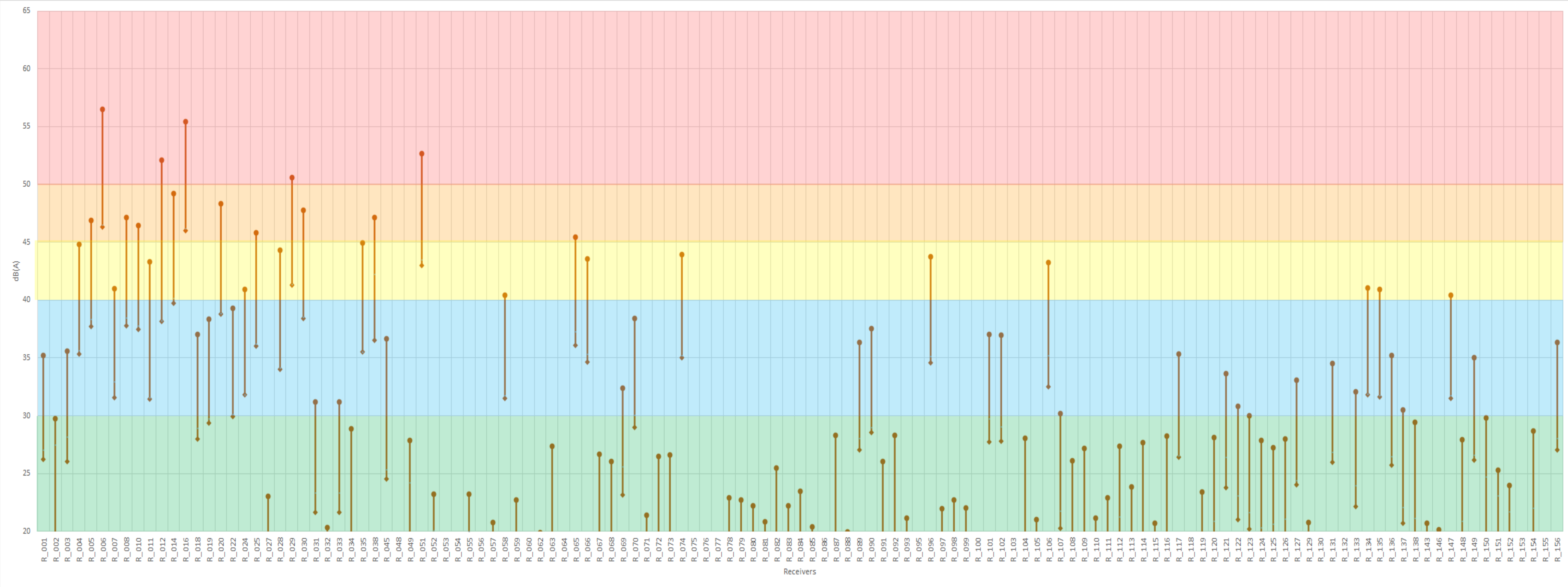

Figure 4-2 : Night Time Predicted Receiver Noise Levels for Calm Meteorological Conditions

5 Receiver Risk Assessment

5.1 Overview

The results in section 4 have been used to undertake an environmental noise impact risk assessment for the Hotham Mining Extension. As the predicted levels are based on large areas and generalised activities the assessment must be considered as high-level and that more detailed analysis is required during the implementation of the proposed management strategies and selection of appropriate noise control.

5.2 Risk Categories

The risk categories used in the risk assessment are a combination of South32's Consequence Severity Rating (HSEC Toolkit No T07), which was used to categorise severity, and the "The assigned level for premises" as stated in Section 8(3) Table 1 of the *Regulations* [2], which was used to choose appropriate noise levels for each risk category. The resultant categories are as follows:

(Note: The colour assigned to each category is shown in Figure 4-1 and Figure 4-2. Mitigation strategies such as long-term planning, scheduling, adaptive management and noise control are discussed in more detail in section 6.)

- **Low (Green).** Indicates that it is unlikely that mining operations will exceed any of the assigned levels at that receiver. Noise impacts on these receivers should still be managed, but in general their risk can be considered as low.
- **Minor (Blue)**. Indicates that the likelihood of the receiver exceeding the night-time assigned levels is possible for certain mining activities in areas close to the receivers. This risk can be mitigated through appropriate scheduling and adaptive management. In some cases, operations in areas close to the receivers may have to be limited to the day shift only.
- **Moderate (Yellow)**. Indicates that the probability of the receiver exceeding the daytime assigned level is possible when mining activities are occurring in certain areas close to the receivers. This risk can be mitigated through appropriate long-term planning, weekly scheduling and adaptive management. In some cases, mining operations in areas close to the receivers may have to be limited to certain times of the year and day shift only.
- **Major (Amber).** The receivers in this category are likely to exceed the daytime assigned levels for mining areas or haul roads that are near to their location. This risk can be mitigated using the same techniques as the moderate category but may also require noise control or commercial arrangements to be considered. Like the moderate category, mining may be limited to certain times of the year as well as day shift only.
- **Critical (Red).** For the receivers that fall into this category it is almost certain that mining operations in certain areas will result in an exceedance at the receiver. For these receiver's alternative options should be considered before moving into the areas close to the receiver.

5.3 Risk Assessment

Two risk assessments have been undertaken. The first risk assessment (section 5.3.1) was undertaken using the modelled worst-case meteorological predicted levels, while the second assessment (section 5.3.2) used the predicted levels for calm conditions.

The purpose of undertaking two risk assessments, based on different wind conditions, is to demonstrate that a receiver's risk profile can change dramatically based on weather conditions. This therefore demonstrates that scheduling mining activities using meteorological conditions is a valid and effective approach to managing mining operations.

5.3.1 Risk Assessment (Worst case Meteorological Conditions)

Table 5-1 provides a summary of the outcomes of the risk assessment for the receivers that were assessed[16]. As can be seen from the table, there are 48 receivers that are classified as low, 38 receivers classified as minor, 15 receivers as moderate, 24 receivers major and 4 receivers are critical.

Table 5-1 : Receiver Risk Classification (Worst Case)

Low				Minor			Moderate	Major		Critical
R_001	R_075	R_097	R_152	R_002	R_104	R_131	R_001	R_004	R_058	R_006
R_027	R_076	R_100	R_153	R_031	R_107	R_133	R_003	R_005	R_065	R_016
R_032	R_077	R_103	R_155	R_033	R_108	R_137	R_018	R_007	R_066	R_029
R_048	R_078	R_105		R_034	R_109	R_138	R_019	R_008	R_074	R_051
R_052	R_079	R_110		R_049	R_112	R_148	R_022	R_010	R_096	
R_053	R_080	R_111		R_063	R_114	R_150	R_045	R_011	R_106	
R_054	R_081	R_113		R_067	R_116	R_151	R_070	R_012	R_134	
R_055	R_083	R_115		R_068	R_120	R_154	R_089	R_014	R_135	
R_056	R_084	R_118		R_069	R_121		R_090	R_020	R_147	
R_057	R_085	R_119		R_072	R_122		R_101	R_024		
R_059	R_086	R_129		R_073	R_123		R_102	R_025		
R_060	R_088	R_130		R_082	R_124		R_117	R_028		
R_062	R_093	R_132		R_087	R_125		R_136	R_030		
R_064	R_095	R_143		R_091	R_126		R_149	R_035		
R_071	R_099	R_146		R_092	R_127		R_156	R_038		

[16] It has been assumed that existing commercial arrangements with receivers will not expire during the development of the proposal and as a result these receivers have not been included in the risk assessment or the table.

5.3.2 Risk Assessment (Calm Meteorological Conditions)

Table 5-2 provides a summary of the outcomes of the risk assessment for the receivers that were assessed using the predicted levels for calm conditions. As can be seen from the table, 101 receivers are classified as low, 11 receivers classified as minor, 13 receivers as moderate, 2 receivers major and 2 receivers are critical. This is a significant difference to the assessment undertaken using worst case meteorological conditions results and it demonstrates that scheduling activities in areas using forecast and observed weather is a credible and effective mechanism to reduce and eliminate the likelihood of exceeding the assigned levels at sensitive receivers.

Table 5-2 : Receiver Risk Classification (Calm Wind Conditions)

Low							Minor	Moderate	Major	Critical
R_001	R_053	R_072	R_088	R_105	R_121	R_143	R_007	R_004	R_029	R_006
R_002	R_054	R_073	R_089	R_107	R_122	R_146	R_011	R_005	R_051	R_016
R_003	R_055	R_075	R_090	R_108	R_123	R_148	R_024	R_008		
R_018	R_056	R_076	R_091	R_109	R_124	R_149	R_028	R_010		
R_019	R_057	R_077	R_092	R_110	R_125	R_150	R_058	R_012		
R_022	R_059	R_078	R_093	R_111	R_126	R_151	R_066	R_014		
R_027	R_060	R_079	R_095	R_112	R_127	R_152	R_096	R_020		
R_031	R_062	R_080	R_097	R_113	R_129	R_153	R_106	R_025		
R_032	R_063	R_081	R_098	R_114	R_130	R_154	R_134	R_030		
R_033	R_064	R_082	R_099	R_115	R_131	R_155	R_135	R_035		
R_034	R_067	R_083	R_100	R_116	R_132	R_156	R_147	R_038		
R_045	R_068	R_084	R_101	R_117	R_133			R_065		
R_048	R_069	R_085	R_102	R_118	R_136			R_074		
R_049	R_070	R_086	R_103	R_119	R_137					
R_052	R_071	R_087	R_104	R_120	R_138					

6 Noise Mitigation

6.1 Overview

The risk assessment in section 5.3 has identified receivers that will potentially exceed the assigned levels when mining is undertaken in certain areas of the WMDE. As a result, the following noise mitigation strategies are proposed for these receivers to mitigate the risk:

- Long Term Planning and Scheduling (see also section 7.1 for current implementation).
- Adaptive Management (see also section 7.2 for current implementation).
- Engineering Noise Control (see also section 7.3 for current implementation).
- Commercial Arrangements (see also section **Error! Reference source not found.** for current implementation).

6.2 Long Term Planning and Scheduling

A predictive long term strategic planning tool, that uses scheduled mine plan data and statistical weather models based on years of historic observed data, may be used to identify the months of the year where pits and blocks can be mined with a low risk of exceeding the assigned level for Moderate and Major risk receivers. These pits and blocks will then be scheduled in for those months.

Long term scheduling activities may, as considered appropriate, use a predictive software tool that uses mine plan data and meteorological information to predict noise impacts at sensitive premises. Adopting this approach during the planning stages allows multiple scenarios to be tested allowing the option with the most acceptable outcomes to be chosen which can effectively reduce the risk of non-compliance during the production phase. The software tool will allow the Planners to:

- Review predicted noise levels under multiple operating and meteorological scenarios
- Review seasonal preference for mining certain pits
- Review potential operational scenarios or operating parameters to be implemented prior to commencing mining in the new area.

6.3 Adaptive Management

Adaptive management during production will be achieved using a combined noise monitoring and predictive system. The system will make use of equipment positional data (from the mine's Fleet Management System and Collision Avoidance System), live weather data (from a dedicated weather station) and fixed plant data (from the mines SCADA system). Using this system will allow Worsley to proactively manage operations due to unplanned events that occur during a shift and when conditions differ from what was used during the planning phase.

6.4 Engineering Noise Control

Worsley incorporates a proactive policy with regards to engineering noise controls on mining equipment (both mobile and fixed) to reduce noise emissions at the source or in the transmission path. This policy, which should be maintained, includes the following strategies:

- **Asset Projects**. Asset Projects will investigate possible noise control opportunities within each project. Noise controls will be selected based on an ALARP process that will be used to identify which noise controls could be considered as the lowest practicable option. Additionally, the project will undertake sound power measurements to ensure that project noise specifications are met.

- **Buy quiet**. Equipment being investigated for procurement will undergo a review of risk analysis. Noise is considered as a significant risk and will be documented in a procurement specification.
- **Equipment Substitution**. Where possible equipment will be substituted with quieter options. For example, Haul Trucks could be substituted for lower noise road trains or a low noise conveyor system.

6.5 Commercial Arrangements

Worsley manages its operations to comply with the noise regulations and any other legislative requirement in force related to noise. Under certain circumstances, where agreed to by the landowner, commercial arrangements may be established which change the noise sensitivity of a property for a given time based on a change in residential status.

7 Ability to Implement Mitigation Strategies

Worsley has managed mining noise in the greater Saddleback and Marradong areas for over three decades. Worsley's historical knowledge of the area, community engagement and commitment of minimising impacts from their operations on the nearby community, assisted Worsley greatly over these years with managing noise from their mining operations. The following sections demonstrate that most of the strategies, as detailed in Section 6, are already being implemented at the mine.

7.1 Long Term Planning and Scheduling

7.1.1 Long Term Planning

Worsley has included noise as a constraint in their 10 to 15 years mine plan to determine the economic viability of new areas planed for mining. For the noise component of the project a predictive long-term strategic noise planning tool was used to evaluate operational risk for each month of the year for 256 pits/blocks and interconnecting haul roads. The tool used 4 years of weather data (i.e. 1.3 million weather samples) to generate probability maps for each month of the year and ran 16,384 scenarios which was used to identify and determine constraints for scheduling day and night shifts. The results from this tool informed the project allowing them to factor the constraints into their determination of mitigation strategies and production rates which allowed Worsley to determine resource recovery time and as a result include this into the determination of the economic viability of the area.

7.1.2 Short Term Scheduling

The weekly mine schedule, which includes scheduling of all development, rehabilitation and mining activities includes a review of meteorological conditions predicted for the week. This information allows the Planning and Operations teams to review the risk of noise impacts at surrounding noise sensitive premises. The weekly schedule allows for communication of the risk before the production week commences and ensures all Operations teams are mindful and manage for any potential risks. Early identification of any risks prior to the schedule time commencing also allows the Schedulers to incorporate alternative mining areas within the plan allowing the operation to continue within the prescribed limits of the *Environmental Protection (Noise) Regulations 1997*.

Worsley is always seeking to improve the scheduling capabilities and is currently investigating options for an improved system that will increase their capability and efficiency of determining and mitigating noise impacts during scheduling.

7.2 Adaptive Management

Worsley's existing operational noise management plan requires production staff to use real-time noise monitoring[17] to manage compliance during production. Worsley's Excessive Mining Noise Withdrawal Procedure [10] requires production to track the noise trend from the monitors staff to stop activities in an area when noise monitors indicate that threshold levels are approached.

[17] Worsley has an extensive noise monitoring network with monitors placed at strategic locations. In addition to these monitors, Worsley also has operators trained in the use of handheld sound level meters who can be sent out to confirm noise levels at sensitive receiver locations if required.

Worsley is always seeking to continuously improve their noise management capabilities. One of the improvements under consideration is enhancing their noise management capability during production by improving their system to include a modelling component that uses real-time data[18] to complement their existing monitoring capability.

7.3 Equipment Noise Controls

Historically, Worsley has been actively seeking out engineering noise control opportunities to reduce mobile equipment noise emissions in the past. Some previous examples are as follows:

- Upgrade of haul packs to the quieter caterpillar 789Q model, which included additional noise controls.
- Implementation and testing of Hitachi EX2500 Excavator noise controls.
- Replacement of drill rigs for newer quieter models.

Any new fleet will be assessed for sound power level and available attenuation kits to be included, this may be done by following an 'As Low as Reasonably Practicable' (ALARP) approach, which takes additional considerations into account, including (but not limited to):

- Noise Reduction Quantification
- Cost
- Safety
- Maintenance
- Operability

7.4 Commercial Arrangements

Worsley manages its operations to comply with the noise regulations and any other legislative requirement in force related to noise. Under certain circumstances, where agreed to by the landowner, commercial arrangements may be established which change the noise sensitivity of a property for a given time based on a change in residential status.

[18] Real-time datasets include equipment positional data (from the mines Fleet Management System and Collision Avoidance System), live weather data (from the mines weather station) and fixed plant data (from the mines SCADA system).

8 Blasting Impacts

8.1 Blast Overview

Blast predictions for the Hotham Extension area were made using worst case meteorological conditions and a maximum charge weight of 30kg. All predictions are based on the assumptions that blasts will be confined and stemmed, and that electronic or signal tube chord detonation will be used instead of detonation chords. Figure 8-1 details the worst-case blast results at each receiver for blast operations.

8.2 Blast Noise Risk Categories

Similar to section 5.2, the Risk profiles for blasting were determined using South32's Consequence Severity Rating (HSEC Toolkit No T07) and the levels stipulated in Section 11(1) of the *Regulations* [2]. The following categories have been used in the risk assessment:

Low (Green) – Indicates that air blast overpressure levels are predicted to be compliant.

Minor (Blue) – Indicates that air blast overpressure levels are predicted to be compliant for 9/10 consecutive blasts during daytime.

Moderate (Yellow) – Indicates that air blast overpressure levels are predicted to be compliant for a single blast during daytime. Compliance for 9/10 consecutive blasts (9/10) may be achieved using blasting mitigation options.

Major (Orange) – Receiver limits will more than likely be exceeded for single blasts under worst case meteorological conditions. Blast mitigation or adaptive management, as described in section 8.3, can be used the achieve compliance.

Critical (Red) – Receiver limits will more than likely be exceeded for single blasts and significant mitigation may be required.

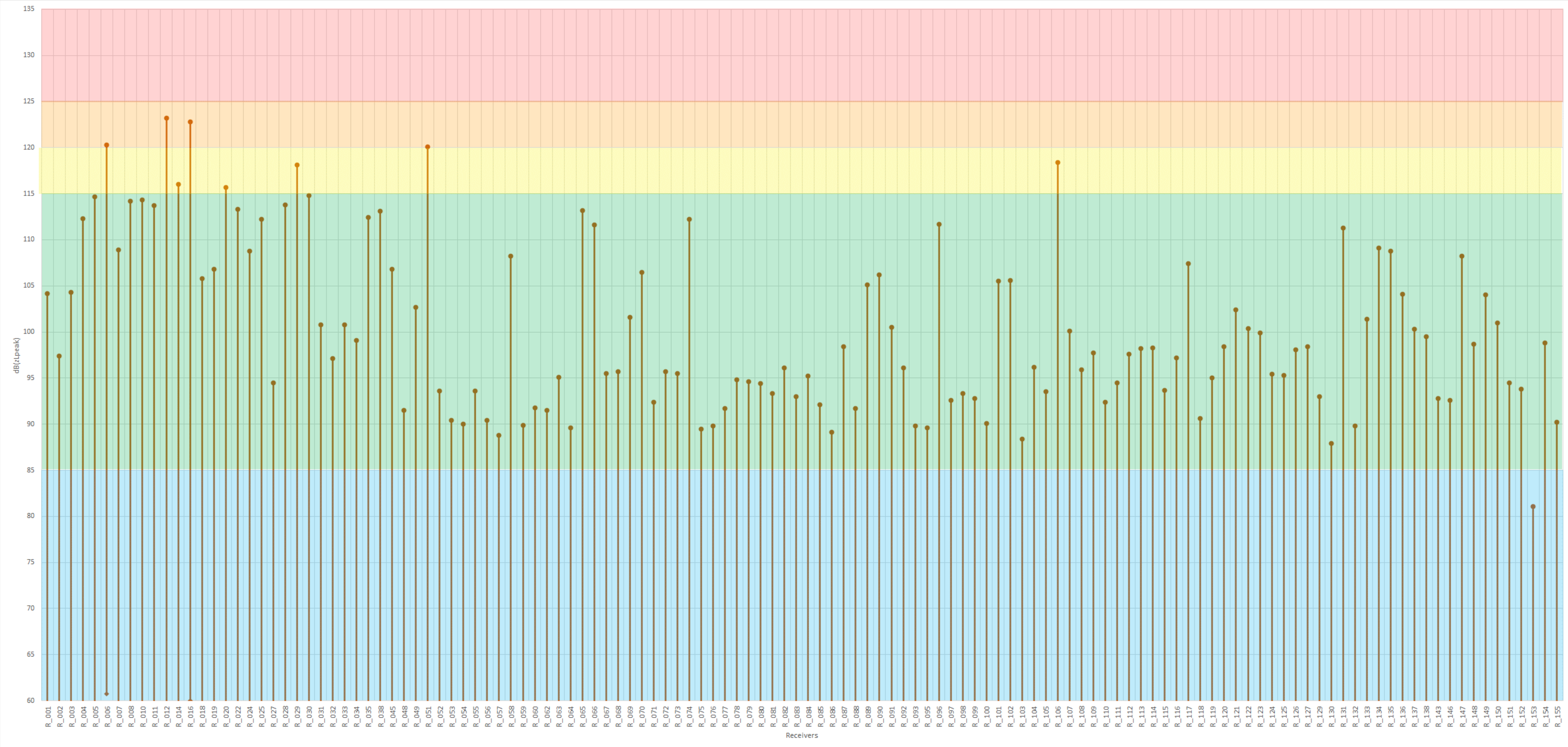

Figure 8-1 : Blast Noise Results

8.3 Blast Noise Risk Assessment Results

As detailed in Figure 8-1, expected noise levels from blasting at the proposed operations were predicted under worst-case meteorological conditions at nearby noise sensitive receivers. The classification results are detailed in Table 8-1.

Table 8-1 : Receiver Risk Classification (Blast Noise)

Low	Minor						Moderate	Major
R_057	R_001	R_033	R_068	R_090	R_114	R_136	R_014	R_006
R_059	R_002	R_034	R_069	R_091	R_115	R_137	R_020	R_012
R_064	R_003	R_035	R_070	R_092	R_116	R_138	R_029	R_016
R_075	R_004	R_038	R_071	R_096	R_117	R_143	R_106	R_051
R_076	R_005	R_045	R_072	R_097	R_118	R_146		
R_086	R_007	R_048	R_073	R_098	R_119	R_147		
R_093	R_008	R_049	R_074	R_099	R_120	R_148		
R_095	R_010	R_052	R_077	R_100	R_121	R_149		
R_103	R_011	R_053	R_078	R_101	R_122	R_150		
R_130	R_018	R_054	R_079	R_102	R_123	R_151		
R_132	R_019	R_055	R_080	R_104	R_124	R_152		
R_153	R_022	R_056	R_081	R_105	R_125	R_154		
	R_024	R_058	R_082	R_107	R_126	R_155		
	R_025	R_060	R_083	R_108	R_127	R_156		
	R_027	R_062	R_084	R_109	R_129			
	R_028	R_063	R_085	R_110	R_131			
	R_030	R_065	R_087	R_111	R_133			
	R_031	R_066	R_088	R_112	R_134			
	R_032	R_067	R_089	R_113	R_135			

The following can be concluded:

- The blast Limit of 115 dB (L_{Zpeak}) for 9/10 consecutive blasts, will be exceeded at eight receivers (i.e. moderate and major risk receivers). It is noted that two of the receivers in the moderate risk category are a marginal exceedance (R_014 and R_020).
- Noise levels at four receivers (i.e.all the major risk receivers) will exceed the 120dB(L_{Zpeak}) for a single blast. It is noted that two (R_006 and R_051) of the five receivers are a marginal exceedance.

8.4 Blasting Noise Mitigation

The following blast noise mitigation strategies are currently part of Worsley's blasting procedures and should be maintained to assure minimum blast noise impacts on sensitive receivers:

1) To reduce the impact of blasting overpressure at receivers detailed in Figure 8-1, blasting should be undertaken during favourable meteorological conditions (e.g. wind direction originating from the receiver) and that a software application should be considered to assist with this determination.
2) Where meteorological conditions alone are unlikely to achieve compliance a reduction in charge mass should be considered. A software application should be considered to assist with this determination.
3) Measure and assess blasting operations to better determine the potential blasting impacts associated with the Hotham West expansion.
4) The blast modelling has assumed electronic or signal tube chord detonation and stemming. This is Worsley's standard practice for blasting near noise sensitive receivers.

8.5 Blast Vibration

A review on Worsley's blasting Noise and Vibration Management Plan and the previous six Blast reports was undertaken. The review of these documents found that Worsley manages and measures both vibration and noise for each blast. The management plan has also identified that there are Aboriginal heritage archaeological and ethnographic sites within the proposed mining envelopes. It is recognised in the plan that vibration from blasting may potentially impact these sites and as a result vibration must also be adequately assessed for these locations.

To minimise vibration impacts the management plan requires Worsley to ascertain vibration potential for each new mining zone and adjust blast design accordingly. If blast effects are expected to be substantial, the potentially affected landowners will be notified before the blast.

The plan also requires vibration to be measured at the most affected noise sensitive premises where possible. The vibration measurements are intended to verify that amenity has not been affected. The review of the last 6 years of blasts reports show that all vibration measurements taken were below the AS2187 threshold levels for structural damage and human comfort as shown in the summary table, Table 8-2. As a result, it can be concluded that managing vibration using the management plan is an appropriate means of ensuring that vibration levels are below the exceedance criteria.

Table 8-2 : Blast Report Results Financial Years 2013 to 2019

Year	Number of Blasts Recorded	Measured Vibration [mm/s]		Exceedance Human Comfort/ Structural
		Minimum	Maximum	
2013/2014	250	0.11	0.86	None
2014/2015	286	undetected	0.5	
2015/2016	306	undetected	1.346	
2016/2017	143	0.039	0.55	
2017/2018	84	0.11	0.71	
2018/2019	33	0.11	0.355	

9 Conclusions and Proposed Mitigation

9.1 Conclusions

An environmental noise impact assessment of the proposed WMDE extension at Worsley's BBM has been undertaken using predictive noise modelling to determine the noise impacts of mining operations on the surrounding community (i.e. sensitive receivers).

The overland conveyor extensions and construction work are not included in the assessment as extensions to the overland conveyor fall under Worsley's State Agreement (see section 2.1.7) and construction work is covered under Regulation 13 of the *Regulations* (see section 2.1.8). For construction activities Worsley will comply with requirements of Regulation 13.

The approach taken in the assessment was to use both worst-case and calm weather conditions combined with realistic worst-case operating conditions to predict possible impacts on sensitive receivers in the study area. The study area was divided in 19 operational areas chosen due to their proximity to sensitive receivers. Using the predicted levels from the modelling the sensitive receivers were then categorised into critical, major, moderate and minor risk depending on their exceedance of the Regulatory assigned levels. The categorisation of the receiver risk was then used to determine possible mitigation measures and recommendations for reducing the risk associated with each receiver.

The results of the impact assessment indicate that compliance can be achieved when noise mitigations are implemented at all sensitive receptor apart from two receptors (R_006 and R_16).

A review of Worsley's Blasting Noise and Vibration Management Plan and the FY19 Blast report was undertaken. The findings of the review found that Worsley considers both noise and vibration impacts for each blast and for the FY19 blasting it was found that all vibration measurements taken were below the AS2187 threshold levels for structural damage and human comfort.

9.2 Mitigation

The following noise mitigation strategies are proposed to mitigate the risk to levels where receiver impacts are below the assigned levels (see section 6 and section 8.3):

- Noise Mitigation Strategies for Mining Activities:
  - Long Term Planning and Scheduling.
  - Adaptive Management.
  - Engineering Noise Control.
  - Commercial agreements.
- Noise Mitigation Strategies for Blasting Activities:
  - A predictive software program that uses forecast (and live) weather and blast parameters should be used to assist operations in determining favourable conditions for blasting.
  - Measure and assess blasting operations associated with the proposal.
  - Use of electronic or signal tube chord detonation and stemming.
- Vibration Mitigation Strategies for Blasting Activities:
  - Worsley to continue using the Noise and Vibration Management Plan to manage vibration as it has been shown to be an appropriate means of ensuring that vibration levels are below the exceedance criteria.

Evidence has been provided in section 7 that demonstrates that Worsley has the ability to not only implement the proposed strategies, but is also continuously looking for future improvements to their noise management practices.

Appendix A: **Applicable Noise Legislation**

Noise management in Western Australia is implemented through the Environmental Protection (Noise) Regulations 1997 which operate under the Environmental Protection Act 1986. The Regulations specify maximum noise levels (assigned levels), which are the highest noise levels that can be received at noise sensitive premises, commercial premises and industrial premises.

Assigned noise levels have been set differently for the different types of premises. For noise sensitive premises, i.e. residences, an 'influencing factor' is incorporated into the assigned noise levels.

The regulations define three types of assigned noise level:

- L_{Amax} assigned noise level is a noise level which is not to be exceeded at any time;
- L_{A1} assigned noise level is not to be exceeded for more than 1% of the time;
- L_{A10} assigned noise level is not to be exceeded for more than 10% of the time.

The L_{A10} noise limit is the most significant for this study since this is representative of continuous noise emissions from the mining operations. Table A1 shows the assigned noise levels for noise sensitive premises. As can be seen from the table the time of day also affects the assigned levels for noise sensitive residences.

Table A1 : Assigned Noise Levels for Noise Sensitive Receivers

Type of premises receiving noise	Time of day	Assigned Levels (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise sensitive premises: highly sensitive area	0700 to 1900 hours Monday to Saturday	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days	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	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 other than those in the Kwinana Industrial Area	All hours	65	80	90
Industrial and utility premises in the Kwinana Industrial Area	All hours	75	85	90

Environmental Protection (Noise) Regulations 1997

A.1: Noise Sensitive Premises

Part C of the regulations details the following requirements for Noise sensitive premises (highly sensitive area) used for the current assessment.

1. Premises occupied solely or mainly for residential or accommodation purposes.

2. Rural premises.

3. Premises used for the purpose of —

   (a) a caravan park or camping ground; or

   (b) a hospital having accommodation for less than 150 in patients; or

   (c) a sanatorium, home or institution for care of persons, a rehabilitation centre, home or institution for persons requiring medical or rehabilitative treatment; or

   (d) education — school, college, university, technical institute, academy or other educational centre, lecture hall or other premises used for the purpose of instruction; or

   (e) public worship; or

   (f) a tavern, hotel, club premises, reception lodge or other premises which provides accommodation for the public; or

   (g) aged care; or

   (h) child care; or

   (i) a prison or detention centre; or

   (j) a water storage dam or a catchment for a water storage dam.

4. Any other premises not referred to in Part A or Part B of this Schedule.

   [Part C amended: Gazette 5 Dec 2013 p. 5715 16.]

A.2: Intrusive or dominant noise characteristics

Received noise levels are subject to penalty corrections if the noise exhibits intrusive or dominant characteristics, i.e. if the noise is impulsive, tonal or modulated. That is, the measured or predicted noise levels are increased by the applicable penalties, and the adjusted noise levels must comply with the assigned noise levels. Regulation 9 sets out objective tests to assess whether the noise is taken to be free of these characteristics. Table A2 lists these penalties.

Table A2 : Assigned penalties for intrusive or dominant noise characteristics

Adjustment where noise emission is not music. These adjustments are cumulative to a maximum of 15 dB		
Where tonality is present	**Where modulation is present**	**Where impulsiveness is present**
+5 dB	+5 dB	+10 dB

Regulation 9 amended in Gazette 5 Dec 2013 p. 5656 7.

A.3: Influencing Factors

The influencing factor depends on land use zonings within 100 metres and 450 metres radius from the noise receiver. The value is dependent on:

- the proportion of industrial land use zonings;
- the proportion of commercial zonings; and
- the presence of major roads within the radius circles.

No influencing factor has been applied to receivers in this study.

Appendix B: **Detailed Area Layout**

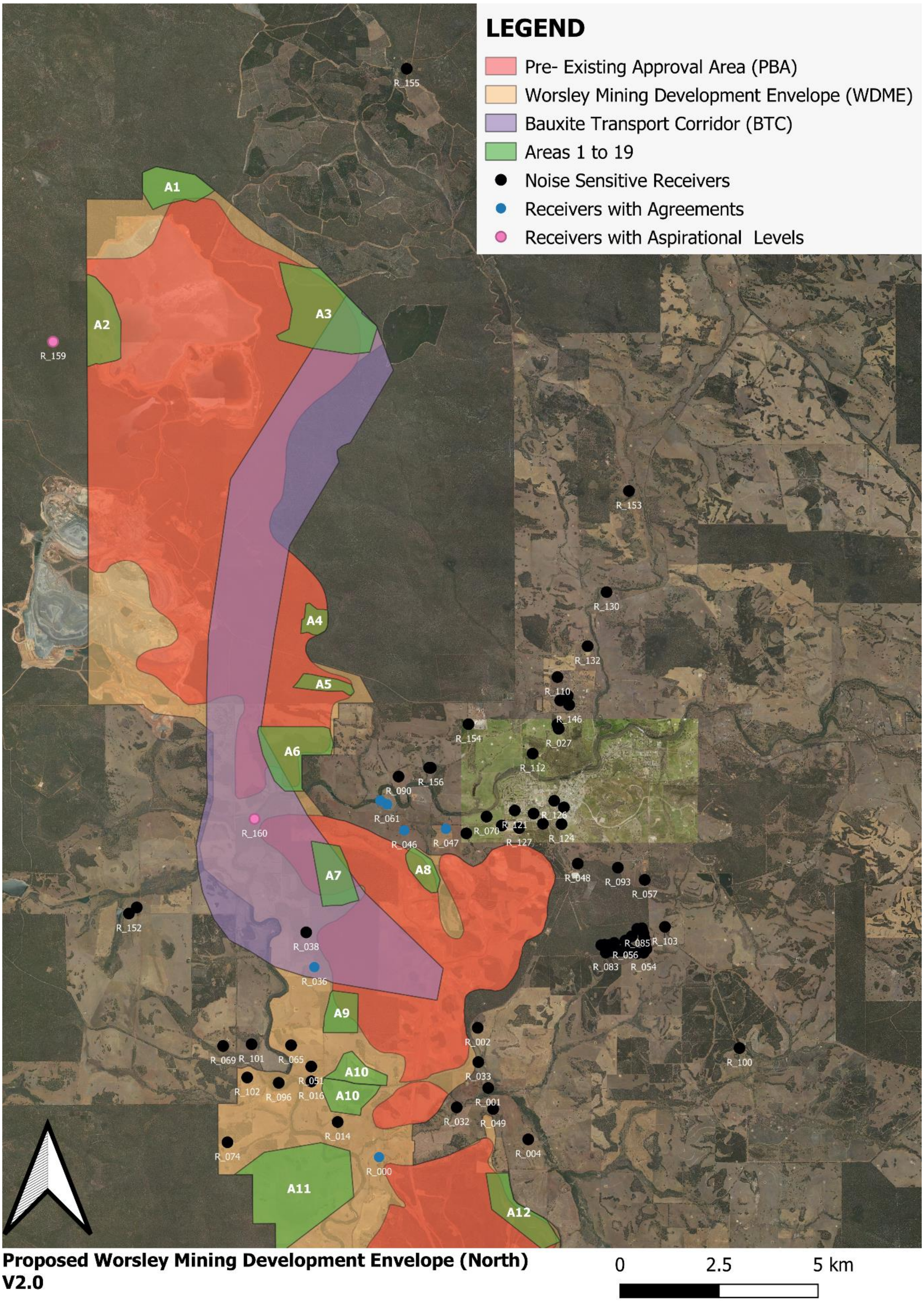

Figure 9-1 : Proposed Mining Development Envelope (Including Assessment Areas - North)

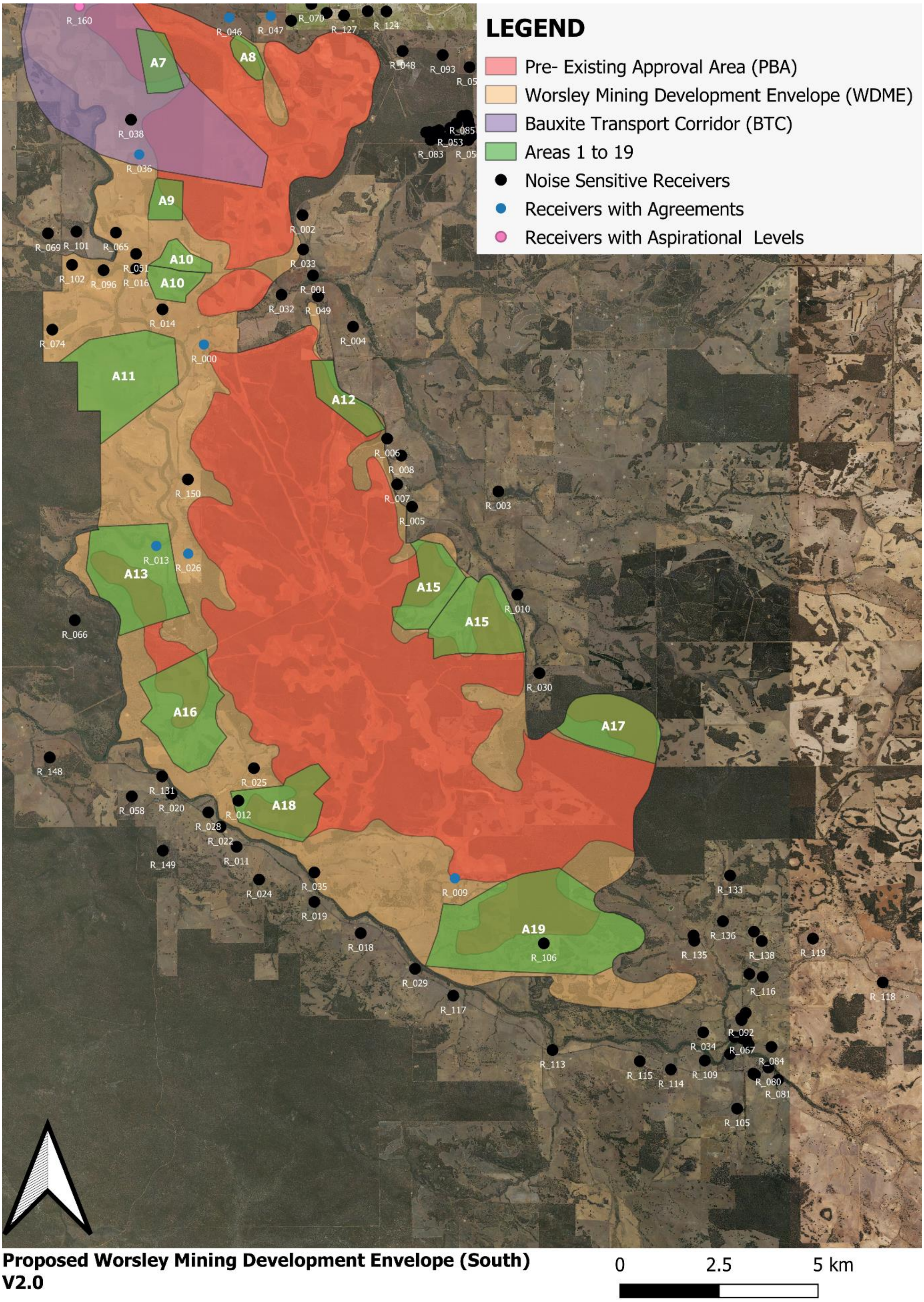

Figure 9-2 : Proposed Mining Development Envelope (Including Assessment Areas - South)

Appendix C: **Noise Sensitive Receivers**

Figure 9-3 : Noise sensitive receivers and coordinates

#	Ref	X	y	#	Ref	X	y
1	R_001	448774	6363072	67	R_086	R_085	452418
2	R_002	448509	6364592	68	R_087	R_086	459698
3	R_003	453452	6357614	69	R_088	R_087	452693
4	R_004	449785	6361774	70	R_089	R_088	447283
5	R_005	451274	6357226	71	R_090	R_089	446511
6	R_006	450646	6358947	72	R_091	R_090	449117
7	R_007	450899	6357793	73	R_092	R_091	459583
8	R_008	451003	6358520	74	R_093	R_092	452049
9	R_010	453933	6355007	75	R_095	452737	6366748
10	R_011	446845	6348640	76	R_096	443485	6363201
11	R_012	446890	6349805	77	R_097	451900	6366539
12	R_014	444973	6362213	78	R_098	451955	6366736
13	R_016	444310	6363239	79	R_099	452018	6366536
14	R_018	449978	6346458	80	R_100	455119	6364079
15	R_019	448806	6347249	81	R_101	442800	6364176
16	R_020	445202	6349976	82	R_102	442689	6363337
17	R_022	446441	6349145	83	R_103	453237	6367141
18	R_024	447412	6347811	84	R_104	459596	6344263
19	R_025	447281	6350626	85	R_105	459481	6342028
20	R_027	445623	6356042	86	R_106	454602	6346201
21	R_028	450553	6372143	87	R_107	459790	6345428
22	R_029	446129	6349510	88	R_108	459713	6343769
23	R_030	451349	6345558	89	R_109	458665	6343240
24	R_031	454491	6353025	90	R_110	450523	6373449
25	R_032	448524	6363726	91	R_111	450522	6372254
26	R_033	447978	6362582	92	R_112	449896	6371516
27	R_034	448524	6363726	93	R_113	454821	6343506
28	R_035	458626	6343955	94	R_114	457809	6343016
29	R_038	448808	6347994	95	R_115	457025	6343223
30	R_045	444178	6367002	96	R_116	460131	6345352
31	R_048	448222	6369502	97	R_117	452316	6344879
32	R_049	451035	6368737	98	R_118	463159	6345216
33	R_051	448899	6362541	99	R_119	461397	6346322
34	R_052	444306	6363614	100	R_120	442126	6350893
35	R_053	451630	6366681	101	R_121	449445	6370080
36	R_054	452240	6366793	102	R_122	449920	6370002
37	R_055	452698	6366489	103	R_123	450155	6369744

38	R_056	451714	6366689	104	R_124	450626	6369736
39	R_057	452238	6366792	105	R_125	450687	6370159
40	R_058	452726	6368329	106	R_126	450441	6370326
41	R_059	444197	6349913	107	R_127	449555	6369637
42	R_060	451832	6366686	108	R_129	450592	6372861
43	R_062	452310	6366586	109	R_130	451762	6375595
44	R_063	452717	6366858	110	R_131	444964	6350418
45	R_064	459414	6343833	111	R_132	451285	6374231
46	R_065	452395	6366903	112	R_133	459305	6347914
47	R_066	443797	6364151	113	R_134	458380	6346399
48	R_067	442758	6354361	114	R_135	458403	6346268
49	R_068	459611	6343864	115	R_136	459124	6346759
50	R_069	459302	6343405	116	R_137	459909	6346496
51	R_070	442081	6364132	117	R_138	460107	6346259
52	R_071	448733	6369925	118	R_143	450785	6372978
53	R_072	452141	6366538	119	R_146	450819	6372747
54	R_073	459674	6343848	120	R_147	444197	6349913
55	R_074	459617	6343800	121	R_148	442123	6350899
56	R_075	442191	6361701	122	R_149	444983	6348544
57	R_076	452530	6366474	123	R_150	445614	6357917
58	R_077	452771	6366585	124	R_151	439901	6367631
59	R_078	452658	6367106	125	R_152	439701	6367478
60	R_079	459890	6342912	126	R_153	452328	6378149
61	R_080	459934	6342883	127	R_154	448276	6372259
62	R_081	460271	6343064	128	R_155	446717	6388813
63	R_082	460516	6342752	129	R_156	447328	6371159
64	R_083	459775	6343643	130	R_159 (Mt Wells Camp)	437788	6381921
65	R_084	451744	6366491	131	R_160 (Tullis Bridge)	442874	6369866
66	R_085	452539	6367092				

Appendix D: **Tabulated Noise Source Data**

D.1: Mobile Equipment SWL

Figure 9-4 : Modelled Mobile Equipment, Sound Power Levels (SWLs)

Equipment Item	Operating Condition	Overall SWL in dB(A)	Octave Band Levels, Hz in dB(A)								
			31.5	63	125	250	500	1k	2k	4k	8k
Surface Miner (2018) Vermeer T1655	Surface mining	120	80	95	103	110	116	119	119	115	106
Haul Truck (2018) Caterpillar 785 XQ	Idle Stationary	102	59	79	91	91	96	98	96	90	75
	Drive By	114	92	103	105	108	110	108	99	90	92
Grader (2018) Caterpillar 16M	High Idle Stationary	112	61	79	98	103	105	108	106	100	91
Excavator (2018) Caterpillar 993K	High Idle Stationary	112	61	79	98	103	105	108	106	100	91
Dozer (2018) Caterpillar D11T	Drive by	114	70	101	97	103	108	109	108	99	88
Excavator (2018) HITACHI EX2500-6	High Idle Stationary	110	62	90	95	99	104	105	103	97	88
Haul Truck / Water Truck (2012) KOMATSU HD985-5	High Idle Stationary	108	-	86	96	99	103	102	100	94	89
Lighting Plant (2012) Light	Normal Operation	97	-	86	89	89	86	89	90	83	75
Scraper (2018) Caterpillar 637E	High Idle Stationary	116	73	86	101	106	110	111	111	104	96
Drill Rig (2018) - Atlas Copco T45	Drilling/Tramming	116	73	90	91	97	107	109	111	110	104

D.2: Fixed Plant SWL

Figure 9-5 : Modelled Fixed Plant Equipment used for the Saddleback, Marradong Crushers and Sound Power Levels (SWLs)

Equipment Item	Operating Condition	Overall SWL in dB(A)	Octave Band Levels, Hz in dB(A)								
			31.5	63	125	250	500	1k	2k	4k	8k
Conveyor Secondary Crusher to Stockpile Saddleback	Normal	89	-	56	70	79	84	84	82	73	67
Conveyor Primary Crusher to Secondary Crusher Saddleback		89	-	56	70	79	84	84	82	73	67
Primary Crusher		118	-	93	102	108	113	113	110	103	92
Primary Crusher Sizer Motor		113	-	83	96	105	109	106	104	97	86
Secondary Crusher Saddleback		118	-	93	102	108	113	113	110	103	92
Dust Collector 2		90	-	72	76	80	84	85	84	77	62
Dust Collector 1		90	-	72	76	80	84	85	84	77	62
Secondary Crusher Marradong (Saddleback)		118	-	93	102	108	113	113	110	103	92
Drive - Conveyor Primary Crusher to Secondary Crusher		98	-	77	81	87	93	93	90	83	73
Drive - Conveyor Secondary Crusher to Stockpile		98	-	77	81	87	93	93	90	83	73
Primary Crusher Transfer Point (Marradong)		113	-	83	91	100	107	108	108	99	84
Primary Crusher Sizer Motor (Marradong)		113	-	83	96	105	109	106	104	97	86
Primary Crusher (Marradong)		118	-	93	102	108	113	113	110	103	92
Conveyors, Lw/m (2018)		75	29	51	58	65	70	68	68	62	58

Appendix E: **Operational Scenarios**

E.1: Scenarios

The scenarios have been developed to represent worst-case equipment numbers with highest production rates (e.g. they include the whole mobile fleet, 100% dozer support, 4 drill rigs working together and the ancillary equipment)

Figure 9-6 : Scenarios

Area	Operation	Equipment	Equipment Location	
			Pit	Haul Road
Area 1 -19	Mining	Dump Truck	2	11
		Excavator	1	
		Dozer	1	
		Grader		1
		Water Truck		1
		Lighting Plant	2	
	Rehabilitation	Dozer	2	
	Development	Scraper	3	
		Dozer	1	
		Surface Miner	1	
	Drilling	Drill Rig	4	

Appendix F: Worst Case Modelling Results

Figure 9-7 : Worst Case Noise Modelled Scenario Results

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_001	40.8	31.4	38.9	31.8	31.1	-5.0	24.9	104.2
R_002	32.8	22.1	30.3	23.7	22.8	-5.3	32.8	97.4
R_003	41.1	31.2	39.2	31.8	31.1	-9.0	28.5	104.3
R_004	49.9	40.4	48.1	40.5	39.9	-6.1	29.5	112.3
R_005	52.0	43.1	49.9	42.7	42.2	-8.5	35.4	114.7
R_006	60.7	51.9	59.1	50.6	49.7	-8.8	37.8	120.3
R_007	46.4	36.8	44.5	36.9	36.4	-8.8	33.2	108.9
R_008	52.2	42.7	50.3	42.6	42.1	-8.0	36.0	114.2
R_010	51.6	42.6	49.6	42.4	41.7	-10.0	31.3	114.3
R_011	46.7	45.0	43.8	36.7	36.9	-5.0	22.1	113.7
R_012	55.7	55.0	45.2	41.6	43.2	-4.6	25.2	123.2
R_014	54.0	45.0	52.1	44.4	44.1	-1.9	29.1	116.0
R_016	60.0	53.1	57.5	50.6	50.3	1.4	35.7	122.8
R_018	42.6	33.3	40.5	33.5	33.0	2.4	38.0	105.8
R_019	43.9	34.4	42.1	34.7	34.2	-22.1	27.8	106.8
R_020	53.3	44.8	51.3	43.8	43.4	-12.6	23.3	115.7
R_022	44.7	35.1	42.9	35.4	34.9	-8.4	26.0	113.3
R_024	46.3	37.0	44.5	37.1	36.6	-4.8	22.4	108.8
R_025	50.9	42.1	49.1	41.4	40.7	-17.8	27.7	112.2
R_027	28.5	17.3	26.1	19.5	18.5	-4.7	24.0	94.5
R_028	48.7	43.6	46.9	39.3	38.8	-19.9	29.9	113.8
R_029	55.5	47.5	53.3	46.1	46.0	-10.8	28.8	118.1
R_030	52.6	43.3	50.9	43.2	42.7	-5.6	20.9	114.8
R_031	36.8	26.9	34.9	27.9	27.2	-15.1	21.8	100.8
R_032	23.4	13.8	21.2	15.2	13.8	-5.0	24.9	97.1
R_033	36.8	26.9	34.9	27.9	27.2	-5.3	32.8	100.8

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_034	34.5	25.3	32.6	25.3	24.6	-9.0	28.5	99.1
R_035	50.2	41.1	48.4	40.7	40.3	-6.1	29.5	112.4
R_038	51.3	42.7	49.3	41.8	41.3	-8.5	35.4	113.1
R_045	41.4	39.6	34.0	29.4	30.4	-8.8	37.8	106.8
R_048	24.8	12.1	21.1	15.0	14.2	-8.8	33.2	91.5
R_049	31.5	21.2	29.1	23.2	23.0	-8.0	36.0	102.7
R_051	57.3	49.4	55.0	47.9	47.6	-10.0	31.3	120.1
R_052	28.8	15.9	24.7	18.0	17.2	-5.0	22.1	93.6
R_053	22.9	9.5	18.6	13.0	12.1	-4.6	25.2	90.4
R_054	22.7	10.9	18.7	13.2	12.2	1.4	35.7	90.0
R_055	28.7	15.8	24.8	18.2	17.3	2.4	38.0	93.6
R_056	23.4	9.5	18.6	13.0	12.1	-22.1	27.8	90.4
R_057	26.0	13.6	22.5	16.4	15.5	-12.6	23.3	88.8
R_058	45.7	36.7	43.7	36.7	36.2	-8.4	26.0	108.2
R_059	24.1	9.3	18.7	12.7	11.6	-4.8	22.4	89.9
R_060	25.1	12.5	21.1	14.5	13.9	-5.4	16.7	91.8
R_062	25.2	12.3	20.9	15.3	14.5	-17.8	27.7	91.5
R_063	33.0	22.7	31.2	24.1	23.5	-2.0	29.2	95.1
R_064	20.6	8.8	17.9	12.3	11.4	2.1	19.7	89.6
R_065	50.7	42.2	48.5	41.3	40.9	-4.7	24.0	113.2
R_066	48.8	40.1	46.7	39.7	39.1	-19.9	29.9	111.6
R_067	32.4	22.0	30.6	23.6	22.8	-10.8	28.8	95.5
R_068	31.7	21.4	29.9	23.0	22.3	-5.6	20.9	95.7
R_069	38.1	28.4	35.8	28.7	28.3	-15.1	21.8	101.6
R_070	43.9	34.0	42.1	34.6	33.9	-5.6	20.9	106.5
R_071	26.8	13.7	22.7	16.3	15.4	-16.2	10.9	92.4
R_072	32.1	21.7	30.3	23.4	22.6	-23.3	23.0	95.7

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_073	32.2	21.8	30.3	23.4	22.7	4.9	45.6	95.5
R_074	49.2	40.5	47.2	40.1	39.6	1.7	23.5	112.2
R_075	21.1	9.3	18.6	12.5	11.3	-2.4	20.2	89.5
R_076	24.4	11.7	19.4	14.9	14.0	-5.3	28.7	89.8
R_077	25.0	12.5	20.5	15.2	14.4	2.4	39.2	91.7
R_078	28.4	17.7	26.5	19.9	19.0	-3.9	24.8	94.8
R_079	28.2	17.5	26.3	19.7	18.9	-6.0	20.5	94.6
R_080	27.8	17.0	25.8	19.2	18.4	-4.8	20.8	94.4
R_081	26.2	15.3	24.2	17.9	17.0	-3.3	24.5	93.3
R_082	31.1	20.6	29.3	22.3	21.6	-6.0	21.1	96.1
R_083	27.8	14.8	23.6	16.8	16.0	-3.1	20.7	93.0
R_084	29.0	18.3	27.1	20.4	19.6	-3.6	25.0	95.2
R_085	25.7	13.3	21.2	16.1	15.3	-3.8	22.0	92.1
R_086	21.6	9.3	18.6	12.5	11.2	-4.7	21.0	89.1
R_087	33.9	23.6	32.2	25.0	24.3	-3.8	21.0	98.4
R_088	25.2	12.5	20.7	15.5	14.6	-14.4	11.7	91.7
R_089	41.9	32.1	40.0	32.7	32.1	-5.8	12.8	105.1
R_090	43.0	33.6	41.1	33.9	33.3	2.3	37.1	106.2
R_091	31.3	21.6	29.0	22.8	22.6	-1.8	32.9	100.5
R_092	34.0	23.6	32.2	25.1	24.3	-14.7	11.6	96.1
R_093	26.5	16.5	18.9	18.6	18.0	-14.5	10.0	89.8
R_095	24.7	12.1	20.0	15.2	14.3	3.2	27.6	89.6
R_096	49.0	40.3	46.9	39.7	39.3	1.7	28.3	111.7
R_097	27.5	14.5	23.5	16.7	15.9	-4.9	22.8	92.6
R_098	28.2	15.3	24.2	17.7	16.9	-14.4	11.5	93.3
R_099	27.4	14.3	23.3	17.0	16.2	-14.4	11.5	92.8
R_100	21.7	9.8	19.0	13.4	12.3	1.5	27.7	90.1

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_101	42.7	33.4	40.4	33.3	32.8	-10.3	11.9	105.5
R_102	42.4	33.1	40.3	33.3	32.9	-4.7	20.7	105.6
R_103	23.4	10.8	18.9	14.1	13.2	-3.6	21.0	88.4
R_104	33.7	23.4	31.9	25.0	24.2	-14.7	10.5	96.2
R_105	26.5	15.6	24.4	18.1	17.3	-14.7	10.4	93.5
R_106	46.9	37.3	45.2	35.8	32.7	-14.7	9.8	118.4
R_107	35.9	25.7	34.1	26.9	26.2	-14.8	9.1	100.1
R_108	31.7	21.3	29.9	23.0	22.2	-14.5	11.1	95.9
R_109	32.9	22.6	31.0	24.1	23.3	-5.5	24.0	97.7
R_110	26.0	14.9	24.0	17.6	16.6	-14.6	10.5	92.4
R_111	28.5	17.3	26.1	19.3	18.4	-3.6	21.5	94.5
R_112	33.0	22.1	30.7	23.8	22.9	-6.0	18.7	97.6
R_113	29.3	13.3	27.5	18.1	16.0	-14.3	12.6	98.2
R_114	33.5	23.4	31.6	24.6	23.7	-4.0	21.1	98.3
R_115	26.0	10.1	25.5	12.4	12.5	5.8	26.6	93.7
R_116	34.0	23.7	32.2	25.1	24.4	6.7	24.8	97.2
R_117	40.8	31.5	38.9	31.8	31.4	0.9	16.3	107.4
R_118	21.9	10.5	19.7	13.9	12.9	-14.3	12.4	90.6
R_119	28.9	18.1	27.0	20.4	19.4	-2.4	22.8	95.0
R_120	33.9	24.1	31.8	24.7	24.0	-4.6	20.9	98.4
R_121	39.3	28.9	37.3	30.0	29.2	3.3	31.9	102.4
R_122	36.6	26.3	34.7	27.3	26.5	-5.9	23.6	100.4
R_123	35.7	25.5	33.9	26.7	26.0	-3.8	24.1	99.9
R_124	33.5	23.0	31.6	24.5	23.8	-5.0	23.3	95.4
R_125	32.9	22.1	30.7	23.7	22.9	-7.2	13.1	95.3
R_126	33.7	23.0	31.6	24.6	23.7	1.1	31.4	98.1
R_127	38.9	29.3	37.0	29.9	29.1	3.4	28.9	98.4

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_129	26.1	14.9	23.7	17.3	16.4	-4.7	19.3	93.0
R_130	21.1	8.9	18.1	12.6	11.6	-14.3	12.3	87.9
R_131	38.8	31.1	36.6	31.1	30.5	-14.9	11.0	111.3
R_132	20.9	9.0	18.0	12.0	11.1	-14.6	36.9	89.8
R_133	37.6	27.4	35.9	28.6	27.8	-19.7	14.0	101.4
R_134	46.5	36.8	44.8	37.2	36.6	-14.5	11.4	109.1
R_135	46.3	36.5	44.6	37.0	36.3	-14.8	11.4	108.8
R_136	40.9	30.9	39.1	31.7	31.0	3.2	17.8	104.1
R_137	36.2	26.0	34.4	27.2	26.5	2.1	19.7	100.3
R_138	35.1	24.8	33.3	26.2	25.4	2.1	23.6	99.5
R_143	26.0	14.3	23.3	17.1	16.1	-11.8	22.2	92.8
R_146	25.7	14.5	23.3	16.4	15.5	-22.2	14.5	92.6
R_147	45.7	36.7	43.7	36.7	36.2	-24.4	15.8	108.2
R_148	33.6	23.9	31.3	24.3	23.8	-26.9	10.7	98.7
R_149	40.6	31.4	38.8	31.7	31.1	-6.7	15.4	104.0
R_150	35.6	24.6	32.8	25.7	24.9	-14.7	8.5	101.0
R_151	28.4	17.5	25.7	19.4	18.6	-14.1	13.4	94.5
R_152	26.9	16.3	24.6	18.1	17.4	-3.2	22.1	93.8
R_153	5.9	-6.6	2.0	-2.0	-2.4	1.0	27.5	81.1
R_154	34.4	23.8	32.2	25.2	24.5	0.0	23.4	98.8
R_155	22.2	9.8	19.1	13.4	12.4	-0.2	18.2	90.2
R_156	41.9	32.1	40.0	32.7	32.1	-0.8	19.4	105.1
R_159 (Mount Wells Camp)	39.7	28.9	37.2	30.7	30.0	-0.5	22.4	109.3
R_160 (Tullis Bridge)	41.9	13.7	20.6	14.8	15.4	0.0	22.0	96.5

Figure 9-8 : Calm Weather Noise Modelled Scenario Results

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_001	35.2	26.3	33.1	26.3	25.7	-8.7	19.1	101.8
R_002	27.0	16.6	24.4	18.3	17.7	-9.0	26.9	94.7
R_003	35.5	26.1	33.4	26.4	25.9	-12.4	23.5	101.9
R_004	44.8	35.8	42.9	35.4	35.2	-9.6	23.7	109.9
R_005	46.9	38.6	44.6	37.7	37.6	-12.0	29.6	112.3
R_006	56.5	48.0	54.8	46.3	45.6	-12.3	32.1	117.7
R_007	41.0	32.0	38.9	31.6	31.2	-12.3	27.3	106.5
R_008	47.1	38.2	45.1	37.8	37.5	-11.5	30.2	111.8
R_010	46.4	38.1	44.3	37.5	36.9	-13.4	25.9	111.9
R_011	42.3	40.8	38.1	31.4	32.3	-8.3	16.1	111.2
R_012	52.1	51.4	39.6	38.1	39.2	-7.9	19.3	120.7
R_014	49.2	40.6	47.2	39.7	39.5	-2.3	30.0	113.6
R_016	55.4	49.4	52.5	46.0	46.3	-1.3	32.6	120.2
R_018	37.0	28.3	34.7	28.0	27.9	-25.4	21.9	103.5
R_019	38.4	29.4	36.3	29.5	29.0	-15.9	17.5	104.4
R_020	48.3	40.4	46.2	38.8	38.5	-11.8	20.1	113.3
R_022	39.2	30.8	37.2	30.0	29.9	-8.1	16.6	110.8
R_024	40.9	32.2	38.9	31.8	31.3	-8.6	11.4	0.0
R_025	45.8	37.5	44.0	36.0	35.4	-21.2	21.8	109.8
R_027	23.0	11.8	20.3	14.3	13.5	-2.4	14.5	91.6
R_028	43.4	39.1	41.5	34.0	33.7	-8.0	18.1	111.3
R_029	50.6	43.3	48.2	41.3	41.4	-23.2	24.0	115.6
R_030	47.7	38.8	45.8	38.4	38.2	-14.1	23.0	112.4
R_031	31.1	21.6	29.0	22.6	21.9	-9.3	15.3	98.3
R_032	18.4	8.9	15.9	10.8	9.2	-18.8	16.1	94.8
R_033	31.1	21.6	29.0	22.6	21.9	-9.3	15.3	98.3

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_034	28.9	20.1	26.9	19.7	19.2	-19.4	6.1	96.6
R_035	44.9	36.5	42.9	35.5	35.5	-26.7	17.1	110.0
R_038	46.1	38.1	43.9	36.6	36.3	0.7	40.9	110.7
R_045	36.6	34.9	28.8	24.5	26.0	-2.7	17.7	104.4
R_048	19.5	6.8	15.7	10.1	9.5	-6.4	14.7	88.1
R_049	26.3	16.3	23.6	18.7	19.0	-9.0	22.8	100.3
R_051	52.6	45.3	50.2	43.0	43.4	-1.3	33.8	117.6
R_052	23.2	10.4	19.0	12.8	12.3	-7.7	19.2	90.6
R_053	17.6	4.4	13.5	8.4	7.7	-9.7	15.0	87.1
R_054	17.5	5.3	13.6	8.5	7.8	-8.5	15.6	86.4
R_055	23.2	10.3	19.1	13.2	12.5	-7.0	19.0	90.5
R_056	18.0	4.4	13.5	8.4	7.7	-9.8	15.6	87.2
R_057	20.8	8.2	16.9	11.5	10.9	-6.9	15.6	85.5
R_058	40.4	31.9	38.3	31.5	31.0	-6.9	19.1	105.8
R_059	22.7	9.8	18.5	12.6	12.1	-7.6	18.6	90.2
R_060	19.6	7.0	15.5	9.5	9.0	-8.5	15.3	88.5
R_062	19.9	7.0	15.3	10.5	9.8	-7.5	15.8	88.2
R_063	27.4	17.2	25.3	18.7	18.5	-17.6	7.3	92.5
R_064	15.7	3.7	12.8	7.7	6.9	-9.5	7.9	85.9
R_065	45.4	37.6	43.0	36.1	36.0	-1.5	31.2	110.8
R_066	43.6	35.5	41.2	34.7	34.2	-5.2	27.1	109.2
R_067	26.7	16.5	24.7	18.2	17.7	-17.8	7.2	92.8
R_068	26.0	15.9	24.0	17.6	17.2	-17.7	5.6	93.0
R_069	32.4	23.1	29.8	23.2	23.1	-0.6	21.8	99.2
R_070	38.4	29.0	36.4	29.2	28.8	-2.7	22.4	104.2
R_071	21.4	8.3	17.1	11.3	10.6	-8.7	17.4	89.2
R_072	26.5	16.3	24.5	18.0	17.6	-17.6	7.1	93.0

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_073	26.6	16.3	24.5	18.2	17.7	-17.6	7.1	92.8
R_074	44.0	35.9	41.7	35.0	34.7	-2.2	21.8	109.8
R_075	15.9	3.9	13.2	7.6	6.6	-14.0	7.4	86.0
R_076	19.2	6.5	13.8	10.1	9.4	-8.4	15.5	86.2
R_077	19.7	7.2	14.9	10.3	9.6	-7.4	15.7	88.4
R_078	22.9	12.2	20.8	14.7	14.2	-17.9	6.2	91.8
R_079	22.7	12.0	20.5	14.5	14.1	-17.9	6.1	91.7
R_080	22.2	11.5	20.0	14.1	13.6	-17.9	5.6	91.4
R_081	20.8	9.8	18.6	12.9	12.2	-18.1	5.0	90.2
R_082	25.5	15.2	23.4	17.0	16.6	-17.7	6.8	93.4
R_083	22.2	9.3	17.8	11.6	11.1	-9.2	18.4	89.9
R_084	23.4	12.8	21.3	15.1	14.7	-17.8	6.2	92.3
R_085	20.4	7.9	15.6	11.2	10.6	-7.3	16.3	88.8
R_086	16.3	3.9	13.2	7.6	6.3	-9.7	13.3	85.5
R_087	28.3	18.2	26.3	19.6	19.1	-17.5	8.0	95.7
R_088	20.0	7.2	15.2	10.6	9.9	-7.7	15.9	88.4
R_089	36.4	27.1	34.3	27.2	27.1	0.8	20.8	102.7
R_090	37.5	28.6	35.4	28.5	28.2	1.7	19.0	103.9
R_091	26.0	16.6	23.4	17.9	18.2	-3.4	10.8	98.2
R_092	28.3	18.2	26.3	19.7	19.3	-17.5	7.9	93.5
R_093	21.2	11.0	13.2	13.4	13.1	-6.2	17.4	
R_095	19.5	6.7	14.4	10.3	9.6	-8.3	15.7	85.9
R_096	43.8	35.6	41.5	34.6	34.1	-0.4	26.1	109.3
R_097	22.0	8.9	17.7	11.4	10.9	-9.6	18.1	89.4
R_098	22.7	9.8	18.5	12.6	12.1	-7.6	18.6	90.2
R_099	22.0	8.9	17.7	12.0	11.4	-8.8	17.9	89.6
R_100	16.8	4.7	13.8	8.7	7.8	-10.7	8.7	86.5

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_101	37.0	28.3	34.5	27.7	27.6	-2.7	25.5	103.1
R_102	36.9	28.1	34.6	27.8	27.9	-0.3	23.1	103.2
R_103	18.3	5.6	13.3	9.4	8.7	-8.4	14.3	84.5
R_104	28.1	18.0	26.0	19.6	19.1	-17.5	7.8	93.6
R_105	21.1	10.2	18.7	13.0	12.5	-18.0	6.6	90.4
R_106	43.2	34.0	41.7	32.5	28.1	-17.9	31.8	115.9
R_107	30.2	20.3	28.2	21.5	21.0	-22.9	9.2	97.5
R_108	26.1	15.8	24.0	17.8	17.2	-17.7	7.0	93.1
R_109	27.2	17.2	25.2	18.7	18.1	-18.0	6.7	95.1
R_110	20.6	9.4	18.3	12.6	11.8	-1.5	12.9	89.1
R_111	22.9	11.7	20.3	14.0	13.5	-2.4	14.5	91.5
R_112	27.3	16.6	24.8	18.3	17.9	-2.4	18.1	95.0
R_113	23.8	8.4	21.8	13.6	12.2	-15.0	16.5	95.8
R_114	27.6	18.0	25.6	19.0	18.3	-25.4	9.5	95.7
R_115	20.2	5.0	19.6	7.8	8.5	-27.7	10.5	91.1
R_116	28.2	18.2	26.2	19.8	19.3	-30.3	6.0	94.6
R_117	35.3	26.4	33.2	26.4	26.4	-9.9	10.4	105.0
R_118	16.9	5.3	14.5	9.3	8.4	-17.9	4.4	87.0
R_119	23.4	12.7	21.2	15.2	14.5	-17.3	8.8	92.1
R_120	28.1	18.7	25.8	19.1	18.6	-6.5	16.3	95.9
R_121	33.7	23.8	31.5	24.6	23.9	-3.3	21.7	100.0
R_122	30.8	21.0	28.8	21.6	21.1	-4.2	17.7	97.9
R_123	29.9	20.2	27.9	21.1	20.9	-4.4	12.6	97.4
R_124	27.8	17.6	25.7	19.1	18.7	-4.8	14.0	92.7
R_125	27.3	16.6	24.9	18.3	17.9	-4.6	16.9	92.6
R_127	33.1	24.0	31.1	24.1	23.6	-3.9	12.8	95.9
R_129	20.6	9.3	18.0	12.4	11.6	-2.1	12.2	89.8

Receiver	Worst Case dB(A)	Single Scenario						
		Drilling dB(A)	Development dB(A)	Mining dB(A)	Rehabilitation dB(A)	Fixed Plant dB(A)	Haulage dB(A)	Blasting dB(Lpeak)
R_130	16.3	3.8	13.0	8.1	7.1	-4.7	10.9	84.1
R_131	34.3	26.0	31.7	26.3	26.9	-21.6	17.3	108.8
R_132	15.9	3.8	12.7	7.3	6.5	-18.2	9.2	86.2
R_133	32.0	22.2	30.1	23.1	22.6	-16.5	16.7	99.0
R_134	41.0	31.9	39.1	31.8	31.6	-16.8	13.8	106.7
R_135	40.9	31.6	39.1	31.7	31.1	-16.8	13.4	106.5
R_136	35.2	25.7	33.3	26.3	25.9	-18.2	13.0	101.7
R_137	30.5	20.7	28.5	21.8	21.2	-27.7	9.9	97.8
R_138	29.4	19.4	27.5	20.7	20.3	-17.1	10.6	96.9
R_143	20.7	9.0	17.8	12.1	11.3	-2.1	13.1	89.6
R_146	20.2	8.8	17.5	11.0	10.5	-2.2	12.0	89.5
R_147	40.4	31.9	38.3	31.5	31.0	-6.9	19.1	105.8
R_148	27.9	18.6	25.5	18.8	18.6	-6.5	16.8	96.1
R_149	34.9	26.3	32.8	26.2	25.8	-16.0	16.4	101.6
R_150	29.8	19.3	26.9	20.1	19.3	-4.6	22.9	98.7
R_151	22.6	12.0	20.0	14.3	13.7	4.0	22.4	91.6
R_152	21.4	10.7	18.8	12.9	12.4	3.7	21.0	90.8
R_153	1.7	-10.7	-2.3	-6.1	-6.6	-19.9	-4.9	76.9
R_154	28.7	18.4	26.3	19.8	19.5	-10.5	18.0	96.2
R_155	17.3	4.6	13.9	8.7	8.0	-12.4	11.0	86.6
R_156	36.4	27.1	34.3	27.2	27.1	0.8	20.8	102.7
R_159 (Mount Wells Camp)	34.8	24.3	32.0	26.2	25.9	13.0	24.9	106.9
R_160 (Tullis Bridge)	36.6	8.7	15.2	10.5	11.5	-2.4	36.6	94.1

Appendix G: **Blast Parameters**

"*AS 2187.2-2006 Explosives - Storage and use - Use of explosives*" was used to calculate the blasting parameters. The empirical formula in this standard was deemed relevant as it is based on research undertaken by Siskind for open cut coal mines in the USA.

The blast noise level at receivers is dependent on the distance between the blast location and the receiver, the amount of explosive used as well as the depth at which each charge is buried. The relevant diffraction over terrain surrounding the mine site was performed using Concawe in SoundPlan.

Airblast levels have been commonly estimated using the following cube root scaling formula:

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

Where:

P = pressure, in kilopascals

Q = explosive charge mass, in kilograms

R = distant from charge, in meters

K_a = site constant

a = site exponent

For confined blasthole charges, when using a site exponent a of −1.45, the site constant K_a is commonly in the range 10 to 100.

K_a=33 was used as blasts are confined in a hole with stemming.

The blast noise source level used for this assessment was estimated to be 185dB(Lpeak) at a frequency of 16Hz.

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