APPENDIX N: BLASTING STUDY

Blast Management & Consulting

Quality Service on Time

Report: Blast Impact Assessment Proposed Jindal Melmoth Iron Ore Project		
Report Date:	27 October 2022	
BM&C Ref No:	BMC_SLR_JindalMIOProject_EIAReport_220126V03	
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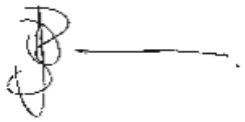
Document Authorised:	JD Zeeman	

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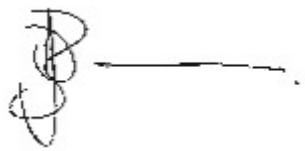
i. Independence Declaration

A declaration that the specialist is independent in a form as may be specified by the competent authority

I, JD Zeeman, declare that -

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct



Signature of the Specialist

ii. Legal Requirements

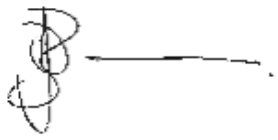
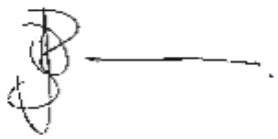
In terms of the NEMA 2014 EIA Regulations contained in GN R982 of 04 December 2014 (as amended by GN R 326 of 07 April 2017) all specialist studies must comply with Appendix 6 of the NEMA EIA Regulations, 2014 (as amended). Table 1 shows the requirements as indicated above.

Table 1: Legal Requirements for All Specialist Studies Conducted

Legal Requirement		**Relevant Section in Specialist study**
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of-	
	(i) the specialist who prepared the report; and	i
	(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 26
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Section ii
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 4
(d)	the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 8
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process;	Section 6
(f)	the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	Section 11
(g)	an identification of any areas to be avoided, including buffers;	Section 11
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 11
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 9
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	Section 17
(k)	any mitigation measures for inclusion in the EMPr;	Section 18.3
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 22
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 21
(n)	a reasoned opinion (Environmental Impact Statement)-	Section 24
	as to whether the proposed activity or portions thereof should be authorised; and	Section 24
	if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 24

Legal Requirement		**Relevant Section in Specialist study**
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 12
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Section 12
(q)	any other information requested by the competent authority.	None

iii. Document Control:

Name & Company	Responsibility	Action	Date	Signature
C Zeeman Blast Management & Consulting	Document Preparation	Report Prepared	26/01/2022	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalised	01/03/2022	
C Zeeman Blast Management & Consulting	Document Preparation	Maps Updated	27/10/2022	
C Zeeman Blast Management & Consulting	Document Preparation	Maps Updated	05/12/2022	
JD Zeeman Blast Management & Consulting	Consultant	Comments updated	15/02/2023	

iv. Basis of Report:

This document has been prepared by Blast Management and Consulting (PTY) Ltd (BMC) with reasonable skill, care and diligence, and taking account of the manpower, timescales and resources devoted to it by agreement with **Jindal Iron Ore (Pty) Ltd** (the Client) as part of the services it has been appointed by the Client to carry out. It is subject to the terms and conditions of that appointment.

BMC shall not be liable for the use of or reliance on any information, advice, recommendations and opinions in this document for any purpose by any person other than the Client. Reliance may be granted to a third party only in the event that and the third party have executed a reliance agreement or collateral warranty.

Information reported herein may be based on the interpretation of public domain data collected by BMC, and/or information supplied by the Client and/or its other advisors and associates. These data have been accepted in good faith as being accurate and valid.

BMC disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

The copyright and intellectual property in all drawings, reports, specifications, bills of quantities, calculations and other information set out in this report remain vested in BMC unless the terms of appointment state otherwise.

This document may contain information of a specialised and/or highly technical nature and the Client is advised to seek clarification on any elements which may be unclear to it.

Information, advice, recommendations and opinions in this document should only be relied upon in the context of the whole document and any documents referenced explicitly herein and should then only be used within the context of the appointment.

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List of Acronyms used in this Report

a and b	Site Constant
APP	Air Pressure Pulse
B	Burden (m)
BH	Blast Hole
BMC	Blast Management & Consulting
D	Distance (m)
E	Explosive Mass (kg)
EIA	Environmental Impact Assessment
Freq.	Frequency
GRP	Gas Release Pulse
I&AP	Interested and Affected Parties
k	Factor value
L	Maximum Throw (m)
Lat/Lon hddd°mm'ss.s"	Latitude/Longitude Hours/degrees/minutes/seconds
M	Charge Height
m (SH)	Stemming height
M/S	Magnitude/Severity
Mc	Charge mass per metre column
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
NOx's	Noxious Fumes
P	Probability
POI	Points of Interest
PPV	Peak Particle Velocity
RPP	Rock Pressure Pulse
SH	Stemming height (m)
USBM	United States Bureau of Mine
WGS 84	Coordinates (South African)
WM	With Mitigation Measures
WOM	Without Mitigation Measures

List of Units used in this Report

%	percentage
cm	centimetre
dB	decibel
dBL	linear decibel
g/cm^3	gram per cubic centimetre
Hz	frequency
kg	kilogram

kg/m^3	kilogram per cubic metre
km	kilometre
kPa	kilopascal
m	metre
m^2	metre squared
mm/s	millimetres per second
ms	milliseconds
Pa	Pascal
ppm	parts per million

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1 Executive Summary

Blast Management & Consulting (BMC) was contracted to perform an initial review of possible impacts with regards to blasting operations in the proposed opencast mining operations. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report concentrates on the ground vibration and air blast intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

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Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report evaluates the effects of ground vibration, air blast and fly rock and intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed are roads, Farm buildings, boreholes, community houses and schools.

The location of structures around the Pit area is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Community Houses, Buildings/Structures and Hydrocencus Boreholes. Ground vibrations predicted for the pit area ranged between low and very high. The expected levels of ground vibration for some of these structures are high and will require specific mitigations in the way of adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Air blast predicted showed the same concerns for opencast blasting. High levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints. The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134dB. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located such that “free blasting” – meaning no controls on blast preparation – will not be possible.

On charges considered it is expected that air blast will be greater than 134 dB at a distance of 393 m and closer to pit boundary. The structures inside the Pit area are expected to be relocated and will then not be of concern as it is currently inside the pit area. Infrastructure at the pit area such

as roads and power lines/pylons are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 412 m. The absolute minimum unsafe zone is then the 412 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Community Houses, Buildings/Structures, D395 and D255 roads falls within the 500 m range from the pit area.

The pit areas are located such that specific concerns were identified and addressed in the report.

This concludes this investigation for the proposed Jindal Melmoth Iron Ore Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

2 Introduction

The Melmoth Iron Ore Project (the Project) site is located 25 km southeast of Melmoth, within the Mthonjaneni Local Municipality in the KwaZulu-Natal Province.

Jindal Iron Ore (Pty) Ltd (Jindal), is owned by Jindal Steel and Power (Mauritius) Limited (74%) and South African BEE partner Mr. Thabang Khomo (Pty) Ltd (26%). Jindal holds two Prospecting Rights over the project site. The prospecting rights are referred to as North Block (PR 10644) and South Block (PR 10652) and have a total combined area of 20 170 ha.

Blast Management & Consulting (BMC) was contracted to perform a review of possible impacts from blasting operations and specifically for the proposed Melmoth Iron Ore Project. Ground vibration, air blast and fly rock are some of the aspects that result from blasting operations and this study considers the possible influences that blasting may have on the surrounding area in this respect. The report concentrates on ground vibration and air blast and intends to provide information, calculations, predictions, possible influences and mitigating aspects of blasting operations for the project.

3 Objectives

The objectives of this document are outlining the expected environmental effects that blasting operations could have on the surrounding environment; and proposing the specific mitigation measures that will be required. This study investigates the related influences of expected ground vibration, air blast and fly rock. These effects are investigated in relation to the blast site area and surrounds and the possible influence on nearby private installations, houses and the owners or occupants.

The objectives were dealt with whilst taking specific protocols into consideration. The protocols applied in this document are based on the author's experience, guidelines taken from literature research, client requirements and general indicators in the various appropriate pieces of South African legislation. There is no direct reference in the following acts to requirements and limits on the effect of ground vibration and air blast and some of the aspects addressed in this report:

- National Environmental Management Act No. 107 of 1998;
- Mine Health and Safety Act No. 29 of 1996;
- Mineral and Petroleum Resources Development Act No. 28 of 2002;
- Explosives Act No. 15 of 2003.

The guidelines and safe blasting criteria are based on internationally accepted standards and specifically criteria for safe blasting for ground vibration and recommendations on air blast published by the United States Bureau of Mines (USBM). There are no specific South African standards and the USBM is well accepted as standard for South Africa.

4 Scope of blast impact study

The scope of the study is determined by the terms of reference to achieve the objectives. The terms of reference can be summarised according to the following steps taken as part of the EIA study with regards to ground vibration, air blast and fly rock due to blasting operations.

- Background information of the proposed site.
- Blasting Operation Requirements.
- Site specific evaluation of blasting operations according to the following:
  - Evaluation of expected ground vibration levels from blasting operations at specific distances and on structures in surrounding areas;
  - Evaluation of expected ground vibration influence on neighbouring communities;
  - Evaluation of expected blasting influence on national and provincial roads surrounding the blasting operations if present;
  - Evaluation of expected ground vibration levels on water boreholes if present within 1500 m from blasting operations;
  - Evaluation of expected air blast levels at specific distances from the operations and possible influence on structures;
  - Evaluation of fly rock unsafe zone;
  - Discussion on the occurrence of noxious fumes and dangers of fumes;
  - Evaluation the location of blasting operations in relation to surrounding areas according to the regulations from the applicable Acts.
- Impact Assessment.
- Mitigations.
- Recommendations.
- Conclusion.

5 Study area

The Melmoth Iron Ore Project site is located 25 km southeast of Melmoth, within the Mthonjaneni Local Municipality in the KwaZulu-Natal Province. The centre point of the site is 28° 43.194'S and 31° 28.735'E.

Figure 1 shows the Conceptual Site Layout for the Jindal Melmoth Iron Ore Project.

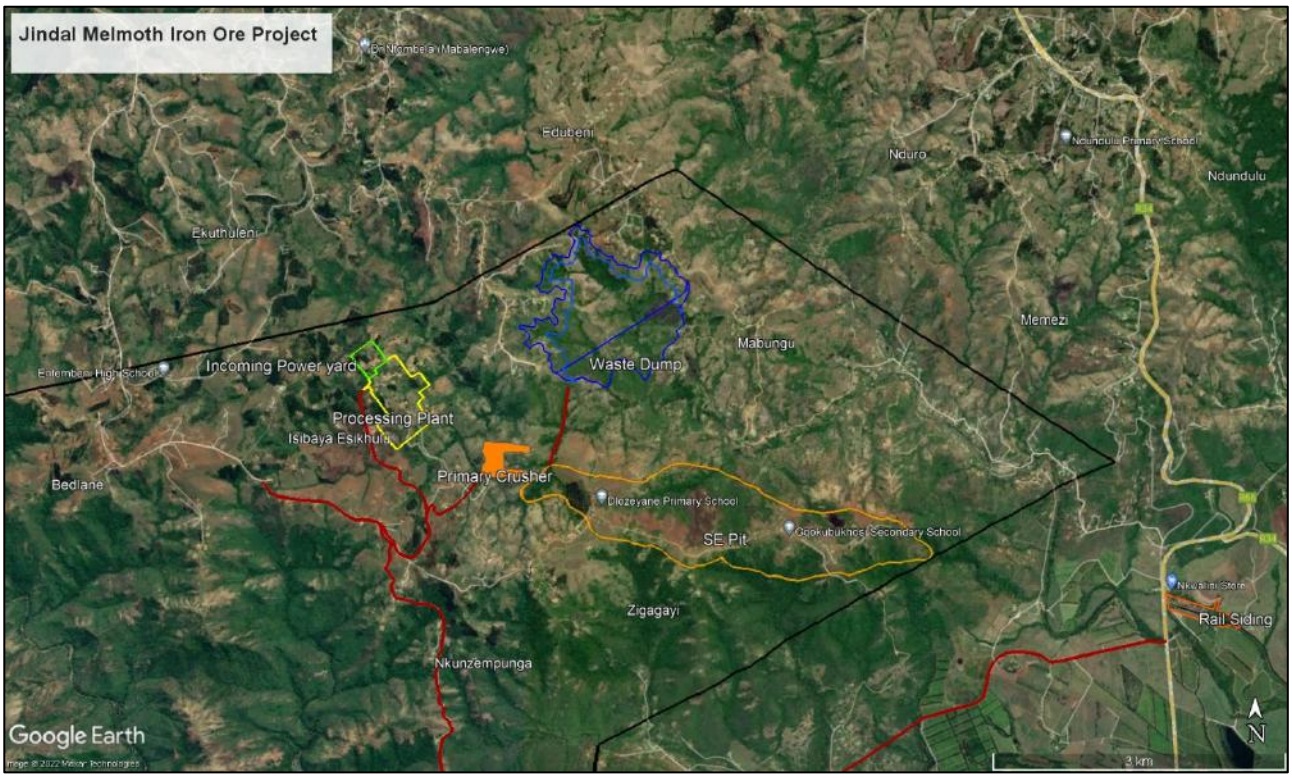

Figure 1: Jindal Melmoth Iron Ore Project - Conceptual Site Layout

6 Methodology

The detailed plan of study consists of the following sections:

- Site visit: Intention to understand location of the site and its surroundings.
- Identifying surface structures / installations that are found within reason from project site. A list of Point of Interests (POI's) is created that will be used for evaluation.
- Base line influence or Blast Monitoring: The project is evaluated as a new operation with no blasting activities currently being done in the project area specific. Information from similar type operations were considered.
- Site evaluation: This consists of evaluation of the mining operations and the possible influences from blasting operations. The methodology is modelling the expected impact based on the expected drilling and blasting information provided for the project. Various accepted mathematical equations are applied to determine the attenuation of ground vibration, air blast and fly rock. These values are then calculated over the distance investigated from site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors then gives an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels then gives an indication of the possible mitigation measures to be applied. The possible environmental or social impacts are then addressed in the detailed EIA phase investigation.
- Reporting: All data is prepared in a single report and provided for review.

7 Site Investigation

The site was visited on 6 December 2021. This site visit was done to get understanding of the location and the structures and installations surrounding the proposed new pit areas.

8 Season applicable to the investigation

The drilling and blasting operations are not season dependable. The investigation into the possible effects from blasting operations is not season bounded.

9 Assumptions and Limitations

The following assumptions have been made:

- The project consists of new pit area where no mining is currently being conducted.
- The anticipated levels of influence estimated in this report are calculated using standard accepted methodology according to international and local regulations.
- The assumption is made that the predictions are a good estimate with significant safety factors to ensure that expected levels are based on worst case scenarios. These will have to be confirmed with actual measurements once the operation is active.
- Drilling and blast designs from was provided by the client.
- The work done is based on the author's knowledge and information provided by the project applicant.

10 Legal Requirements

The protocols applied in this document are based on the author's experience, guidelines elicited by the literature research, client requirements and general indicators provided in the various applicable South African acts. There is no direct reference in the consulted acts specifically with regard to limiting levels for ground vibration and air blast. There is however specific requirements and regulations with regards to blasting operations and the effect of ground vibration and air blast and some of the aspects addressed in this report. The acts consulted are: National Environmental Management Act No. 107 of 1998; Mine Health and Safety Act No. 29 of 1996; Mineral and Petroleum Resources Development Act No. 28 of 2002; and the Explosives Act No. 15 of 2003.

The guidelines and safe blasting criteria applied in this study are as per internationally accepted standards, and specifically the United States Bureau of Mines (USBM) criteria for safe blasting for ground vibration and the recommendations on air blast. There are no specific South African standards and the USBM is well accepted as standard for South Africa. Additional criteria required by various institutions in South Africa was also taken into consideration, i.e. Eskom, Telkom, Transnet, Rand Water Board, etc.

In view of the acts consulted, the following guidelines and regulations are noted: (where possible detail was omitted and only some of the information indicated)

- **MINE HEALTH AND SAFETY ACT 29 OF 1996**

(Gazette No.17242, Notice No. 967 dated 14 June 1996. Commencement date: 15 January 1997 for all sections with the exception of sections 86(2) and (3), which came into operation on 15 January 1998, [Proc.No.4, Gazette No. 17725])

MINE HEALTH AND SAFETY REGULATIONS

CHAPTER 4 EXPLOSIVES

Precautionary measures before initiating explosive charges:

4.7 The employer must take reasonable measures to ensure that when blasting takes place, air and ground vibrations, shock waves and fly material are limited to such an extent and at such a distance from any building, public thoroughfare, railway, power line or any place where persons congregate to ensure that there is no significant risk to the health or safety of persons.

General precautions

4.16 The employer must take reasonable measures to ensure that:

4.16(1) in any mine other than a coal mine, no explosive charges are initiated during the shift unless –

(a) such explosive charges are necessary for the purpose of secondary blasting or reinitiating the misfired holes in development faces;

(b) written permission for such initiation has been granted by a person authorised to do so by the employer; and

(c) reasonable precautions have been taken to prevent, as far as possible, any person from being exposed to smoke or fumes from such initiation of explosive charges;

4.16(2) no blasting operations are carried out within a horizontal distance of 500 metres of any public building, public thoroughfare, railway line, power line, any place where people congregate or any other structure, which it may be necessary to protect in order to prevent any significant risk, unless:

(a) a risk assessment has identified a lesser safe distance and any restrictions and conditions to be complied with;

(b) a copy of the risk assessment, restrictions and conditions contemplated, in paragraph (a) have been provided for approval to the Principal Inspector of Mines;

(c) shot holes written permission has been granted by the Principal Inspector of Mines; and

(d) any restrictions and conditions determined by the Principal Inspector of Mines are complied with.

CHAPTER 17 SURVEYING, MAPPING AND MINE PLANS

Safety Precautions

Responsibilities regarding safety precautions

17(5) The employer must take reasonable measures to ensure that the competent person referred to in regulation 17(2)(a) is at all times aware of-

(a) workings which are being advanced;

(b) surface structures or objects which may be affected by mining;

(c) workings which are being abandoned or closed down, in order to allow the final surveying thereof;

(d) all workings or any place on surface where there is, or is likely to be, a dangerous accumulation of fluid material, noxious or flammable gas; and

(e) safety pillars that are being, or have been, removed.

17(6) The employer must take reasonable measures to ensure that the competent person referred to in regulation 17(2)(a) in writing notifies the employer, which notification must be dated, of any workings being advanced to come within:

(a) a horizontal distance of 100 (one hundred) metres from reserve land, buildings, roads, railways, dams, waste dumps or any other structure whatsoever including structures beyond the mining boundaries, or from any surface, which it may be necessary to protect in order to prevent any significant risk.
(b) 50 (fifty) metres from any excavation, workings, restricted area or any other place where there is, or is likely to be a dangerous accumulation of fluid material, noxious or flammable gas. Such notification must include a sketch plan giving the distance to such place from the nearest survey station.
17(7) The employer must take reasonable measures to ensure that -
(a) no mining operations are carried out within a horizontal distance of 100 (one hundred) metres from reserve land, buildings, roads, railways, dams, waste dumps, or any other structure whatsoever including such structures beyond the mining boundaries, or any surface, which it may be necessary to protect in order to prevent any significant risk, unless a lesser distance has been determined safe by risk assessment and all restrictions and conditions determined in terms of the risk assessment are complied with;
(b) workings coming within 50 (fifty) metres, from any other excavation, workings, restricted area or any other place where there is, or is likely to be a dangerous accumulation of fluid material, noxious or flammable gas are mined subject to such restrictions and stopped at such positions as determined by risk assessment.
(c) where ground movement, as a result of mining operations, poses significant risk, an effective ground movement monitoring system is in place.
(d) survey records and plans relating to conditions described in paragraphs (a) and (b) above, are made available to the persons doing the risk assessment.
17(8) No person may erect, establish or construct any buildings, roads, railways, dams, waste dumps, reserve land, excavations or any other structures whatsoever within a horizontal distance of 100 (one hundred) metres from workings, unless a lesser distance has been determined safe -
(a) in the case of the employer, by risk assessment and all restrictions and conditions determined in terms of the risk assessment are complied with; or
(b) in the case of any other person, by a professional geotechnical specialist and all restrictions and conditions determined by him or her or by the Chief Inspector of Mines are complied with;
17(9) The person(s) responsible for activities in terms of regulations 17(7)(a) and 17(8) must –
(a) in the case of an employer, provide the Chief Inspector of Mines with the distance and accompanying restrictions and conditions for comment, and;
(b) in the case of other persons, provide the Chief Inspector of Mines with the distance and accompanying restrictions and conditions for approval.
17(10) No mining operations, erecting, establishment, or construction, as contemplated in regulations 17(7)(a) and 17(8) respectively, may take place until such written comment or approval, as referred to in 17(9)(a) and 17(9)(b), has been obtained.

- **MINERAL AND PETROLEUM RESOURCES DEVELOPMENT ACT 28 OF 2002**

(Gazette No. 23922, Notice No. 1273 dated 10 October 2002. Commencement date: 1 May 2004 [Proc. No. R25, Gazette No. 26264])
MINERAL AND PETROLEUM RESOURCES DEVELOPMENT REGULATIONS

67. Blasting, vibration and shock management and control
(1) A holder of a right or permit in terms of the Act must comply with the provisions of the Mine Health and Safety Act, 1996, (Act No. 29 of 1996), as well as other applicable law regarding blasting, vibration and shock management and control.
(2) An assessment of impacts relating to blasting, vibration and shock management and control, where applicable, must form part of the environmental impact assessment report and environmental management programme or the environmental management plan, as the case may be.

The Mine Health and Safety Act has specific requirements regarding blasting within 500 m and mining within 100 m from private installations. This will be addressed in the recommendations.

11 Sensitivity of Project

A review of the project and the surrounding areas is done before any specific analysis is undertaken and sensitivity mapping is done, based on typical areas and distance from the proposed mining area. This sensitivity map uses distances normally associated where possible influences may occur and where influence is expected to be very low or none. Three different areas were identified in this regard:

- A highly sensitive area of 500 m around the mining area. Normally, this 500 m area is considered an area that should be cleared of all people and animals prior to blasting. Levels of ground vibration and air blast are also expected to be higher closer to the pit area.
- An area 500 m to 1500 m around the pit area can be considered as being a medium sensitive area. In this area, the possibility of impact is still expected, but it is lower. The expected level of influence may be low, but there may still be reason for concern, as levels could be low enough not to cause structural damage but still upset people.
- An area greater than 1500 m is considered low sensitivity area. In this area, it is relatively certain that influences will be low with low possibility of damages and limited possibility to upset people.

Figure 2 shows the sensitivity mapping with the identified points of interest (POI) in the surrounding areas for the proposed Project area. The specific influences will be determined through the work done for this project in this report.

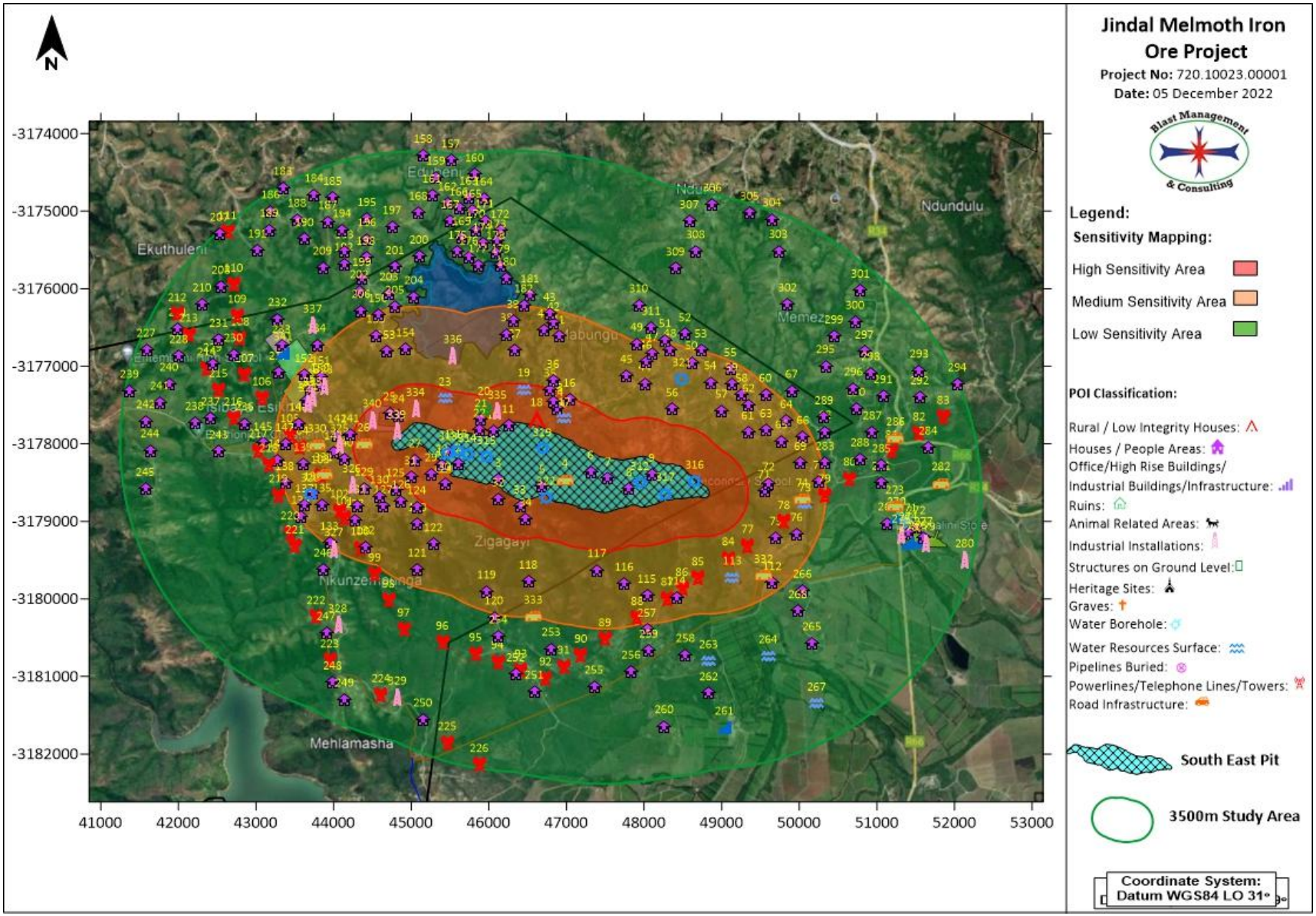

Figure 2: Identified sensitive areas for the Pit areas

12 Consultation process

No specific consultation with external parties was utilised. The work done is based on the author's knowledge and information provided by the client.

13 Influence from blasting operations

Blasting operations are required to break rock for excavation to access the targeted ore material. Explosives in blast holes provide the required energy to conduct the work. Ground vibration, air blast and fly rock are a result of the blasting process. Based on the regulations of the different acts consulted and international accepted standards these effects are required to be within certain limits. The following sections provide guidelines on these limits. As indicated, there are no specific South African ground vibration and air blast limit standard.

13.1 Ground vibration limitations on structures

Ground vibration is measured in velocity with units of millimetres per second (mm/s). Ground vibration can also be reported in units of acceleration or displacement if required. Different types of structures have different tolerances to ground vibration. A steel structure or a concrete structure will have a higher resistance to vibrations than a well-built brick and mortar house. A brick and mortar house will be more resistant to vibrations than a poorly constructed or a traditionally built mud house. Different limits are then applicable to the different types of structures. Limitations on ground vibration take the form of maximum allowable levels or intensity for different installations or structures. Ground vibration limits are also dependent on the frequency of the ground vibration. Frequency is the rate at which the vibration oscillates. Faster oscillation is synonymous with higher frequency and lower oscillation is synonymous with lower frequency. Lower frequencies are less acceptable than higher frequencies because structures have a low natural frequency. Significant ground vibration at low frequencies could cause increased structure vibrations due to the natural low frequency of the structure and this may lead to crack formation or damages.

Currently, the USBM criteria for safe blasting are applied as the industry standard where private structures are of concern. Ground vibration amplitude and frequency is recorded and analysed. The data is then evaluated accordingly. The USBM graph is used for plotting of data and evaluating the data. Figure 3 below provides a graphic representation of the USBM analysis for safe ground vibration levels. The USBM graph is divided mainly into two parts. The red lines in the figure are the USBM criteria:

- Analysed data displayed in the bottom half of the graph shows safe ground vibration levels,
- Analysed data displayed in the top half of the graph shows potentially unsafe ground vibration levels:

Added to the USBM graph is a blue line and green dotted line that represents 6 mm/s and 12.5 mm/s additional criteria that are applied by BM&C.

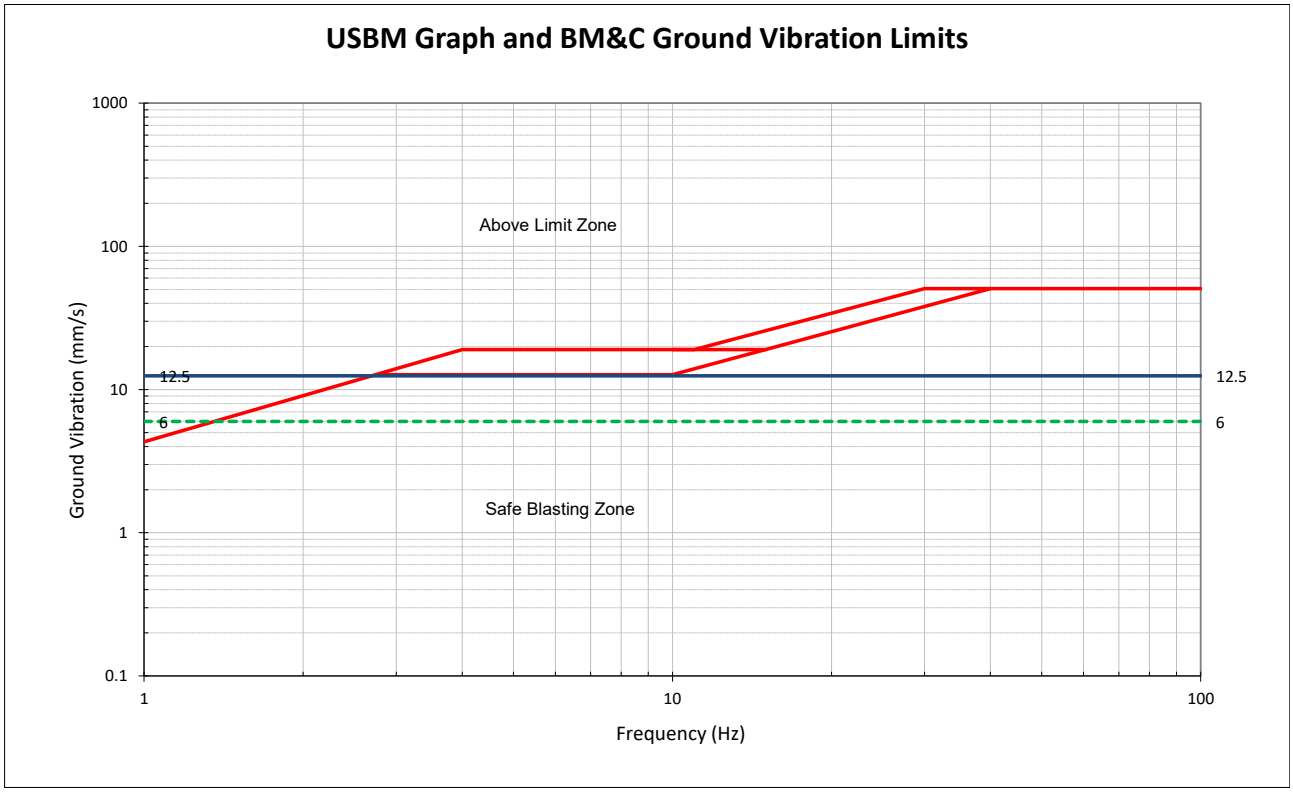

Figure 3: USBM Analysis Graph

The following additional limitations used by BMC in general and that should be considered were determined through research and prescribed by the various institutions; these are as follows:

- National roads/tar roads: 150 mm/s (BM&C).
- Steel pipelines: 50 mm/s (Rand Water Board).
- Electrical lines: 75 mm/s (Eskom).
- Sasol Pipelines: 25 mms/s (Sasol).
- Railways: 150 mm/s (BM&C).
- Concrete less than 3 days old: 5 mm/s [1].

[1] Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

- Concrete after 10 days: 200 mm/s [2].
- Sensitive plant equipment: 12 mm/s or 25 mm/s, depending on type. (Some switches could trip at levels of less than 25 mm/s.)[2].
- Waterwells or Boreholes: 50 mm/s [3].

Considering the above limitations, BMC work is based on the following:

- USBM criteria for safe blasting.
- The additional limits provided above.
- Consideration of private structures in the area of influence.
- Should structures be in poor condition, the basic limit of 25 mm/s is halved to 12.5 mm/s or when structures are in very poor condition limits will be restricted to 6 mm/s. It is a standard accepted method to reduce the limit allowed with poorer condition of structures.
- Traditionally built mud houses are limited to 6 mm/s. The 6 mm/s limit is used due to unknowns on how these structures will react to blasting. There is also no specific scientific data available that would indicate otherwise.
- Input from other consultants in the field locally and internationally.

13.2 Ground vibration limitations and human perceptions

A further aspect of ground vibration and frequency of vibration that must be considered is human perceptions. It should be realized that the legal limit set for structures is significantly greater than the comfort zone of human beings. Humans and animals are sensitive to ground vibration and the vibration of structures. Research has shown that humans will respond to different levels of ground vibration at different frequencies.

Ground vibration is experienced at different levels; BMC considers only the levels that are experienced as “Perceptible”, “Unpleasant” and “Intolerable”. This is indicative of the human being’s perceptions of ground vibration and clearly indicates that humans are sensitive to ground vibration and humans perceive ground vibration levels of 0.8 mm/s as perceptible (See Figure 4). This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.

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[2] Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.

[3] Berger P. R., & Associates Inc., Bradfordwoods, Pennsylvania, 15015, Nov 1980, Survey of Blasting Effects on Ground Water Supplies in Appalachia., Prepared for United States Department of Interior Bureau of Mines.

Indicated on Figure 4 is a blue solid line that indicates a ground vibration level of 12.5 mm/s and a green dotted line that indicates a ground vibration level of 6 mm/s. These are levels that are used in the evaluation.

Generally, people also assume that any vibration of a structure - windows or roofs rattling - will cause damage to the structure. An air blast is one of the causes of vibration of a structure and is the cause of nine out of ten complaints.

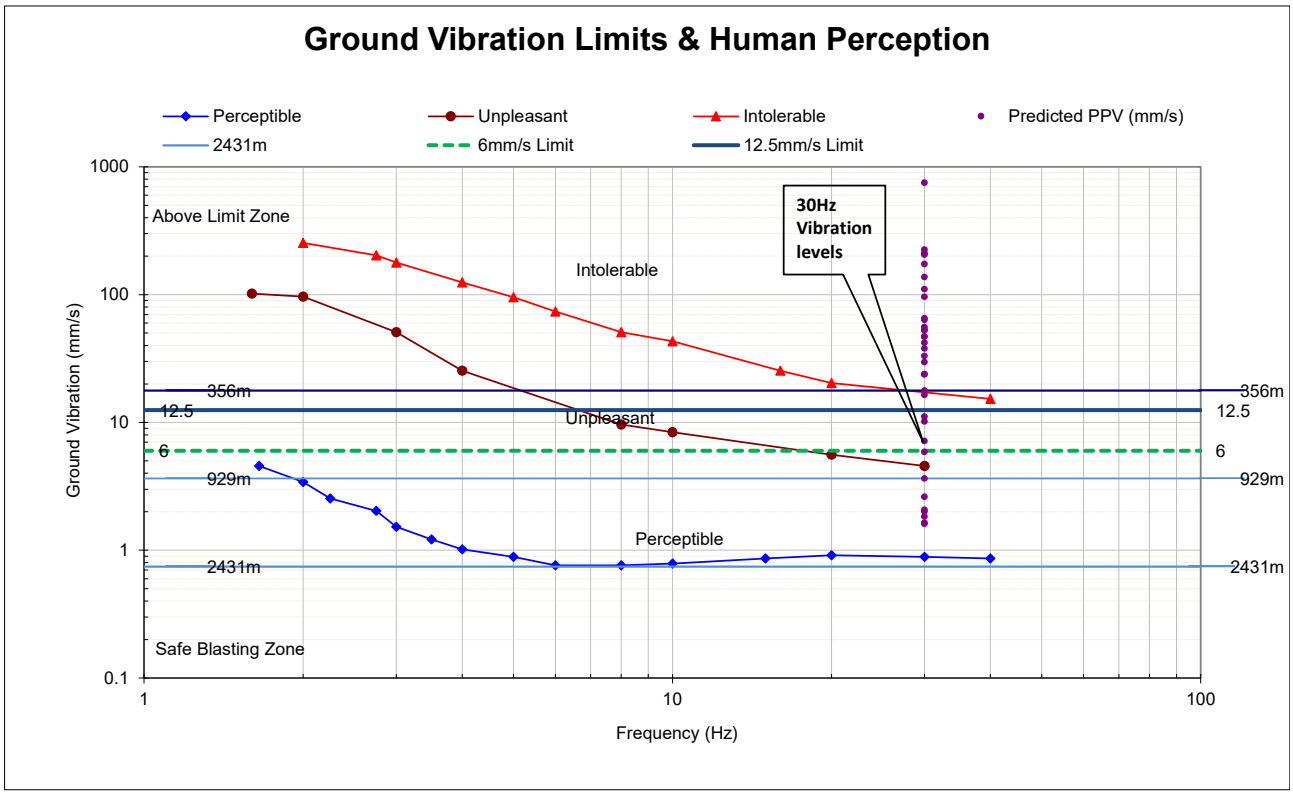


Figure 4: USBM Analysis with Human Perception

13.3 Air blast limitations on structures

Air blast or air-overpressure is a pressure wave generated from the blasting process. Air blast is measured as pressure in pascal (Pa) and reported as a decibel value (dBL). Air blast is normally associated with frequency levels less than 20 Hz, which is at the threshold for hearing. Air blast can be influenced by meteorological conditions such as, the final blast layout, timing, stemming, accessories used, blast covered by a layer of soil or not, etc. Air blast should not be confused with sound that is within the audible range (detected by the human ear). A blast does generate sound as well but for the purpose of possible damage capability we are only concerned with air blast in this report. The three main causes of air blasts can be observed as:

- Direct rock displacement at the blast; the air pressure pulse (APP).
- Vibrating ground some distance away from the blast; rock pressure pulse (RPP).
- Venting of blast holes or blowouts; the gas release pulse (GRP).

The general recommended limit for air blast currently applied in South Africa is 134dB. This is based on work done by the USBM. The USBM also indicates that the level is reduced to 128 dB in proximity of hospitals, schools and sensitive areas where people congregate. Based on work carried out by Siskind *et al.* (1980), monitored air blast amplitudes up to 135dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies. Persson *et al.* (1994) have published estimates of damage thresholds based on empirical data (Table 2). Levels given in Table 2 are at the point of measurement. The weakest points on a structure are the windows and ceilings.

Table 2: Damage Causing Levels for Air Blast

Level	Description
>130 dB	Resonant response of large surfaces (roofs, ceilings). Complaints start.
150 dB	Some windows break
170 dB	Most windows break
180 dB	Structural Damage

The following table showing summary of air blast limits applied in this report applicable:

Table 3: Air Blast Limits

Level	Description
<120 dB	Preferred levels to avoid complaints
120 dB	Bottom limit applied for start of complains
128 dB	USBM Proposed Limit for Schools and Hospitals
134 dB	Current RSA Limit

All attempts should be made to keep air blast levels from blasting operations well below 120dB where the public is of concern.

13.4 Air blast limitations and human perceptions

Considering human perceptions and the misunderstanding about ground vibration and air blast, BMC generally recommends that blasting be done in such a way that air blast levels are kept below 120 dB. This will ensure fewer complaints regarding blasting operations. The effect of air blast on structures that startle people will also be reduced, which in turn reduces the reasons for complaints. It is the effect on structures (like rattling windows, doors or a large roof surface) that startles people. These effects are sometimes erroneously identified as ground vibration and considered to be damaging the structure.

In this report, initial limits for evaluating conditions have been set at 120 dB, 120 dB to 134 dB and greater than 134 dB. The USBM limits for nuisance are 134 dB.

13.5 Fly rock

Blasting practices require some movement of rock to facilitate the excavation process. The extent of movement is dependent on the scale and type of operation. For example, blasting activities at large coal mines are designed to cast the blasted material over a greater distance than in quarries or hard rock operations. The movement should be in the direction of the free face, and therefore the orientation of the blast is important. Material or elements travelling outside of this expected range would be considered to be fly rock. Figure 5 shows schematic of fly rock definitions.

Fly rock can be categorised as follows:

- Throw - the planned forward movement of rock fragments that form the muck pile within the blast zone.
- Fly rock - the undesired propulsion of rock fragments through the air or along the ground beyond the blast zone by the force of the explosion that is contained within the blast clearance (exclusion) zone. When using this definition, fly rock, while undesirable, is only a safety hazard if a breach of the blast clearance (exclusion) zone occurs.
- Wild fly rock - the unexpected propulsion of rock fragments that travels beyond the blast clearance (exclusion) zone when there is some abnormality in a blast or a rock mass.

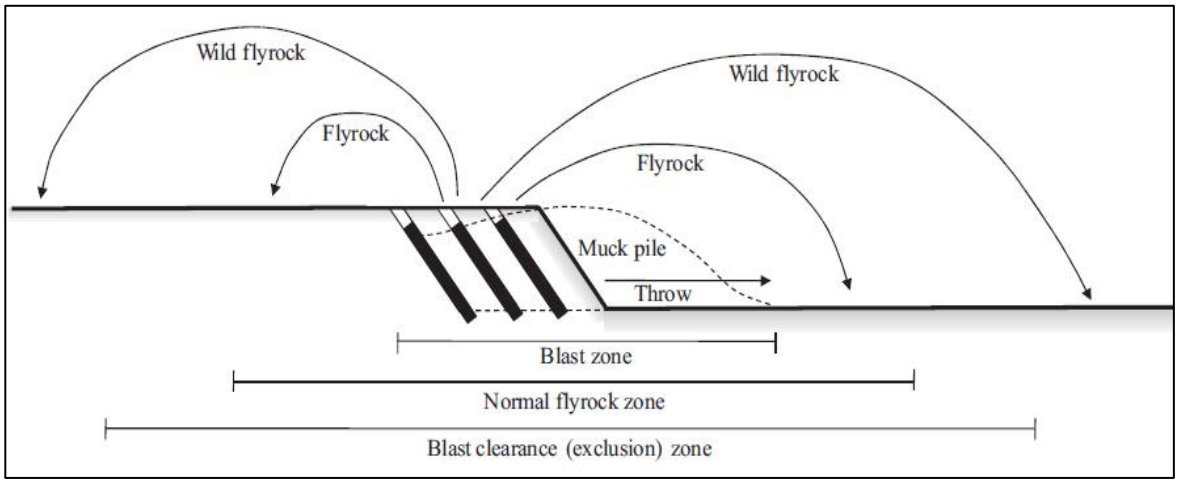


Figure 5: Schematic of fly rock terminology

Fly rock from blasting can result under the following conditions:

When burdens are too small, rock elements can be propelled out of the free face area of the blast.

When burdens are too large and movement of blast material is restricted and stemming length is not correct, rock elements can be forced upwards creating a crater forming fly rock.

If the stemming material is of poor quality or too little stemming material is applied, the stemming is ejected out of the blast hole, which can result in fly rock.

Stemming of correct type and length is required to ensure that explosive energy is efficiently used to its maximum and to control fly rock.

The occurrence of fly rock in any form will have impact if found to travel outside the safe boundary. If a road or structure or people or animals are within the safe boundary of a blast, irrespective of the possibility of fly rock or not, precautions should be taken to stop the traffic, remove people or animals for the period of the blast. The fact is that fly rock will cause damage to the road, vehicles or even death to people or animals. This safe boundary is determined by the appointed blaster or as per mine code of practice. BM&C uses a prediction calculation defined by the International Society of Explosives Engineers (ISEE) to assist with determining minimum distance.

13.6 Noxious Fumes

Explosives used in the mining environment are required to be oxygen balanced. Oxygen balance refers to the stoichiometry of the chemical reaction and the nature of gases produced from the detonation of the explosives. The creation of poisonous fumes such as nitrous oxides and carbon monoxide are particular undesirable. These fumes present themselves as red brown cloud after the blast has detonated. It has been reported that 10ppm to 20ppm can be mildly irritating. Exposure to 150 ppm or more (no time period given) has been reported to cause death from pulmonary oedema. It has been predicted that 50% lethality would occur following exposure to 174ppm for 1 hour. Anybody exposed must be taken to hospital for proper treatment.

Factors contributing to undesirable fumes are typically: poor quality control on explosive manufacture, damage to explosive, lack of confinement, insufficient charge diameter, excessive sleep time, water in blast holes, incorrect product used, or product not loaded properly, and specific types of rock/geology can also contribute to fumes.

13.7 Vibration impact on provincial and national roads

The influence of ground vibration on tarred roads are expected when levels is in the order of 150 mm/s and greater. Or when there is actual movement of ground when blasting is done too close to the road or subsidence is caused due to blasting operations. Normally 100 blast hole diameters are a minimum distance between structure and blast hole to prevent any cracks being formed into the surrounds of a blast hole. Crack forming is not restricted to this distance. Improper timing arrangements may also cause excessive back break and cracks further than expected. Fact remain that blasting must be controlled in the vicinity of roads. Air blast from blasting does not have influence on road surfaces. There is no record of influence on gravel roads due to ground vibration. The only time damage can be induced is when blasting is done next to the road and there is movement of ground. Fly rock will have greater influence on the road as damage from falling debris may impact on the road surface if no control on fly rock is considered.

13.8 Vibration will upset adjacent communities

The effects of ground vibration and air blast will have influence on people. These effects tend to create noises on structures in various forms and people react to these occurrences even at low levels. As with human perception given above – people will experience ground vibration at very low levels. These levels are well below damage capability for most structures.
Much work has also been done in the field of public relations in the mining industry. Most probably one aspect that stands out is “Promote good neighbour ship”. This is achieved through communication and more communication with the neighbours. Consider their concerns and address in a proper manner.

The first level of good practice is to avoid unnecessary problems. One problem that can be reduced is the public's reaction to blasting. Concern for a person's home, particularly where they own it, could be reduced by a scheme of precautionary, compensatory and other measures which offer guaranteed remedies without undue argument or excuse.

In general, it is also in an operator's financial interests not to blast where there is a viable alternative. Where there is a possibility of avoiding blasting, perhaps through new technology, this should be carefully considered in the light of environmental pressures. Historical precedent may not be a helpful guide to an appropriate decision.

Independent structural surveys are one way of ensuring good neighbour ship. There is a part of inherent difficulty in using surveys as the interpretation of changes in crack patterns that occur may be misunderstood. Cracks open and close with the seasonal changes of temperature, humidity and drainage, and numbers increase as buildings age. Additional actions need to be done in order to supplement the surveys as well.

The means of controlling ground vibration, overpressure and fly rock have many features in common and are used by the better operators. It is said that many of the practices also aid cost-effective production. Together these introduce a tighter regime which should reduce the incidence of fly rock and unusually high levels of ground vibration and overpressure. The measures include the need for the following:

- Correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charges which may increase vibration by a factor of two,
- The setting-out and drilling of blasts should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted,

- Correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental overcharging,
- Correct stemming will help control air blast and fly rock and will also aid the control of ground vibration. Controlling the length of the stemming column is important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used,
- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

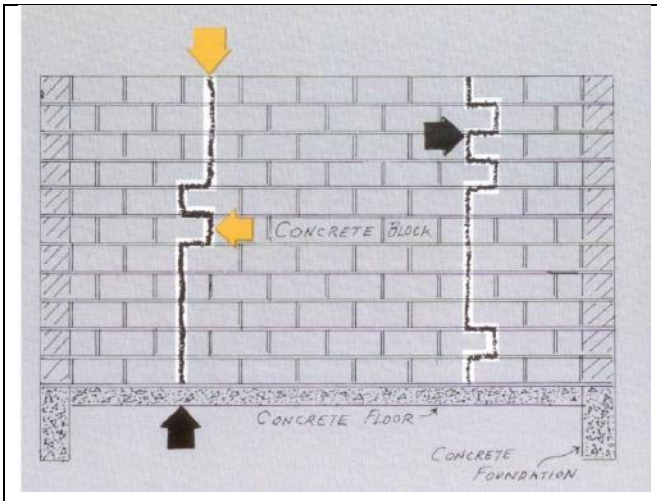
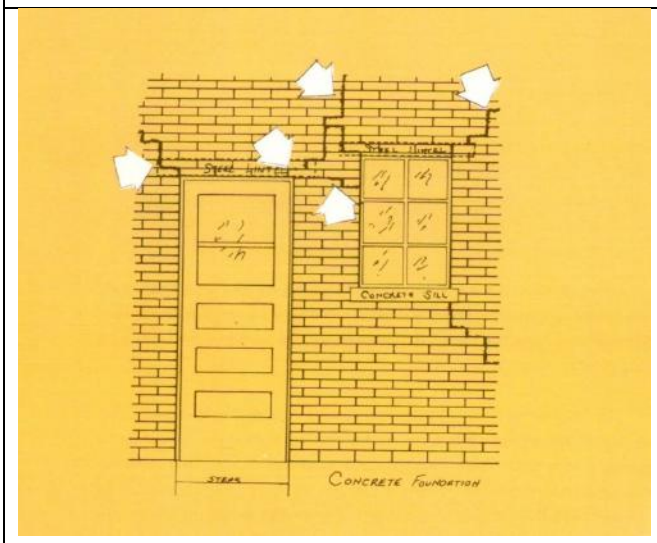
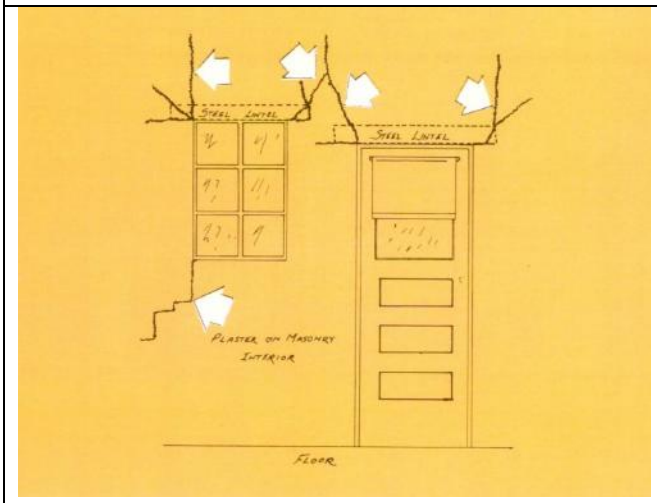
13.9 Cracking of houses and consequent devaluation

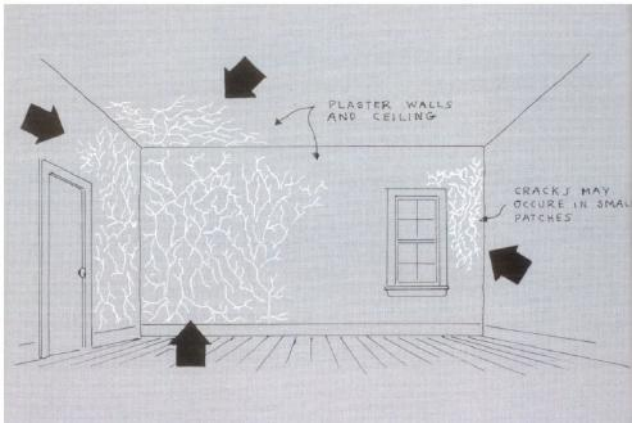
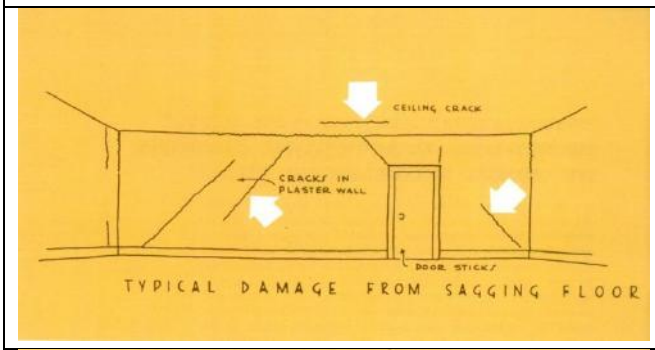
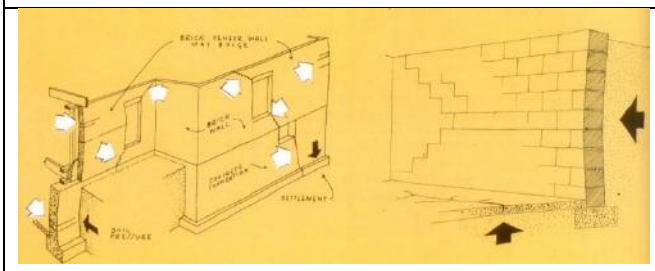
Houses in general have cracks. It is reported that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc. are more reason for cracks that have developed. Visual results of actual damage due to blasting operations are limited. There are cases where it did occur, and a result is shown in Figure 6 below. A typical X crack formation is observed.

Figure 6: Example of blast induced damage.

The table below with figures show illustrations of non-blasting damage that could be found.

Table 4: Examples of typical non-blasting cracks

	Cracks Resulting from Shrinkage of Concrete Blocks
	Typical Lintel Cracks
	Typical Lintel Cracks

	"Crazing" Cracks on Plaster
	Plaster Cracks Caused by Sagging Floors
	Cracks Resulting from Foundational Failure

Observing cracks in the form indicated in Figure 6 on a structure will certainly influence the value as structural damage has occurred. The presence of general vertical cracks or horizontal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Proper building standards are not always applied, and the general existence of cracks may be due to materials used. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. A property valuator will be required for this and I do believe that property value will include the total property and not just the house alone. Mining operations may not have influence to change the status quo of any property.

14 Baseline Results

Baseline work for this report normally consists of two parts. The first part is monitoring of blasting operations if the mine is operational. The second part of baseline work done is familiarising oneself with the surroundings and the typical structures that are found in the area of the project. The information for this is presented below.

14.1 Baseline influence

Currently there are no significant baseline data is available to be used for substantiating expected impacts from blasting operations.

14.2 Structure profile

As part of the baseline, all possible structures in a possible influence area are identified. The site was reviewed using Google Earth imagery. Information sought during the review was to identify surface structures present in a 3500 m radius from the proposed open pit areas, which will require consideration during modelling of blasting operations, e.g. houses, general structures, power lines, pipelines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the open pit area. The list includes structures and POI within the 3500 m boundary – see Table 6 below. A list of structure locations was required to determine the allowable ground vibration limits and air blast limits. Figure 2 shows an aerial view of the planned open pit area and surroundings with POIs. The type of POIs identified is grouped into different classes. These classes are indicated as "Classification" in Table 5. The classification used is a BM&C classification and does not relate to any standard or national or international code or practice. Table 5 shows the descriptions for the classifications used.

Table 5: POI Classification used

Class	Description
1	Rural Building and structures of poor construction
2	Private Houses and people sensitive areas
3	Office, High-rise buildings and Industrial buildings / Infrastructure
4	Ruins
5	Animal related installations and animal sensitive areas
6	Industrial Installations
7	Earth like structures – no surface structure
8	Heritage sites (buildings, infrastructure, activity)
9	Graves
10	Water Borehole
11	Water Resources Surface
12	Pipelines Buried
13	Powerlines / Telephone Lines / Towers
14	Road Infrastructure

Table 6: List of points of interest identified (WGS – LO 31°)

Tag	Description	Classification	Y	X
1	Buildings/Structures (Inside Pit Area)	2	-45471.50	3178089.56
2	Community Houses (Inside Pit Area)	2	-45606.98	3178265.25
3	Community Houses (Inside Pit Area)	2	-46126.78	3178462.14
4	D395 Road (Inside Pit Area)	14	-46985.72	3178467.74
5	Community Houses (Inside Pit Area)	2	-46688.65	3178541.17

Tag	Description	Classification	Y	X
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	2	-47314.73	3178361.05
7	Community Houses (Inside Pit Area)	2	-47535.67	3178445.80
8	Community Houses (Inside Pit Area)	2	-47808.92	3178581.09
9	Community Houses (Inside Pit Area)	2	-48102.69	3178396.09
10	Community Houses (Inside Pit Area)	2	-46056.36	3177841.06
11	Community Houses (Inside Pit Area)	2	-46250.59	3177765.37
12	D395 Road	14	-45408.14	3178312.40
13	D255 Road	14	-46880.02	3177490.67
14	Community Houses	2	-46884.02	3177554.37
15	Community Houses	2	-46839.82	3177463.16
16	Community Houses	2	-47042.32	3177429.40
17	River	11	-46976.10	3177673.56
18	Informal Housing	1	-46618.65	3177677.91
19	River	11	-46455.86	3177298.13
20	Ruins	4	-45941.19	3177533.28
21	Building/Structure	2	-45902.06	3177689.65
22	Buildings/Structures	2	-45884.38	3177816.32
23	River	11	-45438.38	3177414.23
24	Community Houses	2	-44840.13	3177631.90
25	Community Houses	2	-44723.29	3177602.28
26	Road	14	-44391.70	3178004.10
27	Buildings/Structures	2	-45052.48	3178206.54
28	Community Houses	2	-45393.59	3178279.01
29	Community Houses	2	-45259.31	3178390.20
30	Community Houses	2	-45434.19	3178509.93
31	Community Houses	2	-44995.16	3178432.12
32	Community Houses	2	-46126.58	3178709.87
33	Community Houses	2	-46401.76	3178805.60
34	Community Houses	2	-46476.01	3178970.41
35	Buildings/Structures	2	-46792.59	3177298.46
36	Community Houses	2	-46829.82	3177185.78
37	Community Houses	2	-46336.15	3176792.43
38	Community Houses	2	-46232.28	3176586.33
39	Community Houses	2	-46312.98	3176413.78
40	Community Houses	2	-46716.68	3176534.74
41	Community Houses	2	-46901.58	3176614.08
42	Community Houses	2	-46838.88	3176445.25
43	Community Houses	2	-46786.99	3176324.02
44	Community Houses	2	-48012.97	3177224.13
45	Community Houses	2	-47777.24	3177122.48
46	Community Houses	2	-48024.59	3176942.77
47	Community Houses	2	-48103.73	3176835.65
48	Community Houses	2	-48338.59	3176788.54
49	Community Houses	2	-47910.68	3176709.73
50	Community Houses	2	-48613.38	3176950.14
51	Community Houses	2	-48275.81	3176662.59

Tag	Description	Classification	Y	X
52	Community Houses	2	-48528.23	3176585.64
53	Community Houses	2	-48734.09	3176794.34
54	Community Houses	2	-48855.56	3177207.38
55	Community Houses	2	-49115.13	3177035.18
56	Community Houses	2	-48364.03	3177552.93
57	Community Houses	2	-48999.21	3177573.08
58	Community Houses	2	-49260.38	3177365.90
59	Community Houses	2	-49130.77	3177228.55
60	Community Houses	2	-49566.08	3177366.17
61	Community Houses	2	-49338.72	3177850.59
62	Community Houses	2	-49348.79	3177496.53
63	Buildings/Structures	2	-49576.24	3177823.09
64	Community Houses	2	-49838.06	3177704.87
65	Community Houses	2	-49773.66	3177967.35
66	Community Houses	2	-50048.91	3177907.84
67	Community Houses	2	-49904.43	3177315.40
68	Community Houses	2	-50336.87	3177842.92
69	Community Houses	2	-50017.85	3178246.50
70	Community Houses	2	-50261.83	3178488.63
71	Community Houses	2	-49551.15	3178607.43
72	Community Houses	2	-49605.93	3178512.42
73	River	11	-50075.14	3178780.18
74	Road	14	-50039.47	3178719.42
75	Farm Buildings/Structures	2	-49701.72	3179212.12
76	Buildings/Structures	2	-49968.37	3179160.82
77	Power Line/Pylon	13	-49336.95	3179311.43
78	Power Line/Pylon	13	-49802.87	3179006.16
79	Power Line/Pylon	13	-50328.80	3178661.51
80	Power Line/Pylon	13	-50652.44	3178448.50
81	Power Line/Pylon	13	-51191.89	3178095.03
82	Power Line/Pylon	13	-51547.34	3177862.20
83	Power Line/Pylon	13	-51858.45	3177653.67
84	Power Line/Pylon	13	-49087.44	3179477.26
85	Power Line/Pylon	13	-48696.60	3179732.28
86	Power Line/Pylon	13	-48491.56	3179867.68
87	Power Line/Pylon	13	-48302.50	3179992.65
88	Power Line/Pylon	13	-47914.82	3180245.26
89	Power Line/Pylon	13	-47498.92	3180520.32
90	Power Line/Pylon	13	-47188.75	3180726.17
91	Power Line/Pylon	13	-46964.98	3180871.35
92	Power Line/Pylon	13	-46733.03	3181021.62
93	Power Line/Pylon	13	-46416.46	3180919.04
94	Power Line/Pylon	13	-46114.44	3180808.48
95	Power Line/Pylon	13	-45829.96	3180709.62
96	Power Line/Pylon	13	-45403.11	3180561.53
97	Power Line/Pylon	13	-44905.84	3180391.58

Tag	Description	Classification	Y	X
98	Power Line/Pylon	13	-44713.81	3180019.37
99	Power Line/Pylon	13	-44532.37	3179679.45
100	Power Line/Pylon	13	-44344.18	3179342.80
101	Power Line/Pylon	13	-44134.63	3178957.44
102	Power Line/Pylon	13	-44078.87	3178859.67
103	Power Line/Pylon	13	-43832.70	3178416.56
104	Power Line/Pylon	13	-43563.78	3178047.48
105	Power Line/Pylon	13	-43440.08	3177886.48
106	Power Line/Pylon	13	-43078.51	3177411.73
107	Power Line/Pylon	13	-42855.54	3177109.61
108	Power Line/Pylon	13	-42798.41	3176639.97
109	Power Line/Pylon	13	-42761.31	3176346.71
110	Power Line/Pylon	13	-42714.50	3175944.65
111	Power Line/Pylon	13	-42637.09	3175268.93
112	Farm Buildings/Structures	2	-49653.86	3179793.87
113	Dam	11	-49140.90	3179721.81
114	Community Houses	2	-48417.34	3179980.29
115	Community Houses	2	-48037.82	3179956.77
116	Community Houses	2	-47745.98	3179802.53
117	Community Houses	2	-47393.99	3179628.01
118	Community Houses	2	-46510.60	3179773.19
119	Community Houses	2	-45973.94	3179902.49
120	Community Houses	2	-46068.91	3180235.80
121	Community Houses	2	-45078.93	3179619.27
122	Community Houses	2	-45289.56	3179294.13
123	Community Houses	2	-45084.08	3179033.52
124	Community Houses	2	-45074.29	3178814.09
125	Community Houses	2	-44801.19	3178586.79
126	Buildings/Structures	2	-44872.70	3178736.22
127	Community Houses	2	-44642.73	3178803.08
128	Community Houses	2	-44272.90	3178984.59
129	Community Houses	2	-44394.54	3178573.79
130	Community Houses	2	-44594.02	3178679.20
131	Community Houses	2	-44307.91	3178798.35
132	Community Houses	2	-44412.39	3179327.38
133	Community Houses	2	-43949.86	3179278.91
134	Community Houses	2	-43577.15	3178937.17
135	Buildings/Structure	2	-43855.77	3178784.31
136	Community Houses	2	-43736.66	3178630.85
137	Community Houses	2	-43628.29	3178792.67
138	Community Houses	2	-43374.99	3178504.89
139	Community Houses	2	-43608.94	3178256.50
140	Community Houses	2	-44138.21	3178197.73
141	Community Houses	2	-44216.79	3177885.02
142	Community Houses	2	-44049.13	3177890.51
143	Community Houses	2	-44003.36	3178112.42

Tag	Description	Classification	Y	X
144	Community Houses	2	-43279.30	3178206.73
145	Community Houses	2	-43092.12	3177991.54
146	Community Houses	2	-43552.19	3177739.68
147	Community Houses	2	-43374.59	3178005.59
148	Community Houses	2	-43654.59	3177446.49
149	Community Houses	2	-43695.62	3177300.01
150	Buildings/Structures	2	-43827.95	3177236.83
151	Community Houses	2	-43839.94	3177143.18
152	Community Houses	2	-43623.49	3177110.28
153	Community Houses	2	-44680.57	3176809.26
154	Community Houses	2	-44929.90	3176781.72
155	Community Houses	2	-44547.40	3176605.98
156	Community Houses	2	-44574.78	3176336.34
157	Community Houses	2	-45511.95	3174344.67
158	Community Houses	2	-45157.09	3174281.04
159	Community Houses	2	-45321.00	3174565.04
160	Community Houses	2	-45816.45	3174526.76
161	Community Houses	2	-45271.16	3174794.75
162	Community Houses	2	-45469.08	3174896.88
163	Buildings/Structures	2	-45742.57	3174821.19
164	Community Houses	2	-45933.49	3174834.19
165	Community Houses	2	-45790.78	3174989.26
166	Community Houses	2	-45615.40	3174964.38
167	Community Houses	2	-45502.68	3175128.63
168	School (Mxosheni Primary School)	2	-45094.56	3175020.67
169	Community Houses	2	-45653.40	3175343.09
170	Community Houses	2	-45834.67	3175251.29
171	Community Houses	2	-45949.50	3175119.30
172	Community Houses	2	-46145.89	3175253.84
173	Building/Structure	2	-46108.20	3175377.62
174	Community Houses	2	-45917.71	3175420.30
175	Community Houses	2	-45598.72	3175520.67
176	Community Houses	2	-45743.90	3175595.03
177	Community Houses	2	-45860.70	3175698.11
178	Community Houses	2	-46090.36	3175527.64
179	Community Houses	2	-46154.64	3175698.42
180	Community Houses	2	-46228.12	3175867.95
181	Community Houses	2	-46532.94	3176085.07
182	Community Houses	2	-46454.52	3176209.64
183	Community Houses	2	-43349.36	3174698.69
184	Community Houses	2	-43751.12	3174787.86
185	Community Houses	2	-43989.61	3174824.91
186	Community Houses	2	-43192.26	3175000.47
187	Community Houses	2	-43926.69	3175134.81
188	Community Houses	2	-43532.28	3175108.42
189	Community Houses	2	-43173.34	3175239.75

Tag	Description	Classification	Y	X
190	Community Houses	2	-43627.02	3175358.44
191	Community Houses	2	-43023.35	3175503.84
192	Community Houses	2	-44136.50	3175679.18
193	Community Houses	2	-44141.90	3175514.39
194	Community Houses	2	-44112.55	3175241.15
195	Community Houses	2	-44432.33	3175099.34
196	Community Houses	2	-44433.37	3175360.16
197	Community Houses	2	-44755.27	3175199.54
198	Community Houses	2	-44419.94	3175599.50
199	Community Houses	2	-44367.33	3175870.18
200	Community Houses	2	-45101.64	3175582.90
201	Community Houses	2	-44793.03	3175719.02
202	Community Houses	2	-44333.51	3176030.55
203	Community Houses	2	-44717.78	3176060.03
204	Community Houses	2	-45037.39	3176103.04
205	Community Houses	2	-44790.99	3176228.11
206	Community Houses	2	-44356.51	3176284.52
207	Community Houses	2	-42532.40	3175291.33
208	Community Houses	2	-42551.51	3175971.96
209	Community Houses	2	-43860.38	3175724.88
210	Community Houses	2	-42308.09	3176201.26
211	Community Houses	2	-41995.86	3176518.67
212	Power Line/Pylon	13	-41987.89	3176326.99
213	Power Line/Pylon	13	-42133.84	3176588.14
214	Power Line/Pylon	13	-42369.81	3177027.59
215	Power Line/Pylon	13	-42517.78	3177303.81
216	Power Line/Pylon	13	-42712.63	3177671.37
217	Power Line/Pylon	13	-43029.98	3178084.24
218	Power Line/Pylon	13	-43167.67	3178267.68
219	Power Line/Pylon	13	-43291.04	3178663.82
220	Power Line/Pylon	13	-43443.62	3179143.68
221	Power Line/Pylon	13	-43502.65	3179321.26
222	Power Line/Pylon	13	-43777.74	3180230.75
223	Power Line/Pylon	13	-43953.93	3180790.82
224	Power Line/Pylon	13	-44613.81	3181240.35
225	Power Line/Pylon	13	-45465.49	3181853.92
226	Power Line/Pylon	13	-45878.80	3182138.81
227	Community Houses	2	-41588.38	3176784.33
228	Community Houses	2	-42007.28	3176864.63
229	Buildings/Structures	2	-42444.37	3176970.39
230	Community Houses	2	-42710.85	3176847.04
231	Community Houses	2	-42521.68	3176656.80
232	Community Houses	2	-43281.92	3176389.68
233	Community Houses	2	-43332.19	3176736.44
234	Community Houses	2	-43784.81	3176722.89
235	Community Houses	2	-43292.62	3177082.34

Tag	Description	Classification	Y	X
236	Community Houses	2	-42855.64	3177736.54
237	Community Houses	2	-42418.39	3177668.74
238	Community Houses	2	-42211.99	3177729.09
239	Community Houses	2	-41374.41	3177314.02
240	Community Houses	2	-41883.38	3177222.78
241	Community Houses	2	-41761.30	3177467.04
242	Structure	2	-41580.62	3177705.87
243	Community Houses	2	-42523.02	3178098.96
244	Community Houses	2	-41637.42	3178084.53
245	Community Houses	2	-41576.91	3178580.14
246	Community Houses	2	-43869.59	3179618.38
247	Community Houses	2	-43906.08	3180434.93
248	Community Houses	2	-43990.42	3181075.67
249	Buildings/Structures	2	-44144.86	3181296.00
250	Community Houses	2	-45151.20	3181554.48
251	Community Houses	2	-46588.07	3181194.32
252	Community Houses	2	-46346.83	3180971.96
253	Buildings/Structures	2	-46806.33	3180642.56
254	Community Houses	2	-46123.75	3180482.46
255	Community Houses	2	-47357.58	3181130.28
256	Community Houses	2	-47836.29	3180934.41
257	Community Houses	2	-48039.30	3180395.27
258	Community Houses	2	-48535.85	3180720.02
259	Community Houses	2	-48061.57	3180664.19
260	Buildings/Structures	2	-48261.02	3181640.83
261	Industrial Structures	3	-49038.00	3181657.06
262	Buildings/Structures	2	-48835.40	3181215.53
263	Dam	11	-48833.43	3180798.56
264	River	11	-49600.27	3180735.13
265	Buildings/Structures	2	-50163.42	3180570.57
266	Building/Structure	2	-50043.54	3179890.44
267	Dam	11	-50223.96	3181348.14
268	Structure	2	-49982.46	3180156.55
269	Buildings/Structures	2	-51138.09	3179025.98
270	Clinic	3	-51253.98	3178959.00
271	Dam	11	-51396.36	3179040.09
272	Structure	2	-51509.79	3179071.75
273	R66 Road	14	-51232.10	3178808.28
274	Houses	2	-51405.46	3179149.86
275	Railway Line	6	-51315.96	3179180.17
276	Railway Buildings	3	-51528.07	3179265.17
277	Houses	2	-51601.12	3179214.67
278	Industrial Structures	3	-51411.06	3179286.04
279	Railway Line	6	-51636.65	3179283.94
280	Railway Line	6	-52130.79	3179497.77
281	Community Houses	2	-51058.32	3178498.44

Tag	Description	Classification	Y	X
282	R34 Road	14	-51828.82	3178508.11
283	Community Houses	2	-50334.85	3178242.44
284	Farm Buildings/Structures	2	-51662.44	3178044.23
285	Community Houses	2	-51062.51	3178272.97
286	R66 Road	14	-51243.25	3177930.19
287	Community Houses	2	-50942.60	3177849.61
288	Community Houses	2	-50784.63	3178197.69
289	Community Houses	2	-50320.24	3177656.26
290	Community Houses	2	-50731.85	3177547.41
291	Community Houses	2	-51082.02	3177383.57
292	Community Houses	2	-51552.62	3177399.11
293	Community Houses	2	-51547.74	3177055.43
294	Community Houses	2	-52038.25	3177228.66
295	Community Houses	2	-50338.27	3176994.80
296	Community Houses	2	-50700.91	3177285.90
297	Community Houses	2	-50839.37	3176807.42
298	Community Houses	2	-50920.52	3177089.48
299	Community Houses	2	-50449.52	3176611.40
300	Community Houses	2	-50720.75	3176425.37
301	Community Houses	2	-50790.41	3176021.91
302	Community Houses	2	-49851.88	3176200.14
303	Community Houses	2	-49733.34	3175511.84
304	Community Houses	2	-49650.68	3175103.50
305	Community Houses	2	-49362.92	3175020.69
306	Community Houses	2	-48882.02	3174909.41
307	Community Houses	2	-48585.46	3175127.15
308	Community Houses	2	-48665.26	3175515.07
309	Community Houses	2	-48406.32	3175736.03
310	Community Houses	2	-47931.37	3176211.61
311	Community Houses	2	-48094.92	3176501.21
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	10	-47948.00	3178503.01
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	10	-45477.00	3178118.01
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	10	-45725.00	3178140.01
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	10	-45975.00	3178172.01
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	10	-48654.00	3178483.01
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	10	-48278.00	3178645.01
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	10	-45606.00	3178086.01
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	10	-46690.00	3178068.01
320	Hydrocencus Borehole (GJ03)	10	-43703.00	3178652.01
321	Hydrocencus Borehole (MWGA02)	10	-48490.00	3177166.01
322	Hydrocencus Borehole (MWGA05)	10	-46741.00	3178691.01
323	Overland Piping (Planned)	6	-43873.94	3177254.72
324	Overland Piping (Planned)	6	-43673.68	3177491.38
325	Overland Piping (Planned)	6	-44077.32	3178011.43
326	Overland Piping (Planned)	6	-44237.08	3178534.46
327	Overland Piping (Planned)	6	-44004.67	3179355.88

Tag	Description	Classification	Y	X
328	Overland Piping (Planned)	6	-44056.77	3180336.47
329	Overland Piping (Planned)	6	-44823.20	3181269.06
330	Conceptual Plant Access Road (Planned)	14	-43790.53	3178016.81
331	Conceptual Plant Access Road (Planned)	14	-43873.75	3178387.14
332	Conceptual Plant Access Road (Planned)	14	-49542.18	3179700.45
333	Conceptual Plant Access Road (Planned)	14	-46574.28	3180226.14
334	Waste Rock Dump (Planned)	6	-45058.21	3177548.65
335	Waste Rock Dump (Planned)	6	-46111.46	3177583.02
336	Waste Rock Dump (Planned)	6	-45538.03	3176866.38
337	Waste Rock Dump (Planned)	6	-43731.63	3176470.60
338	Processing Plant (Planned)	6	-43727.45	3177415.61
339	Primary Crusher (Planned)	6	-44815.40	3177837.83
340	Primary Crusher (Planned)	6	-44498.45	3177695.09
341	Incoming Power Yard (Planned)	3	-43353.01	3176829.35

During the site visit the structures were observed and the initial POI list ground-truthed and finalised as represented in this section. Structures ranged from well-built structures to informal building styles.

Table 7: Structure Profile

Structure Photo	Description
	Community Houses

	Community Houses
	Dirt Road
	Thatched Roof/Community Houses
	Borehole

	
	Power Lines
	Reservoirs
	Wind Mill

	Farm Animal Structure
	Community Houses
	Structure
	Buildings/Structures

	C
	Community Houses
	
	Farm Animals

	
	Community Houses
	Community Houses
	Community Houses

	Building/Structure
	Borehole
	Building/Structure
	School

	Community Houses
	Dam
	Structure
	Dam

	Power Lines/Pylons
	Buildings/Structures
	Community Houses

15 Blasting Operations

In order to evaluate the possible influence from blasting operations with regards to ground vibration, air blast and fly rock a planned blast design is required to determine possible influences. In the mining process blasting will definitely be required.

Currently a final blast design for the project is not available but information from blasting operations during mining of the permit area was provided. Using this data JKSimblast blast design software was used to design and simulate the blast. This designed blast was applied for the evaluation done in this report. The simulation of the blast provided the best prediction possible. Table 8 shows summary technical information of the blast design presented. Figure 7 below shows planned hole design plan view. Figure 8 shows planned hole design side view.

Table 8: Blast design technical information

Design No.:	Planned		
Hole Diameter(mm)	171mm		
Burden(m)	4.4m		
Spacing(m)	5.1m		
Ave Hole Depth(m)	11.3m		
Sub drill/Sub grade	0.96m		
Stemming(m)	3.6m		
Explosive type	Emulsion		
Charge mass/meter (kg/m)	26.41		
Ave Charge length(m)	7.7		
Ave Charge mass(kg)	203.4		
Av in hole density	1.15		
Powder Factor (kg/m3)	0.81kg/m³		
Predictions from Design (BME)			
Charge Mass / Delay (kg)	**Distance to structure (m)**	**Ground Vibration (mm/s)**	**Air blast (dB)**
128.34 (4 hole firing)	500	2.21	116.92

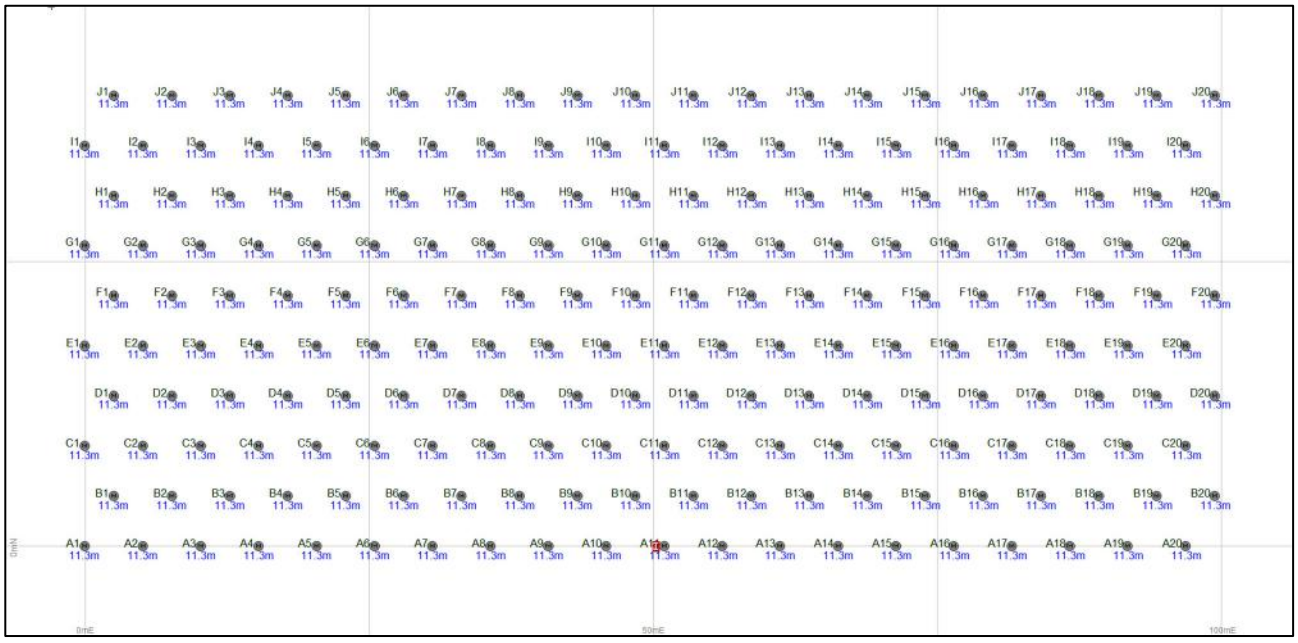


Figure 7: Blast Area with blastholes and depths

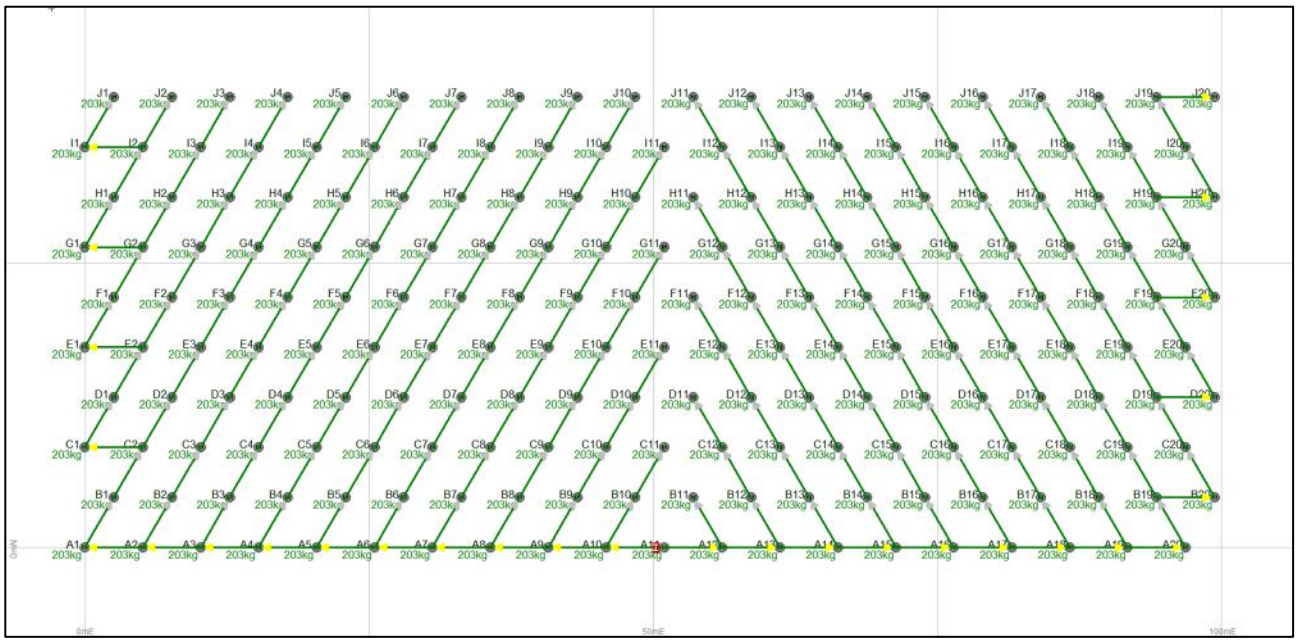


Figure 8: Blast Area with blastholes and charge per blasthole

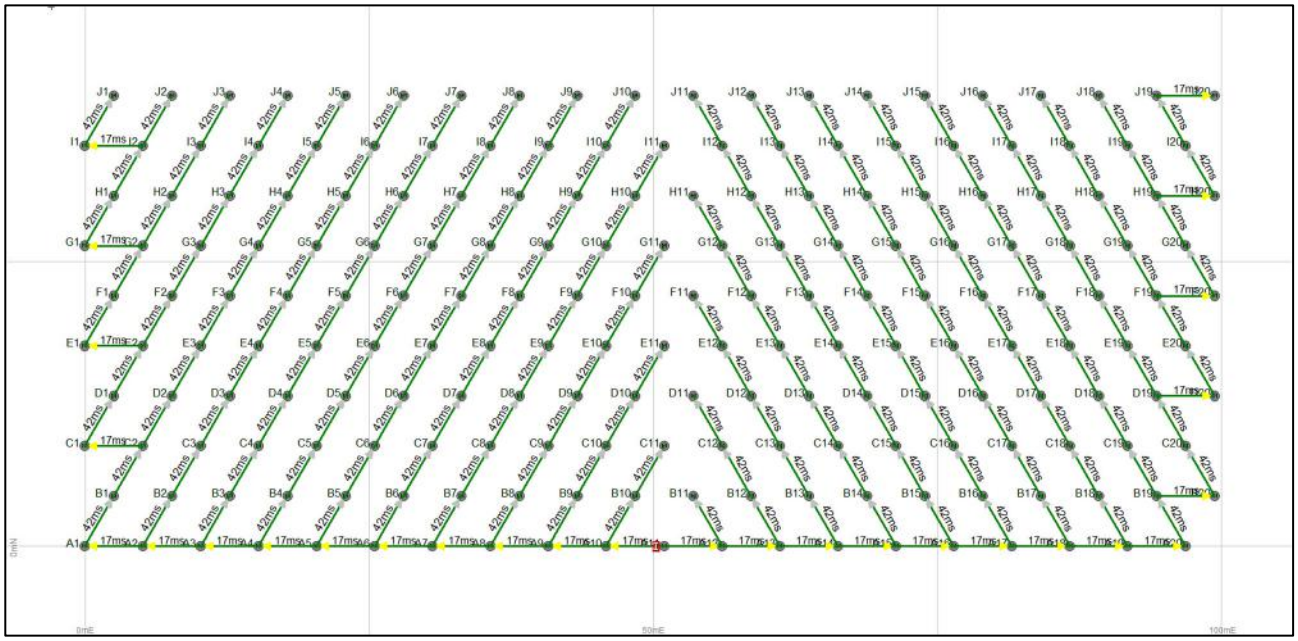


Figure 9: Blast Area with blastholes and blast timing

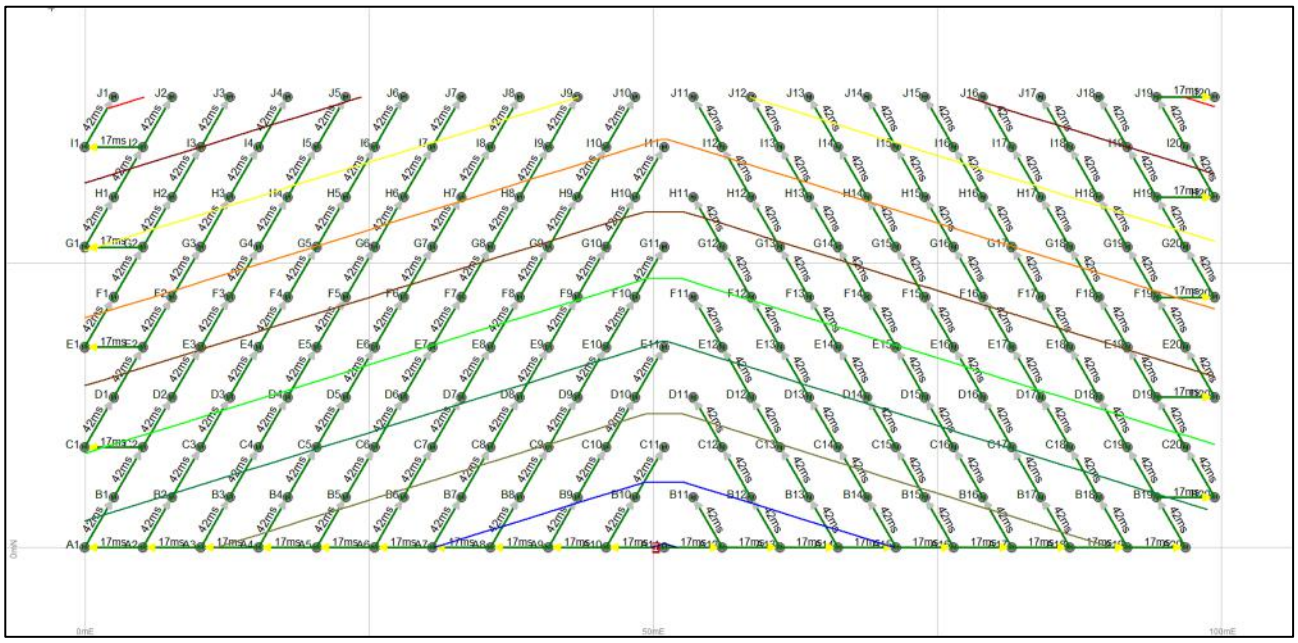


Figure 10: Blast simulated showing blast timing contours

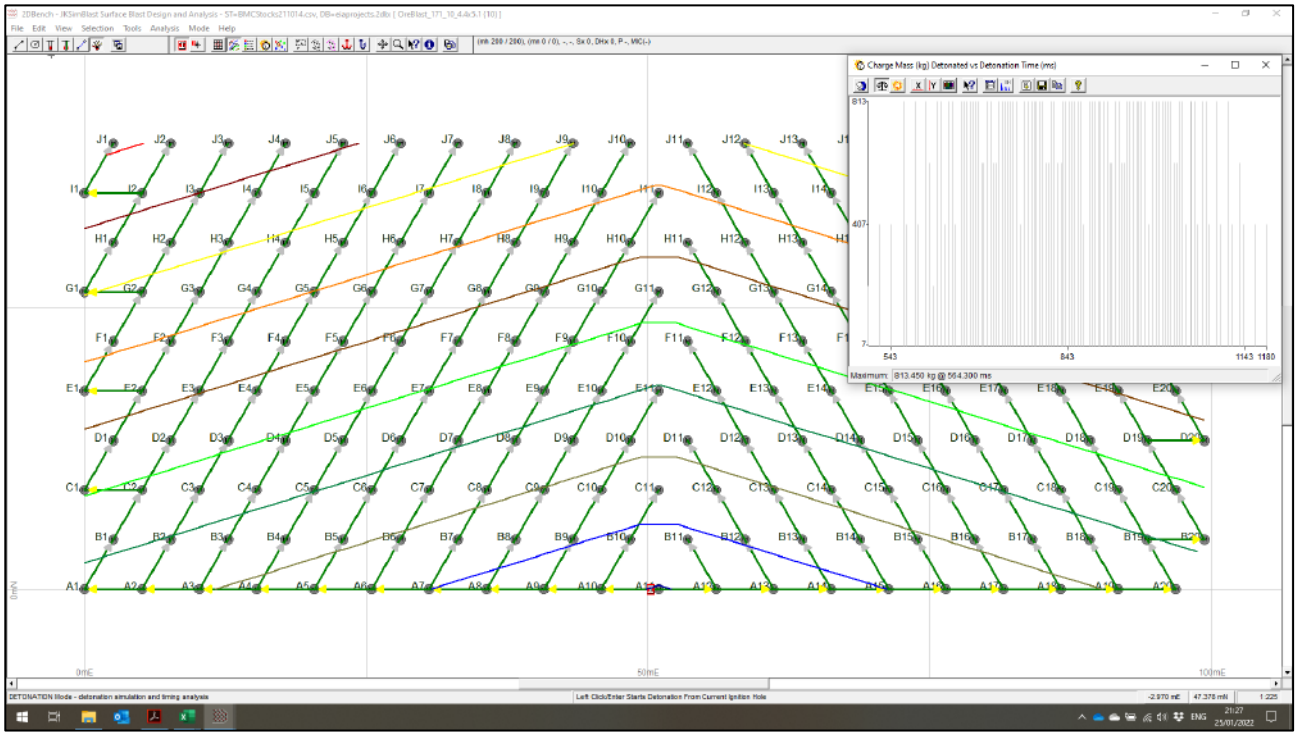


Figure 11: Blast simulated showing maximum charge mass per delay

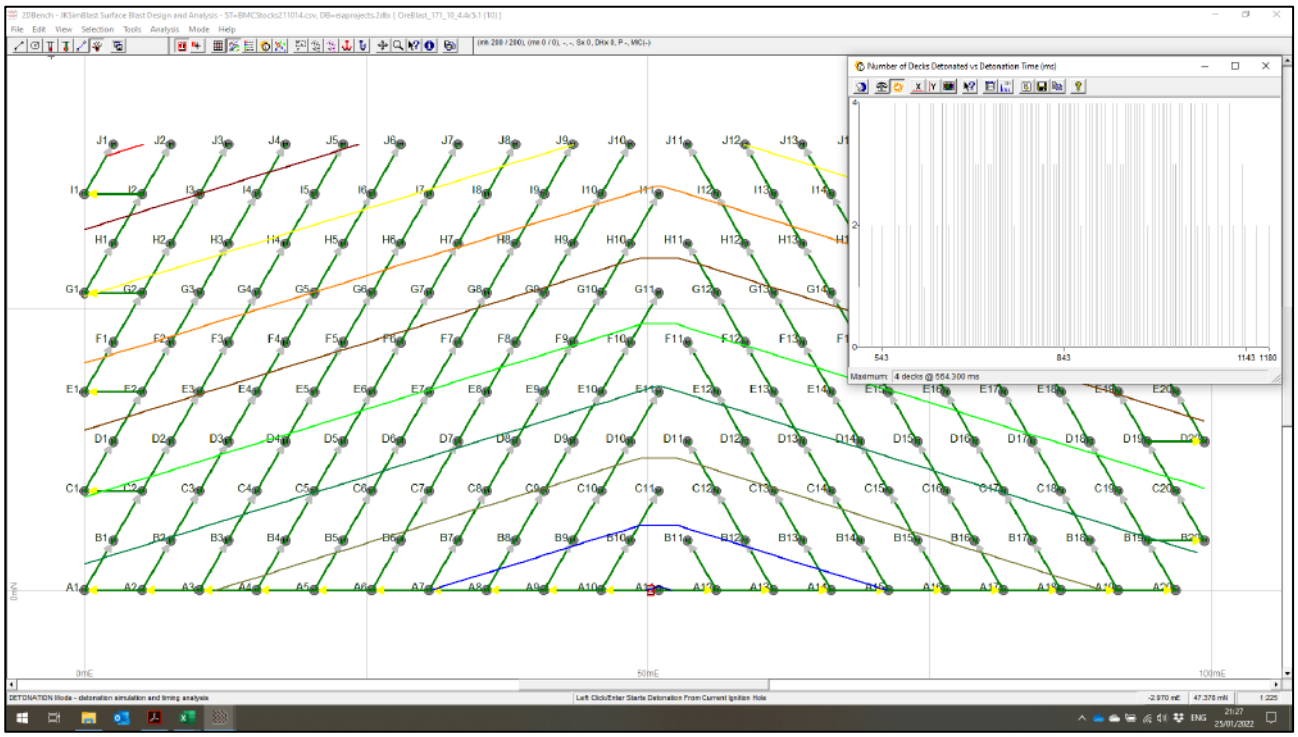


Figure 12: Blast simulated showing maximum number of blastholes per delay

The simulation work done provided information that is applied for predicting ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 171 mm diameter single blast hole and the maximum charge was extracted from the blast simulation in JKSimblast. The maximum charge relates to the total number of blast holes that detonates simultaneously based on the blast layout and initiation timing of the blast as per blast design provided. Thus, the maximum mass of explosives detonating at once. The minimum charge relates to 203.4 kg and the maximum charge relates to 813.5 kg. These values were applied in all predictions for ground vibration and air blast.

15.1 Ground Vibration

Predicting ground vibration and possible decay, a standard accepted mathematical process of scaled distance is used. The equation applied (Equation 1) uses the charge mass and distance with two site constants. The site constants are specific to a site where blasting is to be done. In the absence of measured values an acceptable standard set of constants is applied.

Equation 1:

$$PPV = a\left(\frac{D}{\sqrt{E}}\right)^{-b}$$

Where:

PPV = Predicted ground vibration (mm/s)

a = Site constant

b = Site constant

D = Distance (m)

E = Explosive Mass (kg)

Applicable and accepted factors a and b for new operations is as follows:
Factors:
a = 1143
b = -1.65

Utilizing the abovementioned equation and the given factors, allowable levels for specific limits and expected ground vibration levels can then be calculated for various distances.

Review of the type of structures that are found within the possible influence zone of the proposed mining area and the limitations that may be applicable, different limiting levels of ground vibration will be required. This is due to the typical structures and installations observed surrounding the site and location of the project area. Structure types and qualities vary greatly, and this calls for limits to be considered as follows: 6 mm/s, 12.5 mm/s levels and 25 mm/s at least.

Based on the designs presented on expected drilling and charging design, the following Table 9 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. The charge masses are 203.4 kg and 813.5 kg for the Pit area.

Table 9: Expected Ground Vibration at Various Distances from Charges Applied in this Study

No.	Distance (m)	Expected PPV (mm/s) for 203.4 kg Charge	Expected PPV (mm/s) for 813.5 kg Charge
1	50.0	144.3	452.7
2	100.0	73.9	231.9
3	150.0	23.5	73.9
4	200.0	14.6	46.0
5	250.0	10.1	31.8
6	300.0	7.5	23.5
7	400.0	4.7	14.6
8	500.0	3.2	10.1
9	600.0	2.4	7.5
10	700.0	1.9	5.8
11	800.0	1.5	4.7
12	900.0	1.2	3.8
13	1000.0	1.0	3.2
14	1250.0	0.7	2.2
15	1500.0	0.5	1.7
16	1750.0	0.4	1.3
17	2000.0	0.3	1.0
18	2500.0	0.2	0.7
19	3000.0	0.2	0.5
20	3500.0	0.1	0.1

15.2 Air blast

The prediction of air blast as a pre-operational effect is difficult to define exactly. There are many variables that have influence on the outcome of air blast. Air blast is the direct result from the blast process, although influenced by meteorological conditions, wind strength and direction, the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result. Air blast is also an aspect that can be controlled to a great degree by applying basic rules.
In most cases mainly an indication of typical levels can be obtained. The indication of levels or the prediction of air blast in this report is used to predefine possible indicators of concern.

Standard accepted prediction equations are applied for the prediction of air blast. A standard cube root scaling prediction formula is applied for air blast predictions. The following Equation 2 was used to calculate possible air blast values in millibar. This equation does not take temperature or any weather conditions into account.

Equation 2:

$$P = \mathrm{A} \times \left(\frac{\mathrm{D}}{\mathrm{E}^{\frac{1}{3}}}\right)^{-B}$$

Where:

P = Air blast level (mB)
D = Distance from source (m)
E = Maximum charge mass per delay (kg)
A = Constant - (14.3)
B = Constant – (-0.71)

The constants for A and B were then selected according to the information as provided in Figure 13 below. Various types of mining operations are expected to yield different results. The information provided in Figure 13 is based on detailed research that was conducted for each of the different types of mining environments. In this report, the data for “Metal Mine” was applied in the prediction or air blast.

Air Overpressure Prediction Equations

Blasting	Metric Equations mb	U.S. Equations psi	Statistical Type	Source
Open air (no confinement)	$P = 3589 \times SD_3^{-1.38}$	$P = 187 \times SD_3^{-1.38}$	Best Fit	Perkins
Coal mines (parting)	$P = 2596 \times SD_3^{-1.62}$	$P = 169 \times SD_3^{-1.62}$	Best Fit	USBM RI 8485
Coal mines (highwall)	$P = 5.37 \times SD_3^{-0.79}$	$P = 0.162 \times SD_3^{-0.79}$	Best Fit	USBM RI 8485
Quarry face	$P = 37.1 \times SD_3^{-0.97}$	$P = 1.32 \times SD_3^{-0.97}$	Best Fit	USBM RI 8485
Metal Mine	$P = 14.3 \times SD_3^{-0.71}$	$P = 0.401 \times SD_3^{-0.71}$	Best Fit	USBM RI 8485
Construction (average)	$P = 24.8 \times SD_3^{-1.1}$	$P = 1 \times SD_3^{-1.1}$	Best Fit	Oriard (2005)
Construction (highly confined)	$P = 2.48 \times SD_3^{-1.1}$	$P = 0.1 \times SD_3^{-1.1}$	Best Fit	Oriard (2005)
Buried (total confinement)	$P = 1.73 \times SD_3^{-0.96}$	$P = 0.061 \times SD_3^{-0.96}$	Best Fit	USBM RI 8485

Table 26.7 - Air overpressure prediction equations.

Figure 13: Proposed prediction equations

The air pressure calculated in Equation 2 is converted to decibels in Equation 3. The reporting of air blast in the decibel scale is more readily accepted in the mining industry.

Equation 3:

$$p_s = 20 \text{ x } \log \frac{P}{P_o}$$

Where:

p_s = Air blast level (dB)

P = Air blast level (Pa (mB x 100))

P_o = Reference Pressure (2 x 10^{-5} Pa)

Although the above equation was applied for prediction of air blast levels, additional measures are also recommended to ensure that air blast and associated fly-rock possibilities are minimized as best possible.

As discussed earlier the prediction of air blast is very subjective. Following in Table 10 below is a summary of values predicted according to Equation 2.

Table 10: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) for 203.4 kg Charge	Air blast (dB) for 813.5 kg Charge
1	50.0	143.8	146.7
2	100.0	141.3	144.2
3	150.0	137.1	139.9
4	200.0	135.3	138.1
5	250.0	133.9	136.8
6	300.0	132.8	135.6
7	400.0	131.0	133.9
8	500.0	129.7	132.5
9	600.0	128.5	131.4

No.	Distance (m)	Air blast (dB) for 203.4 kg Charge	Air blast (dB) for 813.5 kg Charge
10	700.0	127.6	130.4
11	800.0	126.7	129.6
12	900.0	126.0	128.9
13	1000.0	125.4	128.2
14	1250.0	124.0	126.8
15	1500.0	122.9	125.7
16	1750.0	121.9	124.8
17	2000.0	121.1	124.0
18	2500.0	119.7	122.6
19	3000.0	118.6	121.5
20	3500.0	117.7	114.7

16 Construction Phase: Impact Assessment and Mitigation Measures

During the construction phase no mining drilling and blasting operations is expected. No detail impact evaluation was done during the construction phase.

17 Operational Phase: Impact Assessment and Mitigation Measures

The area surrounding the proposed mining area was reviewed for structures, traffic, roads, human interface, animals' interface etc. Various installations and structures were observed. These are listed in Table 6. This section concentrates on the outcome of modelling the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces. In evaluation, the charge mass scenarios selected as indicated in section 14.2 is considered with regards to ground vibration and air blast.

Ground vibration and air blast was calculated from the edge of the pit outline and modelled accordingly. Blasting further away from the pit edge will certainly have lesser influence on the surroundings. A worst case is then applicable with calculation from pit edge. As explained previously reference is only made to some structures and these references covers the extent of all structures surrounding the mine.

The following aspects with comments are addressed for each of the evaluations done:

- Ground Vibration Modelling Results
- Ground Vibration and human perception
- Vibration impact on national and provincial road
- Vibration will upset adjacent communities
- Cracking of houses and consequent devaluation
- Air blast Modelling Results
- Impact of fly rock
- Noxious fumes Influence Results

Please note that this analysis does not take geology, topography or actual final drill and blast pattern into account. The data is based on good practise applied internationally and considered very good estimates based on the information provided and supplied in this document.

17.1 Review of expected ground vibration

Presented herewith are the expected ground vibration level contours and discussion of relevant influences. Expected ground vibration levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns and human perception. Tables are provided for each of the different charge models done with regards to:

- "Tag" No. is the number corresponding to the POI figures.
- "Description" indicates the type of the structure.
- "Distance" is the distance between the structure and edge of the pit area.
- "Specific Limit" is the maximum limit for ground vibration at the specific structure or installation.
- "Predicted PPV (mm/s)" is the calculated ground vibration at the structure.
- The "Structure Response @ 10Hz and Human Tolerance @ 30Hz" indicates the possible concern and if there is any concern for structural damage or potential negative human perception, respectively. Indicators used are "perceptible"," unpleasant", "intolerable" which stems from the human perception information given and indicators such as "high" or "low" is given for the possibility of damage to a structure. Levels below 0.76 mm/s could be considered to have negligible possibility of influence.

Ground vibration is calculated and modelled for the pit area at the minimum and maximum charge mass at specific distances from the opencast mining area. The charge masses applied are according to blast designs discussed in Section 15. These levels are then plotted and overlaid with current mining plans to observe possible influences at structures identified. Structures or POI's for consideration are also plotted in this model. Ground vibration predictions were done considering distances ranging from 50 m to 3500 m around the opencast mining area.

The simulation provided shows ground vibration contours only for a limited number of levels. The levels used are considered the basic limits that will be applicable for the type of structures observed surrounding the pit areas. These levels are: 6 mm/s, 12.5 mm/s, 25 mm/s and 50 mm/s. This enables immediate review of possible concerns that may be applicable to any of the privately-owned structures, social gathering areas or sensitive installations.

Data is provided as follows: Vibration contours; a table with predicted ground vibration values and evaluation for each POI. Additional colour codes used in the tables are as follows:

Structure Evaluations:
Vibration levels higher than proposed limit applicable to Structures / Installations is coloured "Red"
People's Perception Evaluation:
Vibration levels indicated as Intolerable on human perception scale is coloured "Red"
Vibration levels indicated as Unpleasant on human perception scale is coloured "Mustard"
Vibration levels indicated as Perceptible on human perception scale is coloured "Light Green"
POI's that are found inside the pit area is coloured "Olive Green"

Simulations for expected ground vibration levels from minimum and maximum charge mass are presented below.

17.1.1 Ground vibration minimum charge mass per delay – South East Pit – 203.4 kg

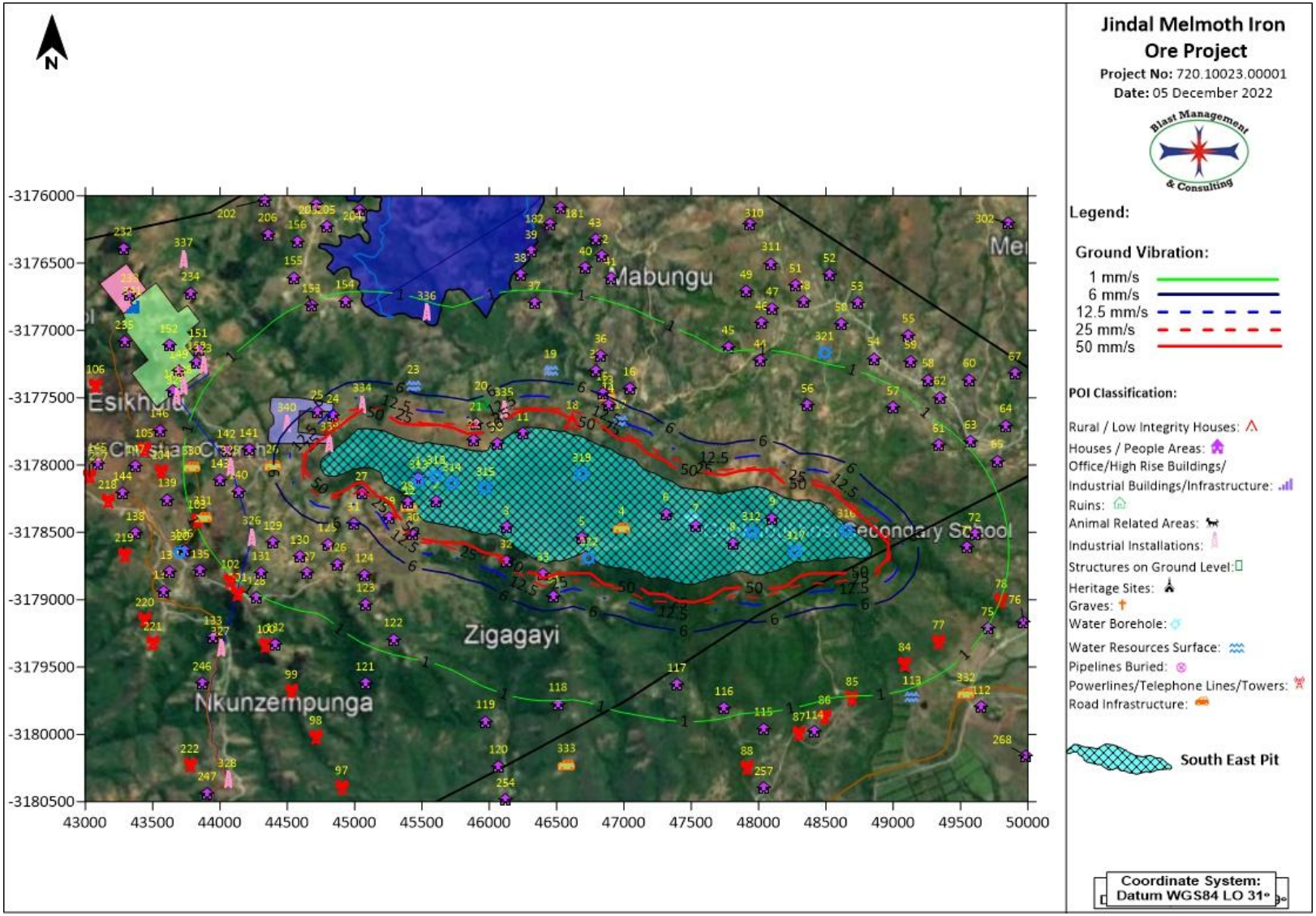


Figure 14: Ground vibration influence from minimum charge per delay

Table 11: Ground vibration evaluation for minimum charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Buildings/Structures (Inside Pit Area)	12.5	-	203.4	-	-	-
2	Community Houses (Inside Pit Area)	6	-	203.4	-	-	-
3	Community Houses (Inside Pit Area)	6	-	203.4	-	-	-
4	D395 Road (Inside Pit Area)	150	-	203.4	-	-	-
5	Community Houses (Inside Pit Area)	6	-	203.4	-	-	-
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	25	-	203.4	-	-	-
7	Community Houses (Inside Pit Area)	6	-	203.4	-	-	-
8	Community Houses (Inside Pit Area)	6	-	203.4	-	-	-
9	Community Houses (Inside Pit Area)	6	-	203.4	-	-	-
10	Community Houses (Inside Pit Area)	6	-	203.4	-	-	-
11	Community Houses (Inside Pit Area)	6	-	203.4	-	-	-
12	D395 Road	150	19	203.4	731.8	Problematic	N/A
13	D255 Road	150	350	203.4	5.8	Acceptable	N/A
14	Community Houses	6	297	203.4	7.6	Problematic	Unpleasant
15	Community Houses	6	356	203.4	5.7	Acceptable	Unpleasant
16	Community Houses	6	473	203.4	3.5	Acceptable	Perceptible
17	River	200	221	203.4	12.4	Acceptable	N/A
18	Informal Housing	6	89	203.4	55.2	Problematic	Intolerable
19	River	200	432	203.4	4.1	Acceptable	N/A
20	Ruins	6	318	203.4	6.8	Problematic	N/A
21	Building/Structure	12.5	197	203.4	15.0	Problematic	Unpleasant
22	Buildings/Structures	12.5	76	203.4	71.7	Problematic	Intolerable
23	River	200	393	203.4	4.8	Acceptable	N/A
24	Community Houses	6	198	203.4	14.9	Problematic	Unpleasant
25	Community Houses	6	299	203.4	7.6	Problematic	Unpleasant
26	Road	150	356	203.4	5.7	Acceptable	N/A
27	Buildings/Structures	12.5	184	203.4	16.8	Problematic	Unpleasant
28	Community Houses	6	20	203.4	659.8	Problematic	Intolerable
29	Community Houses	6	184	203.4	16.9	Problematic	Unpleasant
30	Community Houses	6	128	203.4	30.6	Problematic	Intolerable
31	Community Houses	6	373	203.4	5.2	Acceptable	Perceptible
32	Community Houses	6	118	203.4	35.2	Problematic	Intolerable

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
33	Community Houses	6	79	203.4	67.3	Problematic	Intolerable
34	Community Houses	6	244	203.4	10.5	Problematic	Unpleasant
35	Buildings/Structures	12.5	500	203.4	3.2	Acceptable	Perceptible
36	Community Houses	6	618	203.4	2.3	Acceptable	Perceptible
37	Community Houses	6	929	203.4	1.2	Acceptable	Perceptible
38	Community Houses	6	1135	203.4	0.8	Acceptable	Perceptible
39	Community Houses	6	1308	203.4	0.7	Acceptable	Too Low
40	Community Houses	6	1225	203.4	0.7	Acceptable	Too Low
41	Community Houses	6	1185	203.4	0.8	Acceptable	Perceptible
42	Community Houses	6	1334	203.4	0.6	Acceptable	Too Low
43	Community Houses	6	1443	203.4	0.6	Acceptable	Too Low
44	Community Houses	6	939	203.4	1.1	Acceptable	Perceptible
45	Community Houses	6	1057	203.4	0.9	Acceptable	Perceptible
46	Community Houses	6	1220	203.4	0.7	Acceptable	Too Low
47	Community Houses	6	1331	203.4	0.6	Acceptable	Too Low
48	Community Houses	6	1415	203.4	0.6	Acceptable	Too Low
49	Community Houses	6	1455	203.4	0.6	Acceptable	Too Low
50	Community Houses	6	1332	203.4	0.6	Acceptable	Too Low
51	Community Houses	6	1525	203.4	0.5	Acceptable	Too Low
52	Community Houses	6	1659	203.4	0.4	Acceptable	Too Low
53	Community Houses	6	1509	203.4	0.5	Acceptable	Too Low
54	Community Houses	6	1147	203.4	0.8	Acceptable	Perceptible
55	Community Houses	6	1408	203.4	0.6	Acceptable	Too Low
56	Community Houses	6	695	203.4	1.9	Acceptable	Perceptible
57	Community Houses	6	885	203.4	1.3	Acceptable	Perceptible
58	Community Houses	6	1208	203.4	0.8	Acceptable	Too Low
59	Community Houses	6	1246	203.4	0.7	Acceptable	Too Low
60	Community Houses	6	1410	203.4	0.6	Acceptable	Too Low
61	Community Houses	6	884	203.4	1.3	Acceptable	Perceptible
62	Community Houses	6	1173	203.4	0.8	Acceptable	Perceptible
63	Buildings/Structures	12.5	1065	203.4	0.9	Acceptable	Perceptible
64	Community Houses	6	1339	203.4	0.6	Acceptable	Too Low
65	Community Houses	6	1132	203.4	0.8	Acceptable	Perceptible
66	Community Houses	6	1398	203.4	0.6	Acceptable	Too Low
67	Community Houses	6	1659	203.4	0.4	Acceptable	Too Low
68	Community Houses	6	1684	203.4	0.4	Acceptable	Too Low
69	Community Houses	6	1236	203.4	0.7	Acceptable	Too Low
70	Community Houses	6	1429	203.4	0.6	Acceptable	Too Low
71	Community Houses	6	712	203.4	1.8	Acceptable	Perceptible
72	Community Houses	6	774	203.4	1.6	Acceptable	Perceptible
73	River	200	1243	203.4	0.7	Acceptable	N/A
74	Road	150	1202	203.4	0.8	Acceptable	N/A
75	Farm Buildings/Structures	12.5	1026	203.4	1.0	Acceptable	Perceptible
76	Buildings/Structures	12.5	1238	203.4	0.7	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
77	Power Line/Pylon	75	815	203.4	1.4	Acceptable	N/A
78	Power Line/Pylon	75	1027	203.4	1.0	Acceptable	N/A
79	Power Line/Pylon	75	1489	203.4	0.5	Acceptable	N/A
80	Power Line/Pylon	75	1821	203.4	0.4	Acceptable	N/A
81	Power Line/Pylon	75	2411	203.4	0.2	Acceptable	N/A
82	Power Line/Pylon	75	2812	203.4	0.2	Acceptable	N/A
83	Power Line/Pylon	75	3170	203.4	0.2	Acceptable	N/A
84	Power Line/Pylon	75	836	203.4	1.4	Acceptable	N/A
85	Power Line/Pylon	75	1040	203.4	1.0	Acceptable	N/A
86	Power Line/Pylon	75	1141	203.4	0.8	Acceptable	N/A
87	Power Line/Pylon	75	1211	203.4	0.7	Acceptable	N/A
88	Power Line/Pylon	75	1417	203.4	0.6	Acceptable	N/A
89	Power Line/Pylon	75	1634	203.4	0.5	Acceptable	N/A
90	Power Line/Pylon	75	1862	203.4	0.4	Acceptable	N/A
91	Power Line/Pylon	75	2045	203.4	0.3	Acceptable	N/A
92	Power Line/Pylon	75	2231	203.4	0.3	Acceptable	N/A
93	Power Line/Pylon	75	2189	203.4	0.3	Acceptable	N/A
94	Power Line/Pylon	75	2103	203.4	0.3	Acceptable	N/A
95	Power Line/Pylon	75	2067	203.4	0.3	Acceptable	N/A
96	Power Line/Pylon	75	2085	203.4	0.3	Acceptable	N/A
97	Power Line/Pylon	75	2071	203.4	0.3	Acceptable	N/A
98	Power Line/Pylon	75	1796	203.4	0.4	Acceptable	N/A
99	Power Line/Pylon	75	1605	203.4	0.5	Acceptable	N/A
100	Power Line/Pylon	75	1342	203.4	0.6	Acceptable	N/A
101	Power Line/Pylon	75	1097	203.4	0.9	Acceptable	N/A
102	Power Line/Pylon	75	1055	203.4	0.9	Acceptable	N/A
103	Power Line/Pylon	75	999	203.4	1.0	Acceptable	N/A
104	Power Line/Pylon	75	1185	203.4	0.8	Acceptable	N/A
105	Power Line/Pylon	75	1311	203.4	0.7	Acceptable	N/A
106	Power Line/Pylon	75	1763	203.4	0.4	Acceptable	N/A
107	Power Line/Pylon	75	2082	203.4	0.3	Acceptable	N/A
108	Power Line/Pylon	75	2363	203.4	0.2	Acceptable	N/A
109	Power Line/Pylon	75	2566	203.4	0.2	Acceptable	N/A
110	Power Line/Pylon	75	2867	203.4	0.2	Acceptable	N/A
111	Power Line/Pylon	75	3421	203.4	0.1	Acceptable	N/A
112	Farm Buildings/Structures	12.5	1391	203.4	0.6	Acceptable	Too Low
113	Dam	50	1085	203.4	0.9	Acceptable	N/A
114	Community Houses	6	1229	203.4	0.7	Acceptable	Too Low
115	Community Houses	6	1141	203.4	0.8	Acceptable	Perceptible
116	Community Houses	6	946	203.4	1.1	Acceptable	Perceptible
117	Community Houses	6	747	203.4	1.7	Acceptable	Perceptible
118	Community Houses	6	1046	203.4	1.0	Acceptable	Perceptible
119	Community Houses	6	1255	203.4	0.7	Acceptable	Too Low
120	Community Houses	6	1548	203.4	0.5	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
121	Community Houses	6	1283	203.4	0.7	Acceptable	Too Low
122	Community Houses	6	910	203.4	1.2	Acceptable	Perceptible
123	Community Houses	6	757	203.4	1.6	Acceptable	Perceptible
124	Community Houses	6	591	203.4	2.5	Acceptable	Perceptible
125	Community Houses	6	503	203.4	3.2	Acceptable	Perceptible
126	Buildings/Structures	12.5	654	203.4	2.1	Acceptable	Perceptible
127	Community Houses	6	739	203.4	1.7	Acceptable	Perceptible
128	Community Houses	6	1045	203.4	1.0	Acceptable	Perceptible
129	Community Houses	6	634	203.4	2.2	Acceptable	Perceptible
130	Community Houses	6	633	203.4	2.2	Acceptable	Perceptible
131	Community Houses	6	868	203.4	1.3	Acceptable	Perceptible
132	Community Houses	6	1306	203.4	0.7	Acceptable	Too Low
133	Community Houses	6	1466	203.4	0.5	Acceptable	Too Low
134	Community Houses	6	1481	203.4	0.5	Acceptable	Too Low
135	Buildings/Structure	12.5	1167	203.4	0.8	Acceptable	Perceptible
136	Community Houses	6	1179	203.4	0.8	Acceptable	Perceptible
137	Community Houses	6	1356	203.4	0.6	Acceptable	Too Low
138	Community Houses	6	1457	203.4	0.6	Acceptable	Too Low
139	Community Houses	6	1164	203.4	0.8	Acceptable	Perceptible
140	Community Houses	6	636	203.4	2.2	Acceptable	Perceptible
141	Community Houses	6	539	203.4	2.8	Acceptable	Perceptible
142	Community Houses	6	705	203.4	1.8	Acceptable	Perceptible
143	Community Houses	6	751	203.4	1.7	Acceptable	Perceptible
144	Community Houses	6	1481	203.4	0.5	Acceptable	Too Low
145	Community Houses	6	1656	203.4	0.4	Acceptable	Too Low
146	Community Houses	6	1220	203.4	0.7	Acceptable	Too Low
147	Community Houses	6	1373	203.4	0.6	Acceptable	Too Low
148	Community Houses	6	1216	203.4	0.7	Acceptable	Too Low
149	Community Houses	6	1251	203.4	0.7	Acceptable	Too Low
150	Buildings/Structures	12.5	1178	203.4	0.8	Acceptable	Perceptible
151	Community Houses	6	1227	203.4	0.7	Acceptable	Too Low
152	Community Houses	6	1418	203.4	0.6	Acceptable	Too Low
153	Community Houses	6	988	203.4	1.0	Acceptable	Perceptible
154	Community Houses	6	956	203.4	1.1	Acceptable	Perceptible
155	Community Houses	6	1227	203.4	0.7	Acceptable	Too Low
156	Community Houses	6	1469	203.4	0.5	Acceptable	Too Low
157	Community Houses	6	3411	203.4	0.1	Acceptable	Too Low
158	Community Houses	6	3449	203.4	0.1	Acceptable	Too Low
159	Community Houses	6	3173	203.4	0.2	Acceptable	Too Low
160	Community Houses	6	3226	203.4	0.1	Acceptable	Too Low
161	Community Houses	6	2941	203.4	0.2	Acceptable	Too Low
162	Community Houses	6	2857	203.4	0.2	Acceptable	Too Low
163	Buildings/Structures	12.5	2947	203.4	0.2	Acceptable	Too Low
164	Community Houses	6	2906	203.4	0.2	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
165	Community Houses	6	2773	203.4	0.2	Acceptable	Too Low
166	Community Houses	6	2810	203.4	0.2	Acceptable	Too Low
167	Community Houses	6	2631	203.4	0.2	Acceptable	Too Low
168	School (Mxosheni Primary School)	25	2709	203.4	0.2	Acceptable	Too Low
169	Community Houses	6	2444	203.4	0.2	Acceptable	Too Low
170	Community Houses	6	2507	203.4	0.2	Acceptable	Too Low
171	Community Houses	6	2621	203.4	0.2	Acceptable	Too Low
172	Community Houses	6	2470	203.4	0.2	Acceptable	Too Low
173	Building/Structure	12.5	2349	203.4	0.3	Acceptable	Too Low
174	Community Houses	6	2327	203.4	0.3	Acceptable	Too Low
175	Community Houses	6	2259	203.4	0.3	Acceptable	Too Low
176	Community Houses	6	2189	203.4	0.3	Acceptable	Too Low
177	Community Houses	6	2063	203.4	0.3	Acceptable	Too Low
178	Community Houses	6	2200	203.4	0.3	Acceptable	Too Low
179	Community Houses	6	2025	203.4	0.3	Acceptable	Too Low
180	Community Houses	6	1853	203.4	0.4	Acceptable	Too Low
181	Community Houses	6	1645	203.4	0.5	Acceptable	Too Low
182	Community Houses	6	1515	203.4	0.5	Acceptable	Too Low
183	Community Houses	6	3468	203.4	0.1	Acceptable	Too Low
184	Community Houses	6	3211	203.4	0.2	Acceptable	Too Low
185	Community Houses	6	3089	203.4	0.2	Acceptable	Too Low
186	Community Houses	6	3291	203.4	0.1	Acceptable	Too Low
187	Community Houses	6	2823	203.4	0.2	Acceptable	Too Low
188	Community Houses	6	3021	203.4	0.2	Acceptable	Too Low
189	Community Houses	6	3106	203.4	0.2	Acceptable	Too Low
190	Community Houses	6	2757	203.4	0.2	Acceptable	Too Low
191	Community Houses	6	2995	203.4	0.2	Acceptable	Too Low
192	Community Houses	6	2240	203.4	0.3	Acceptable	Too Low
193	Community Houses	6	2390	203.4	0.2	Acceptable	Too Low
194	Community Houses	6	2656	203.4	0.2	Acceptable	Too Low
195	Community Houses	6	2701	203.4	0.2	Acceptable	Too Low
196	Community Houses	6	2447	203.4	0.2	Acceptable	Too Low
197	Community Houses	6	2548	203.4	0.2	Acceptable	Too Low
198	Community Houses	6	2219	203.4	0.3	Acceptable	Too Low
199	Community Houses	6	1978	203.4	0.3	Acceptable	Too Low
200	Community Houses	6	2147	203.4	0.3	Acceptable	Too Low
201	Community Houses	6	2028	203.4	0.3	Acceptable	Too Low
202	Community Houses	6	1840	203.4	0.4	Acceptable	Too Low
203	Community Houses	6	1702	203.4	0.4	Acceptable	Too Low
204	Community Houses	6	1627	203.4	0.5	Acceptable	Too Low
205	Community Houses	6	1524	203.4	0.5	Acceptable	Too Low
206	Community Houses	6	1598	203.4	0.5	Acceptable	Too Low
207	Community Houses	6	3470	203.4	0.1	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
208	Community Houses	6	2968	203.4	0.2	Acceptable	Too Low
209	Community Houses	6	2323	203.4	0.3	Acceptable	Too Low
210	Community Houses	6	3016	203.4	0.2	Acceptable	Too Low
211	Community Houses	6	3115	203.4	0.2	Acceptable	Too Low
212	Power Line/Pylon	75	3216	203.4	0.1	Acceptable	N/A
213	Power Line/Pylon	75	2961	203.4	0.2	Acceptable	N/A
214	Power Line/Pylon	75	2561	203.4	0.2	Acceptable	N/A
215	Power Line/Pylon	75	2330	203.4	0.3	Acceptable	N/A
216	Power Line/Pylon	75	2059	203.4	0.3	Acceptable	N/A
217	Power Line/Pylon	75	1720	203.4	0.4	Acceptable	N/A
218	Power Line/Pylon	75	1600	203.4	0.5	Acceptable	N/A
219	Power Line/Pylon	75	1594	203.4	0.5	Acceptable	N/A
220	Power Line/Pylon	75	1713	203.4	0.4	Acceptable	N/A
221	Power Line/Pylon	75	1787	203.4	0.4	Acceptable	N/A
222	Power Line/Pylon	75	2380	203.4	0.2	Acceptable	N/A
223	Power Line/Pylon	75	2839	203.4	0.2	Acceptable	N/A
224	Power Line/Pylon	75	2968	203.4	0.2	Acceptable	N/A
225	Power Line/Pylon	75	3267	203.4	0.1	Acceptable	N/A
226	Power Line/Pylon	75	3453	203.4	0.1	Acceptable	N/A
227	Community Houses	6	3378	203.4	0.1	Acceptable	Too Low
228	Community Houses	6	2958	203.4	0.2	Acceptable	Too Low
229	Buildings/Structures	12.5	2514	203.4	0.2	Acceptable	Too Low
230	Community Houses	6	2330	203.4	0.3	Acceptable	Too Low
231	Community Houses	6	2589	203.4	0.2	Acceptable	Too Low
232	Community Houses	6	2152	203.4	0.3	Acceptable	Too Low
233	Community Houses	6	1878	203.4	0.4	Acceptable	Too Low
234	Community Houses	6	1568	203.4	0.5	Acceptable	Too Low
235	Community Houses	6	1709	203.4	0.4	Acceptable	Too Low
236	Community Houses	6	1908	203.4	0.4	Acceptable	Too Low
237	Community Houses	6	2350	203.4	0.3	Acceptable	Too Low
238	Community Houses	6	2548	203.4	0.2	Acceptable	Too Low
239	Community Houses	6	3439	203.4	0.1	Acceptable	Too Low
240	Community Houses	6	2963	203.4	0.2	Acceptable	Too Low
241	Community Houses	6	3030	203.4	0.2	Acceptable	Too Low
242	Structure	12.5	3179	203.4	0.2	Acceptable	Too Low
243	Community Houses	6	2227	203.4	0.3	Acceptable	Too Low
244	Community Houses	6	3111	203.4	0.2	Acceptable	Too Low
245	Community Houses	6	3221	203.4	0.1	Acceptable	Too Low
246	Community Houses	6	1796	203.4	0.4	Acceptable	Too Low
247	Community Houses	6	2518	203.4	0.2	Acceptable	Too Low
248	Community Houses	6	3070	203.4	0.2	Acceptable	Too Low
249	Buildings/Structures	12.5	3193	203.4	0.2	Acceptable	Too Low
250	Community Houses	6	3093	203.4	0.2	Acceptable	Too Low
251	Community Houses	6	2432	203.4	0.2	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
252	Community Houses	6	2243	203.4	0.3	Acceptable	Too Low
253	Buildings/Structures	12.5	1845	203.4	0.4	Acceptable	Too Low
254	Community Houses	6	1779	203.4	0.4	Acceptable	Too Low
255	Community Houses	6	2248	203.4	0.3	Acceptable	Too Low
256	Community Houses	6	2075	203.4	0.3	Acceptable	Too Low
257	Community Houses	6	1579	203.4	0.5	Acceptable	Too Low
258	Community Houses	6	1974	203.4	0.3	Acceptable	Too Low
259	Community Houses	6	1848	203.4	0.4	Acceptable	Too Low
260	Buildings/Structures	12.5	2836	203.4	0.2	Acceptable	Too Low
261	Industrial Structures	50	2972	203.4	0.2	Acceptable	Too Low
262	Buildings/Structures	12.5	2521	203.4	0.2	Acceptable	Too Low
263	Dam	50	2104	203.4	0.3	Acceptable	N/A
264	River	200	2195	203.4	0.3	Acceptable	N/A
265	Buildings/Structures	12.5	2319	203.4	0.3	Acceptable	Too Low
266	Building/Structure	12.5	1719	203.4	0.4	Acceptable	Too Low
267	Dam	50	3015	203.4	0.2	Acceptable	N/A
268	Structure	12.5	1878	203.4	0.4	Acceptable	Too Low
269	Buildings/Structures	12.5	2331	203.4	0.3	Acceptable	Too Low
270	Clinic	25	2435	203.4	0.2	Acceptable	Too Low
271	Dam	50	2588	203.4	0.2	Acceptable	N/A
272	Structure	12.5	2705	203.4	0.2	Acceptable	Too Low
273	R66 Road	150	2398	203.4	0.2	Acceptable	N/A
274	Houses	12.5	2616	203.4	0.2	Acceptable	Too Low
275	Railway Line	150	2534	203.4	0.2	Acceptable	Too Low
276	Railway Buildings	25	2759	203.4	0.2	Acceptable	Too Low
277	Houses	12.5	2820	203.4	0.2	Acceptable	Too Low
278	Industrial Structures	50	2650	203.4	0.2	Acceptable	Too Low
279	Railway Line	150	2869	203.4	0.2	Acceptable	Too Low
280	Railway Line	150	3400	203.4	0.1	Acceptable	Too Low
281	Community Houses	6	2223	203.4	0.3	Acceptable	Too Low
282	R34 Road	150	2992	203.4	0.2	Acceptable	N/A
283	Community Houses	6	1543	203.4	0.5	Acceptable	Too Low
284	Farm Buildings/Structures	12.5	2881	203.4	0.2	Acceptable	Too Low
285	Community Houses	6	2250	203.4	0.3	Acceptable	Too Low
286	R66 Road	150	2501	203.4	0.2	Acceptable	N/A
287	Community Houses	6	2239	203.4	0.3	Acceptable	Too Low
288	Community Houses	6	1991	203.4	0.3	Acceptable	Too Low
289	Community Houses	6	1760	203.4	0.4	Acceptable	Too Low
290	Community Houses	6	2171	203.4	0.3	Acceptable	Too Low
291	Community Houses	6	2557	203.4	0.2	Acceptable	Too Low
292	Community Houses	6	2973	203.4	0.2	Acceptable	Too Low
293	Community Houses	6	3123	203.4	0.2	Acceptable	Too Low
294	Community Houses	6	3486	203.4	0.1	Acceptable	Too Low
295	Community Houses	6	2190	203.4	0.3	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
296	Community Houses	6	2281	203.4	0.3	Acceptable	Too Low
297	Community Houses	6	2683	203.4	0.2	Acceptable	Too Low
298	Community Houses	6	2573	203.4	0.2	Acceptable	Too Low
299	Community Houses	6	2548	203.4	0.2	Acceptable	Too Low
300	Community Houses	6	2866	203.4	0.2	Acceptable	Too Low
301	Community Houses	6	3219	203.4	0.1	Acceptable	Too Low
302	Community Houses	6	2501	203.4	0.2	Acceptable	Too Low
303	Community Houses	6	3049	203.4	0.2	Acceptable	Too Low
304	Community Houses	6	3396	203.4	0.1	Acceptable	Too Low
305	Community Houses	6	3386	203.4	0.1	Acceptable	Too Low
306	Community Houses	6	3369	203.4	0.1	Acceptable	Too Low
307	Community Houses	6	3091	203.4	0.2	Acceptable	Too Low
308	Community Houses	6	2729	203.4	0.2	Acceptable	Too Low
309	Community Houses	6	2460	203.4	0.2	Acceptable	Too Low
310	Community Houses	6	1944	203.4	0.3	Acceptable	Too Low
311	Community Houses	6	1665	203.4	0.4	Acceptable	Too Low
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	50	-	203.4	-	-	-
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	50	-	203.4	-	-	-
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	50	-	203.4	-	-	-
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	50	-	203.4	-	-	-
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	50	-	203.4	-	-	-
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	50	-	203.4	-	-	-
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	50	-	203.4	-	-	-
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	50	-	203.4	-	-	-
320	Hydrocencus Borehole (GJ03)	50	1219	203.4	0.7	Acceptable	N/A
321	Hydrocencus Borehole (MWGA02)	50	1100	203.4	0.9	Acceptable	N/A
322	Hydrocencus Borehole (MWGA05)	50	21	203.4	599.7	Problematic	N/A
323	Overland Piping (Planned)	50	1131	203.4	0.8	Acceptable	N/A
324	Overland Piping (Planned)	50	1179	203.4	0.8	Acceptable	N/A
325	Overland Piping (Planned)	50	671	203.4	2.0	Acceptable	N/A
326	Overland Piping (Planned)	50	713	203.4	1.8	Acceptable	N/A
327	Overland Piping (Planned)	50	1501	203.4	0.5	Acceptable	N/A
328	Overland Piping (Planned)	50	2375	203.4	0.2	Acceptable	N/A
329	Overland Piping (Planned)	50	2939	203.4	0.2	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
330	Conceptual Plant Access Road (Planned)	150	957	203.4	1.1	Acceptable	N/A
331	Conceptual Plant Access Road (Planned)	150	950	203.4	1.1	Acceptable	N/A
332	Conceptual Plant Access Road (Planned)	150	1250	203.4	0.7	Acceptable	N/A
333	Conceptual Plant Access Road (Planned)	150	1503	203.4	0.5	Acceptable	N/A
334	Waste Rock Dump (Planned)	250	181	203.4	17.2	Acceptable	N/A
335	Waste Rock Dump (Planned)	250	188	203.4	16.2	Acceptable	N/A
336	Waste Rock Dump (Planned)	250	938	203.4	1.1	Acceptable	N/A
337	Waste Rock Dump (Planned)	250	1799	203.4	0.4	Acceptable	N/A
338	Processing Plant (Planned)	50	1165	203.4	0.8	Acceptable	N/A
339	Primary Crusher (Planned)	150	54	203.4	125.5	Acceptable	N/A
340	Primary Crusher (Planned)	150	368	203.4	5.3	Acceptable	N/A
341	Incoming Power Yard (Planned)	50	1803	203.4	0.4	Acceptable	N/A

17.1.2 Ground vibration maximum charge mass per delay – South East Pit – 813.5 kg

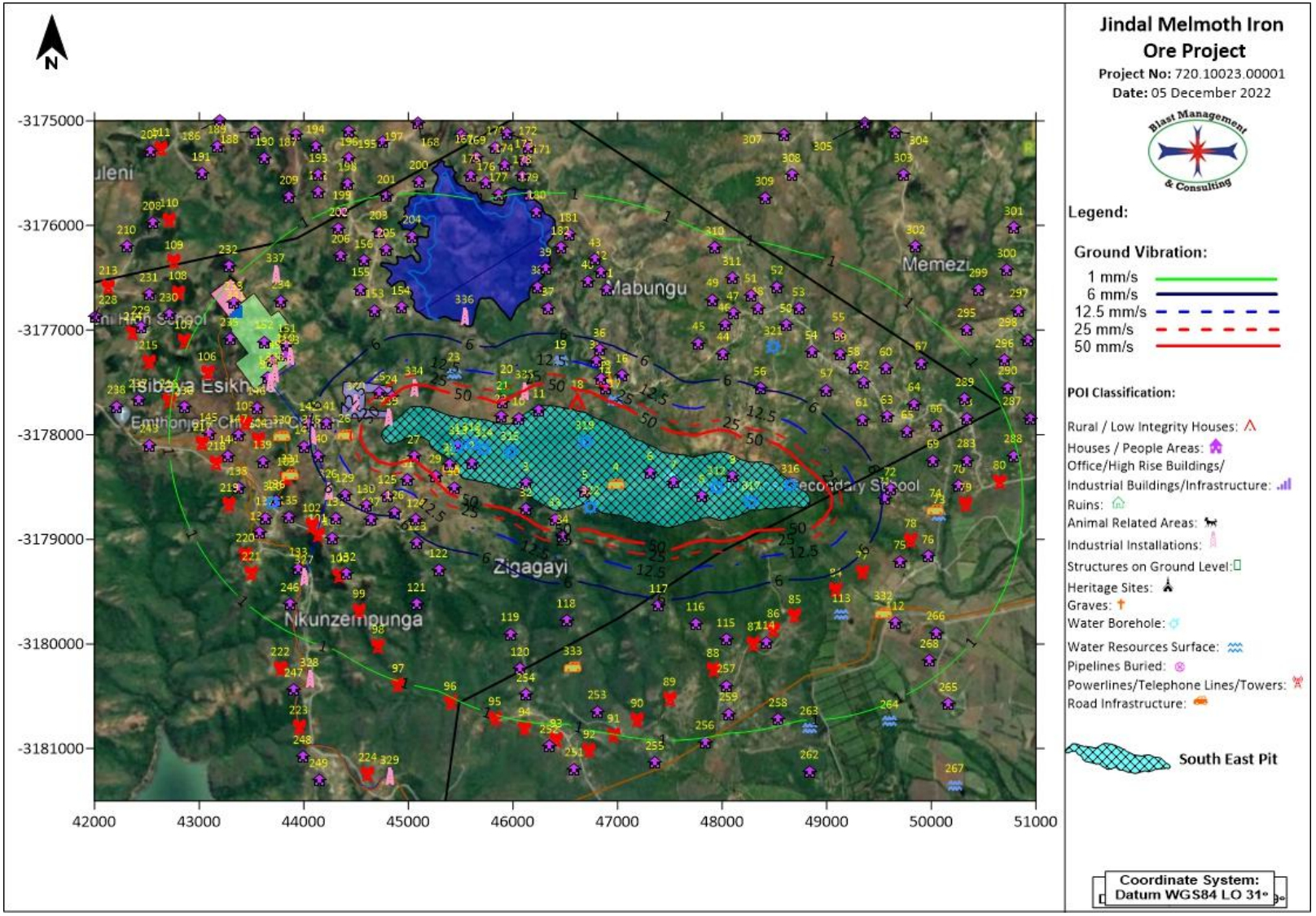


Figure 15: Ground vibration influence from maximum charge per delay

Table 12: Ground vibration evaluation for maximum charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Buildings/Structures (Inside Pit Area)	12.5	-	813.5	-	-	-
2	Community Houses (Inside Pit Area)	6	-	813.5	-	-	-
3	Community Houses (Inside Pit Area)	6	-	813.5	-	-	-
4	D395 Road (Inside Pit Area)	150	-	813.5	-	-	-
5	Community Houses (Inside Pit Area)	6	-	813.5	-	-	-
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	25	-	813.5	-	-	-
7	Community Houses (Inside Pit Area)	6	-	813.5	-	-	-
8	Community Houses (Inside Pit Area)	6	-	813.5	-	-	-
9	Community Houses (Inside Pit Area)	6	-	813.5	-	-	-
10	Community Houses (Inside Pit Area)	6	-	813.5	-	-	-
11	Community Houses (Inside Pit Area)	6	-	813.5	-	-	-
12	D395 Road	150	19	813.5	2296.6	Problematic	N/A
13	D255 Road	150	350	813.5	18.2	Acceptable	N/A
14	Community Houses	6	297	813.5	23.9	Problematic	Intolerable
15	Community Houses	6	356	813.5	17.7	Problematic	Unpleasant
16	Community Houses	6	473	813.5	11.1	Problematic	Unpleasant
17	River	200	221	813.5	38.9	Acceptable	N/A
18	Informal Housing	6	89	813.5	173.3	Problematic	Intolerable
19	River	200	432	813.5	12.9	Acceptable	N/A
20	Ruins	6	318	813.5	21.4	Problematic	N/A
21	Building/Structure	12.5	197	813.5	47.1	Problematic	Intolerable
22	Buildings/Structures	12.5	76	813.5	225.1	Problematic	Intolerable
23	River	200	393	813.5	15.1	Acceptable	N/A
24	Community Houses	6	198	813.5	46.7	Problematic	Intolerable
25	Community Houses	6	299	813.5	23.7	Problematic	Intolerable
26	Road	150	356	813.5	17.7	Acceptable	N/A
27	Buildings/Structures	12.5	184	813.5	52.8	Problematic	Intolerable
28	Community Houses	6	20	813.5	2070.4	Problematic	Intolerable
29	Community Houses	6	184	813.5	52.9	Problematic	Intolerable
30	Community Houses	6	128	813.5	96.0	Problematic	Intolerable
31	Community Houses	6	373	813.5	16.4	Problematic	Unpleasant
32	Community Houses	6	118	813.5	110.4	Problematic	Intolerable

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
33	Community Houses	6	79	813.5	211.2	Problematic	Intolerable
34	Community Houses	6	244	813.5	33.1	Problematic	Intolerable
35	Buildings/Structures	12.5	500	813.5	10.2	Acceptable	Unpleasant
36	Community Houses	6	618	813.5	7.1	Problematic	Unpleasant
37	Community Houses	6	929	813.5	3.6	Acceptable	Perceptible
38	Community Houses	6	1135	813.5	2.6	Acceptable	Perceptible
39	Community Houses	6	1308	813.5	2.1	Acceptable	Perceptible
40	Community Houses	6	1225	813.5	2.3	Acceptable	Perceptible
41	Community Houses	6	1185	813.5	2.4	Acceptable	Perceptible
42	Community Houses	6	1334	813.5	2.0	Acceptable	Perceptible
43	Community Houses	6	1443	813.5	1.8	Acceptable	Perceptible
44	Community Houses	6	939	813.5	3.6	Acceptable	Perceptible
45	Community Houses	6	1057	813.5	2.9	Acceptable	Perceptible
46	Community Houses	6	1220	813.5	2.3	Acceptable	Perceptible
47	Community Houses	6	1331	813.5	2.0	Acceptable	Perceptible
48	Community Houses	6	1415	813.5	1.8	Acceptable	Perceptible
49	Community Houses	6	1455	813.5	1.7	Acceptable	Perceptible
50	Community Houses	6	1332	813.5	2.0	Acceptable	Perceptible
51	Community Houses	6	1525	813.5	1.6	Acceptable	Perceptible
52	Community Houses	6	1659	813.5	1.4	Acceptable	Perceptible
53	Community Houses	6	1509	813.5	1.6	Acceptable	Perceptible
54	Community Houses	6	1147	813.5	2.6	Acceptable	Perceptible
55	Community Houses	6	1408	813.5	1.8	Acceptable	Perceptible
56	Community Houses	6	695	813.5	5.9	Acceptable	Unpleasant
57	Community Houses	6	885	813.5	3.9	Acceptable	Perceptible
58	Community Houses	6	1208	813.5	2.4	Acceptable	Perceptible
59	Community Houses	6	1246	813.5	2.2	Acceptable	Perceptible
60	Community Houses	6	1410	813.5	1.8	Acceptable	Perceptible
61	Community Houses	6	884	813.5	4.0	Acceptable	Perceptible
62	Community Houses	6	1173	813.5	2.5	Acceptable	Perceptible
63	Buildings/Structures	12.5	1065	813.5	2.9	Acceptable	Perceptible
64	Community Houses	6	1339	813.5	2.0	Acceptable	Perceptible
65	Community Houses	6	1132	813.5	2.6	Acceptable	Perceptible
66	Community Houses	6	1398	813.5	1.9	Acceptable	Perceptible
67	Community Houses	6	1659	813.5	1.4	Acceptable	Perceptible
68	Community Houses	6	1684	813.5	1.4	Acceptable	Perceptible
69	Community Houses	6	1236	813.5	2.3	Acceptable	Perceptible
70	Community Houses	6	1429	813.5	1.8	Acceptable	Perceptible
71	Community Houses	6	712	813.5	5.7	Acceptable	Unpleasant
72	Community Houses	6	774	813.5	4.9	Acceptable	Perceptible
73	River	200	1243	813.5	2.3	Acceptable	N/A
74	Road	150	1202	813.5	2.4	Acceptable	N/A
75	Farm Buildings/Structures	12.5	1026	813.5	3.1	Acceptable	Perceptible
76	Buildings/Structures	12.5	1238	813.5	2.3	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
77	Power Line/Pylon	75	815	813.5	4.5	Acceptable	N/A
78	Power Line/Pylon	75	1027	813.5	3.1	Acceptable	N/A
79	Power Line/Pylon	75	1489	813.5	1.7	Acceptable	N/A
80	Power Line/Pylon	75	1821	813.5	1.2	Acceptable	N/A
81	Power Line/Pylon	75	2411	813.5	0.8	Acceptable	N/A
82	Power Line/Pylon	75	2812	813.5	0.6	Acceptable	N/A
83	Power Line/Pylon	75	3170	813.5	0.5	Acceptable	N/A
84	Power Line/Pylon	75	836	813.5	4.3	Acceptable	N/A
85	Power Line/Pylon	75	1040	813.5	3.0	Acceptable	N/A
86	Power Line/Pylon	75	1141	813.5	2.6	Acceptable	N/A
87	Power Line/Pylon	75	1211	813.5	2.4	Acceptable	N/A
88	Power Line/Pylon	75	1417	813.5	1.8	Acceptable	N/A
89	Power Line/Pylon	75	1634	813.5	1.4	Acceptable	N/A
90	Power Line/Pylon	75	1862	813.5	1.2	Acceptable	N/A
91	Power Line/Pylon	75	2045	813.5	1.0	Acceptable	N/A
92	Power Line/Pylon	75	2231	813.5	0.9	Acceptable	N/A
93	Power Line/Pylon	75	2189	813.5	0.9	Acceptable	N/A
94	Power Line/Pylon	75	2103	813.5	0.9	Acceptable	N/A
95	Power Line/Pylon	75	2067	813.5	1.0	Acceptable	N/A
96	Power Line/Pylon	75	2085	813.5	1.0	Acceptable	N/A
97	Power Line/Pylon	75	2071	813.5	1.0	Acceptable	N/A
98	Power Line/Pylon	75	1796	813.5	1.2	Acceptable	N/A
99	Power Line/Pylon	75	1605	813.5	1.5	Acceptable	N/A
100	Power Line/Pylon	75	1342	813.5	2.0	Acceptable	N/A
101	Power Line/Pylon	75	1097	813.5	2.8	Acceptable	N/A
102	Power Line/Pylon	75	1055	813.5	3.0	Acceptable	N/A
103	Power Line/Pylon	75	999	813.5	3.2	Acceptable	N/A
104	Power Line/Pylon	75	1185	813.5	2.4	Acceptable	N/A
105	Power Line/Pylon	75	1311	813.5	2.1	Acceptable	N/A
106	Power Line/Pylon	75	1763	813.5	1.3	Acceptable	N/A
107	Power Line/Pylon	75	2082	813.5	1.0	Acceptable	N/A
108	Power Line/Pylon	75	2363	813.5	0.8	Acceptable	N/A
109	Power Line/Pylon	75	2566	813.5	0.7	Acceptable	N/A
110	Power Line/Pylon	75	2867	813.5	0.6	Acceptable	N/A
111	Power Line/Pylon	75	3421	813.5	0.4	Acceptable	N/A
112	Farm Buildings/Structures	12.5	1391	813.5	1.9	Acceptable	Perceptible
113	Dam	50	1085	813.5	2.8	Acceptable	N/A
114	Community Houses	6	1229	813.5	2.3	Acceptable	Perceptible
115	Community Houses	6	1141	813.5	2.6	Acceptable	Perceptible
116	Community Houses	6	946	813.5	3.5	Acceptable	Perceptible
117	Community Houses	6	747	813.5	5.2	Acceptable	Perceptible
118	Community Houses	6	1046	813.5	3.0	Acceptable	Perceptible
119	Community Houses	6	1255	813.5	2.2	Acceptable	Perceptible
120	Community Houses	6	1548	813.5	1.6	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
121	Community Houses	6	1283	813.5	2.1	Acceptable	Perceptible
122	Community Houses	6	910	813.5	3.8	Acceptable	Perceptible
123	Community Houses	6	757	813.5	5.1	Acceptable	Perceptible
124	Community Houses	6	591	813.5	7.7	Problematic	Unpleasant
125	Community Houses	6	503	813.5	10.0	Problematic	Unpleasant
126	Buildings/Structures	12.5	654	813.5	6.5	Acceptable	Unpleasant
127	Community Houses	6	739	813.5	5.3	Acceptable	Perceptible
128	Community Houses	6	1045	813.5	3.0	Acceptable	Perceptible
129	Community Houses	6	634	813.5	6.9	Problematic	Unpleasant
130	Community Houses	6	633	813.5	6.9	Problematic	Unpleasant
131	Community Houses	6	868	813.5	4.1	Acceptable	Perceptible
132	Community Houses	6	1306	813.5	2.1	Acceptable	Perceptible
133	Community Houses	6	1466	813.5	1.7	Acceptable	Perceptible
134	Community Houses	6	1481	813.5	1.7	Acceptable	Perceptible
135	Buildings/Structure	12.5	1167	813.5	2.5	Acceptable	Perceptible
136	Community Houses	6	1179	813.5	2.5	Acceptable	Perceptible
137	Community Houses	6	1356	813.5	2.0	Acceptable	Perceptible
138	Community Houses	6	1457	813.5	1.7	Acceptable	Perceptible
139	Community Houses	6	1164	813.5	2.5	Acceptable	Perceptible
140	Community Houses	6	636	813.5	6.8	Problematic	Unpleasant
141	Community Houses	6	539	813.5	8.9	Problematic	Unpleasant
142	Community Houses	6	705	813.5	5.8	Acceptable	Unpleasant
143	Community Houses	6	751	813.5	5.2	Acceptable	Perceptible
144	Community Houses	6	1481	813.5	1.7	Acceptable	Perceptible
145	Community Houses	6	1656	813.5	1.4	Acceptable	Perceptible
146	Community Houses	6	1220	813.5	2.3	Acceptable	Perceptible
147	Community Houses	6	1373	813.5	1.9	Acceptable	Perceptible
148	Community Houses	6	1216	813.5	2.3	Acceptable	Perceptible
149	Community Houses	6	1251	813.5	2.2	Acceptable	Perceptible
150	Buildings/Structures	12.5	1178	813.5	2.5	Acceptable	Perceptible
151	Community Houses	6	1227	813.5	2.3	Acceptable	Perceptible
152	Community Houses	6	1418	813.5	1.8	Acceptable	Perceptible
153	Community Houses	6	988	813.5	3.3	Acceptable	Perceptible
154	Community Houses	6	956	813.5	3.5	Acceptable	Perceptible
155	Community Houses	6	1227	813.5	2.3	Acceptable	Perceptible
156	Community Houses	6	1469	813.5	1.7	Acceptable	Perceptible
157	Community Houses	6	3411	813.5	0.4	Acceptable	Too Low
158	Community Houses	6	3449	813.5	0.4	Acceptable	Too Low
159	Community Houses	6	3173	813.5	0.5	Acceptable	Too Low
160	Community Houses	6	3226	813.5	0.5	Acceptable	Too Low
161	Community Houses	6	2941	813.5	0.5	Acceptable	Too Low
162	Community Houses	6	2857	813.5	0.6	Acceptable	Too Low
163	Buildings/Structures	12.5	2947	813.5	0.5	Acceptable	Too Low
164	Community Houses	6	2906	813.5	0.6	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
165	Community Houses	6	2773	813.5	0.6	Acceptable	Too Low
166	Community Houses	6	2810	813.5	0.6	Acceptable	Too Low
167	Community Houses	6	2631	813.5	0.7	Acceptable	Too Low
168	School (Mxosheni Primary School)	25	2709	813.5	0.6	Acceptable	Too Low
169	Community Houses	6	2444	813.5	0.7	Acceptable	Too Low
170	Community Houses	6	2507	813.5	0.7	Acceptable	Too Low
171	Community Houses	6	2621	813.5	0.7	Acceptable	Too Low
172	Community Houses	6	2470	813.5	0.7	Acceptable	Too Low
173	Building/Structure	12.5	2349	813.5	0.8	Acceptable	Perceptible
174	Community Houses	6	2327	813.5	0.8	Acceptable	Perceptible
175	Community Houses	6	2259	813.5	0.8	Acceptable	Perceptible
176	Community Houses	6	2189	813.5	0.9	Acceptable	Perceptible
177	Community Houses	6	2063	813.5	1.0	Acceptable	Perceptible
178	Community Houses	6	2200	813.5	0.9	Acceptable	Perceptible
179	Community Houses	6	2025	813.5	1.0	Acceptable	Perceptible
180	Community Houses	6	1853	813.5	1.2	Acceptable	Perceptible
181	Community Houses	6	1645	813.5	1.4	Acceptable	Perceptible
182	Community Houses	6	1515	813.5	1.6	Acceptable	Perceptible
183	Community Houses	6	3468	813.5	0.4	Acceptable	Too Low
184	Community Houses	6	3211	813.5	0.5	Acceptable	Too Low
185	Community Houses	6	3089	813.5	0.5	Acceptable	Too Low
186	Community Houses	6	3291	813.5	0.5	Acceptable	Too Low
187	Community Houses	6	2823	813.5	0.6	Acceptable	Too Low
188	Community Houses	6	3021	813.5	0.5	Acceptable	Too Low
189	Community Houses	6	3106	813.5	0.5	Acceptable	Too Low
190	Community Houses	6	2757	813.5	0.6	Acceptable	Too Low
191	Community Houses	6	2995	813.5	0.5	Acceptable	Too Low
192	Community Houses	6	2240	813.5	0.9	Acceptable	Perceptible
193	Community Houses	6	2390	813.5	0.8	Acceptable	Perceptible
194	Community Houses	6	2656	813.5	0.6	Acceptable	Too Low
195	Community Houses	6	2701	813.5	0.6	Acceptable	Too Low
196	Community Houses	6	2447	813.5	0.7	Acceptable	Too Low
197	Community Houses	6	2548	813.5	0.7	Acceptable	Too Low
198	Community Houses	6	2219	813.5	0.9	Acceptable	Perceptible
199	Community Houses	6	1978	813.5	1.0	Acceptable	Perceptible
200	Community Houses	6	2147	813.5	0.9	Acceptable	Perceptible
201	Community Houses	6	2028	813.5	1.0	Acceptable	Perceptible
202	Community Houses	6	1840	813.5	1.2	Acceptable	Perceptible
203	Community Houses	6	1702	813.5	1.3	Acceptable	Perceptible
204	Community Houses	6	1627	813.5	1.4	Acceptable	Perceptible
205	Community Houses	6	1524	813.5	1.6	Acceptable	Perceptible
206	Community Houses	6	1598	813.5	1.5	Acceptable	Perceptible
207	Community Houses	6	3470	813.5	0.4	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
208	Community Houses	6	2968	813.5	0.5	Acceptable	Too Low
209	Community Houses	6	2323	813.5	0.8	Acceptable	Perceptible
210	Community Houses	6	3016	813.5	0.5	Acceptable	Too Low
211	Community Houses	6	3115	813.5	0.5	Acceptable	Too Low
212	Power Line/Pylon	75	3216	813.5	0.5	Acceptable	N/A
213	Power Line/Pylon	75	2961	813.5	0.5	Acceptable	N/A
214	Power Line/Pylon	75	2561	813.5	0.7	Acceptable	N/A
215	Power Line/Pylon	75	2330	813.5	0.8	Acceptable	N/A
216	Power Line/Pylon	75	2059	813.5	1.0	Acceptable	N/A
217	Power Line/Pylon	75	1720	813.5	1.3	Acceptable	N/A
218	Power Line/Pylon	75	1600	813.5	1.5	Acceptable	N/A
219	Power Line/Pylon	75	1594	813.5	1.5	Acceptable	N/A
220	Power Line/Pylon	75	1713	813.5	1.3	Acceptable	N/A
221	Power Line/Pylon	75	1787	813.5	1.2	Acceptable	N/A
222	Power Line/Pylon	75	2380	813.5	0.8	Acceptable	N/A
223	Power Line/Pylon	75	2839	813.5	0.6	Acceptable	N/A
224	Power Line/Pylon	75	2968	813.5	0.5	Acceptable	N/A
225	Power Line/Pylon	75	3267	813.5	0.5	Acceptable	N/A
226	Power Line/Pylon	75	3453	813.5	0.4	Acceptable	N/A
227	Community Houses	6	3378	813.5	0.4	Acceptable	Too Low
228	Community Houses	6	2958	813.5	0.5	Acceptable	Too Low
229	Buildings/Structures	12.5	2514	813.5	0.7	Acceptable	Too Low
230	Community Houses	6	2330	813.5	0.8	Acceptable	Perceptible
231	Community Houses	6	2589	813.5	0.7	Acceptable	Too Low
232	Community Houses	6	2152	813.5	0.9	Acceptable	Perceptible
233	Community Houses	6	1878	813.5	1.1	Acceptable	Perceptible
234	Community Houses	6	1568	813.5	1.5	Acceptable	Perceptible
235	Community Houses	6	1709	813.5	1.3	Acceptable	Perceptible
236	Community Houses	6	1908	813.5	1.1	Acceptable	Perceptible
237	Community Houses	6	2350	813.5	0.8	Acceptable	Perceptible
238	Community Houses	6	2548	813.5	0.7	Acceptable	Too Low
239	Community Houses	6	3439	813.5	0.4	Acceptable	Too Low
240	Community Houses	6	2963	813.5	0.5	Acceptable	Too Low
241	Community Houses	6	3030	813.5	0.5	Acceptable	Too Low
242	Structure	12.5	3179	813.5	0.5	Acceptable	Too Low
243	Community Houses	6	2227	813.5	0.9	Acceptable	Perceptible
244	Community Houses	6	3111	813.5	0.5	Acceptable	Too Low
245	Community Houses	6	3221	813.5	0.5	Acceptable	Too Low
246	Community Houses	6	1796	813.5	1.2	Acceptable	Perceptible
247	Community Houses	6	2518	813.5	0.7	Acceptable	Too Low
248	Community Houses	6	3070	813.5	0.5	Acceptable	Too Low
249	Buildings/Structures	12.5	3193	813.5	0.5	Acceptable	Too Low
250	Community Houses	6	3093	813.5	0.5	Acceptable	Too Low
251	Community Houses	6	2432	813.5	0.7	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
252	Community Houses	6	2243	813.5	0.9	Acceptable	Perceptible
253	Buildings/Structures	12.5	1845	813.5	1.2	Acceptable	Perceptible
254	Community Houses	6	1779	813.5	1.2	Acceptable	Perceptible
255	Community Houses	6	2248	813.5	0.8	Acceptable	Perceptible
256	Community Houses	6	2075	813.5	1.0	Acceptable	Perceptible
257	Community Houses	6	1579	813.5	1.5	Acceptable	Perceptible
258	Community Houses	6	1974	813.5	1.1	Acceptable	Perceptible
259	Community Houses	6	1848	813.5	1.2	Acceptable	Perceptible
260	Buildings/Structures	12.5	2836	813.5	0.6	Acceptable	Too Low
261	Industrial Structures	50	2972	813.5	0.5	Acceptable	Too Low
262	Buildings/Structures	12.5	2521	813.5	0.7	Acceptable	Too Low
263	Dam	50	2104	813.5	0.9	Acceptable	N/A
264	River	200	2195	813.5	0.9	Acceptable	N/A
265	Buildings/Structures	12.5	2319	813.5	0.8	Acceptable	Perceptible
266	Building/Structure	12.5	1719	813.5	1.3	Acceptable	Perceptible
267	Dam	50	3015	813.5	0.5	Acceptable	N/A
268	Structure	12.5	1878	813.5	1.1	Acceptable	Perceptible
269	Buildings/Structures	12.5	2331	813.5	0.8	Acceptable	Perceptible
270	Clinic	25	2435	813.5	0.7	Acceptable	Too Low
271	Dam	50	2588	813.5	0.7	Acceptable	N/A
272	Structure	12.5	2705	813.5	0.6	Acceptable	Too Low
273	R66 Road	150	2398	813.5	0.8	Acceptable	N/A
274	Houses	12.5	2616	813.5	0.7	Acceptable	Too Low
275	Railway Line	150	2534	813.5	0.7	Acceptable	Too Low
276	Railway Buildings	25	2759	813.5	0.6	Acceptable	Too Low
277	Houses	12.5	2820	813.5	0.6	Acceptable	Too Low
278	Industrial Structures	50	2650	813.5	0.6	Acceptable	Too Low
279	Railway Line	150	2869	813.5	0.6	Acceptable	Too Low
280	Railway Line	150	3400	813.5	0.4	Acceptable	Too Low
281	Community Houses	6	2223	813.5	0.9	Acceptable	Perceptible
282	R34 Road	150	2992	813.5	0.5	Acceptable	N/A
283	Community Houses	6	1543	813.5	1.6	Acceptable	Perceptible
284	Farm Buildings/Structures	12.5	2881	813.5	0.6	Acceptable	Too Low
285	Community Houses	6	2250	813.5	0.8	Acceptable	Perceptible
286	R66 Road	150	2501	813.5	0.7	Acceptable	N/A
287	Community Houses	6	2239	813.5	0.9	Acceptable	Perceptible
288	Community Houses	6	1991	813.5	1.0	Acceptable	Perceptible
289	Community Houses	6	1760	813.5	1.3	Acceptable	Perceptible
290	Community Houses	6	2171	813.5	0.9	Acceptable	Perceptible
291	Community Houses	6	2557	813.5	0.7	Acceptable	Too Low
292	Community Houses	6	2973	813.5	0.5	Acceptable	Too Low
293	Community Houses	6	3123	813.5	0.5	Acceptable	Too Low
294	Community Houses	6	3486	813.5	0.4	Acceptable	Too Low
295	Community Houses	6	2190	813.5	0.9	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
296	Community Houses	6	2281	813.5	0.8	Acceptable	Perceptible
297	Community Houses	6	2683	813.5	0.6	Acceptable	Too Low
298	Community Houses	6	2573	813.5	0.7	Acceptable	Too Low
299	Community Houses	6	2548	813.5	0.7	Acceptable	Too Low
300	Community Houses	6	2866	813.5	0.6	Acceptable	Too Low
301	Community Houses	6	3219	813.5	0.5	Acceptable	Too Low
302	Community Houses	6	2501	813.5	0.7	Acceptable	Too Low
303	Community Houses	6	3049	813.5	0.5	Acceptable	Too Low
304	Community Houses	6	3396	813.5	0.4	Acceptable	Too Low
305	Community Houses	6	3386	813.5	0.4	Acceptable	Too Low
306	Community Houses	6	3369	813.5	0.4	Acceptable	Too Low
307	Community Houses	6	3091	813.5	0.5	Acceptable	Too Low
308	Community Houses	6	2729	813.5	0.6	Acceptable	Too Low
309	Community Houses	6	2460	813.5	0.7	Acceptable	Too Low
310	Community Houses	6	1944	813.5	1.1	Acceptable	Perceptible
311	Community Houses	6	1665	813.5	1.4	Acceptable	Perceptible
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	50	-	813.5	-	-	-
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	50	-	813.5	-	-	-
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	50	-	813.5	-	-	-
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	50	-	813.5	-	-	-
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	50	-	813.5	-	-	-
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	50	-	813.5	-	-	-
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	50	-	813.5	-	-	-
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	50	-	813.5	-	-	-
320	Hydrocencus Borehole (GJ03)	50	1219	813.5	2.3	Acceptable	N/A
321	Hydrocencus Borehole (MWGA02)	50	1100	813.5	2.8	Acceptable	N/A
322	Hydrocencus Borehole (MWGA05)	50	21	813.5	1881.8	Problematic	N/A
323	Overland Piping (Planned)	50	1131	813.5	2.6	Acceptable	N/A
324	Overland Piping (Planned)	50	1179	813.5	2.5	Acceptable	N/A
325	Overland Piping (Planned)	50	671	813.5	6.2	Acceptable	N/A
326	Overland Piping (Planned)	50	713	813.5	5.6	Acceptable	N/A
327	Overland Piping (Planned)	50	1501	813.5	1.7	Acceptable	N/A
328	Overland Piping (Planned)	50	2375	813.5	0.8	Acceptable	N/A
329	Overland Piping (Planned)	50	2939	813.5	0.5	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
330	Conceptual Plant Access Road (Planned)	150	957	813.5	3.5	Acceptable	N/A
331	Conceptual Plant Access Road (Planned)	150	950	813.5	3.5	Acceptable	N/A
332	Conceptual Plant Access Road (Planned)	150	1250	813.5	2.2	Acceptable	N/A
333	Conceptual Plant Access Road (Planned)	150	1503	813.5	1.6	Acceptable	N/A
334	Waste Rock Dump (Planned)	250	181	813.5	54.1	Acceptable	N/A
335	Waste Rock Dump (Planned)	250	188	813.5	50.8	Acceptable	N/A
336	Waste Rock Dump (Planned)	250	938	813.5	3.6	Acceptable	N/A
337	Waste Rock Dump (Planned)	250	1799	813.5	1.2	Acceptable	N/A
338	Processing Plant (Planned)	50	1165	813.5	2.5	Acceptable	N/A
339	Primary Crusher (Planned)	150	54	813.5	393.8	Problematic	N/A
340	Primary Crusher (Planned)	150	368	813.5	16.8	Acceptable	N/A
341	Incoming Power Yard (Planned)	50	1803	813.5	1.2	Acceptable	N/A

17.2 Summary of ground vibration levels

The opencast operations were evaluated for expected levels of ground vibration from future blasting operations. Review of the site and the surrounding installations / houses / buildings showed that structures vary in distances from the pit area. The influences will also vary with distance from the pit area. The model used for evaluation does indicate significant levels. It will be imperative to ensure that the monitoring program is continued to confirm levels of ground vibration to ensure that ground vibration levels are not exceeded. Additional monitoring points may need to be considered.

The distances between structures and the pit areas are a contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated those levels of ground vibration will change as well. In view of the minimum and maximum charge specific attention will need to be given to specific areas. The minimum charge used indicated twenty-seven POI's of concern and the maximum charge indicated forty POI's of concern (included are the Community Houses, Buildings/Structures, School and Hydrocencus Boreholes inside the pit areas) in relation to possible structural damage.

On a human perception scale forty-three POI's were identified where vibration levels may be perceptible and lower for the minimum charge and hundred and twenty-six POI's for the maximum charge. Eight POI's were identified where vibration levels may be unpleasant for the minimum charge and fifteen for the maximum charge. Perceptible levels of vibration may be experienced up to 2431 m and intolerable up to 356 m. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 373 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have lesser influence on these points.

The evaluation mainly considered a distance up to 3500 m from the pit area. The closest structures observed are the D395 Road, Community Houses, Hydrocencus Boreholes, Building/Structures and Informal Housing. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage. The ground vibration levels predicted for these POI's ranged between 6.8 mm/s and 2296.6 mm/s for structures surrounding the open pit area.

The nearest public houses are located 20 m from the pit boundary. Ground vibration level predicted at this building where people may be present is 2070.4mm/s for the maximum charge. In view of this specific mitigations will be required.

Structure conditions ranged from industrial construction to poor condition structures.

Mitigation of ground vibration was considered and discussed in Section 18.3. A detail inspection of the area and accurate identification of structures will also need to be done to ensure the levels of ground vibration allowable and limit to be applied.

17.3 Ground Vibration and human perception

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to an average of 30Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 16 below). The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. Based on the maximum charge and ground vibration predicted over distance it can be seen from Figure 16 that up to a distance of 2431 m people may experience levels of ground vibration as perceptible, up to 929 m as unpleasant and intolerable at 356 m.

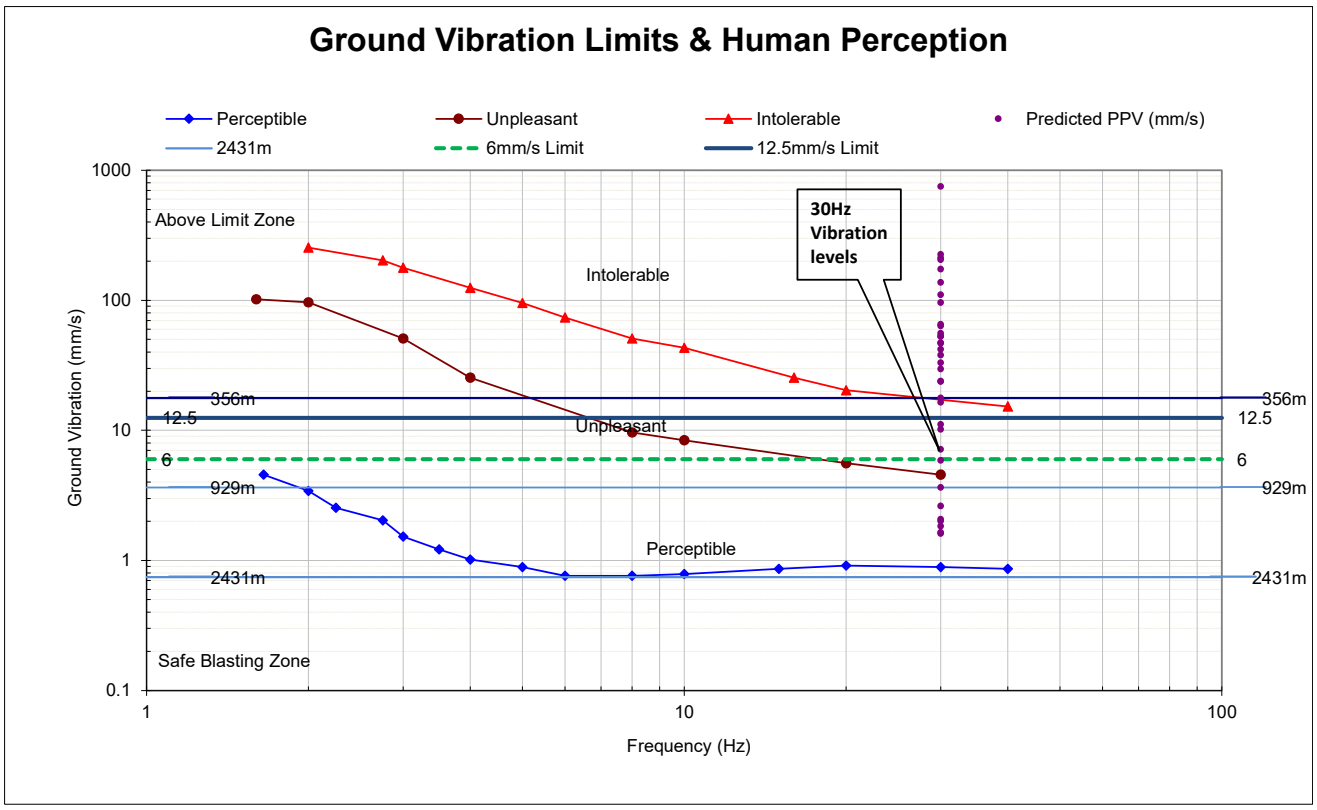


Figure 16: The effect of ground vibration with human perception and vibration limits

17.4 Vibration impact on roads

The D395 road runs through the Pit area. This road is specifically of concern when blasting is done more in regards with fly rock concerns than ground vibration. The D255 road is at closest distance of 350 m to the Pit area. The R66 is at 2398 m and the R34 road at 2992 m. There are other Roads and Gravel roads in the vicinity of the Project area but are all expected to be within the recommended limits. There may however be people and animals on these routes and will require careful planning to maintain safe blasting radius. It will be required that clearance distances are set, and road travel managed during blasting operations.

17.5 Potential that vibration will upset adjacent communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. There are Community Houses that falls within the Pit area. It is accepted that these dwellings will be relocated. The nearest houses outside the pit area are at closest distance approximately 19 m from the planned operation. These buildings are located such that levels of ground vibration predicted may be problematic and damaging.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 2431 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 1185 m. Within these distance ranges there are a number of houses. The

anticipated ground vibration levels are certain to have possibility of upsetting the house holds within these ranges. Intolerable levels are expected up to a distance of 356 m.

The importance of good public relations cannot be over emphasised. People tend to react negatively on experiencing of effects from blasting such as ground vibration and air blast. Even at low levels when damage to structures is out of the question it may upset people. Proper and appropriate communication with neighbours about blasting, monitoring and actions done for proper control will be required.

17.6 Cracking of houses and consequent devaluation

The structures found in the areas of concern ranges from traditional building, informal building styles to brick and mortar structures. There are various buildings found within the 3500 m range from the mining area. Building style and materials will certainly contribute to additional cracking apart from influences such as blasting operations.

The presence of general vertical cracks, horizontal and diagonal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. Mining operations may not have influence to change the status quo of any property if correct precautions are considered.

The proposed limits as applied in this document i.e. 6 mm/s, 12.5 mm/s and 25 mm/s are considered sufficient to ensure that additional damage is not introduced to the different categories of structures. It is expected that, should levels of ground vibration be maintained within these limits, the possibility of inducing damage is limited.

17.7 Review of expected air blast

Presented herewith are the expected air blast level contours and discussion of relevant influences. Expected air blast levels were calculated for each POI identified surrounding the mining area and evaluated with regards to possible structural concerns. Tables are provided for each of the different charge models done with regards to:

- “Tag” No. is number corresponding to the location indicated on POI figures;
- “Description” indicates the type of the structure;
- “Distance” is the distance between the structure and edge of the pit area;
- “Air Blast (dB)” is the calculated air blast level at the structure;
- “Possible concern” indicates if there is any concern for structural damage or human perception. Indicators used are:

- "Problematic" where there is real concern for possible damage – at levels greater than 134 dB;
- "Complaint" where people will be complaining due to the experienced effect on structures at levels of 120 dB and higher (not necessarily damaging);
- "Acceptable" if levels are less than 120 dB;
- "Low" where there is very limited possibility that the levels will give rise to any influence on people or structures. Levels below 115 dB could be considered to have low or negligible possibility of influence.

Presented are simulations for expected air blast levels from two different charge masses at each pit area. Colour codes used in tables are as follows:

Air blast levels higher than proposed limit is coloured "Red"
Air blast levels indicated as possible Complaint is coloured "Mustard"
POI's that are found inside the pit area is coloured "Olive Green"

17.7.1 Air blast minimum charge mass per delay – South East – 203.4 kg

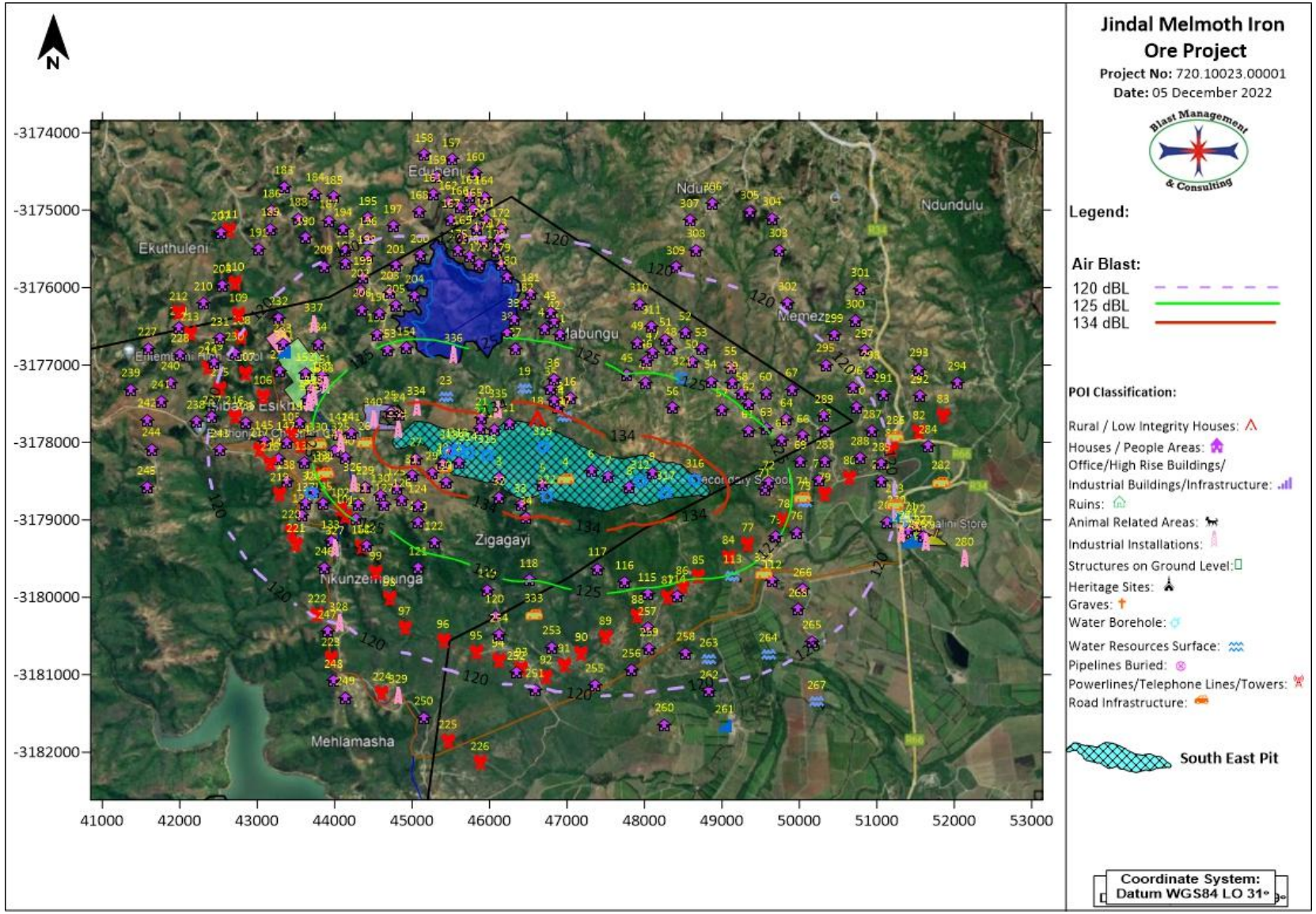


Figure 17: Air blast influence from minimum charge

Table 13: Air blast evaluation for minimum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Buildings/Structures (Inside Pit Area)	-	-	-
2	Community Houses (Inside Pit Area)	-	-	-
3	Community Houses (Inside Pit Area)	-	-	-
4	D395 Road (Inside Pit Area)	-	-	-
5	Community Houses (Inside Pit Area)	-	-	-
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	-	-	-
7	Community Houses (Inside Pit Area)	-	-	-
8	Community Houses (Inside Pit Area)	-	-	-
9	Community Houses (Inside Pit Area)	-	-	-
10	Community Houses (Inside Pit Area)	-	-	-
11	Community Houses (Inside Pit Area)	-	-	-
12	D395 Road	19	149.9	N/A
13	D255 Road	350	131.8	N/A
14	Community Houses	297	132.8	Complaint
15	Community Houses	356	131.7	Complaint
16	Community Houses	473	130.0	Complaint
17	River	221	134.7	N/A
18	Informal Housing	89	140.2	Problematic
19	River	432	130.5	N/A
20	Ruins	318	132.4	Complaint
21	Building/Structure	197	135.4	Problematic
22	Buildings/Structures	76	141.2	Problematic
23	River	393	131.1	N/A
24	Community Houses	198	135.4	Problematic
25	Community Houses	299	132.8	Complaint
26	Road	356	131.7	N/A
27	Buildings/Structures	184	135.8	Problematic
28	Community Houses	20	149.5	Problematic
29	Community Houses	184	135.8	Problematic
30	Community Houses	128	138.0	Problematic
31	Community Houses	373	131.4	Complaint
32	Community Houses	118	138.6	Problematic
33	Community Houses	79	141.0	Problematic
34	Community Houses	244	134.1	Problematic
35	Buildings/Structures	500	129.7	Complaint
36	Community Houses	618	128.3	Complaint
37	Community Houses	929	125.8	Complaint
38	Community Houses	1135	124.6	Complaint
39	Community Houses	1308	123.7	Complaint
40	Community Houses	1225	124.1	Complaint
41	Community Houses	1185	124.3	Complaint
42	Community Houses	1334	123.6	Complaint
43	Community Houses	1443	123.1	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Community Houses	939	125.8	Complaint
45	Community Houses	1057	125.0	Complaint
46	Community Houses	1220	124.1	Complaint
47	Community Houses	1331	123.6	Complaint
48	Community Houses	1415	123.2	Complaint
49	Community Houses	1455	123.1	Complaint
50	Community Houses	1332	123.6	Complaint
51	Community Houses	1525	122.8	Complaint
52	Community Houses	1659	122.3	Complaint
53	Community Houses	1509	122.8	Complaint
54	Community Houses	1147	124.5	Complaint
55	Community Houses	1408	123.3	Complaint
56	Community Houses	695	127.6	Complaint
57	Community Houses	885	126.1	Complaint
58	Community Houses	1208	124.2	Complaint
59	Community Houses	1246	124.0	Complaint
60	Community Houses	1410	123.3	Complaint
61	Community Houses	884	126.1	Complaint
62	Community Houses	1173	124.4	Complaint
63	Buildings/Structures	1065	125.0	Complaint
64	Community Houses	1339	123.6	Complaint
65	Community Houses	1132	124.6	Complaint
66	Community Houses	1398	123.3	Complaint
67	Community Houses	1659	122.3	Complaint
68	Community Houses	1684	122.2	Complaint
69	Community Houses	1236	124.1	Complaint
70	Community Houses	1429	123.2	Complaint
71	Community Houses	712	127.5	Complaint
72	Community Houses	774	127.0	Complaint
73	River	1243	124.0	N/A
74	Road	1202	124.2	N/A
75	Farm Buildings/Structures	1026	125.2	Complaint
76	Buildings/Structures	1238	124.1	Complaint
77	Power Line/Pylon	815	126.6	N/A
78	Power Line/Pylon	1027	125.2	N/A
79	Power Line/Pylon	1489	122.9	N/A
80	Power Line/Pylon	1821	121.7	N/A
81	Power Line/Pylon	2411	120.0	N/A
82	Power Line/Pylon	2812	119.0	N/A
83	Power Line/Pylon	3170	118.3	N/A
84	Power Line/Pylon	836	126.5	N/A
85	Power Line/Pylon	1040	125.1	N/A
86	Power Line/Pylon	1141	124.6	N/A
87	Power Line/Pylon	1211	124.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
88	Power Line/Pylon	1417	123.2	N/A
89	Power Line/Pylon	1634	122.4	N/A
90	Power Line/Pylon	1862	121.5	N/A
91	Power Line/Pylon	2045	121.0	N/A
92	Power Line/Pylon	2231	120.4	N/A
93	Power Line/Pylon	2189	120.5	N/A
94	Power Line/Pylon	2103	120.8	N/A
95	Power Line/Pylon	2067	120.9	N/A
96	Power Line/Pylon	2085	120.9	N/A
97	Power Line/Pylon	2071	120.9	N/A
98	Power Line/Pylon	1796	121.8	N/A
99	Power Line/Pylon	1605	122.5	N/A
100	Power Line/Pylon	1342	123.6	N/A
101	Power Line/Pylon	1097	124.8	N/A
102	Power Line/Pylon	1055	125.0	N/A
103	Power Line/Pylon	999	125.4	N/A
104	Power Line/Pylon	1185	124.3	N/A
105	Power Line/Pylon	1311	123.7	N/A
106	Power Line/Pylon	1763	121.9	N/A
107	Power Line/Pylon	2082	120.9	N/A
108	Power Line/Pylon	2363	120.1	N/A
109	Power Line/Pylon	2566	119.6	N/A
110	Power Line/Pylon	2867	118.9	N/A
111	Power Line/Pylon	3421	117.8	N/A
112	Farm Buildings/Structures	1391	123.4	Complaint
113	Dam	1085	124.9	N/A
114	Community Houses	1229	124.1	Complaint
115	Community Houses	1141	124.6	Complaint
116	Community Houses	946	125.7	Complaint
117	Community Houses	747	127.2	Complaint
118	Community Houses	1046	125.1	Complaint
119	Community Houses	1255	124.0	Complaint
120	Community Houses	1548	122.7	Complaint
121	Community Houses	1283	123.8	Complaint
122	Community Houses	910	125.9	Complaint
123	Community Houses	757	127.1	Complaint
124	Community Houses	591	128.6	Complaint
125	Community Houses	503	129.6	Complaint
126	Buildings/Structures	654	128.0	Complaint
127	Community Houses	739	127.2	Complaint
128	Community Houses	1045	125.1	Complaint
129	Community Houses	634	128.2	Complaint
130	Community Houses	633	128.2	Complaint
131	Community Houses	868	126.2	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
132	Community Houses	1306	123.7	Complaint
133	Community Houses	1466	123.0	Complaint
134	Community Houses	1481	123.0	Complaint
135	Buildings/Structure	1167	124.4	Complaint
136	Community Houses	1179	124.4	Complaint
137	Community Houses	1356	123.5	Complaint
138	Community Houses	1457	123.1	Complaint
139	Community Houses	1164	124.4	Complaint
140	Community Houses	636	128.2	Complaint
141	Community Houses	539	129.2	Complaint
142	Community Houses	705	127.5	Complaint
143	Community Houses	751	127.1	Complaint
144	Community Houses	1481	123.0	Complaint
145	Community Houses	1656	122.3	Complaint
146	Community Houses	1220	124.1	Complaint
147	Community Houses	1373	123.4	Complaint
148	Community Houses	1216	124.2	Complaint
149	Community Houses	1251	124.0	Complaint
150	Buildings/Structures	1178	124.4	Complaint
151	Community Houses	1227	124.1	Complaint
152	Community Houses	1418	123.2	Complaint
153	Community Houses	988	125.5	Complaint
154	Community Houses	956	125.6	Complaint
155	Community Houses	1227	124.1	Complaint
156	Community Houses	1469	123.0	Complaint
157	Community Houses	3411	117.8	Acceptable
158	Community Houses	3449	117.7	Acceptable
159	Community Houses	3173	118.3	Acceptable
160	Community Houses	3226	118.2	Acceptable
161	Community Houses	2941	118.7	Acceptable
162	Community Houses	2857	118.9	Acceptable
163	Buildings/Structures	2947	118.7	Acceptable
164	Community Houses	2906	118.8	Acceptable
165	Community Houses	2773	119.1	Acceptable
166	Community Houses	2810	119.0	Acceptable
167	Community Houses	2631	119.4	Acceptable
168	School (Mxosheni Primary School)	2709	119.2	Acceptable
169	Community Houses	2444	119.9	Acceptable
170	Community Houses	2507	119.7	Acceptable
171	Community Houses	2621	119.5	Acceptable
172	Community Houses	2470	119.8	Acceptable
173	Building/Structure	2349	120.1	Complaint
174	Community Houses	2327	120.2	Complaint
175	Community Houses	2259	120.4	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
176	Community Houses	2189	120.5	Complaint
177	Community Houses	2063	120.9	Complaint
178	Community Houses	2200	120.5	Complaint
179	Community Houses	2025	121.0	Complaint
180	Community Houses	1853	121.6	Complaint
181	Community Houses	1645	122.3	Complaint
182	Community Houses	1515	122.8	Complaint
183	Community Houses	3468	117.7	Acceptable
184	Community Houses	3211	118.2	Acceptable
185	Community Houses	3089	118.4	Acceptable
186	Community Houses	3291	118.1	Acceptable
187	Community Houses	2823	119.0	Acceptable
188	Community Houses	3021	118.6	Acceptable
189	Community Houses	3106	118.4	Acceptable
190	Community Houses	2757	119.1	Acceptable
191	Community Houses	2995	118.6	Acceptable
192	Community Houses	2240	120.4	Complaint
193	Community Houses	2390	120.0	Acceptable
194	Community Houses	2656	119.4	Acceptable
195	Community Houses	2701	119.3	Acceptable
196	Community Houses	2447	119.9	Acceptable
197	Community Houses	2548	119.6	Acceptable
198	Community Houses	2219	120.5	Complaint
199	Community Houses	1978	121.2	Complaint
200	Community Houses	2147	120.7	Complaint
201	Community Houses	2028	121.0	Complaint
202	Community Houses	1840	121.6	Complaint
203	Community Houses	1702	122.1	Complaint
204	Community Houses	1627	122.4	Complaint
205	Community Houses	1524	122.8	Complaint
206	Community Houses	1598	122.5	Complaint
207	Community Houses	3470	117.7	Acceptable
208	Community Houses	2968	118.7	Acceptable
209	Community Houses	2323	120.2	Complaint
210	Community Houses	3016	118.6	Acceptable
211	Community Houses	3115	118.4	Acceptable
212	Power Line/Pylon	3216	118.2	N/A
213	Power Line/Pylon	2961	118.7	N/A
214	Power Line/Pylon	2561	119.6	N/A
215	Power Line/Pylon	2330	120.2	N/A
216	Power Line/Pylon	2059	120.9	N/A
217	Power Line/Pylon	1720	122.0	N/A
218	Power Line/Pylon	1600	122.5	N/A
219	Power Line/Pylon	1594	122.5	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
220	Power Line/Pylon	1713	122.1	N/A
221	Power Line/Pylon	1787	121.8	N/A
222	Power Line/Pylon	2380	120.0	N/A
223	Power Line/Pylon	2839	118.9	N/A
224	Power Line/Pylon	2968	118.7	N/A
225	Power Line/Pylon	3267	118.1	N/A
226	Power Line/Pylon	3453	117.7	N/A
227	Community Houses	3378	117.9	Acceptable
228	Community Houses	2958	118.7	Acceptable
229	Buildings/Structures	2514	119.7	Acceptable
230	Community Houses	2330	120.2	Complaint
231	Community Houses	2589	119.5	Acceptable
232	Community Houses	2152	120.7	Complaint
233	Community Houses	1878	121.5	Complaint
234	Community Houses	1568	122.6	Complaint
235	Community Houses	1709	122.1	Complaint
236	Community Houses	1908	121.4	Complaint
237	Community Houses	2350	120.1	Complaint
238	Community Houses	2548	119.6	Acceptable
239	Community Houses	3439	117.8	Acceptable
240	Community Houses	2963	118.7	Acceptable
241	Community Houses	3030	118.5	Acceptable
242	Structure	3179	118.3	Acceptable
243	Community Houses	2227	120.5	Complaint
244	Community Houses	3111	118.4	Acceptable
245	Community Houses	3221	118.2	Acceptable
246	Community Houses	1796	121.8	Complaint
247	Community Houses	2518	119.7	Acceptable
248	Community Houses	3070	118.5	Acceptable
249	Buildings/Structures	3193	118.2	Acceptable
250	Community Houses	3093	118.4	Acceptable
251	Community Houses	2432	119.9	Acceptable
252	Community Houses	2243	120.4	Complaint
253	Buildings/Structures	1845	121.6	Complaint
254	Community Houses	1779	121.8	Complaint
255	Community Houses	2248	120.4	Complaint
256	Community Houses	2075	120.9	Complaint
257	Community Houses	1579	122.6	Complaint
258	Community Houses	1974	121.2	Complaint
259	Community Houses	1848	121.6	Complaint
260	Buildings/Structures	2836	118.9	Acceptable
261	Industrial Structures	2972	118.7	Acceptable
262	Buildings/Structures	2521	119.7	Acceptable
263	Dam	2104	120.8	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
264	River	2195	120.5	N/A
265	Buildings/Structures	2319	120.2	Complaint
266	Building/Structure	1719	122.0	Complaint
267	Dam	3015	118.6	N/A
268	Structure	1878	121.5	Complaint
269	Buildings/Structures	2331	120.2	Complaint
270	Clinic	2435	119.9	Acceptable
271	Dam	2588	119.5	N/A
272	Structure	2705	119.3	Acceptable
273	R66 Road	2398	120.0	N/A
274	Houses	2616	119.5	Acceptable
275	Railway Line	2534	119.6	N/A
276	Railway Buildings	2759	119.1	Acceptable
277	Houses	2820	119.0	Acceptable
278	Industrial Structures	2650	119.4	Acceptable
279	Railway Line	2869	118.9	N/A
280	Railway Line	3400	117.8	N/A
281	Community Houses	2223	120.5	Complaint
282	R34 Road	2992	118.6	N/A
283	Community Houses	1543	122.7	Complaint
284	Farm Buildings/Structures	2881	118.8	Acceptable
285	Community Houses	2250	120.4	Complaint
286	R66 Road	2501	119.7	N/A
287	Community Houses	2239	120.4	Complaint
288	Community Houses	1991	121.1	Complaint
289	Community Houses	1760	121.9	Complaint
290	Community Houses	2171	120.6	Complaint
291	Community Houses	2557	119.6	Acceptable
292	Community Houses	2973	118.7	Acceptable
293	Community Houses	3123	118.4	Acceptable
294	Community Houses	3486	117.7	Acceptable
295	Community Houses	2190	120.5	Complaint
296	Community Houses	2281	120.3	Complaint
297	Community Houses	2683	119.3	Acceptable
298	Community Houses	2573	119.6	Acceptable
299	Community Houses	2548	119.6	Acceptable
300	Community Houses	2866	118.9	Acceptable
301	Community Houses	3219	118.2	Acceptable
302	Community Houses	2501	119.7	Acceptable
303	Community Houses	3049	118.5	Acceptable
304	Community Houses	3396	117.8	Acceptable
305	Community Houses	3386	117.8	Acceptable
306	Community Houses	3369	117.9	Acceptable
307	Community Houses	3091	118.4	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
308	Community Houses	2729	119.2	Acceptable
309	Community Houses	2460	119.8	Acceptable
310	Community Houses	1944	121.3	Complaint
311	Community Houses	1665	122.2	Complaint
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	-	-	-
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	-	-	-
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	-	-	-
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	-	-	-
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	-	-	-
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	-	-	-
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	-	-	-
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	-	-	-
320	Hydrocencus Borehole (GJ03)	1219	124.2	N/A
321	Hydrocencus Borehole (MWGA02)	1100	124.8	N/A
322	Hydrocencus Borehole (MWGA05)	21	149.2	N/A
323	Overland Piping (Planned)	1131	124.6	N/A
324	Overland Piping (Planned)	1179	124.4	N/A
325	Overland Piping (Planned)	671	127.8	N/A
326	Overland Piping (Planned)	713	127.5	N/A
327	Overland Piping (Planned)	1501	122.9	N/A
328	Overland Piping (Planned)	2375	120.0	N/A
329	Overland Piping (Planned)	2939	118.7	N/A
330	Conceptual Plant Access Road (Planned)	957	125.6	N/A
331	Conceptual Plant Access Road (Planned)	950	125.7	N/A
332	Conceptual Plant Access Road (Planned)	1250	124.0	N/A
333	Conceptual Plant Access Road (Planned)	1503	122.9	N/A
334	Waste Rock Dump (Planned)	181	135.9	N/A
335	Waste Rock Dump (Planned)	188	135.7	N/A
336	Waste Rock Dump (Planned)	938	125.8	N/A
337	Waste Rock Dump (Planned)	1799	121.7	N/A
338	Processing Plant (Planned)	1165	124.4	N/A
339	Primary Crusher (Planned)	54	143.3	N/A
340	Primary Crusher (Planned)	368	131.5	N/A
341	Incoming Power Yard (Planned)	1803	121.7	Complaint

17.7.2 Air blast maximum charge mass per delay – South East Pit – 813.5 kg

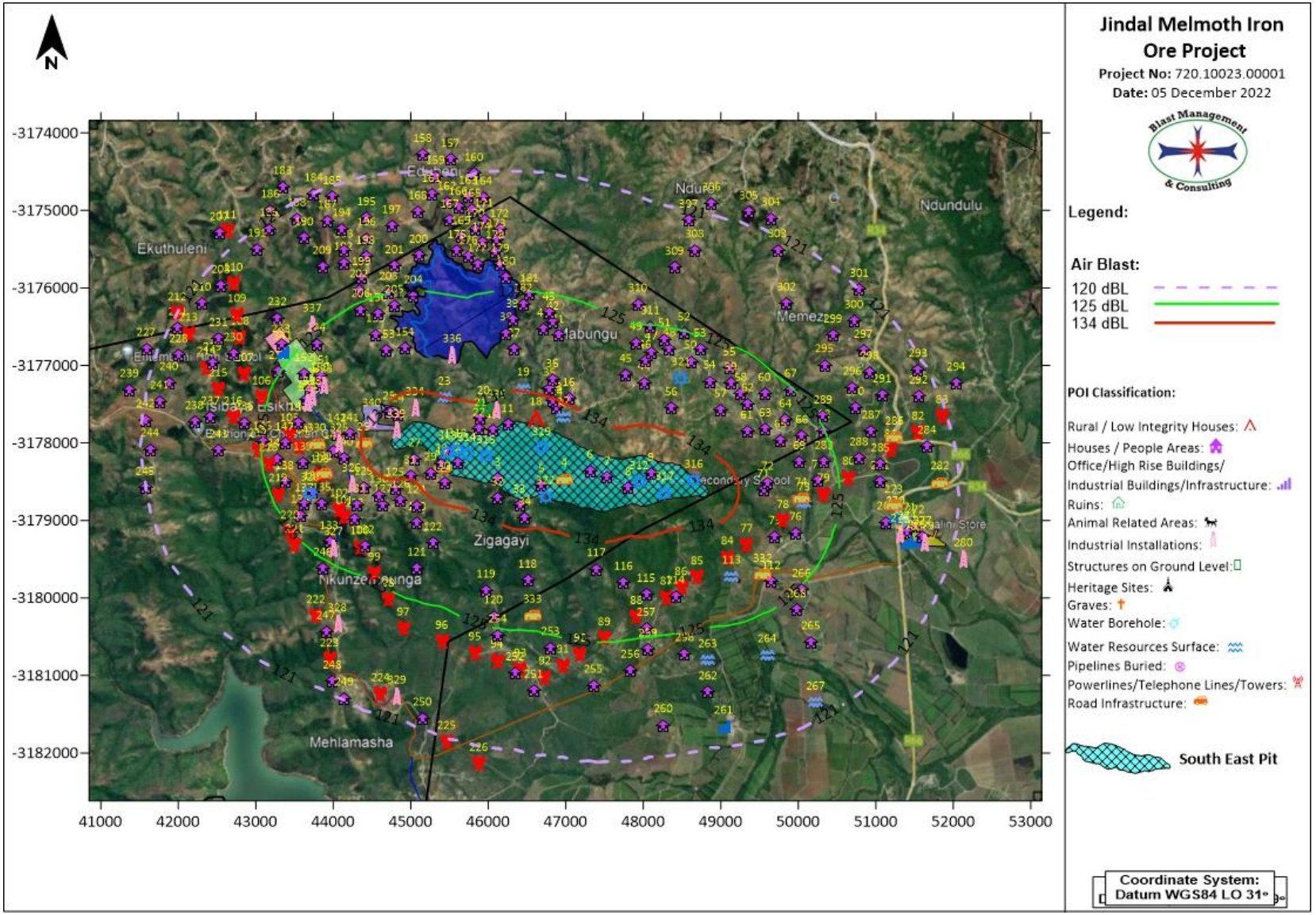


Figure 18: Air blast influence from maximum charge

Table 14: Air blast influence from maximum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Buildings/Structures (Inside Pit Area)	-	-	-
2	Community Houses (Inside Pit Area)	-	-	-
3	Community Houses (Inside Pit Area)	-	-	-
4	D395 Road (Inside Pit Area)	-	-	-
5	Community Houses (Inside Pit Area)	-	-	-
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	-	-	-
7	Community Houses (Inside Pit Area)	-	-	-
8	Community Houses (Inside Pit Area)	-	-	-
9	Community Houses (Inside Pit Area)	-	-	-
10	Community Houses (Inside Pit Area)	-	-	-
11	Community Houses (Inside Pit Area)	-	-	-
12	D395 Road	19	152.8	N/A
13	D255 Road	350	134.7	N/A
14	Community Houses	297	135.7	Problematic
15	Community Houses	356	134.6	Problematic
16	Community Houses	473	132.8	Complaint
17	River	221	137.5	N/A
18	Informal Housing	89	143.1	Problematic
19	River	432	133.4	N/A
20	Ruins	318	135.3	Problematic
21	Building/Structure	197	138.2	Problematic
22	Buildings/Structures	76	144.1	Problematic
23	River	393	134.0	N/A
24	Community Houses	198	138.2	Problematic
25	Community Houses	299	135.7	Problematic
26	Road	356	134.6	N/A
27	Buildings/Structures	184	138.7	Problematic
28	Community Houses	20	152.4	Problematic
29	Community Houses	184	138.7	Problematic
30	Community Houses	128	140.9	Problematic
31	Community Houses	373	134.3	Problematic
32	Community Houses	118	141.4	Problematic
33	Community Houses	79	143.8	Problematic
34	Community Houses	244	136.9	Problematic
35	Buildings/Structures	500	132.5	Complaint
36	Community Houses	618	131.2	Complaint
37	Community Houses	929	128.7	Complaint
38	Community Houses	1135	127.4	Complaint
39	Community Houses	1308	126.6	Complaint
40	Community Houses	1225	127.0	Complaint
41	Community Houses	1185	127.2	Complaint
42	Community Houses	1334	126.5	Complaint
43	Community Houses	1443	125.9	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Community Houses	939	128.6	Complaint
45	Community Houses	1057	127.9	Complaint
46	Community Houses	1220	127.0	Complaint
47	Community Houses	1331	126.5	Complaint
48	Community Houses	1415	126.1	Complaint
49	Community Houses	1455	125.9	Complaint
50	Community Houses	1332	126.5	Complaint
51	Community Houses	1525	125.6	Complaint
52	Community Houses	1659	125.1	Complaint
53	Community Houses	1509	125.7	Complaint
54	Community Houses	1147	127.4	Complaint
55	Community Houses	1408	126.1	Complaint
56	Community Houses	695	130.5	Complaint
57	Community Houses	885	129.0	Complaint
58	Community Houses	1208	127.1	Complaint
59	Community Houses	1246	126.9	Complaint
60	Community Houses	1410	126.1	Complaint
61	Community Houses	884	129.0	Complaint
62	Community Houses	1173	127.2	Complaint
63	Buildings/Structures	1065	127.8	Complaint
64	Community Houses	1339	126.4	Complaint
65	Community Houses	1132	127.5	Complaint
66	Community Houses	1398	126.2	Complaint
67	Community Houses	1659	125.1	Complaint
68	Community Houses	1684	125.0	Complaint
69	Community Houses	1236	126.9	Complaint
70	Community Houses	1429	126.0	Complaint
71	Community Houses	712	130.3	Complaint
72	Community Houses	774	129.8	Complaint
73	River	1243	126.9	N/A
74	Road	1202	127.1	N/A
75	Farm Buildings/Structures	1026	128.1	Complaint
76	Buildings/Structures	1238	126.9	Complaint
77	Power Line/Pylon	815	129.5	N/A
78	Power Line/Pylon	1027	128.1	N/A
79	Power Line/Pylon	1489	125.8	N/A
80	Power Line/Pylon	1821	124.5	N/A
81	Power Line/Pylon	2411	122.8	N/A
82	Power Line/Pylon	2812	121.9	N/A
83	Power Line/Pylon	3170	121.1	N/A
84	Power Line/Pylon	836	129.3	N/A
85	Power Line/Pylon	1040	128.0	N/A
86	Power Line/Pylon	1141	127.4	N/A
87	Power Line/Pylon	1211	127.0	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
88	Power Line/Pylon	1417	126.1	N/A
89	Power Line/Pylon	1634	125.2	N/A
90	Power Line/Pylon	1862	124.4	N/A
91	Power Line/Pylon	2045	123.8	N/A
92	Power Line/Pylon	2231	123.3	N/A
93	Power Line/Pylon	2189	123.4	N/A
94	Power Line/Pylon	2103	123.6	N/A
95	Power Line/Pylon	2067	123.8	N/A
96	Power Line/Pylon	2085	123.7	N/A
97	Power Line/Pylon	2071	123.7	N/A
98	Power Line/Pylon	1796	124.6	N/A
99	Power Line/Pylon	1605	125.3	N/A
100	Power Line/Pylon	1342	126.4	N/A
101	Power Line/Pylon	1097	127.6	N/A
102	Power Line/Pylon	1055	127.9	N/A
103	Power Line/Pylon	999	128.2	N/A
104	Power Line/Pylon	1185	127.2	N/A
105	Power Line/Pylon	1311	126.6	N/A
106	Power Line/Pylon	1763	124.7	N/A
107	Power Line/Pylon	2082	123.7	N/A
108	Power Line/Pylon	2363	122.9	N/A
109	Power Line/Pylon	2566	122.4	N/A
110	Power Line/Pylon	2867	121.7	N/A
111	Power Line/Pylon	3421	120.7	N/A
112	Farm Buildings/Structures	1391	126.2	Complaint
113	Dam	1085	127.7	N/A
114	Community Houses	1229	127.0	Complaint
115	Community Houses	1141	127.4	Complaint
116	Community Houses	946	128.6	Complaint
117	Community Houses	747	130.0	Complaint
118	Community Houses	1046	127.9	Complaint
119	Community Houses	1255	126.8	Complaint
120	Community Houses	1548	125.5	Complaint
121	Community Houses	1283	126.7	Complaint
122	Community Houses	910	128.8	Complaint
123	Community Houses	757	129.9	Complaint
124	Community Houses	591	131.5	Complaint
125	Community Houses	503	132.5	Complaint
126	Buildings/Structures	654	130.8	Complaint
127	Community Houses	739	130.1	Complaint
128	Community Houses	1045	127.9	Complaint
129	Community Houses	634	131.0	Complaint
130	Community Houses	633	131.0	Complaint
131	Community Houses	868	129.1	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
132	Community Houses	1306	126.6	Complaint
133	Community Houses	1466	125.9	Complaint
134	Community Houses	1481	125.8	Complaint
135	Buildings/Structure	1167	127.3	Complaint
136	Community Houses	1179	127.2	Complaint
137	Community Houses	1356	126.4	Complaint
138	Community Houses	1457	125.9	Complaint
139	Community Houses	1164	127.3	Complaint
140	Community Houses	636	131.0	Complaint
141	Community Houses	539	132.0	Complaint
142	Community Houses	705	130.4	Complaint
143	Community Houses	751	130.0	Complaint
144	Community Houses	1481	125.8	Complaint
145	Community Houses	1656	125.1	Complaint
146	Community Houses	1220	127.0	Complaint
147	Community Houses	1373	126.3	Complaint
148	Community Houses	1216	127.0	Complaint
149	Community Houses	1251	126.8	Complaint
150	Buildings/Structures	1178	127.2	Complaint
151	Community Houses	1227	127.0	Complaint
152	Community Houses	1418	126.1	Complaint
153	Community Houses	988	128.3	Complaint
154	Community Houses	956	128.5	Complaint
155	Community Houses	1227	127.0	Complaint
156	Community Houses	1469	125.8	Complaint
157	Community Houses	3411	120.7	Complaint
158	Community Houses	3449	120.6	Complaint
159	Community Houses	3173	121.1	Complaint
160	Community Houses	3226	121.0	Complaint
161	Community Houses	2941	121.6	Complaint
162	Community Houses	2857	121.7	Complaint
163	Buildings/Structures	2947	121.6	Complaint
164	Community Houses	2906	121.6	Complaint
165	Community Houses	2773	121.9	Complaint
166	Community Houses	2810	121.9	Complaint
167	Community Houses	2631	122.3	Complaint
168	School (Mxosheni Primary School)	2709	122.1	Complaint
169	Community Houses	2444	122.7	Complaint
170	Community Houses	2507	122.6	Complaint
171	Community Houses	2621	122.3	Complaint
172	Community Houses	2470	122.7	Complaint
173	Building/Structure	2349	123.0	Complaint
174	Community Houses	2327	123.0	Complaint
175	Community Houses	2259	123.2	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
176	Community Houses	2189	123.4	Complaint
177	Community Houses	2063	123.8	Complaint
178	Community Houses	2200	123.4	Complaint
179	Community Houses	2025	123.9	Complaint
180	Community Houses	1853	124.4	Complaint
181	Community Houses	1645	125.2	Complaint
182	Community Houses	1515	125.7	Complaint
183	Community Houses	3468	120.6	Complaint
184	Community Houses	3211	121.0	Complaint
185	Community Houses	3089	121.3	Complaint
186	Community Houses	3291	120.9	Complaint
187	Community Houses	2823	121.8	Complaint
188	Community Houses	3021	121.4	Complaint
189	Community Houses	3106	121.2	Complaint
190	Community Houses	2757	122.0	Complaint
191	Community Houses	2995	121.5	Complaint
192	Community Houses	2240	123.3	Complaint
193	Community Houses	2390	122.8	Complaint
194	Community Houses	2656	122.2	Complaint
195	Community Houses	2701	122.1	Complaint
196	Community Houses	2447	122.7	Complaint
197	Community Houses	2548	122.5	Complaint
198	Community Houses	2219	123.3	Complaint
199	Community Houses	1978	124.0	Complaint
200	Community Houses	2147	123.5	Complaint
201	Community Houses	2028	123.9	Complaint
202	Community Houses	1840	124.5	Complaint
203	Community Houses	1702	124.9	Complaint
204	Community Houses	1627	125.2	Complaint
205	Community Houses	1524	125.6	Complaint
206	Community Houses	1598	125.3	Complaint
207	Community Houses	3470	120.6	Complaint
208	Community Houses	2968	121.5	Complaint
209	Community Houses	2323	123.0	Complaint
210	Community Houses	3016	121.4	Complaint
211	Community Houses	3115	121.2	Complaint
212	Power Line/Pylon	3216	121.0	N/A
213	Power Line/Pylon	2961	121.5	N/A
214	Power Line/Pylon	2561	122.4	N/A
215	Power Line/Pylon	2330	123.0	N/A
216	Power Line/Pylon	2059	123.8	N/A
217	Power Line/Pylon	1720	124.9	N/A
218	Power Line/Pylon	1600	125.3	N/A
219	Power Line/Pylon	1594	125.3	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
220	Power Line/Pylon	1713	124.9	N/A
221	Power Line/Pylon	1787	124.6	N/A
222	Power Line/Pylon	2380	122.9	N/A
223	Power Line/Pylon	2839	121.8	N/A
224	Power Line/Pylon	2968	121.5	N/A
225	Power Line/Pylon	3267	120.9	N/A
226	Power Line/Pylon	3453	120.6	N/A
227	Community Houses	3378	120.7	Complaint
228	Community Houses	2958	121.5	Complaint
229	Buildings/Structures	2514	122.6	Complaint
230	Community Houses	2330	123.0	Complaint
231	Community Houses	2589	122.4	Complaint
232	Community Houses	2152	123.5	Complaint
233	Community Houses	1878	124.4	Complaint
234	Community Houses	1568	125.5	Complaint
235	Community Houses	1709	124.9	Complaint
236	Community Houses	1908	124.2	Complaint
237	Community Houses	2350	123.0	Complaint
238	Community Houses	2548	122.5	Complaint
239	Community Houses	3439	120.6	Complaint
240	Community Houses	2963	121.5	Complaint
241	Community Houses	3030	121.4	Complaint
242	Structure	3179	121.1	Complaint
243	Community Houses	2227	123.3	Complaint
244	Community Houses	3111	121.2	Complaint
245	Community Houses	3221	121.0	Complaint
246	Community Houses	1796	124.6	Complaint
247	Community Houses	2518	122.5	Complaint
248	Community Houses	3070	121.3	Complaint
249	Buildings/Structures	3193	121.1	Complaint
250	Community Houses	3093	121.3	Complaint
251	Community Houses	2432	122.7	Complaint
252	Community Houses	2243	123.2	Complaint
253	Buildings/Structures	1845	124.5	Complaint
254	Community Houses	1779	124.7	Complaint
255	Community Houses	2248	123.2	Complaint
256	Community Houses	2075	123.7	Complaint
257	Community Houses	1579	125.4	Complaint
258	Community Houses	1974	124.0	Complaint
259	Community Houses	1848	124.4	Complaint
260	Buildings/Structures	2836	121.8	Complaint
261	Industrial Structures	2972	121.5	Complaint
262	Buildings/Structures	2521	122.5	Complaint
263	Dam	2104	123.6	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
264	River	2195	123.4	N/A
265	Buildings/Structures	2319	123.0	Complaint
266	Building/Structure	1719	124.9	Complaint
267	Dam	3015	121.4	N/A
268	Structure	1878	124.3	Complaint
269	Buildings/Structures	2331	123.0	Complaint
270	Clinic	2435	122.7	Complaint
271	Dam	2588	122.4	N/A
272	Structure	2705	122.1	Complaint
273	R66 Road	2398	122.8	N/A
274	Houses	2616	122.3	Complaint
275	Railway Line	2534	122.5	N/A
276	Railway Buildings	2759	122.0	Complaint
277	Houses	2820	121.8	Complaint
278	Industrial Structures	2650	122.2	Complaint
279	Railway Line	2869	121.7	N/A
280	Railway Line	3400	120.7	N/A
281	Community Houses	2223	123.3	Complaint
282	R34 Road	2992	121.5	N/A
283	Community Houses	1543	125.5	Complaint
284	Farm Buildings/Structures	2881	121.7	Complaint
285	Community Houses	2250	123.2	Complaint
286	R66 Road	2501	122.6	N/A
287	Community Houses	2239	123.3	Complaint
288	Community Houses	1991	124.0	Complaint
289	Community Houses	1760	124.7	Complaint
290	Community Houses	2171	123.4	Complaint
291	Community Houses	2557	122.4	Complaint
292	Community Houses	2973	121.5	Complaint
293	Community Houses	3123	121.2	Complaint
294	Community Houses	3486	120.5	Complaint
295	Community Houses	2190	123.4	Complaint
296	Community Houses	2281	123.1	Complaint
297	Community Houses	2683	122.1	Complaint
298	Community Houses	2573	122.4	Complaint
299	Community Houses	2548	122.5	Complaint
300	Community Houses	2866	121.7	Complaint
301	Community Houses	3219	121.0	Complaint
302	Community Houses	2501	122.6	Complaint
303	Community Houses	3049	121.4	Complaint
304	Community Houses	3396	120.7	Complaint
305	Community Houses	3386	120.7	Complaint
306	Community Houses	3369	120.7	Complaint
307	Community Houses	3091	121.3	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
308	Community Houses	2729	122.0	Complaint
309	Community Houses	2460	122.7	Complaint
310	Community Houses	1944	124.1	Complaint
311	Community Houses	1665	125.1	Complaint
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	-	-	-
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	-	-	-
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	-	-	-
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	-	-	-
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	-	-	-
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	-	-	-
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	-	-	-
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	-	-	-
320	Hydrocencus Borehole (GJ03)	1219	127.0	N/A
321	Hydrocencus Borehole (MWGA02)	1100	127.6	N/A
322	Hydrocencus Borehole (MWGA05)	21	152.0	N/A
323	Overland Piping (Planned)	1131	127.5	N/A
324	Overland Piping (Planned)	1179	127.2	N/A
325	Overland Piping (Planned)	671	130.7	N/A
326	Overland Piping (Planned)	713	130.3	N/A
327	Overland Piping (Planned)	1501	125.7	N/A
328	Overland Piping (Planned)	2375	122.9	N/A
329	Overland Piping (Planned)	2939	121.6	N/A
330	Conceptual Plant Access Road (Planned)	957	128.5	N/A
331	Conceptual Plant Access Road (Planned)	950	128.5	N/A
332	Conceptual Plant Access Road (Planned)	1250	126.8	N/A
333	Conceptual Plant Access Road (Planned)	1503	125.7	N/A
334	Waste Rock Dump (Planned)	181	138.8	N/A
335	Waste Rock Dump (Planned)	188	138.5	N/A
336	Waste Rock Dump (Planned)	938	128.6	N/A
337	Waste Rock Dump (Planned)	1799	124.6	N/A
338	Processing Plant (Planned)	1165	127.3	N/A
339	Primary Crusher (Planned)	54	146.2	N/A
340	Primary Crusher (Planned)	368	134.4	N/A
341	Incoming Power Yard (Planned)	1803	124.6	Complaint

17.8 Summary of findings for air blast

Review of the air blast levels indicate greater concerns. Air blast predicted for the maximum charge ranges between 120.5 and 152.4 dB for all the POI's considered. This includes the nearest points such as the Community Houses and Buildings/Structures. These levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and that could lead to complaints.

Minimum charge predictions identified that hundred and forty-four POI's at the pit area could experience levels of air blast that could lead to complaints. Maximum charge predictions indicate that two hundred and sixteen POI's at the pit area could experience air blast that could lead to complaints. Sixteen POI's were identified where damage may be induced.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 393 m and closer to pit boundary. Infrastructure at the pit areas such as roads and power lines/pylons are present, but air blast does not have any influence on these installations.

The possible negative effects from air blast are expected to be the same than that of ground vibration. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pit is located such that "free blasting" – meaning no controls on blast preparation – will not be possible. The effect of stemming control will need to be considered. In many cases the lack of proper control on stemming material and length contributes mostly to complaints from neighbours.

17.9 Fly-rock unsafe zone

The occurrence of fly rock in any form will have a negative impact if found to travel outside the unsafe zone. This unsafe zone may be anything between 10 m or 1000 m. A general unsafe zone applied by most mines is normally considered to be within a radius of 500 m from the blast; but needs to be qualified and determined as best possible.

Calculations are also used to help and assist determining safe distances. A safe distance from blasting is calculated following rules and guidelines from the International Society of Explosives Engineers (ISEE) Blasters Handbook. Using this calculation, the minimum safe distances can be determined that should be cleared of people, animals and equipment. Figure 19 shows the results from the ISEE calculations for fly rock range based on an 171 mm diameter blast hole and 3.6 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 412 m. The absolute minimum unsafe zone is then the 412 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated. Figure 20 shows the area around the Pit that incorporates the 412 m unsafe zone. Any blasting conducted within the pit boundary will have safe boundaries that is based on the specific blast. This report uses the edge of pit area as basis.

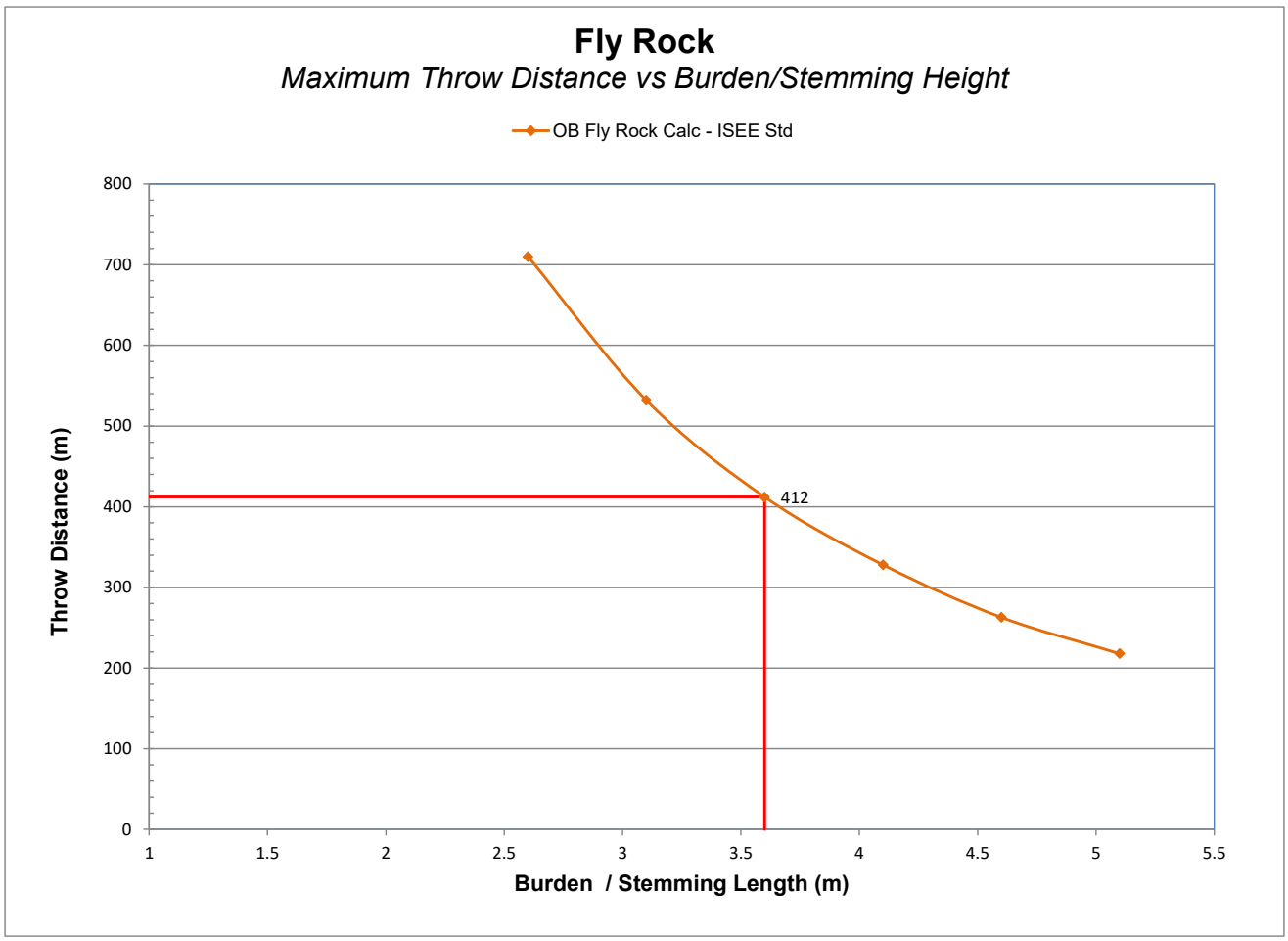


Figure 19: Fly rock prediction calculation

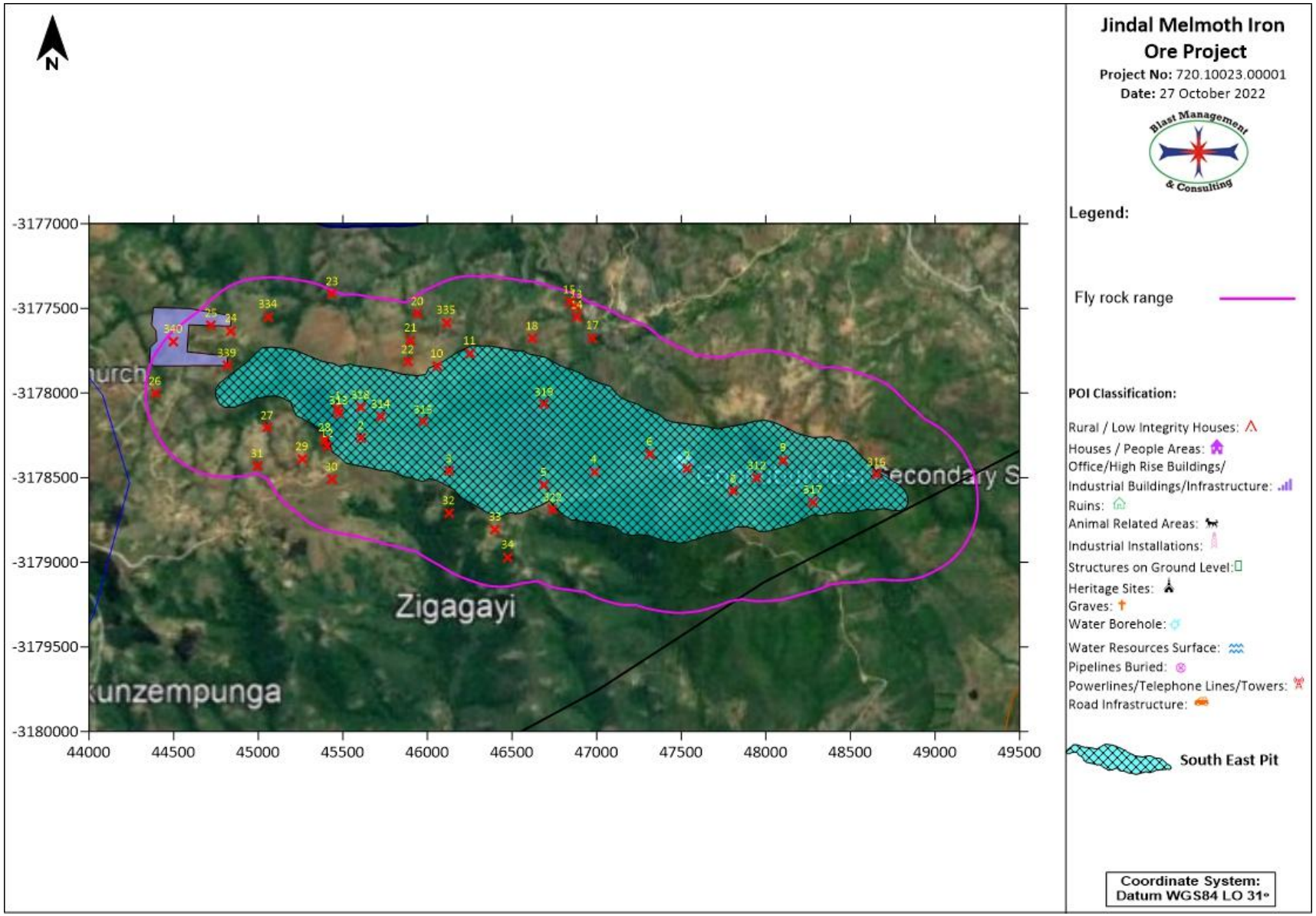


Figure 20: Predicted Fly Rock Exclusion Zone

Review of the calculated unsafe zone showed forty-five POI's for the Pit area (including nineteen POI's inside the pit area at this stage), are within the unsafe zone. Table 15 below shows the POI's of concern and coordinates.

Table 15: Fly rock concern POI's

Tag	Description	Y	X
1	Buildings/Structures (Inside Pit Area)	-45471.50	3178089.56
2	Community Houses (Inside Pit Area)	-45606.98	3178265.25
3	Community Houses (Inside Pit Area)	-46126.78	3178462.14
4	D395 Road (Inside Pit Area)	-46985.72	3178467.74
5	Community Houses (Inside Pit Area)	-46688.65	3178541.17
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	-47314.73	3178361.05
7	Community Houses (Inside Pit Area)	-47535.67	3178445.80
8	Community Houses (Inside Pit Area)	-47808.92	3178581.09
9	Community Houses (Inside Pit Area)	-48102.69	3178396.09
10	Community Houses (Inside Pit Area)	-46056.36	3177841.06
11	Community Houses (Inside Pit Area)	-46250.59	3177765.37
12	D395 Road	-45408.14	3178312.40
13	D255 Road	-46880.02	3177490.67
14	Community Houses	-46884.02	3177554.37
15	Community Houses	-46839.82	3177463.16
17	River	-46976.10	3177673.56
18	Informal Housing	-46618.65	3177677.91
20	Ruins	-45941.19	3177533.28
21	Building/Structure	-45902.06	3177689.65
22	Buildings/Structures	-45884.38	3177816.32
23	River	-45438.38	3177414.23
24	Community Houses	-44840.13	3177631.90
25	Community Houses	-44723.29	3177602.28
26	Road	-44391.70	3178004.10
27	Buildings/Structures	-45052.48	3178206.54
28	Community Houses	-45393.59	3178279.01
29	Community Houses	-45259.31	3178390.20
30	Community Houses	-45434.19	3178509.93
31	Community Houses	-44995.16	3178432.12
32	Community Houses	-46126.58	3178709.87
33	Community Houses	-46401.76	3178805.60
34	Community Houses	-46476.01	3178970.41
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	-47948.00	3178503.01
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	-45477.00	3178118.01
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	-45725.00	3178140.01
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	-45975.00	3178172.01
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	-48654.00	3178483.01
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	-48278.00	3178645.01
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	-45606.00	3178086.01
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	-46690.00	3178068.01

Tag	Description	Y	X
322	Hydrocencus Borehole (MWGA05)	-46741.00	3178691.01
334	Waste Rock Dump (Planned)	-45058.21	3177548.65
335	Waste Rock Dump (Planned)	-46111.46	3177583.02
339	Primary Crusher (Planned)	-44815.40	3177837.83
340	Primary Crusher (Planned)	-44498.45	3177695.09

17.10 Noxious fumes

The occurrence of fumes in the form the NOx gas is not a given and very dependent on various factors as discussed in Section 13.6. However, the occurrence of fumes should be closely monitored. Furthermore, nothing can be stated as to fume dispersal to nearby farmsteads, but if anybody is present in the path of the fume cloud it could be problematic.

18 Potential Environmental Impact Assessment: Operational Phase

18.1 Assessment Methodology

The method used for the assessment of impacts is set out in Table 16. This assessment methodology enables the assessment of environmental impacts including: cumulative impacts, the intensity of impacts (including the nature of impacts and the degree to which impacts may cause irreplaceable loss of resources), the extent of the impacts, the duration and reversibility of impacts, the probability of the impact occurring, and the degree to which the impacts can be mitigated.

Table 16: SLR EIA Methodology

PART A: DEFINITIONS AND CRITERIA*		
Definition of SIGNIFICANCE		**Significance = consequence x probability**
Definition of CONSEQUENCE		**Consequence is a function of intensity, spatial extent and duration**
Criteria for ranking of the INTENSITY of environmental impacts	**VH**	Severe change, disturbance or degradation. Associated with severe consequences. May result in severe illness, injury or death. Targets, limits and thresholds of concern continually exceeded. Substantial intervention will be required. Vigorous/widespread community mobilization against project can be expected. May result in legal action if impact occurs.
	H	Prominent change, disturbance or degradation. Associated with real and substantial consequences. May result in illness or injury. Targets, limits and thresholds of concern regularly exceeded. Will definitely require intervention. Threats of community action. Regular complaints can be expected when the impact takes place.
	M	Moderate change, disturbance or discomfort. Associated with real but not substantial consequences. Targets, limits and thresholds of concern may occasionally be exceeded. Likely to require some intervention. Occasional complaints can be expected.

	L	Minor (Slight) change, disturbance or nuisance. Associated with minor consequences or deterioration. Targets, limits and thresholds of concern rarely exceeded. Require only minor interventions or clean-up actions. Sporadic complaints could be expected.
	VL	Negligible change, disturbance or nuisance. Associated with very minor consequences or deterioration. Targets, limits and thresholds of concern never exceeded. No interventions or clean-up actions required. No complaints anticipated.
	VL+	Negligible change or improvement. Almost no benefits. Change not measurable/will remain in the current range.
	L+	Minor change or improvement. Minor benefits. Change not measurable/will remain in the current range. Few people will experience benefits.
	M+	Moderate change or improvement. Real but not substantial benefits. Will be within or marginally better than the current conditions. Small number of people will experience benefits.
	H+	Prominent change or improvement. Real and substantial benefits. Will be better than current conditions. Many people will experience benefits. General community support.
	VH+	Substantial, large-scale change or improvement. Considerable and widespread benefit. Will be much better than the current conditions. Favourable publicity and/or widespread support expected.
Criteria for ranking the DURATION of impacts	**VL**	Very short, always less than a year. Quickly reversible
	L	Short-term, occurs for more than 1 but less than 5 years. Reversible over time.
	M	Medium-term, 5 to 10 years.
	H	Long term, between 10 and 20 years. (Likely to cease at the end of the operational life of the activity)
	VH	Very long, permanent, +20 years (Irreversible. Beyond closure)
Criteria for ranking the EXTENT of impacts	**VL**	A part of the site/property.
	L	Whole site.
	M	Beyond the site boundary, affecting immediate neighbours
	H	Local area, extending far beyond site boundary.
	VH	Regional/National

PART B: DETERMINING CONSEQUENCE

INTENSITY = VL

DURATION	Very long	**VH**	**Low**	**Low**	**Medium**	**Medium**	**High**
	Long term	**H**	**Low**	**Low**	**Low**	**Medium**	**Medium**
	Medium term	**M**	**Very Low**	**Low**	**Low**	**Low**	**Medium**
	Short term	**L**	**Very low**	**Very Low**	**Low**	**Low**	**Low**
	Very short	**VL**	**Very low**	**Very Low**	**Very Low**	**Low**	**Low**

INTENSITY = L

DURATION	Very long	**VH**	**Medium**	**Medium**	**Medium**	**High**	**High**
	Long term	**H**	**Low**	**Medium**	**Medium**	**Medium**	**High**
	Medium term	**M**	**Low**	**Low**	**Medium**	**Medium**	**Medium**
	Short term	**L**	**Low**	**Low**	**Low**	**Medium**	**Medium**
	Very short	**VL**	**Very low**	**Low**	**Low**	**Low**	**Medium**

INTENSITY = M

DURATION	Very long	**VH**	**Medium**	**High**	**High**	**High**	**Very High**

	Long term	H	Medium	Medium	Medium	High	High
	Medium term	M	Medium	Medium	Medium	High	High
	Short term	L	Low	Medium	Medium	Medium	High
	Very short	VL	Low	Low	Low	Medium	Medium
INTENSITY = H							
DURATION	Very long	VH	High	High	High	Very High	Very High
	Long term	H	Medium	High	High	High	Very High
	Medium term	M	Medium	Medium	High	High	High
	Short term	L	Medium	Medium	Medium	High	High
	Very short	VL	Low	Medium	Medium	Medium	High
INTENSITY = VH							
DURATION	Very long	VH	High	High	Very High	Very High	Very High
	Long term	H	High	High	High	Very High	Very High
	Medium term	M	Medium	High	High	High	Very High
	Short term	L	Medium	Medium	High	High	High
	Very short	VL	Low	Medium	Medium	High	High

VL	L	M	H	VH
A part of the site/ property	Whole site	Beyond the site, affecting neighbours	Extending far beyond site but localised	Regional/ National
EXTENT				

PART C: DETERMINING SIGNIFICANCE							
PROBABILITY (of exposure to impacts)	Definite/ Continuous	VH	Very Low	Low	Medium	High	Very High
	Probable	H	Very Low	Low	Medium	High	Very High
	Possible/ frequent	M	Very Low	Very Low	Low	Medium	High
	Conceivable	L	Insignificant	Very Low	Low	Medium	High
	Unlikely/ improbable	VL	Insignificant	Insignificant	Very Low	Low	Medium

VL	L	M	H	VVH
CONSEQUENCE				

PART D: INTERPRETATION OF SIGNIFICANCE	
Significance	**Decision guideline**
Very High	Potential fatal flaw unless mitigated to lower significance.
High	It must have an influence on the decision. Substantial mitigation will be required.
Medium	It should have an influence on the decision. Mitigation will be required.
Low	Unlikely that it will have a real influence on the decision. Limited mitigation is likely required.
Very Low	It will not have an influence on the decision. Does not require any mitigation
Insignificant	Inconsequential, not requiring any consideration.

***VH = very high, H = high, M= medium, L= low and VL= very low and + denotes a positive impact.**

18.2 Detailed Assessment of Potential Impacts

Issue: Impact Of Blasting Effects On Surrounding Areas

Description Of Impact

Blasting operations are required to break rock for excavation to access the targeted ore material. Explosives in blast holes provide the required energy to conduct the work. Ground vibration, air blast and fly rock are a result of the blasting process.

Ground vibration, air blast and fly rock are expected to be considered mainly during the operational phase of the project.

Blasting operation will generate ground vibration, air blast and fly rock. The type of blast and parameters will determine the intensity of ground vibration and air blast and range of fly rock to be experienced. The intensity for ground vibration and air blast and occurrence of fly rock will also differ over distance from the blast area being done. Blasts create movement of rock but elements may travel further from the blast. The range of expected fly rock is predicted and considered.

Ground vibration and air blast limits depends on the type of structure. Different types of structures / installations have different allowable limits. This was considered in evaluation with the distance from the pit areas. The expected influences were considered and evaluated in this assessment.

18.2.1 Impact Assessment: Construction Phase

Potential Impacts: Ground Vibration

No blasting operations are expected to be done during the construction phase. There is no ground vibration, air blast or fly rock impact anticipated.

The impact for ground vibration can be assessed as insignificant. (Table 17).

Table 17: Impact summary – Ground Vibration Impact in Construction Phase

Issue: Ground vibration		
Phases: Construction Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Negligible or no change, disturbance or nuisance. (VL)	Negligible or no change, disturbance or nuisance. (VL)
Duration	Very Short if any (VL)	Very Short if any (VL)
Extent	On site only if any (VL)	On site only if any (VL)
Consequence	Very Low (VL)	Very Low (VL)
Probability	Very Low (VL)	Very Low (VL)
Significance	Insignificant	Insignificant
Degree to which impact can be reversed	Blasting is not expected in the construction phase	
Degree to which impact may cause irreplaceable loss of resources	Very Low	

Mitigation/ Enhancement Measures

No specific mitigation measures required.

Potential Impacts: Air Blast

The impact for air blast can be assessed as insignificant. (**Table 18**).

Table 18: Impact summary – Air Blast Impact in Construction Phase

Issue: Ground vibration		
Phases: Construction Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Negligible or no change, disturbance or nuisance. (VL)	Negligible or no change, disturbance or nuisance. (VL)
Duration	Very Short if any (VL)	Very Short if any (VL)
Extent	On site only if any (VL)	On site only if any (VL)
Consequence	Very Low (VL)	Very Low (VL)
Probability	Very Low (VL)	Very Low (VL)
Significance	Insignificant	Insignificant
Degree to which impact can be reversed	Blasting is not expected in the construction phase	
Degree to which impact may cause irreplaceable loss of resources	Very Low	

Mitigation/ Enhancement Measures

No specific mitigation measures required.

Potential Impacts: Fly Rock

The impact for fly rock can be assessed as insignificant. (**Table 19**).

Table 19: Impact summary – Fly Rock Impact in Construction Phase

Issue: Ground vibration		
Phases: Construction Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Negligible or no change, disturbance or nuisance. (VL)	Negligible or no change, disturbance or nuisance. (VL)
Duration	Very Short if any (VL)	Very Short if any (VL)
Extent	On site only if any (VL)	On site only if any (VL)
Consequence	Very Low (VL)	Very Low (VL)
Probability	Very Low (VL)	Very Low (VL)
Significance	Insignificant	Insignificant

Degree to which impact can be reversed	Blasting is not expected in the construction phase
Degree to which impact may cause irreplaceable loss of resources	Very Low

Mitigation/ Enhancement Measures

No specific mitigation measures required.

18.2.2 Impact Assessment: Operational Phase

Potential Impacts: Ground Vibration

Predicted levels of ground vibrations were greater than recommended limits for specific points of concern identified. The probability of damage and possible reason for complaints at these points is significant.

The impact on the D395 Road, Community Houses, Informal Housing, Ruins, Buildings/Structures, Hydrocencus Borehole during the operational phase is assessed to have a prominent intensity and would occur over the long-term. It could impact immediate neighbours and as such the significance prior to mitigation is assessed to be HIGH. With the implementation of mitigation measures the impact can be reduced to LOW (**Table 20**).

Table 20: Impact summary – Ground Vibration Impact in Operational Phase

Issue: Contamination of Surface Water Resources		
Phases: Operational Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change or disturbance (H)	Moderate change or disturbance (M)
Duration	Long-term (H)	Long-term (H)
Extent	Beyond the site boundary, affecting immediate neighbours (M)	Beyond the site boundary, affecting immediate neighbours (M)
Consequence	High (H)	Medium (M)
Probability	Probable (H)	Possible/ frequent (M)
Significance	High (H)	Low (L)
Degree to which impact can be reversed	Provided mitigation measures are implemented the impact can be managed and reduced significantly.	
Degree to which impact may cause irreplaceable loss of resources	Medium as the impact may cause damage to structures if not controlled properly.	

Mitigation/ Enhancement Measures

Mitigation of ground vibration for this can be done applying the following methods:

- Conduct a test blast to assist with defining expected ground vibration levels for future blast designs.

- Do blast design that considers the actual blasting and the ground vibration levels to be adhered too.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.
- Consider relocation of households closest to the pit areas – preferably within 500 m from pit edge.

- Good housekeeping practices should be implemented and maintained with monitoring of each blast.
- Evacuating of people and animals out of the danger zone.
- Structural surveys will need to be done as indicated in the report.

Monitoring

Monitoring should be implemented as per Section 21.

Potential Impacts: Air Blast

Predicted levels of air blast were greater than recommended limits for specific points of concern identified. The probability of damage and possible reason for complaints at these points is significant.

The impact on the Community Houses, Informal Housing, Buildings/Structures during the operational phase is assessed to have a prominent intensity and would occur over the long-term. It could impact immediate neighbours and as such the significance prior to mitigation is assessed to be HIGH. With the implementation of mitigation measures the impact can be reduced to LOW (**Table 21**).

Table 21: Impact summary – Ground Vibration Impact in Operational Phase

Issue: Contamination of Surface Water Resources		
Phases: Operational Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change or disturbance (H)	Moderate change or disturbance (M)
Duration	Long-term (H)	Long-term (H)
Extent	Beyond the site boundary, affecting immediate neighbours (M)	Beyond the site boundary, affecting immediate neighbours (M)
Consequence	High (H)	Medium (M)
Probability	Probable (H)	Possible/ frequent (M)
Significance	High (H)	Low (L)
Degree to which impact can be reversed	Provided mitigation measures are implemented the impact can be managed and reduced significantly.	
Degree to which impact may cause irreplaceable loss of resources	Medium as the impact may cause damage to structures if not controlled properly.	

Mitigation/ Enhancement Measures

Mitigation of air blast can be done applying the following methods:

- Conduct a test blast to assist with defining expected air blast levels for future blast designs.
- Do blast design that considers the actual blasting and the air blast levels to be adhered too.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole. Smaller diameter blastholes will also have better stemming vs explosive column ratio.
- Blast design to consider proper stemming management.
- Use of crushed aggregate with size of 10% the drill diameter.
- Consider increase of stemming lengths to ratio of 25 to 30 times the blast diameter.
- Consider relocation of households closest to the pit areas – preferably within 500 m from pit edge.
- Good housekeeping practices should be implemented and maintained with monitoring of each blast.
- Structural surveys will need to be done as indicated in the report.

Monitoring

Monitoring should be implemented as per Section 21.

Potential Impacts: Fly Rock

Predicted range of fly rock extends to range of 412 m. this range includes specific points of concern identified. The probability of impact or damage is significant when blasting is conducted within 500 m from the points of interest identified.

The impact on the D395 Road, Community Houses, Informal Housing, Ruins, Buildings/Structures, Hydrocencus Borehole during the operational phase is assessed to have a prominent intensity and would occur over the long-term. It could impact immediate neighbours and as such the significance prior to mitigation is assessed to be HIGH. With the implementation of mitigation measures the impact can be reduced to LOW (**Table 22**).

Table 22: Impact summary – Fly Rock Impact in Operational Phase

Issue: Contamination of Surface Water Resources		
Phases: Operational Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Prominent change or disturbance (H)	Moderate change or disturbance (M)
Duration	Long-term (H)	Long-term (H)
Extent	Beyond the site boundary, affecting immediate neighbours (M)	Beyond the site boundary, affecting immediate neighbours (M)
Consequence	High (H)	Medium (M)
Probability	Probable (H)	Possible/ frequent (M)
Significance	High (H)	Low (L)
Degree to which impact can be reversed	Provided mitigation measures are implemented the impact can be managed and reduced significantly.	

Degree to which impact may cause irreplaceable loss of resources	Medium as the impact may cause damage to structures if not controlled properly.

Mitigation/ Enhancement Measures

Mitigation of fly rock can be done applying the following methods – same methods as air blast:

- Conduct a test blast to assist with defining expected ground vibration levels for future blast designs.
- Do blast design that considers the actual blasting and the ground vibration levels to be adhered too.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.
- Consider relocation of households closest to the pit areas – preferably within 500 m from pit edge.

- Good housekeeping practices should be implemented and maintained with monitoring of each blast.
- Evacuating of people and animals out of the danger zone.
- Structural surveys will need to be done as indicated in the report.

Monitoring

Video monitoring of each blast should be done for observing any fly rock. Visual inspection of blast and areas to be done for signs of fly rock and noted.

18.2.3 Impact Assessment: Decommissioning and Closure Phases

Potential Impacts: Ground Vibration

No blasting operations are expected to be done during the construction phase. There is no ground vibration, air blast and fly rock impacts anticipated.

The ground vibration impact can be assessed as insignificant. (**Table 23**).

Table 23: Impact summary – Ground Vibration Impact in Decommissioning and Closure Phases

Issue: Ground vibration		
Phases: Construction Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Negligible or no change, disturbance or nuisance. (VL)	Negligible or no change, disturbance or nuisance. (VL)
Duration	Very Short if any (VL)	Very Short if any (VL)
Extent	On site only if any (VL)	On site only if any (VL)
Consequence	Very Low (VL)	Very Low (VL)
Probability	Very Low (VL)	Very Low (VL)
Significance	Insignificant	Insignificant

Degree to which impact can be reversed	Blasting is not expected in the construction phase
Degree to which impact may cause irreplaceable loss of resources	Very Low

Mitigation/ Enhancement Measures

No specific mitigation measures required.

Potential Impacts: Air Blast

The air blast impact can be assessed as insignificant. (**Table 24**).

Table 24: Impact summary – Air Blast Impact in Decommissioning and Closure Phases

Issue: Ground vibration		
Phases: Construction Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Negligible or no change, disturbance or nuisance. (VL)	Negligible or no change, disturbance or nuisance. (VL)
Duration	Very Short if any (VL)	Very Short if any (VL)
Extent	On site only if any (VL)	On site only if any (VL)
Consequence	Very Low (VL)	Very Low (VL)
Probability	Very Low (VL)	Very Low (VL)
Significance	Insignificant	Insignificant
Degree to which impact can be reversed	Blasting is not expected in the construction phase	
Degree to which impact may cause irreplaceable loss of resources	Very Low	

Mitigation/ Enhancement Measures

No specific mitigation measures required.

Potential Impacts: Fly Rock

The fly rock impact can be assessed as insignificant. (**Table 25**).

Table 25: Impact summary – Fly Rock Impact in Decommissioning and Closure Phases

Issue: Ground vibration		
Phases: Construction Phase		
Criteria	Without Mitigation	With Mitigation
Intensity	Negligible or no change, disturbance or nuisance. (VL)	Negligible or no change, disturbance or nuisance. (VL)
Duration	Very Short if any (VL)	Very Short if any (VL)
Extent	On site only if any (VL)	On site only if any (VL)

Consequence	Very Low (VL)	Very Low (VL)
Probability	Very Low (VL)	Very Low (VL)
Significance	Insignificant	Insignificant
Degree to which impact can be reversed	Blasting is not expected in the construction phase	
Degree to which impact may cause irreplaceable loss of resources	Very Low	

Mitigation/ Enhancement Measures

No specific mitigation measures required.

18.2.4 Cumulative Impacts

The cumulative impact from blasting consists of when multiple blasts are conducted simultaneously. This will increase exposure time. Multiple blasts may not necessarily have a vibration level add on effect – meaning that ground vibration levels will not be the multiple of multiple blasts conducted. The time length of each blast will increase to the total time of exposure. The longer the exposure or period vibration is generated will have added effect on the people and surroundings. Longer blasts tend to be more disturbing than shorter blasts. The environmental aspects that have been assessed cumulatively in this section include:

- Ground Vibration and air blast from blasting operations.
- The time length of blasts to be done.

18.3 Mitigations

Considering the evaluations made according to the planned blast design specific mitigations are required. Ground vibration is the primary possible cause of structural damage and requires more detailed planning in preventing damage and maintaining levels within accepted norms. Air blast and fly rock can be controlled using proper charging methodology irrespective of the blast hole diameter and patterns used. Ground vibration requires more detailed planning and forms the focus for mitigation measures. The houses surrounding the pit area are generally in small groups of structures. Within these groups there are different types of structures. The type of structure with the lowest ground vibration level permitted was used for adjudication of being problematic or not. This was typically traditional mud built houses.

Table 26 shows list of POI's that will need to be considered and Table 27 the POI's that needs specific attention due to location within the pit area. Figure 21 shows the location of these POI's in relation to the pit area.

Table 26: Structures identified as problematic in and around the project area

Tag	Description	Classification	Y	X
1	Buildings/Structures (Inside Pit Area)	2	-45471.50	3178089.56
2	Community Houses (Inside Pit Area)	2	-45606.98	3178265.25
3	Community Houses (Inside Pit Area)	2	-46126.78	3178462.14
4	D395 Road (Inside Pit Area)	14	-46985.72	3178467.74
5	Community Houses (Inside Pit Area)	2	-46688.65	3178541.17
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	2	-47314.73	3178361.05
7	Community Houses (Inside Pit Area)	2	-47535.67	3178445.80
8	Community Houses (Inside Pit Area)	2	-47808.92	3178581.09
9	Community Houses (Inside Pit Area)	2	-48102.69	3178396.09
10	Community Houses (Inside Pit Area)	2	-46056.36	3177841.06
11	Community Houses (Inside Pit Area)	2	-46250.59	3177765.37
12	D395 Road	14	-45408.14	3178312.40
14	Community Houses	2	-46884.02	3177554.37
15	Community Houses	2	-46839.82	3177463.16
16	Community Houses	2	-47042.32	3177429.40
18	Informal Housing	1	-46618.65	3177677.91
20	Ruins	4	-45941.19	3177533.28
21	Building/Structure	2	-45902.06	3177689.65
22	Buildings/Structures	2	-45884.38	3177816.32
24	Community Houses	2	-44840.13	3177631.90
25	Community Houses	2	-44723.29	3177602.28
27	Buildings/Structures	2	-45052.48	3178206.54
28	Community Houses	2	-45393.59	3178279.01
29	Community Houses	2	-45259.31	3178390.20
30	Community Houses	2	-45434.19	3178509.93
31	Community Houses	2	-44995.16	3178432.12
32	Community Houses	2	-46126.58	3178709.87
33	Community Houses	2	-46401.76	3178805.60
34	Community Houses	2	-46476.01	3178970.41
36	Community Houses	2	-46829.82	3177185.78
124	Community Houses	2	-45074.29	3178814.09
125	Community Houses	2	-44801.19	3178586.79
129	Community Houses	2	-44394.54	3178573.79
130	Community Houses	2	-44594.02	3178679.20
140	Community Houses	2	-44138.21	3178197.73
141	Community Houses	2	-44216.79	3177885.02
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	10	-47948.00	3178503.01
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	10	-45477.00	3178118.01
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	10	-45725.00	3178140.01
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	10	-45975.00	3178172.01
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	10	-48654.00	3178483.01
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	10	-48278.00	3178645.01
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	10	-45606.00	3178086.01
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	10	-46690.00	3178068.01
322	Hydrocencus Borehole (MWGA05)	10	-46741.00	3178691.01
339	Primary Crusher (Planned)	6	-44815.40	3177837.83

Table 27: Structures identified inside the planned pit area

Tag	Description	Classification	Y	X

1	Buildings/Structures (Inside Pit Area)	2	-45471.50	3178089.56
2	Community Houses (Inside Pit Area)	2	-45606.98	3178265.25
3	Community Houses (Inside Pit Area)	2	-46126.78	3178462.14
4	D395 Road (Inside Pit Area)	14	-46985.72	3178467.74
5	Community Houses (Inside Pit Area)	2	-46688.65	3178541.17
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	2	-47314.73	3178361.05
7	Community Houses (Inside Pit Area)	2	-47535.67	3178445.80
8	Community Houses (Inside Pit Area)	2	-47808.92	3178581.09
9	Community Houses (Inside Pit Area)	2	-48102.69	3178396.09
10	Community Houses (Inside Pit Area)	2	-46056.36	3177841.06
11	Community Houses (Inside Pit Area)	2	-46250.59	3177765.37
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	10	-47948.00	3178503.01
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	10	-45477.00	3178118.01
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	10	-45725.00	3178140.01
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	10	-45975.00	3178172.01
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	10	-48654.00	3178483.01
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	10	-48278.00	3178645.01
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	10	-45606.00	3178086.01
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	10	-46690.00	3178068.01

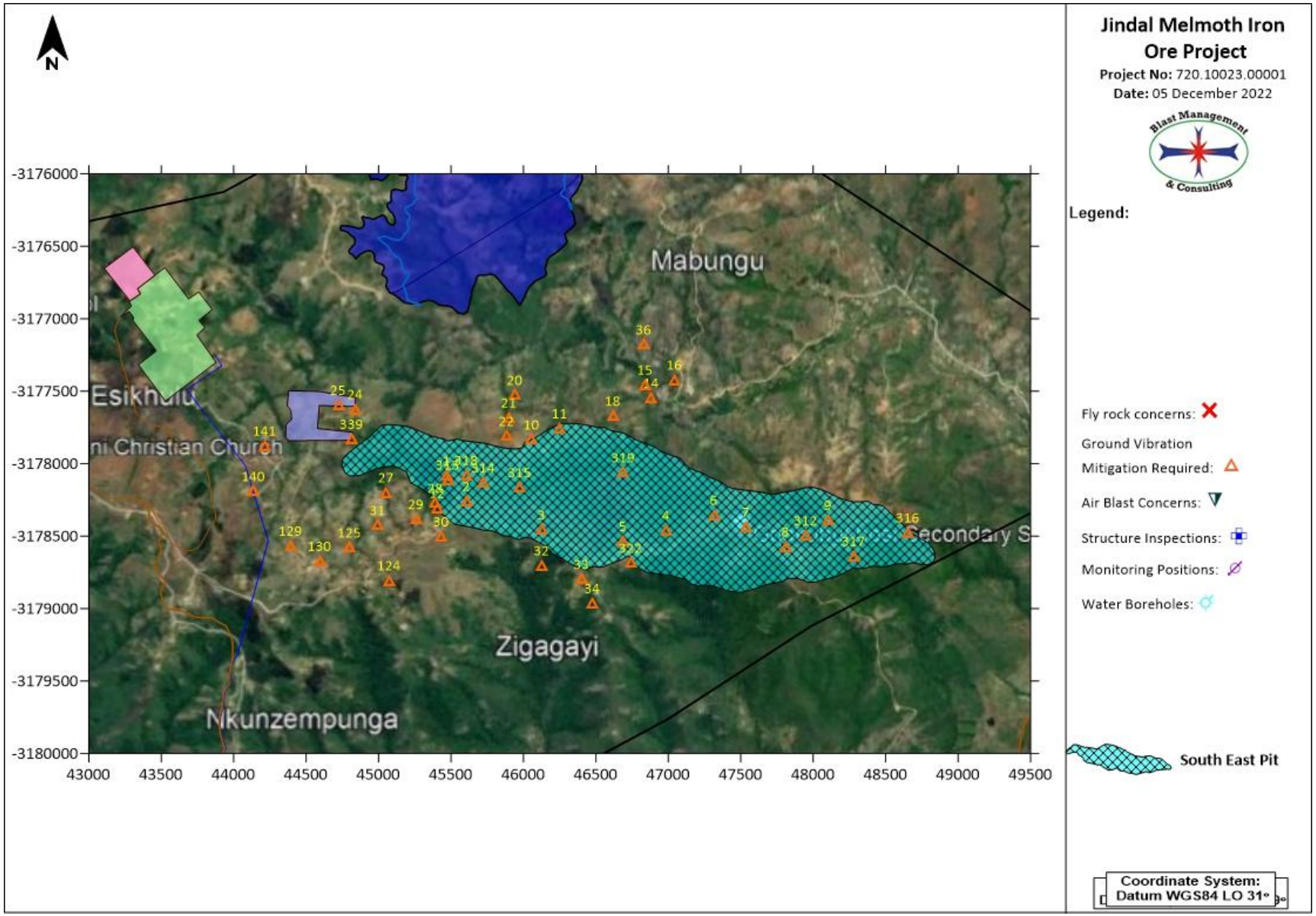


Figure 21: Structures identified where ground vibration mitigation will be required

18.3.1 Ground Vibration

Mitigation of ground vibration can be done applying the following methods:

- Conduct a test blast to assist with defining expected ground vibration levels for future blast designs.
- Do blast design that considers the actual blasting and the ground vibration levels to be adhered too.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.
- Consider relocation of households closest to the pit areas – preferably within 500 m from pit edge.
- Good housekeeping practices should be implemented and maintained with monitoring of each blast.
- Evacuating of people and animals out of the danger zone.
- Structural surveys will need to be done as indicated in the report.
- Do blast design that considers the actual location of the blast in relation to the point of concern and the expected levels of ground vibration. The design to ensure that levels expected are adhere to the limits applicable.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.
- Relocate the POI / acquire the POI of concern – mined owned.

The identified POI's of concern is found in close proximity of the actual operations. Some of the POI's identified includes mine infrastructure. In order to give indication of the possibilities of mitigation to consider two basic indicators are presented. Firstly, the maximum charge per delay that can be allowed for the shortest distance between blast and POI. Secondly the minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay. The table gives indication for planning of blasts when blasting is done at shortest distance to the POI's.
Table 28 do show mitigation in the form of maximum charge mass that will be allowed to maintain safe levels of ground vibration from current pit edge distance to POI. Table 29 shows minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay for associated structure types and limits applicable.
It must be noted that there are instances where maximum allowed charge mass is very small. These small allowable charges are considered not viable for proper drilling and blasting. It may be required to consider relocation of either the POI or ensure that blasting is done further away from the POI – thus creating distance between blast and POI.

Table 28: Mitigation measures: Maximum charge per delay for distance to POI

Tag	Description	Y	X	Ground Vibration Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Maximum allowable charge for current distance (kg)
12	D395 Road	-45408.14	3178312.40	150	19	813.5	30
14	Community Houses	-46884.02	3177554.37	6	297	813.5	152
15	Community Houses	-46839.82	3177463.16	6	356	813.5	219
16	Community Houses	-47042.32	3177429.40	6	473	813.5	386
18	Informal Housing	-46618.65	3177677.91	6	89	813.5	14
20	Ruins	-45941.19	3177533.28	6	318	813.5	175
21	Building/Structure	-45902.06	3177689.65	12.5	197	813.5	163
22	Buildings/Structures	-45884.38	3177816.32	12.5	76	813.5	24
24	Community Houses	-44840.13	3177631.90	6	198	813.5	68
25	Community Houses	-44723.29	3177602.28	6	299	813.5	154
27	Buildings/Structures	-45052.48	3178206.54	12.5	184	813.5	142
28	Community Houses	-45393.59	3178279.01	6	20	813.5	1
29	Community Houses	-45259.31	3178390.20	6	184	813.5	58
30	Community Houses	-45434.19	3178509.93	6	128	813.5	28
31	Community Houses	-44995.16	3178432.12	6	373	813.5	240
32	Community Houses	-46126.58	3178709.87	6	118	813.5	24
33	Community Houses	-46401.76	3178805.60	6	79	813.5	11
34	Community Houses	-46476.01	3178970.41	6	244	813.5	103
36	Community Houses	-46829.82	3177185.78	6	618	813.5	658
124	Community Houses	-45074.29	3178814.09	6	591	813.5	601
125	Community Houses	-44801.19	3178586.79	6	503	813.5	436
129	Community Houses	-44394.54	3178573.79	6	634	813.5	692
130	Community Houses	-44594.02	3178679.20	6	633	813.5	690
140	Community Houses	-44138.21	3178197.73	6	636	813.5	698
141	Community Houses	-44216.79	3177885.02	6	539	813.5	502
322	Hydrocencus Borehole (MWGA05)	-46741.00	3178691.01	50	21	813.5	10

Based on evaluation done for the planned charge masses mitigation will be required for a number of Community houses, houses, buildings, Hydrocencus boreholes, informal houses. These POI's vary in distance and it will be required that each be evaluated in relation to a blast to be done. The distance should be checked, the charge mass allowed be calculated and then a design of charging or timing applied to ensure that the limits are not exceed. This must be confirmed with monitoring of ground vibration at the POI.

Table 29: Mitigation measures: Minimum distances required

Example POI	Specific Limit (mm/s)	Total Mass/Delay (kg)	Minimum Distance (m)
Minimum charge per delay			
D395 Road	150	203.4	49
Community Houses	6	203.4	344
Informal Housing	6	203.4	344
Ruins	6	203.4	344
Building/Structure	12.5	203.4	220

Example POI	Specific Limit (mm/s)	Total Mass/Delay (kg)	Minimum Distance (m)
Buildings/Structures	12.5	203.4	220
Hydrocencus Borehole	50	203.4	95
Primary Crusher (Planned)	150	203.4	49
Maximum charge per delay			
D395 Road	150	813.5	98
Community Houses	6	813.5	687
Informal Housing	6	813.5	687
Ruins	6	813.5	687
Building/Structure	12.5	813.5	440
Buildings/Structures	12.5	813.5	440
Hydrocencus Borehole	50	813.5	190
Primary Crusher (Planned)	150	813.5	98

Data provided in tables above clearly indicate that distance between blast and POI will have influence on the allowed charge mass per delay with regards to the different ground vibration limits.

18.3.2 Air Blast and Fly rock

Though more concentration is placed on ground vibration air blast and fly rock are as important. In many cases air blast is the largest contributor to complaints. Air blast and fly rock can be controlled using proper charging methodology irrespective of the blast hole diameter and patterns used.
The following mitigations may be applied:

- Conduct a test blast to assist with defining expected air blast levels for future blast designs.
- Do blast design that considers the actual blasting and the air blast levels to be adhered too.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole. Smaller diameter blastholes will also have better stemming vs explosive column ratio.
- Blast design to consider proper stemming management.
- Use of crushed aggregate with size of 10% the drill diameter.
- Consider increase of stemming lengths to ratio of 25 to 30 times the blast diameter.
- Consider relocation of households closest to the pit areas – preferably within 500 m from pit edge.
- Good housekeeping practices should be implemented and maintained with monitoring of each blast.
- Structural surveys will need to be done as indicated in the report.

19 Closure Phase: Impact Assessment and Mitigation Measures

During the closure phase no mining, drilling and blasting operations are expected. It is uncertain if any blasting will be done for demolition. If any demolition blasting will be required, it will be reviewed as civil blasting and addressed accordingly.

20 Alternatives (Comparison and Recommendation)

No specific alternative mining methods are currently under discussion or considered for drilling and blasting.

21 Monitoring

A monitoring programme for recording blasting operations is recommended. The following elements should be part of such a monitoring program:

- Ground vibration and air blast results;
- Blast Information summary;
- Meteorological information at time of the blast;
- Video Recording of the blast;
- Fly rock observations.

Ground vibration and air blast monitoring requires identified locations for monitoring. Monitoring of ground vibration and air blast is done to ensure that the generated levels of ground vibration and air blast comply with recommendations.

Eleven monitoring positions were identified as possible locations that will need to be considered. Not all points will be required at once but active monitoring and observation of where blasting is done will dictate the requirements for the areas around the pit. Monitoring positions are indicated in Figure 22 and Table 30 lists the positions with coordinates. These points will need to be re-defined after the first blasts done and the monitoring programme defined.

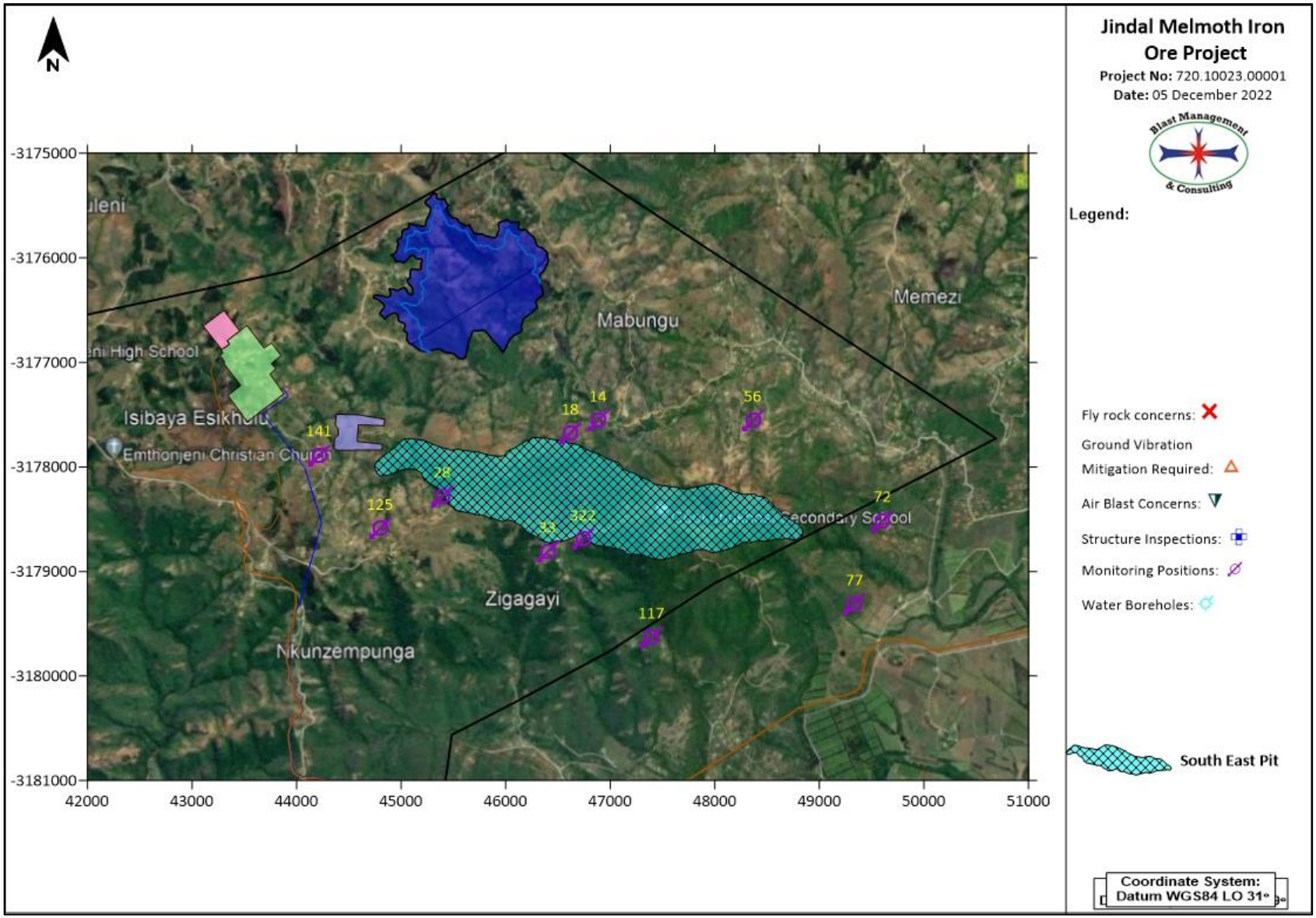


Figure 22: Suggested monitoring positions

Table 30: List of possible monitoring positions

Tag	Description	Y	X
14	Community Houses	-46884.02	3177554.37
18	Informal Housing	-46618.65	3177677.91
28	Community Houses	-45393.59	3178279.01
33	Community Houses	-46401.76	3178805.60
56	Community Houses	-48364.03	3177552.93
72	Community Houses	-49605.93	3178512.42
77	Power Line/Pylon	-49336.95	3179311.43
117	Community Houses	-47393.99	3179628.01
125	Community Houses	-44801.19	3178586.79
141	Community Houses	-44216.79	3177885.02
322	Hydrocencus Borehole (MWGA05)	-46741.00	3178691.01

22 Recommendations

The following recommendations are proposed.

22.1 Regulatory requirements – MHSA Reg. 4.16(2)

Regulatory requirements indicate specific requirements for all non-mining structures and installations within 500 m from the mining operation. Forty-eight POI's are observed within 500 m from the mining area. The mine will have to apply for the necessary authorisations as prescribed in the various acts, and specifically Mine Health and Safety Act Reg 4.16 as well as recommendations regarding infrastructure within the pit area. Table 31 shows list of these installations. Figure 23 below shows the 500 m boundary around the opencast pit area. The location of non-mining installations is clearly observed.

Table 31: List of possible installations within the regulatory 500 m

Tag	Description	Y	X
1	Buildings/Structures (Inside Pit Area)	-45471.50	3178089.56
2	Community Houses (Inside Pit Area)	-45606.98	3178265.25
3	Community Houses (Inside Pit Area)	-46126.78	3178462.14
4	D395 Road (Inside Pit Area)	-46985.72	3178467.74
5	Community Houses (Inside Pit Area)	-46688.65	3178541.17
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	-47314.73	3178361.05
7	Community Houses (Inside Pit Area)	-47535.67	3178445.80
8	Community Houses (Inside Pit Area)	-47808.92	3178581.09
9	Community Houses (Inside Pit Area)	-48102.69	3178396.09
10	Community Houses (Inside Pit Area)	-46056.36	3177841.06
11	Community Houses (Inside Pit Area)	-46250.59	3177765.37
12	D395 Road	-45408.14	3178312.40
13	D255 Road	-46880.02	3177490.67
14	Community Houses	-46884.02	3177554.37
15	Community Houses	-46839.82	3177463.16
16	Community Houses	-47042.32	3177429.40

Tag	Description	Y	X
17	River	-46976.10	3177673.56
18	Informal Housing	-46618.65	3177677.91
19	River	-46455.86	3177298.13
20	Ruins	-45941.19	3177533.28
21	Building/Structure	-45902.06	3177689.65
22	Buildings/Structures	-45884.38	3177816.32
23	River	-45438.38	3177414.23
24	Community Houses	-44840.13	3177631.90
25	Community Houses	-44723.29	3177602.28
26	Road	-44391.70	3178004.10
27	Buildings/Structures	-45052.48	3178206.54
28	Community Houses	-45393.59	3178279.01
29	Community Houses	-45259.31	3178390.20
30	Community Houses	-45434.19	3178509.93
31	Community Houses	-44995.16	3178432.12
32	Community Houses	-46126.58	3178709.87
33	Community Houses	-46401.76	3178805.60
34	Community Houses	-46476.01	3178970.41
35	Buildings/Structures	-46792.59	3177298.46
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	-47948.00	3178503.01
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	-45477.00	3178118.01
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	-45725.00	3178140.01
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	-45975.00	3178172.01
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	-48654.00	3178483.01
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	-48278.00	3178645.01
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	-45606.00	3178086.01
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	-46690.00	3178068.01
322	Hydrocencus Borehole (MWGA05)	-46741.00	3178691.01
334	Waste Rock Dump (Planned)	-45058.21	3177548.65
335	Waste Rock Dump (Planned)	-46111.46	3177583.02
339	Primary Crusher (Planned)	-44815.40	3177837.83
340	Primary Crusher (Planned)	-44498.45	3177695.09

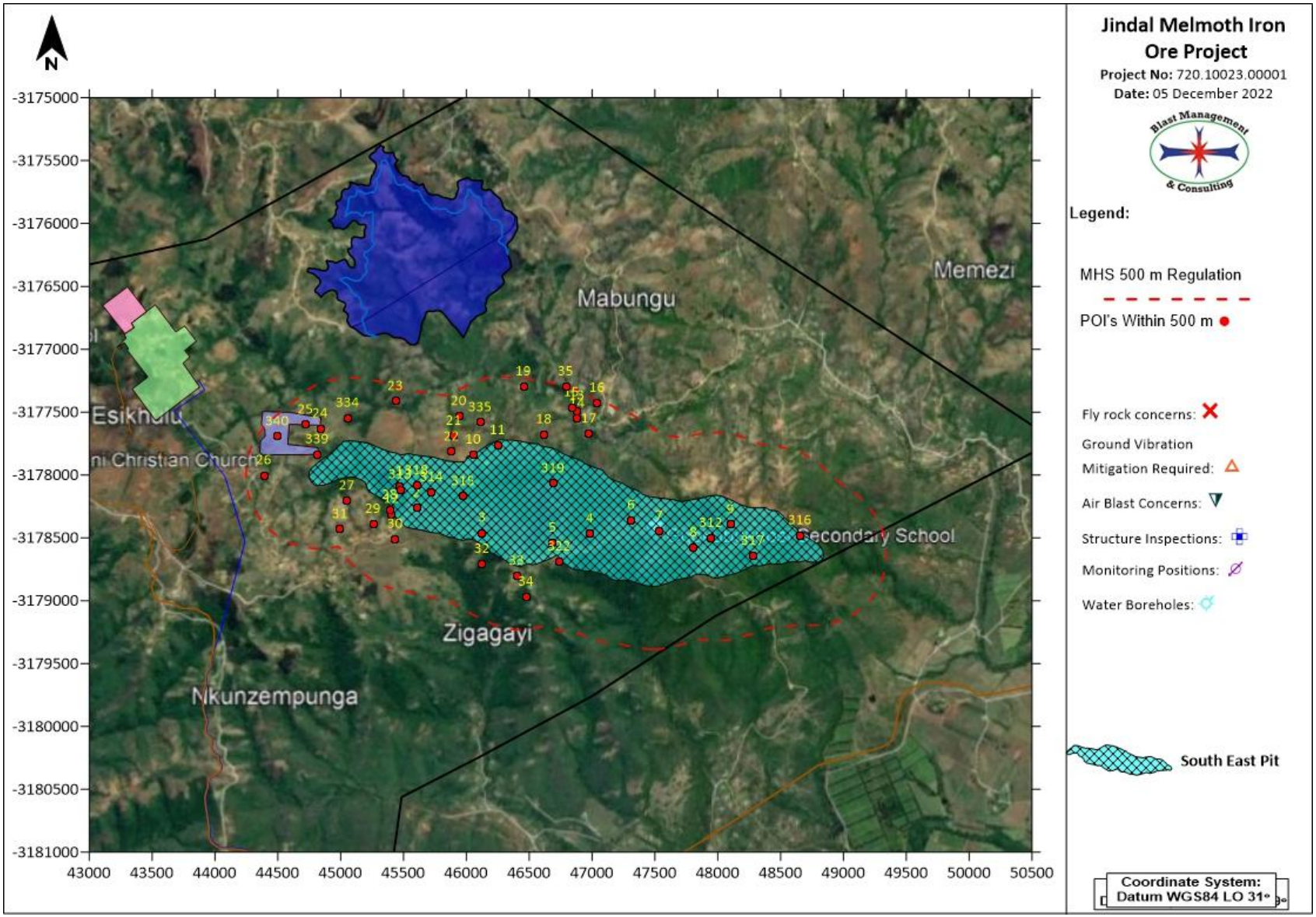


Figure 23: Regulatory 500 m range for the Pit area

22.1 Regulatory requirements – MHSA Reg. 17.6(a)

On review of the pit area's location, it is such that Mine Health and Safety act regulation 17.6(a) will be applicable and will need to be considered. The location of the opencast Pit boundary is closer than 100 m from private installations and the necessary legal requirements will need to be addressed. Figure 24 shows the Pit areas with 100 m boundary that will need to be considered with indication of infrastructure within the 100 m – this consists mainly of the heritage structures and a borehole. Table 32 shows list of POI's identified.

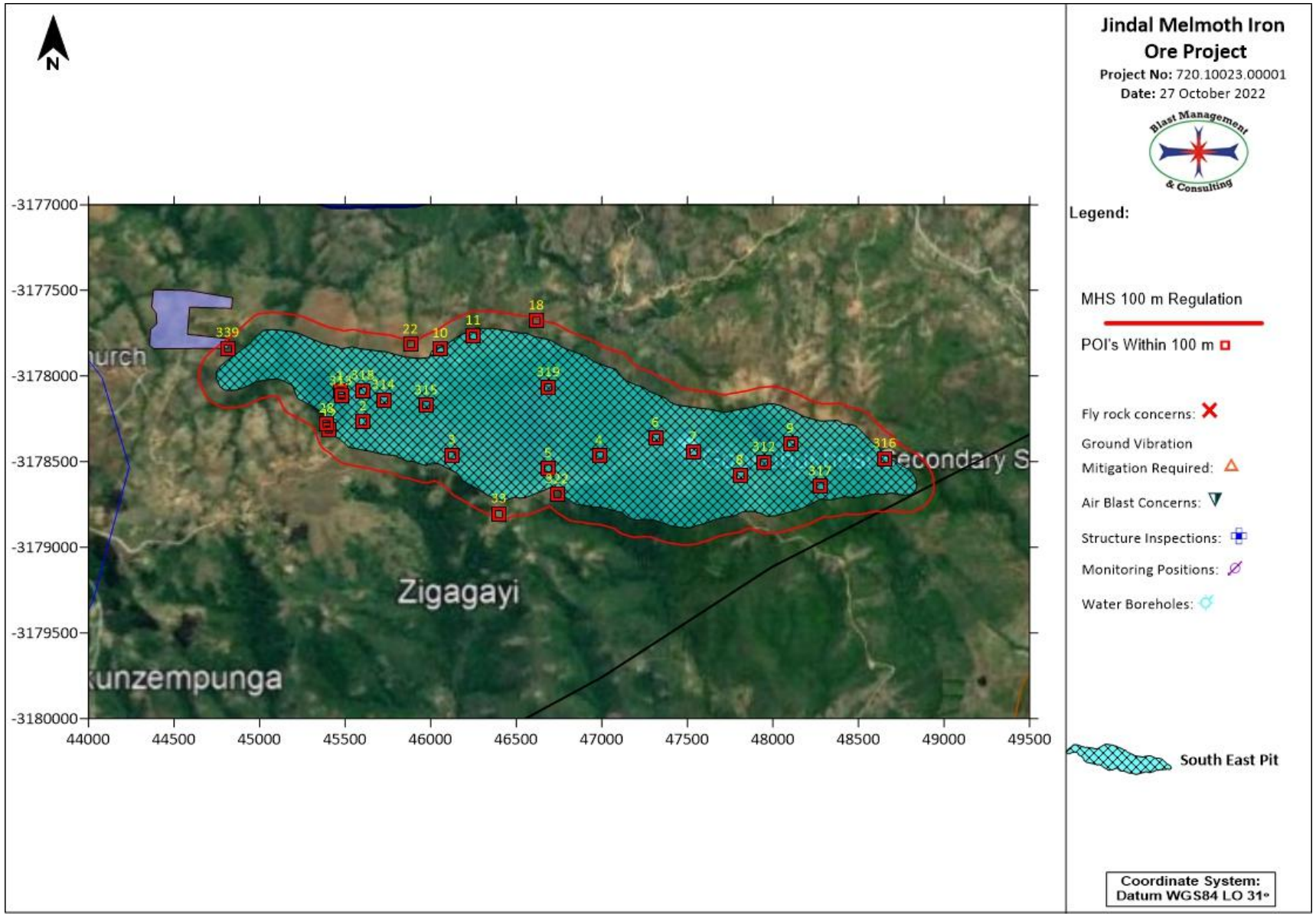


Figure 24: Regulatory 100 m range for the Pit area

Table 32: List of possible installations within the regulatory 100 m

Tag	Description	Y	X
1	Buildings/Structures (Inside Pit Area)	-45471.50	3178089.56
2	Community Houses (Inside Pit Area)	-45606.98	3178265.25
3	Community Houses (Inside Pit Area)	-46126.78	3178462.14
4	D395 Road (Inside Pit Area)	-46985.72	3178467.74
5	Community Houses (Inside Pit Area)	-46688.65	3178541.17
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	-47314.73	3178361.05
7	Community Houses (Inside Pit Area)	-47535.67	3178445.80
8	Community Houses (Inside Pit Area)	-47808.92	3178581.09
9	Community Houses (Inside Pit Area)	-48102.69	3178396.09
10	Community Houses (Inside Pit Area)	-46056.36	3177841.06
11	Community Houses (Inside Pit Area)	-46250.59	3177765.37
12	D395 Road	-45408.14	3178312.40
18	Informal Housing	-46618.65	3177677.91
22	Buildings/Structures	-45884.38	3177816.32
28	Community Houses	-45393.59	3178279.01
33	Community Houses	-46401.76	3178805.60
312	Hydrocencus Borehole (GJ01) - Inside Pit Area	-47948.00	3178503.01
313	Hydrocencus Borehole (GJ02) - Inside Pit Area	-45477.00	3178118.01
314	Hydrocencus Borehole (GJ14) - Inside Pit Area	-45725.00	3178140.01
315	Hydrocencus Borehole (GJ15) - Inside Pit Area	-45975.00	3178172.01
316	Hydrocencus Borehole (MWGA03) - Inside Pit Area	-48654.00	3178483.01
317	Hydrocencus Borehole (MWGA04) - Inside Pit Area	-48278.00	3178645.01
318	Hydrocencus Borehole (MWGA06) Inside Pit Area	-45606.00	3178086.01
319	Hydrocencus Borehole (MWGA07) - Inside Pit Area	-46690.00	3178068.01
322	Hydrocencus Borehole (MWGA05)	-46741.00	3178691.01
339	Primary Crusher (Planned)	-44815.40	3177837.83

22.2 Blast Designs

Blast designs can be reviewed prior to first blast planned and done. Consideration should be given to location of the blast in relation to the points of concern. The limits of the concerned points to be factored into such design. The following parameters can be applied to assist: changed diameter of blastholes, electronic initiation can be applied as an additional mitigation measure. This will allow for single blast hole firing instead of multiple blast holes where necessary if ground vibration is of concern for the specific blast. Single blast hole firing will provide single hole firing – thus less charge mass per delay and less influence. Attention must be given to stemming material and stemming length.

22.3 Test Blasting

It is always good to conduct a first test blast to confirm levels and ground vibration and air blast. It is recommended that such a blast be done, and detail monitoring done and used to help define blasting operations going forward. This test blast can be based on the existing design and only after this blast it may be necessary to define if changes are required or not.

22.4 Stemming length

The current proposed stemming lengths used provides for limited control on fly rock. Consideration can be given to increase this length for better control. Specific designs where distances between blast and point of concern are known should be considered. Recommended stemming length should range between 25 and 30 times the blast hole diameter. In cases for strict fly control this should range between 30 and 34 times the blast holes diameter. Increased stemming lengths will also contribute to more acceptable air blast levels.

22.5 Safe blasting distance and evacuation

Calculated minimum safe distance is 412 m. The final blast designs that may be used will determine the final decision on safe distance to evacuate people and animals. This distance may be greater pending the final code of practice of the mine and responsible blaster's decision on safe distance. The blaster has a legal obligation concerning the safe distance and he needs to determine this distance.

22.6 Road management

The D395 road runs through the Pit area. Rerouting of this road will be required. Future route of the road must be considered. The D255 road is at closest distance of 350 m to the Pit area. The R66 is at 2398 m and the R34 road at 2992 m. There are other Roads and Gravel roads in the vicinity of the Project area but are all expected to be within the recommended limits. There may however be people and animals on these routes and will require careful planning to maintain safe blasting radius. It will be required that clearance distances are set, and road travel managed during blasting operations. Typical Stop and Go arrangements may be required when blasting is done within the mine's safe distance area.

22.7 Photographic Inspections

The option of photographic survey of all structures up to 1500 m from the pit area is recommended. The mine will be operating for a significant number of years. This will give advantage on any negotiations with regards to complaints from neighbours on structural issues due to blasting. This process can however only succeed if done in conjunction with a proper monitoring program. It is expected that ground vibration levels will be significantly less than proposed limits at 1500 m, but this process will ensure record of the pre-blasting status of the nearest structures to the pit area. At 1500 m the expected level of ground vibration will be perceptible.

At 1500 m the expected level of ground vibration will be perceptible. Figure 25 shows extent of the range of 1500 m around the pit area with POI's identified. It must be noted that a point may represent a group of structures found in the vicinity of the point identified.

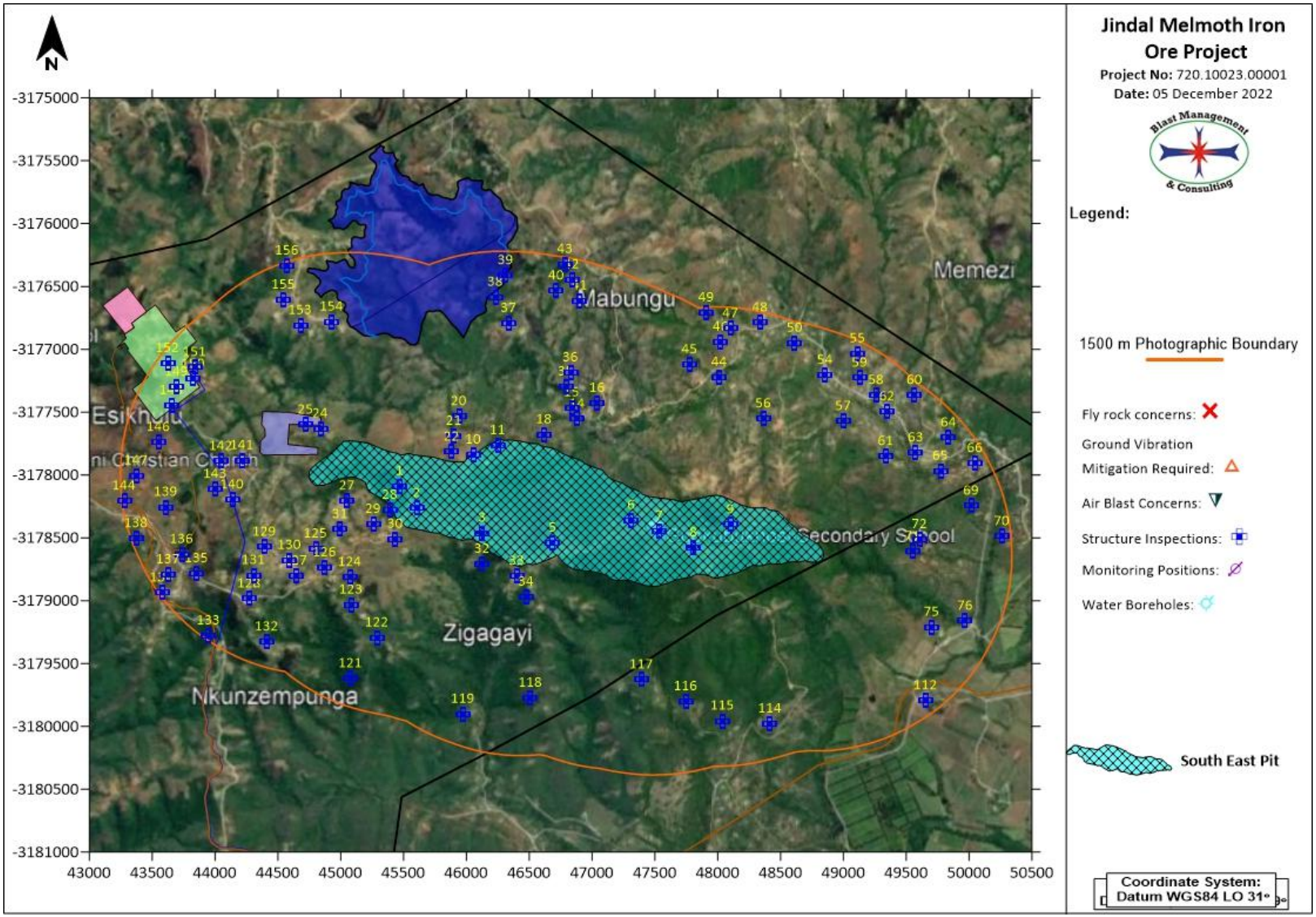


Figure 25: 1500 m area around the Pit area identified for structure inspections.

Table 33: List of structures identified for inspections

Tag	Description	Y	X
1	Buildings/Structures (Inside Pit Area)	-45471.50	3178089.56
2	Community Houses (Inside Pit Area)	-45606.98	3178265.25
3	Community Houses (Inside Pit Area)	-46126.78	3178462.14
5	Community Houses (Inside Pit Area)	-46688.65	3178541.17
6	School (Gqokubukhosi Secondary School) - Inside Pit Area	-47314.73	3178361.05
7	Community Houses (Inside Pit Area)	-47535.67	3178445.80
8	Community Houses (Inside Pit Area)	-47808.92	3178581.09
9	Community Houses (Inside Pit Area)	-48102.69	3178396.09
10	Community Houses (Inside Pit Area)	-46056.36	3177841.06
11	Community Houses (Inside Pit Area)	-46250.59	3177765.37
14	Community Houses	-46884.02	3177554.37
15	Community Houses	-46839.82	3177463.16
16	Community Houses	-47042.32	3177429.40
18	Informal Housing	-46618.65	3177677.91
20	Ruins	-45941.19	3177533.28
21	Building/Structure	-45902.06	3177689.65
22	Buildings/Structures	-45884.38	3177816.32
24	Community Houses	-44840.13	3177631.90
25	Community Houses	-44723.29	3177602.28
27	Buildings/Structures	-45052.48	3178206.54
28	Community Houses	-45393.59	3178279.01
29	Community Houses	-45259.31	3178390.20
30	Community Houses	-45434.19	3178509.93
31	Community Houses	-44995.16	3178432.12
32	Community Houses	-46126.58	3178709.87
33	Community Houses	-46401.76	3178805.60
34	Community Houses	-46476.01	3178970.41
35	Buildings/Structures	-46792.59	3177298.46
36	Community Houses	-46829.82	3177185.78
37	Community Houses	-46336.15	3176792.43
38	Community Houses	-46232.28	3176586.33
39	Community Houses	-46312.98	3176413.78
40	Community Houses	-46716.68	3176534.74
41	Community Houses	-46901.58	3176614.08
42	Community Houses	-46838.88	3176445.25
43	Community Houses	-46786.99	3176324.02
44	Community Houses	-48012.97	3177224.13
45	Community Houses	-47777.24	3177122.48
46	Community Houses	-48024.59	3176942.77
47	Community Houses	-48103.73	3176835.65
48	Community Houses	-48338.59	3176788.54
49	Community Houses	-47910.68	3176709.73
50	Community Houses	-48613.38	3176950.14
54	Community Houses	-48855.56	3177207.38
55	Community Houses	-49115.13	3177035.18

56	Community Houses	-48364.03	3177552.93
57	Community Houses	-48999.21	3177573.08
58	Community Houses	-49260.38	3177365.90
59	Community Houses	-49130.77	3177228.55
60	Community Houses	-49566.08	3177366.17
61	Community Houses	-49338.72	3177850.59
62	Community Houses	-49348.79	3177496.53
63	Buildings/Structures	-49576.24	3177823.09
64	Community Houses	-49838.06	3177704.87
65	Community Houses	-49773.66	3177967.35
66	Community Houses	-50048.91	3177907.84
69	Community Houses	-50017.85	3178246.50
70	Community Houses	-50261.83	3178488.63
71	Community Houses	-49551.15	3178607.43
72	Community Houses	-49605.93	3178512.42
75	Farm Buildings/Structures	-49701.72	3179212.12
76	Buildings/Structures	-49968.37	3179160.82
112	Farm Buildings/Structures	-49653.86	3179793.87
114	Community Houses	-48417.34	3179980.29
115	Community Houses	-48037.82	3179956.77
116	Community Houses	-47745.98	3179802.53
117	Community Houses	-47393.99	3179628.01
118	Community Houses	-46510.60	3179773.19
119	Community Houses	-45973.94	3179902.49
121	Community Houses	-45078.93	3179619.27
122	Community Houses	-45289.56	3179294.13
123	Community Houses	-45084.08	3179033.52
124	Community Houses	-45074.29	3178814.09
125	Community Houses	-44801.19	3178586.79
126	Buildings/Structures	-44872.70	3178736.22
127	Community Houses	-44642.73	3178803.08
128	Community Houses	-44272.90	3178984.59
129	Community Houses	-44394.54	3178573.79
130	Community Houses	-44594.02	3178679.20
131	Community Houses	-44307.91	3178798.35
132	Community Houses	-44412.39	3179327.38
133	Community Houses	-43949.86	3179278.91
134	Community Houses	-43577.15	3178937.17
135	Buildings/Structure	-43855.77	3178784.31
136	Community Houses	-43736.66	3178630.85
137	Community Houses	-43628.29	3178792.67
138	Community Houses	-43374.99	3178504.89
139	Community Houses	-43608.94	3178256.50
140	Community Houses	-44138.21	3178197.73
141	Community Houses	-44216.79	3177885.02
142	Community Houses	-44049.13	3177890.51
143	Community Houses	-44003.36	3178112.42

144	Community Houses	-43279.30	3178206.73
146	Community Houses	-43552.19	3177739.68
147	Community Houses	-43374.59	3178005.59
148	Community Houses	-43654.59	3177446.49
149	Community Houses	-43695.62	3177300.01
150	Buildings/Structures	-43827.95	3177236.83
151	Community Houses	-43839.94	3177143.18
152	Community Houses	-43623.49	3177110.28
153	Community Houses	-44680.57	3176809.26
154	Community Houses	-44929.90	3176781.72
155	Community Houses	-44547.40	3176605.98
156	Community Houses	-44574.78	3176336.34

22.8 Recommended ground vibration and air blast levels

The ground vibration and air blast levels limits recommended for blasting operations in this area are provided in Table 34.

Table 34: Recommended ground vibration air blast limits

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
National Roads/Tar Roads:	150	N/A
Electrical Lines:	75	N/A
Railway:	150	N/A
Transformers	25	N/A
Water Wells	50	N/A
Telecoms Tower	50	134
General Houses of proper construction	USBM Criteria or 25 mm/s	Shall not exceed 134dB at point of concern but 120 dB preferred
Houses of lesser proper construction (preferred)	12.5	
Rural building – Mud houses	6	

22.9 Blasting times

A further consideration of blasting times is when weather conditions could influence the effects yielded by blasting operations. It is recommended not to blast too early in the morning when it is still cool or when there is a possibility of atmospheric inversion or too late in the afternoon in winter. Do not blast in fog. Do not blast in the dark. Refrain from blasting when wind is blowing strongly in the direction of an outside receptor. Do not blast with low overcast clouds. These ‘do nots’ stem from the influence that weather has on air blast. The energy of air blast cannot be increased but it is distributed differently and therefore is difficult to mitigate.

It is recommended that a standard blasting time is fixed and blasting notice boards setup at various routes around the project area that will inform the community of blasting dates and times.

22.10 Video monitoring of each blast

Video of each blast will help to define if fly rock occurred and from origin. Immediate mitigation measure can then be applied if necessary. The video will also be a record of blast conditions.

23 Knowledge Gaps

The data provided from client and information gathered was sufficient to conduct this study. Surface surroundings change continuously, and this should be considered prior to initial blasting operations considered. This report may need to be reviewed and updated if necessary. This report is based on data provided and internationally accepted methods and methodology used for calculations and predictions.

24 Project Result

The project will have specific mitigations to consider. Specific with houses at close proximity of the pit area. Effective resolvent of the houses closest to the pit will be required with proper management of blasting on the pit edges close to these houses. In view of the data evaluated and recommendations done and the recommendations resolve it is the opinion of the author that the project can be executed successfully. Proper management and control on the aspects of ground vibration, air blast and fly rock will be required.

25 Conclusion

Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report evaluates the effects of ground vibration, air blast and fly rock and intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed are roads, Farm buildings, boreholes, community houses and schools.

The location of structures around the Pit area is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Community Houses, Buildings/Structures and Hydrocencus Boreholes. Ground vibrations predicted for the pit area ranged between low and very high. The expected levels of ground vibration for some of these structures are high and will require specific mitigations in the way of adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Air blast predicted showed the same concerns for opencast blasting. High levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints. The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134dB. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located such that "free blasting" – meaning no controls on blast preparation – will not be possible.

On charges considered it is expected that air blast will be greater than 134 dB at a distance of 393 m and closer to pit boundary. The structures inside the Pit area are expected to be relocated and will then not be of concern as it is currently inside the pit area. Infrastructure at the pit area such as roads and power lines/pylons are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 412 m. The absolute minimum unsafe zone is then the 412 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Community Houses, Buildings/Structures, D395 and D255 roads falls within the 500 m range from the pit area.

The pit areas are located such that specific concerns were identified and addressed in the report.

This concludes this investigation for the proposed Jindal Melmoth Iron Ore Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

26 Curriculum Vitae of Author

J D Zeeman was a member of the Permanent Force - SA Ammunition Core for period January 1983 to January 1990. During this period, work involved testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition.
From July 1992 to December 1995, Mr Zeeman worked at AECI Explosives Ltd. Initial work involved testing science on small scale laboratory work and large-scale field work. Later, work entailed managing various testing facilities and testing projects. Due to restructuring of the Technical Department, Mr Zeeman was retrenched but fortunately was able to take up an appointment with AECI Explosives Ltd.'s Pumpable Emulsion Explosives Group for underground applications.

From December 1995 to June 1997 Mr Zeeman provided technical support to the Underground Bulk Systems Technology business unit and performed project management on new products.
Mr Zeeman started Blast Management & Consulting in June 1997. The main areas of focus are Pre-blast monitoring, Insitu monitoring, Post-blast monitoring and specialized projects.

Mr Zeeman holds the following qualifications:

1985 - 1987	Diploma: Explosives Technology, Technikon Pretoria
1990 - 1992	BA Degree, University of Pretoria
1994	National Higher Diploma: Explosives Technology, Technikon Pretoria
1997	Project Management Certificate: Damelin College
2000	Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997, with work being done at various levels for all the major mining companies in South Africa. Some of the projects in which BM&C has been involved include:
Iso-Seismic Surveys for Kriel Colliery in conjunction with Bauer & Crosby Pty Ltd.; Iso-Seismic surveys for Impala Platinum Limited; Iso-Seismic surveys for Kromdraai Opencast Mine; Photographic Surveys for Kriel Colliery; Photographic Surveys for Goedehoop Colliery; Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village; Photographic Surveys for Aquarius – Everest South Project; Photographic Surveys for Kromdraai Opencast Mine; Photographic inspections for various other companies, including Landau Colliery, Platinum Joint Venture – three mini-pit areas; Continuous ground vibration and air blast monitoring for various coal mines; Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients, e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road; Monitoring of ground vibration induced on surface in underground mining environment; Monitoring and management of blasting in close relation to water pipelines in opencast mining environment; Specialized testing of explosives characteristics; Supply and service of seismographs and VOD measurement equipment and accessories; Assistance in protection of ancient mining works for Rhino Minerals (Pty) Ltd.; Planning, design, auditing and monitoring of blasting in new quarry on new road project, Sterkspruit, with Africon, B&E International and Group 5 Roads; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Pandora Joint Venture 180 houses – whole village; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Section - 1000 houses / structures.

BMC have installed a world class calibration facility for seismographs, which is accredited by Instantel, Ontario Canada as an accredited Instantel facility. The projects listed above are only part of the capability and professional work that is done by BMC.

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