APPENDIX J

Blasting and Vibration Assessment

Blast Management & Consulting

Quality Service on Time

Report: Blast Impact Assessment Proposed Turfvlakte Coal Project Exxaro Coal (Pty) Ltd.	
Date:	5 November 2018
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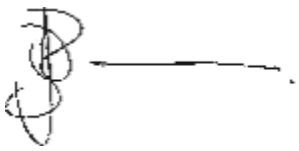
Signed:	
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i. Document Prepared and Authorised by:

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ii. Study Team Qualifications and Background

The study team comprises J D Zeeman (as the member of Blast Management & Consulting) and Blast Management & Consulting employees. Blast Management & Consulting's main areas of concern are pre-blast consultation and monitoring, insitu monitoring, post-blast monitoring and consulting as well as specialised projects. Blast Management & Consulting has been active in the mining industry since 1997 and work has been done at various levels for mining companies in South Africa, Botswana, Namibia, Mozambique, Democratic Republic of Congo, Sierra Leone and Côte d'Ivoire.

J D 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 Explosive Engineers

iii. Independence Declaration

Blast Management & Consulting is an independent company. The work done for the report was performed in an objective manner and according to national and international standards, which means that the results and findings may not all be positive for the client. Blast Management & Consulting has the required expertise to conduct such an investigation and draft the specialist report relevant to the study. Blast Management & Consulting did not engage in any behaviour that could be result in a conflict of interest in undertaking this study.

iv. Legal Requirements

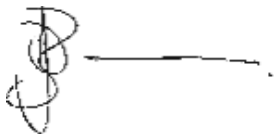
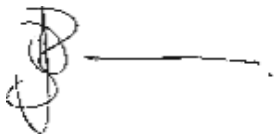
In terms of the NEMA 2014 EIA Regulations contained in GN R982 of 04 December 2014 all specialist studies must comply with Appendix 6 of the NEMA 2014 EIA Regulations (GN R982 of 04 December 2014). Table 1 show the requirements as indicated above.

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 ii and 23
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Section iii
(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 17.12
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 21

Legal Requirement		Relevant Section in Specialist study
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 20
(n)	a reasoned opinion (Environmental Impact Statement)-	Section 23
	as to whether the proposed activity or portions thereof should be authorised; and	Section 23
	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 23
(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

v. Document Control:

Name & Company	Responsibility	Action	Date	Signature
C Zeeman Blast Management & Consulting	Document Preparation	Report Prepared	23/02/2018	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalise	21/04/2018	
C Zeeman Blast Management & Consulting	Document Changes	Report Prepared	7/11/2018	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalise	7/11/2018	

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List of Acronyms used in this Report

a and b	Site Constant
ANFO	Ammonium nitrate fuel oil
APP	Air Pressure Pulse
B	Burden (m)
BH	Blast Hole
BM&C	Blast Management & Consulting
Bs	Scaled Burden($m^{3/2}kg^{-1/2}$)
D	Distance (m)
D	Duration (s)
E	East
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	Latitude/Longitude
hddd°mm'ss.s"	Hours/degrees/minutes/seconds
M	Charge Height
m (SH)	Stemming height
M/S	Magnitude/Severity
Mc	Charge mass per metre column
N	North
NE	North East
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
NOx's	Noxious Fumes
NW	North West
P	Probability
POI	Points of Interest
PPD	Peak particle displacement
PPV	Peak Particle Velocity
PVS	Peak vector sum
RPP	Rock Pressure Pulse
S	Scale

S	South
SE	South East
SH	Stemming height(m)
SW	South West
T	Blasted Tonnage
TNT	Explosives (Trinitrotoluene)
USBM	United States Bureau of Mine
W	West
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	acceleration
g/cm^3	gram per cubic centimetre
Hz	frequency
kg	kilogram
kg/m^3	kilogram per cubic metre
kg/t	kilogram pertonne
km	kilometre
kPa	kilopascal
m	metre
m^2	metre squared
MJ	Mega Joules
MJ/m³	Mega Joules per cubic meter
MJ/t	Mega Joules per tonne
mm/s	millimetres persecond
mm/s^2	millimetres per second square
ms	milliseconds
Pa	Pascal
ppm	parts per million
psi	pounds per square inch
θ	theta or angle

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1 Executive Summary

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed new opencast mining operation. 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.

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 is typical roads (tar and gravel), low cost houses, corrugated iron structures, brick and mortar houses, boreholes and heritage sites.

This project is a greenfield project with no existing blasting operations.

The location of structures around the Pit 1 and Pit 2 areas is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the conveyor, pan, building/structures and Manketti Lodge for Pit 1 and Pit 2. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human perception.

Ground vibration mitigation will be required for these structures. Ground vibrations predicted for all pit areas ranged between low and very high. There are 5 POI's identified for Pit 1 and Pit 2 that is the main concern with regards to ground vibration. There are POI's as close as 309 m from the pit boundary. The expected levels of ground vibration for 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 some concerns for opencast blasting. Maximum air blast levels predicted showed levels less than limit for structures but at levels where complaints can be expected. High levels may contribute to effects such as rattling of roofs or door or windows that could lead to complaints. The current accepted limit on air blast is 134dBL. 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.

Minimum charge predictions identified that one POI at Pit A1and one POI at Pit 2 could experience levels of air blast that could lead to complaints. Maximum charge predictions indicate two POI's at Pit 1 and two POI's at Pit 2 that could lead to complaints.

Based on the charges considered it is expected that air blast will be greater than 134 dB at a distance of 117 m and closer to pit boundaries. Minimum and Maximum charge predictions identified that two POI's at Pit 1 and two POI's at Pit 2 could experience levels of air blast that could lead to complaints. Infrastructure at all pit areas such as roads is present but air blast does not have any influence on these installations.

An exclusion zone for safe blasting was also calculated. The exclusion zone was established to be at least 305 m. The use of the normal practice observed in mines of 500 m exclusion zone will include the Conveyor and Pans. The use of minimum 500 m exclusion zone is rather recommended and it will be required that evacuation be negotiated when blasting.

Recommendations were made and should be considered. Specific actions will be required for all pit areas such as Mine Health and Safety Act requirements when blasting is done within 500 m from private structures. Specific blast design that will consider the installations around the pit areas will be needed. Closure of roads during blasting must also be considered.

The pit areas are located such that specific concerns were identified and addressed in the report. The author is however of the opinion that with careful planning of blasting operations and necessary permissions blasting operations will be possible. A changed consideration of blast designs and possible bench levels may be required.

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

2 Introduction

Exxaro (Pty) Ltd (Exxaro) proposes to develop a new coal mine in the Waterberg District Municipality in the Lephalale area of Limpopo Province, Republic of South Africa. The project is known as the Turfvlakte Coal Project.

The mining layout is determined by the geological structure dividing the mining area into two pits, namely Pit 1 and Pit 2. The mining operation will commence in the lowest stripping areas with the shortest distance to the infrastructure servitude area. The pit layout is of such design that it will be suitable for truck and shovel operation.

The mining scenarios were determined by the production target and quality of product. The following products and production targets can be obtained from the Turfvlakte resource:

- Power station product: crush & screen only at CV > 23MJ/kg.
- Export product washed at any required CV.
- Products according to the characteristic of the GG4/5 products.

The abovementioned production targets, existing market and railway capacity allocated to the Turfvlakte project will generate different mining scenarios. Implementation of the optimum mining scenario will be dependent mostly on the market and railing allocation assuming maximum ROM production of 3 million tonnes per annum.

The material flow will be a function of the mining scenario discussed above. If the GG washing plant will be used for coal processing, discards will be handled by the GG infrastructure as it is impossible to wash the Turfvlakte coal separately and split discards.

The project is located within the Lephalale Local Municipality in the Waterberg District Municipality of Limpopo Province, South Africa at coordinates (Lat/Lon WGS84) 23°40'49.49"S; 27°34'50.06"E. The Turfvlakte Coal Project lays approximately 4 km south-west from the Marapong village and 16 km west from the town of Lephalale.

As part of Environmental Impact Assessment (EIA), Blast Management & Consulting (BM&C) was contracted to perform a review of possible impacts from blasting operations and specifically for the proposed Turfvlakte Coal 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; 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 project is located within the Lephalale Local Municipality in the Waterberg District Municipality of Limpopo Province, South Africa at coordinates (Lat/Lon WGS84) 23°40'49.49"S; 27°34'50.06"E. The Turfvlakte Coal Project lays approximately 4 km south-west from the Marapong village and 16 km west from the town of Lephalale.

Figure 1 shows the Mine Layout Pit 1 and Pit 2 in the Mine Infrastructure Area (MIA).

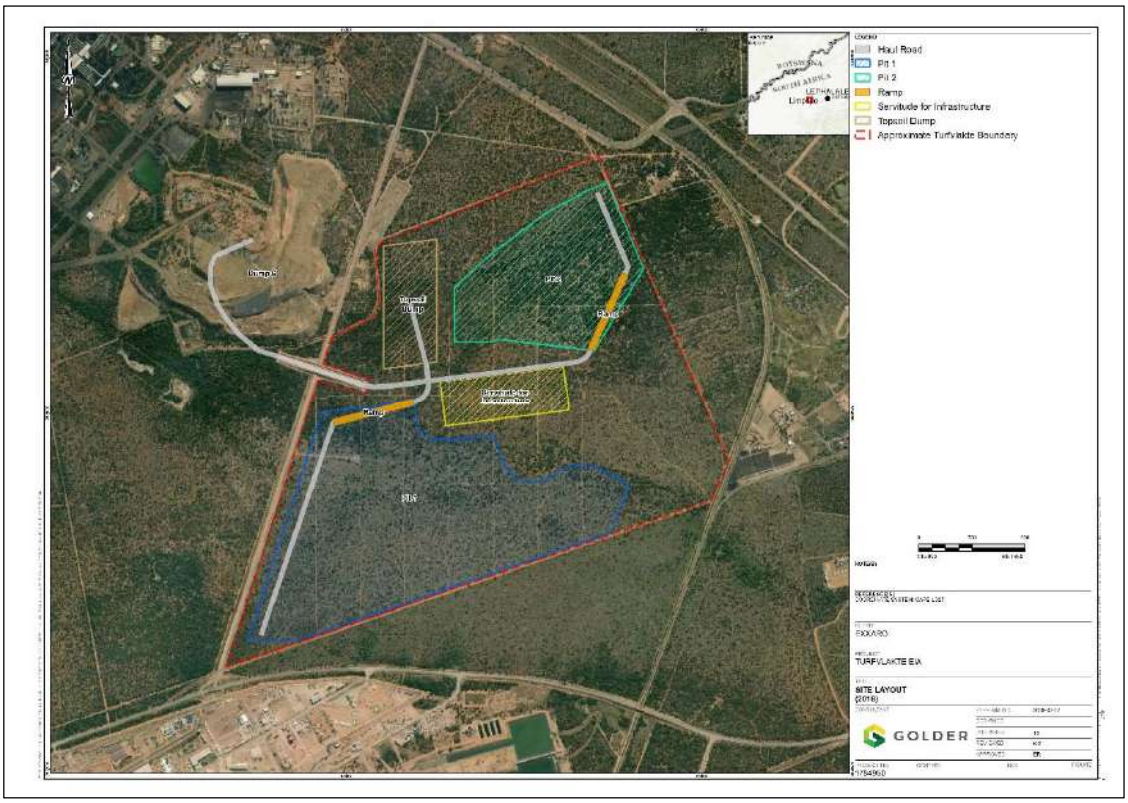


Figure 1: Mine Layout Pit 1 and Pit 2 in the Mine Infrastructure Area (MIA)

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) are created that will be used for evaluation;
- Base line influence or Blast Monitoring: No specific baseline was done for the Turfvlakte Project. The project is a planned new operation with no blasting activities currently being done.
- 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 forr eview.
- The project consists of mainly two pit areas – Pit 1 and 2. The report considers the whole of Pit 1 as one area and Pit 2 as a second area. These two areas are reviewed and evaluated in this report.

7 Site Investigation

The site was visited on 13 March 2018. 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 is a greenfield project with no drilling and blasting operations currently active.
- 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.
- The limitation is that no data is available from this operation for a confirmation of the predicted values as it is a greenfield site with no current blasting activities.
- Blast Management & Consulting was not involved in the blast design. The information on blast design applied 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

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.

- **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 current pit layout indicates a prospect that planned pit areas may be close private installations. The Mine Health and Safety Act has specific requirements regarding blasting within 500 m from private installations. This condition will be addressed in the recommendations as well.

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. Two 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 Turfvlakte Coal Project area. The specific influences will be determined through the work done for this project in this report.

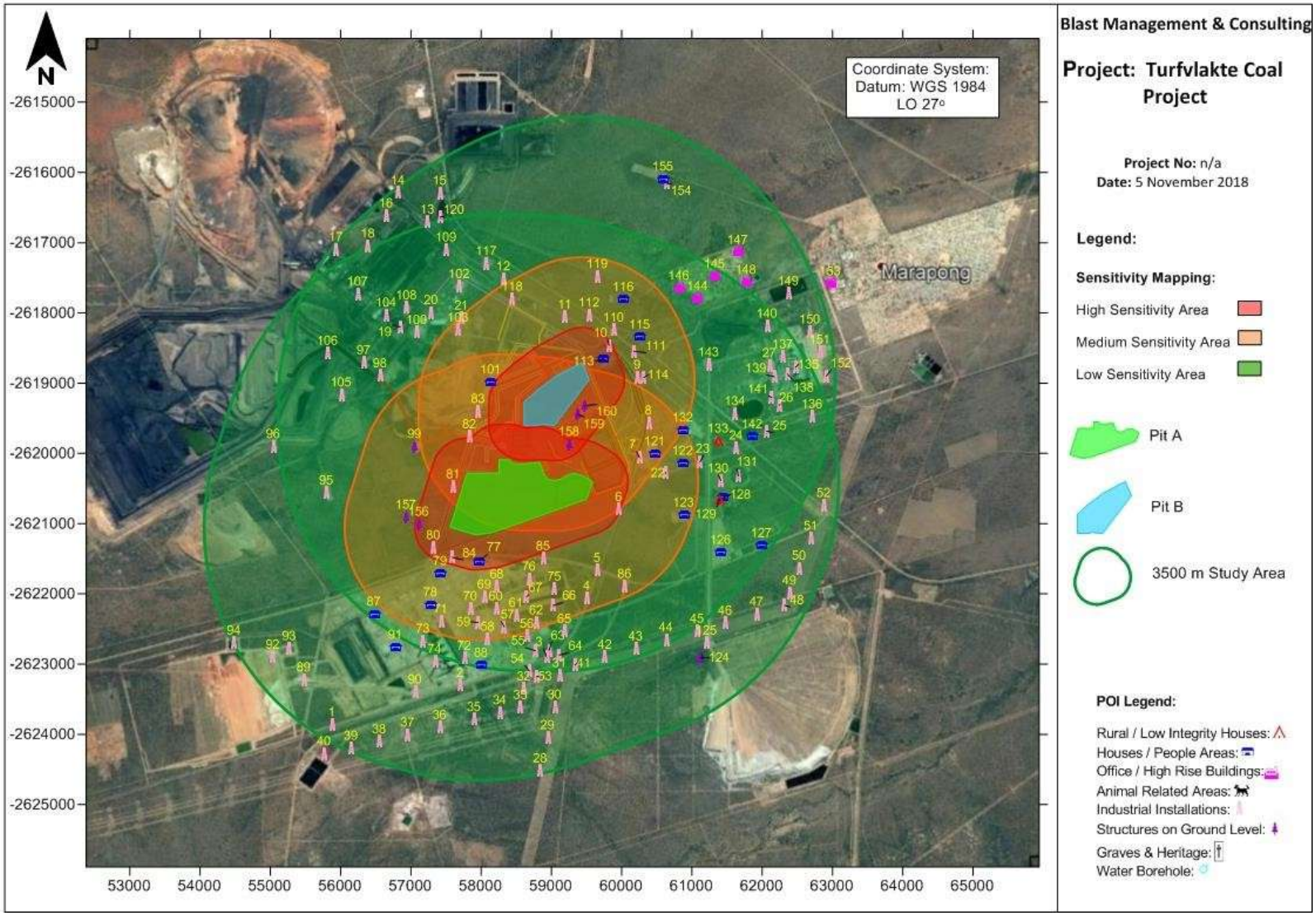


Figure 2: Identified sensitive areas for Pit 1 & Pit 2

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 from 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 used by BM&C.

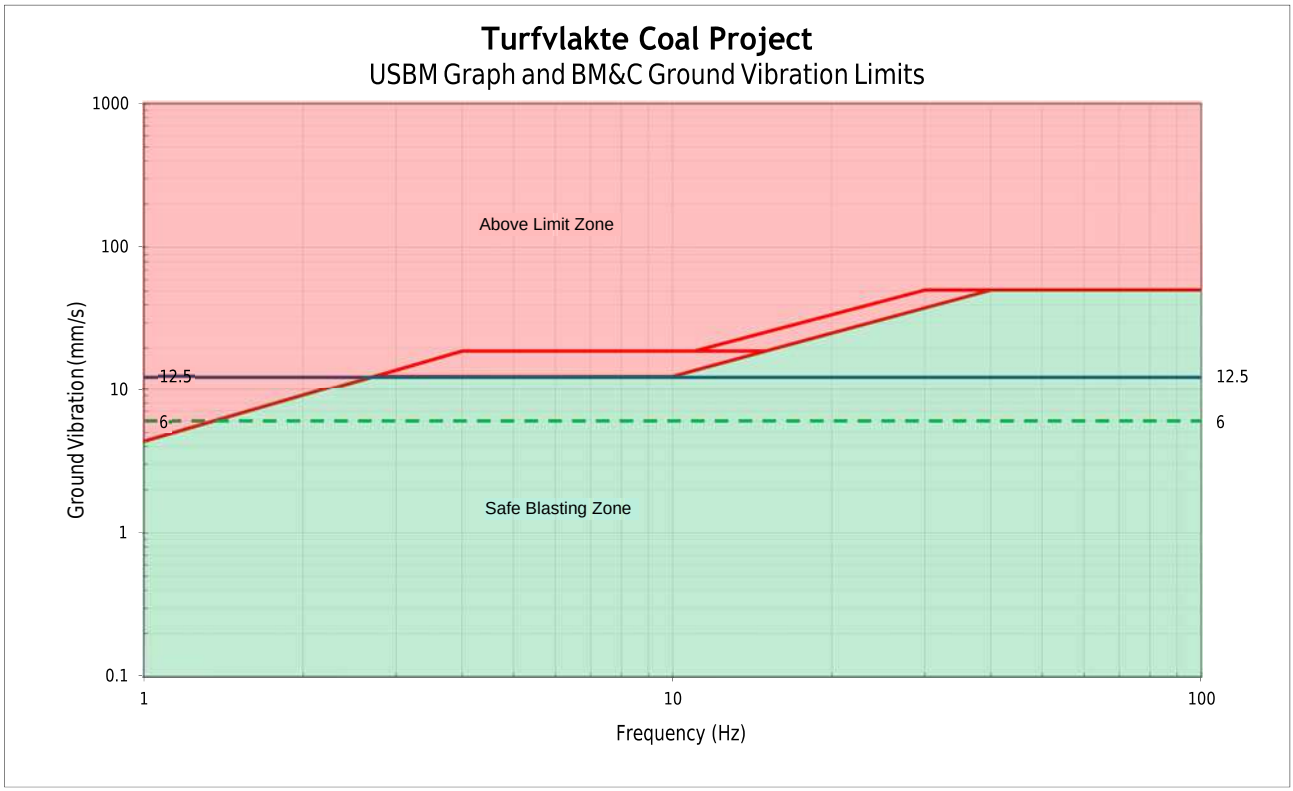


Figure 3: USBM Analysis Graph

Additional limitations 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 Pipe Lines: 25 mms/s (Sasol);
- Railways: 150 mm/s BM&C;

- Concrete less than 3 days old: 5 mm/s [1];
- 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, BM&C 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.

[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.

[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.

Ground vibration is experienced at different levels; BM&C 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 4.5 mm/s as unpleasant (See Figure 4). This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.
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.

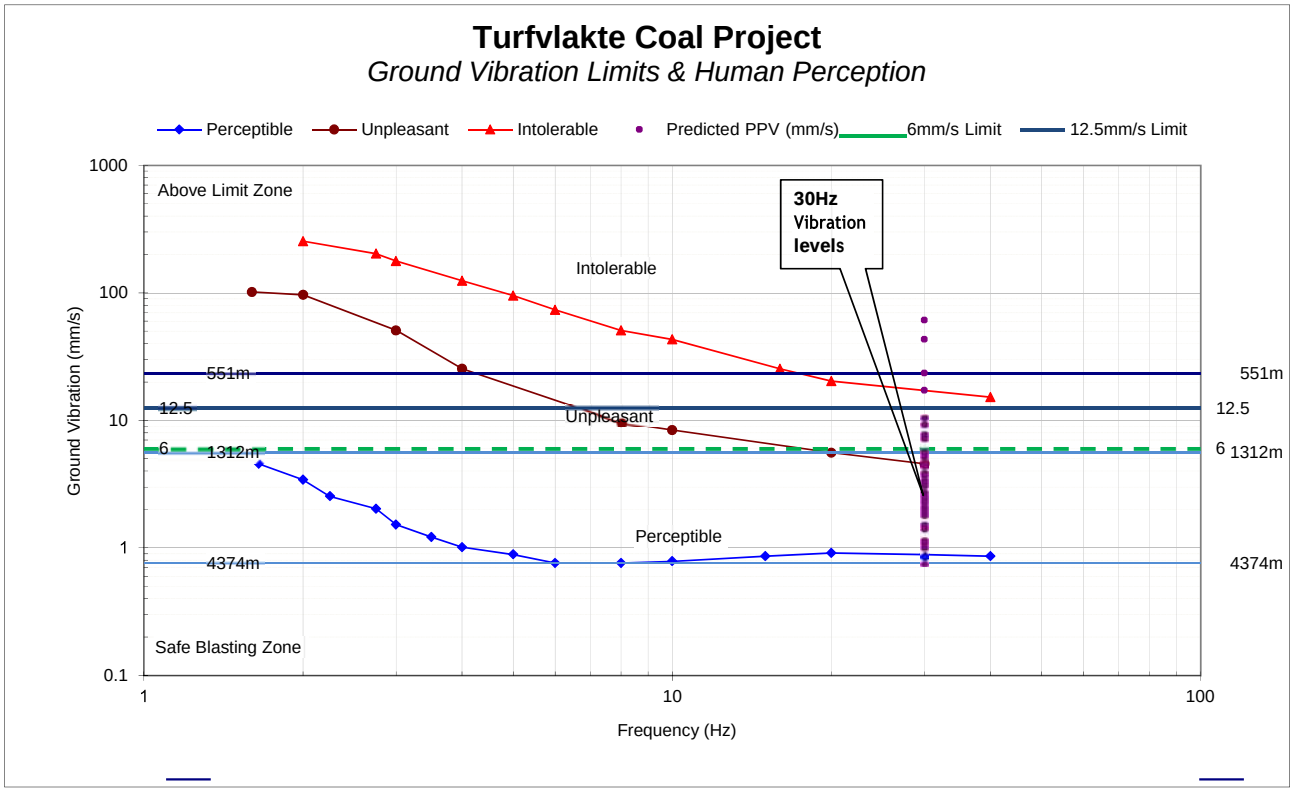


Figure 4: USBM Analysis with Human Perception

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 Limits 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

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, BM&C generally recommends that blasting be done in such a way that air blast levels are kept below 120dB. 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 120dB, 120 dB to 134dB and greater than 134dB. The USBM limits for nuisance is 134dB.

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.

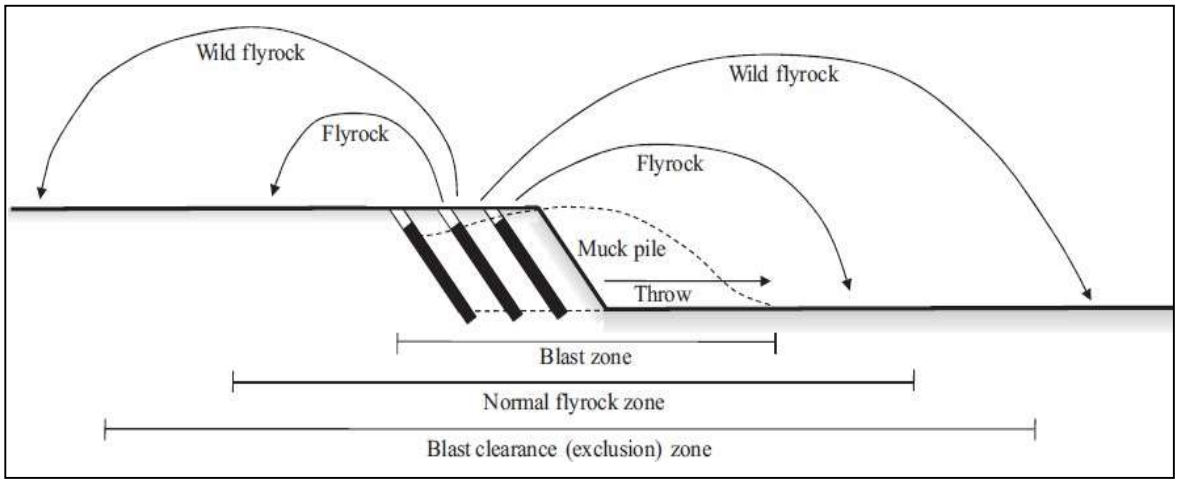


Figure 5: Schematic of fly rock terminology

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 to 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.

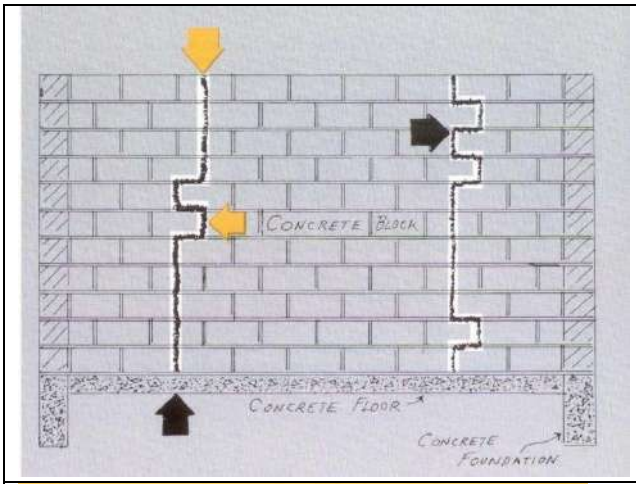
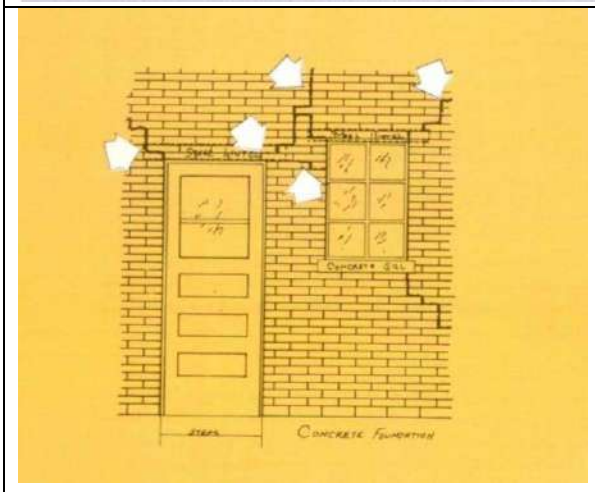
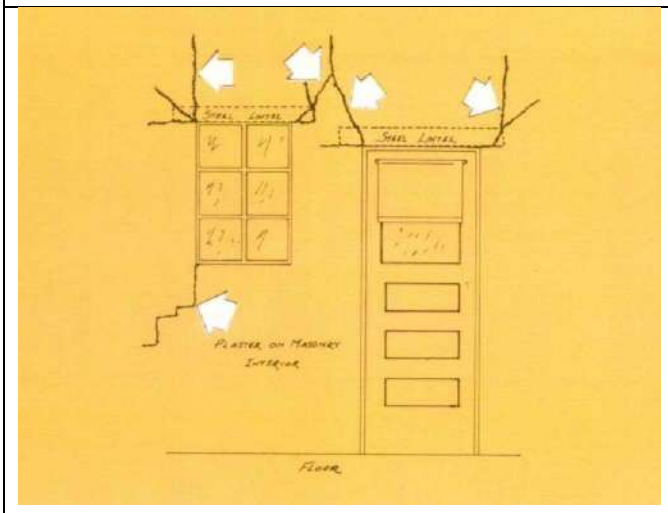
13.9 Cracking of houses and consequent devaluation

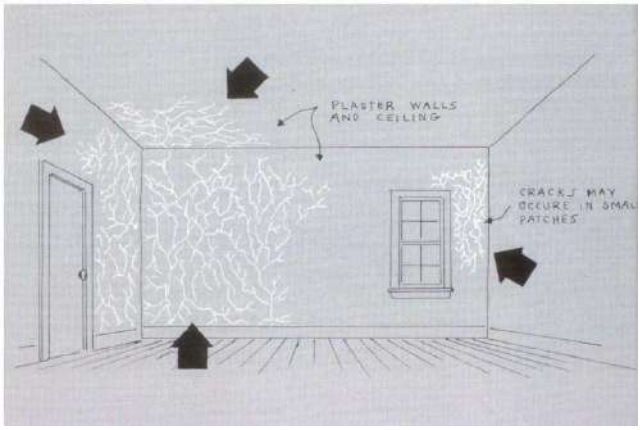
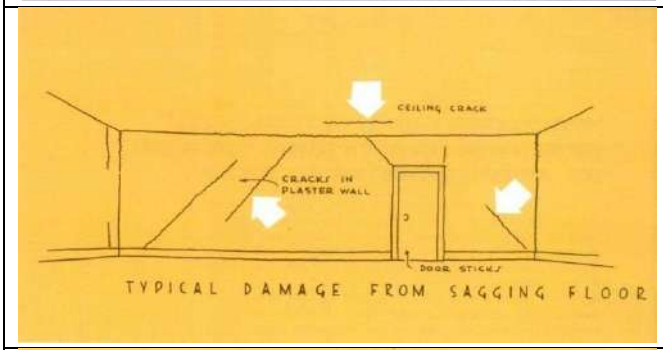
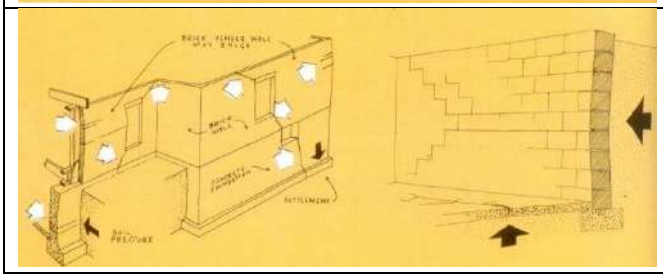
Houses in general have cracks. It is reported that a house could develop up to 15 cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc. are more reason 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 3: 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

The base line information for the project is based on zero influence with regards to blast impacts. The project is currently not active with any blasting operations being done. As part of the baseline all possible structures in a possible influence area is identified.

14.1 Structure profile

As part of the baseline, all possible structures in a possible influence area are identified. The site was reviewed and detailed here. 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 mine boundary which will require consideration during modelling of blasting operations, e.g. houses, general structures, power lines, pipe lines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the Pit 1 and Pit 2 areas. The list includes structures and points of interest (POI) within the 3500 m boundary – see Table 5 below. A list of structure locations was required in order to determine the allowable ground vibration limits and air blast limits. Figure 7 shows an aerial view of the pit areas and surroundings with POIs. The type of POIs identified is grouped into different classes. These classes are indicated as "Classification" in Table 4. The classification used is a BM&C classification and does not relate to any standard or national or international code or practice. Table 4 shows the descriptions for the classifications used.

Table 4: POI Classification used

Class	Description
1	Rural Building and structures of poor construction
2	Private Houses and people sensitive areas
3	Office and High-rise buildings
4	Animal related installations and animal sensitive areas
5	Industrial buildings and installations
6	Earth like structures – no surface structure
7	Graves & Heritage
8	Water Borehole

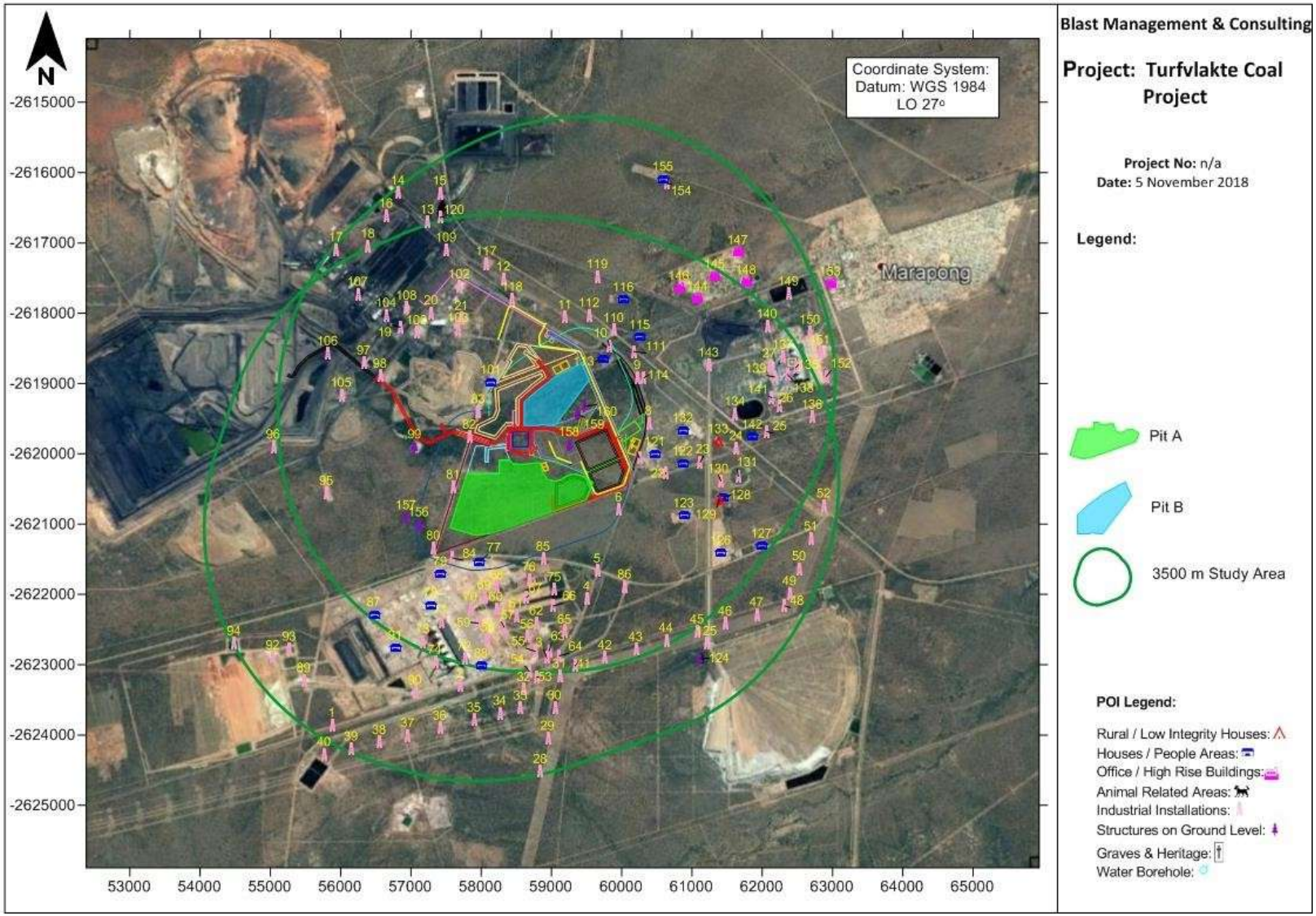


Figure 7: Aerial view and surface plan of the proposed mining area for Pit 1 and Pit 2 with points of interest identified

Table 5: List of points of interest identified (WGS – LO 27°)

Tag	Description	Classification	Y	X
1	Railway Line	5	-55880.71	2623859.82
2	Railway Line	5	-57705.44	2623300.09
3	Railway Line	5	-58934.61	2622901.87
4	Railway Line	5	-59508.13	2622060.70
5	Bridge	5	-59652.82	2621664.75
6	Railway Line	5	-59965.28	2620795.47
7	Railway Line	5	-60252.96	2620062.26
8	Railway Line	5	-60384.87	2619564.94
9	Railway Line	5	-60225.62	2618913.61
10	Railway Line	5	-59817.77	2618460.97
11	Railway Line	5	-59196.84	2618054.53
12	Railway Line	5	-58321.60	2617512.16
13	Railway Line	5	-57241.68	2616703.12
14	Railway Line	5	-56820.42	2616289.36
15	Railway Line	5	-57415.04	2616292.91
16	Railway Line	5	-56653.72	2616612.86
17	Railway Line	5	-55939.72	2617093.45
18	Railway Line	5	-56393.99	2617042.86
19	Railway Line	5	-56847.22	2618200.65
20	Railway Line	5	-57290.56	2617993.36
21	Railway Line	5	-57724.34	2618072.60
22	Railway Line	5	-60633.98	2620276.74
23	Railway Line	5	-61117.11	2620118.65
24	Railway Line	5	-61634.58	2619919.83
25	Railway Line	5	-62066.32	2619683.51
26	Railway Line	5	-62240.35	2619313.41
27	Railway Line	5	-62107.38	2618746.93
28	Power Lines/Pylons	5	-58844.53	2624515.37
29	Power Lines/Pylons	5	-58949.70	2624044.37
30	Power Lines/Pylons	5	-59050.85	2623608.99
31	Power Lines/Pylons	5	-59120.72	2623157.16
32	Power Lines/Pylons	5	-58613.29	2623349.69
33	Power Lines/Pylons	5	-58563.53	2623613.61
34	Power Lines/Pylons	5	-58270.70	2623689.43
35	Power Lines/Pylons	5	-57903.45	2623785.56
36	Power Lines/Pylons	5	-57414.89	2623899.01
37	Power Lines/Pylons	5	-56956.40	2624006.80
38	Power Lines/Pylons	5	-56552.31	2624102.92
39	Power Lines/Pylons	5	-56152.08	2624192.78
40	Power Lines/Pylons	5	-55767.70	2624273.60
41	Power Lines/Pylons	5	-59334.74	2623013.67

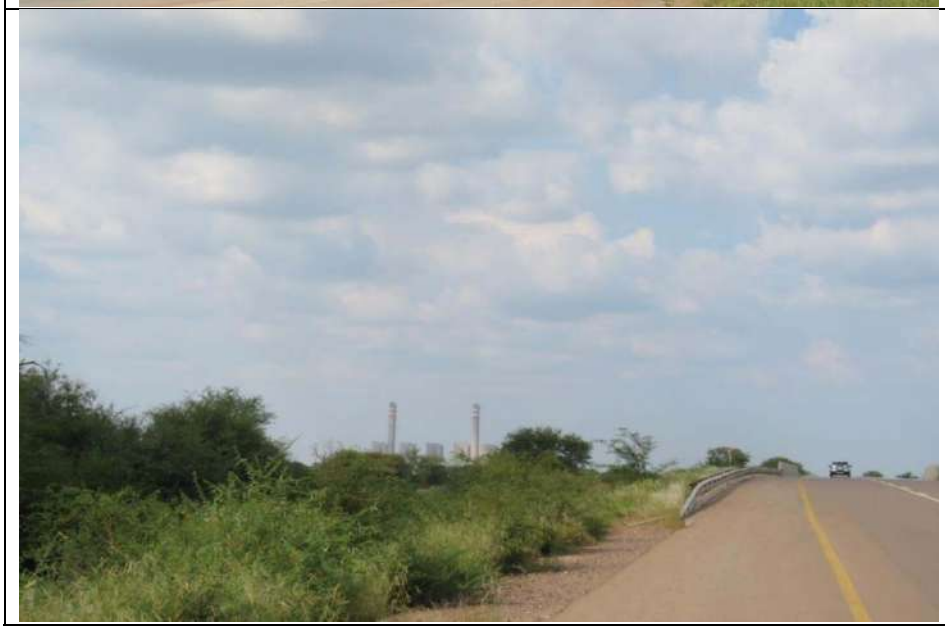
Tag	Description	Classification	Y	X
42	Power Lines/Pylons	5	-59766.07	2622898.74
43	Power Lines/Pylons	5	-60204.71	2622777.71
44	Power Lines/Pylons	5	-60635.51	2622652.35
45	Power Lines/Pylons	5	-61078.44	2622530.53
46	Power Lines/Pylons	5	-61479.02	2622412.24
47	Power Lines/Pylons	5	-61926.70	2622284.74
48	Power Lines/Pylons	5	-62321.11	2622164.88
49	Power Lines/Pylons	5	-62391.95	2621987.54
50	Power Lines/Pylons	5	-62530.94	2621633.12
51	Power Lines/Pylons	5	-62697.33	2621206.43
52	Power Lines/Pylons	5	-62880.72	2620736.58
53	Power Lines/Pylons	5	-58793.77	2623180.57
54	Power Lines/Pylons	5	-58682.22	2623097.24
55	Power Lines/Pylons	5	-58768.28	2622809.99
56	Power Lines/Pylons	5	-58655.81	2622601.26
57	Power Lines/Pylons	5	-58327.77	2622468.76
58	Power Lines/Pylons	5	-58096.91	2622643.57
59	Power Lines/Pylons	5	-57956.69	2622407.36
60	Power Lines/Pylons	5	-58214.46	2622208.26
61	Power Lines/Pylons	5	-58503.00	2622302.46
62	Power Lines/Pylons	5	-58790.76	2622408.73
63	Power Lines/Pylons	5	-58965.59	2622802.56
64	Power Lines/Pylons	5	-59114.68	2622871.13
65	Power Lines/Pylons	5	-59192.28	2622531.51
66	Power Lines/Pylons	5	-59025.15	2622166.63
67	Power Lines/Pylons	5	-58645.40	2622043.30
68	Power Lines/Pylons	5	-58228.70	2621895.44
69	Power Lines/Pylons	5	-58052.41	2622039.29
70	Power Lines/Pylons	5	-57850.57	2622209.13
71	Medupi Power Station	5	-57431.65	2622390.43
72	Medupi Power Station	5	-57764.28	2622915.36
73	Cooling Towers	5	-57177.44	2622671.91
74	Cooling Towers	5	-57346.80	2622960.91
75	Water Reservoirs	5	-59047.13	2621928.00
76	Tailing Dams	5	-58687.76	2621786.30
77	Buildings/Structures	2	-57977.92	2621532.99
78	Buildings/Structures	2	-57284.09	2622152.11
79	Buildings/Structures	2	-57422.05	2621705.43
80	Conveyor	5	-57325.56	2621340.99
81	Conveyor	5	-57608.62	2620471.60
82	Bridge	5	-57836.83	2619761.73
83	Conveyor	5	-57962.09	2619399.15
84	D1675 Road	5	-57595.00	2621480.66
85	D1675 Road	5	-58885.43	2621495.06

Tag	Description	Classification	Y	X
86	D2649 Road	5	-60045.97	2621891.74
87	Buildings/Structures	2	-56477.80	2622288.29
88	Buildings/Structures	2	-58003.09	2623014.41
89	Conveyor	5	-55480.76	2623221.09
90	Conveyor	5	-57064.84	2623391.39
91	Buildings/Structures	2	-56781.74	2622758.92
92	Conveyor	5	-55039.40	2622894.57
93	Dam	5	-55273.29	2622773.65
94	Dam	5	-54486.35	2622696.06
95	Explosive Magazines Exxaro	5	-55803.07	2620557.96
96	Sub Station	5	-55044.67	2619897.32
97	Exxaro Grootgeluk Mine Activity	5	-56333.37	2618705.29
98	Mine Buildings/Structures	5	-56564.04	2618893.13
99	Pan	6	-57056.05	2619900.30
100	Industrial Buildings	5	-57089.12	2618274.63
101	Building/Structure	2	-58141.47	2618979.14
102	Mine Buildings/Structures	5	-57692.58	2617621.18
103	Industrial Buildings	5	-57675.66	2618241.97
104	Water Reservoirs	5	-56654.39	2618031.09
105	Industrial Buildings/Structures	5	-56011.22	2619164.87
106	Mine Activity	5	-55819.99	2618571.92
107	Water Reservoirs	5	-56247.58	2617727.53
108	Industrial Buildings/Structures	5	-56942.66	2617924.38
109	Conveyor	5	-57506.09	2617099.38
110	D2816 Road	5	-59890.91	2618242.77
111	D2001 Road	5	-60171.39	2618546.16
112	D2001 Road	5	-59541.31	2618027.52
113	Manketti Lodge	2	-59746.58	2618652.80
114	Reservoir	5	-60314.01	2618920.85
115	Buildings/Structures	2	-60262.50	2618342.33
116	Buildings/Structures	2	-60030.53	2617805.13
117	Sub Station	5	-58079.94	2617296.20
118	Conveyor	5	-58447.32	2617801.36
119	Conveyor	5	-59658.90	2617479.64
120	Dams	5	-57417.71	2616636.93
121	Buildings/Structures	2	-60474.89	2620003.81
122	Buildings/Structures	2	-60872.99	2620138.16
123	Buildings/Structures	2	-60886.47	2620875.22
124	Pan	6	-61114.68	2622905.99
125	Conveyor	5	-61212.73	2622694.55
126	Buildings/Structures	2	-61414.49	2621406.21
127	Buildings/Structures	2	-61995.21	2621310.06
128	Buildings/Structures	2	-61450.85	2620628.44
129	Informal Housing	1	-61392.82	2620649.26

Tag	Description	Classification	Y	X
130	Pivot Irrigation	5	-61411.50	2620386.00
131	Pivot Irrigation	5	-61657.45	2620319.62
132	Buildings/Structures	2	-60876.52	2619666.49
133	Informal Housing	1	-61377.56	2619820.94
134	Dam	5	-61618.23	2619431.87
135	Eskom Power Station-Matimba	5	-62474.82	2618774.63
136	Airfield	5	-62716.08	2619475.45
137	Cooling Towers	5	-62298.96	2618620.18
138	Cooling Towers	5	-62358.25	2618870.01
139	Industrial Buildings/Structures	5	-62173.19	2618908.02
140	Conveyor	5	-62073.87	2618181.98
141	Industrial Buildings/Structures	5	-62137.28	2619205.46
142	Buildings/Structures	2	-61862.18	2619759.82
143	Conveyor	5	-61242.86	2618733.12
144	Marapong Community Buildings	3	-61083.33	2617787.81
145	Marapong Community Buildings	3	-61327.04	2617470.08
146	Marapong Community Buildings	3	-60819.51	2617635.48
147	Marapong Community Buildings	3	-61655.49	2617124.75
148	Marapong Community Buildings	3	-61772.79	2617553.49
149	Dams	5	-62376.94	2617719.18
150	Industrial Buildings/Structures	5	-62683.75	2618267.99
151	Power Lines/Pylons	5	-62825.52	2618553.39
152	Power Lines/Pylons	5	-62906.47	2618901.58
153	Marapong Hospital	3	-62973.30	2617574.85
154	Dam	5	-60641.90	2616155.53
155	Buildings/Structures	2	-60592.50	2616094.12
156	Pan	6	-57115.07	2621003.69
157	Pan	6	-56935.28	2620903.70
158	Pan	6	-59256.95	2619864.34
159	Pan	6	-59378.44	2619444.34
160	Pan	6	-59470.44	2619321.67

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 6 shows photos of structures found in the area.

Table 6: Structure Profile

Structure Photo	Description
	Medupi Powerstation Towers
	Bridge near Medupi Powerstation

	Bidge and telecoms tower
	Coveyor belt

	Conveyor belt
	Medupi Powerstation

	Exxaro Conveyer belt tower
	Conveyor belt

	Coal silo
	Matimba Powerstation

	Conevyor belt and powerlines
	Entrance to Matimba Powerstation

	Powerlines near project area
	Ligth industrial area next to D1675 (Steenbokpan road)
	Intersection at D1675 and D2001 (Steenbokpan road and Lephalale to Grootegeluk road)

	Ligth industrial area next to D1675 (Steenbokpan road)
	Watertank at industrial area
	Ligth industrial area next to D1675 (Steenbokpan road)

	Manketti Lodge (GoogleEarth)

15 Blasting Operations

The mining operation is divided into three activities, namely overburden B1 (activity 1) including B5 if present, coal B6, B9A, B9B, B11 (activity 2) and inter-burden B10 (activity 3). Benches are determined by the geological bench thickness, i.e. where the overburden thickness exceeds 30 meters, it is split into two sub-benches.

Mining will start as indicated by the access ramps. The haul road was determined to ensure that pit access is at one of the lowest stripping areas initially. The main criteria that was used, in the determination of the pit layout, is overburden removal cost and the total energy stripping ex-pit factor. The proposed pit design is deemed to meet the appropriate criteria of shallow pit entry (minimising the box-cut size), low stripping during the payback phase and good product yields to accommodate the project payback.

All coal mined is crushed and screened at the Turfvlakte site, from where it is transported to the beneficiation plant according to the investigated scenario or sold directly as a +23MJ/kg CV product.

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 for the overburden material. Indications are that coal will firstly be mechanically dug and ripped with drilling and blasting as a last option.

This report concentrates on the drilling and blasting of the overburden. Coal requires significantly less explosives per unit than the overburden. The overburden blasts are considered as a worst-case scenario and is used as indicator of possible influence.

Currently a final blast design is not available but information was provided of planned benches heights and drill rig information. Based on standard blasting practices 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 7 shows summary technical information of the blast designed. Outcome of the design on JKSimblast is summarised in Table 8. Figure 9 below shows the blast layout with blast holes, simulation and maximum charge mass per delay. Figure 10 shows simulation timing contours with number of blast holes per delay from the typical timing applied.

Table 7: Blast design technical information

Description	Value
Bench Height (m):	20
B/H Depth - Min (m):	20
B/H Diameter (mm):	172
Sub Drill Length (m):	0
Burden (m):	5.5
Spacing (m):	5.5
Drill Pattern:	
Quantity Blast Holes:	456
Explosive Type:	
Charge per b/h - (kg):	456
Stemming Length – (m):	4.3
Charge per delay (kg/delay):	456
Powder Factor (kg/m3):	0.75

Table 8: Blast design information from simulation

DESIGN FACTORS FOR:			
Blast Name:			
Scenario:	**Scenario 1**	**Scenario 1**	
Area Option:	**-**	**1**	
Hole Option:	**-**	**1**	
Deck Option:	**-**	**1**	
Downhole Delay Option:	**-**	**1**	
Surface Delay Option:	**-**	**1**	
Using Marked Holes and blast Parameters:			
	Av. Burden	5.5	m
	Av. Spacing	5.5	m
	All Hole Lengths	6 000.000	m

	Volume	181 500.000	m³
	Rock SG	2.69	
	Tonnage	488 235	tonnes
	Marked Holes	300	
	Charge Mass	136 797.352	kg
	Charge Energy	367 984.876	MJ
	POWDER FACTOR	0.754	kg/m³
	POWDER FACTOR	0.28	kg/t
	ENERGY FACTOR	2.027	MJ/m³
	ENERGY FACTOR	0.754	MJ/t

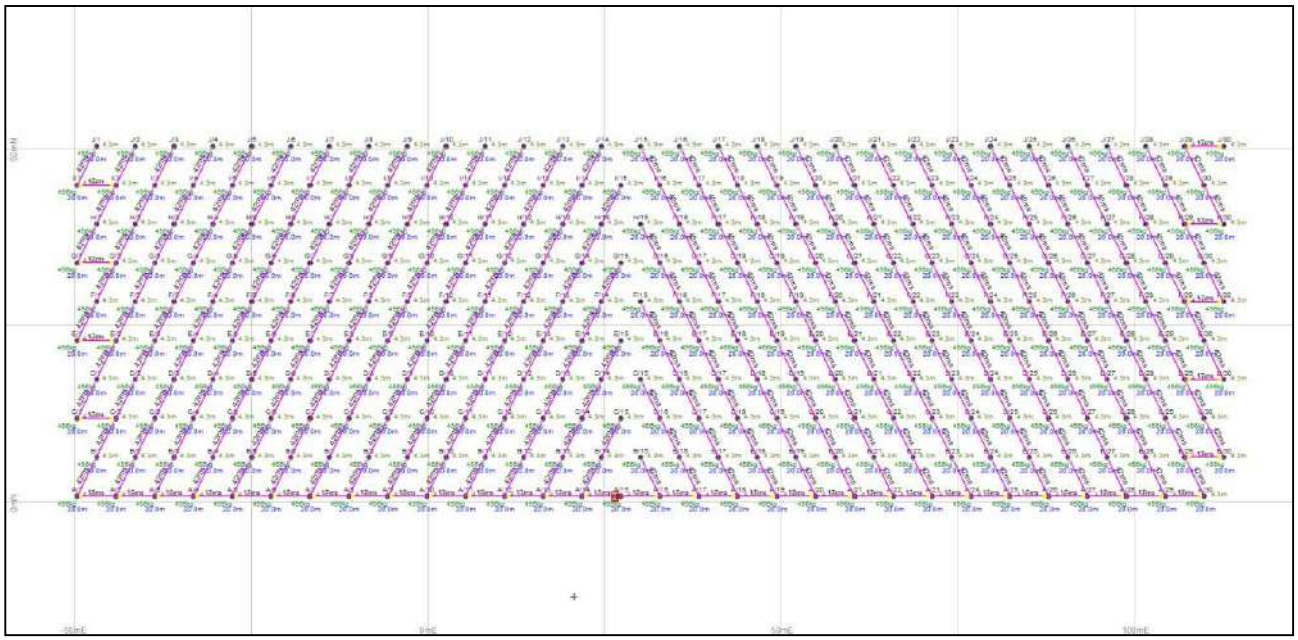


Figure 8: Blast layout and blast preparation information

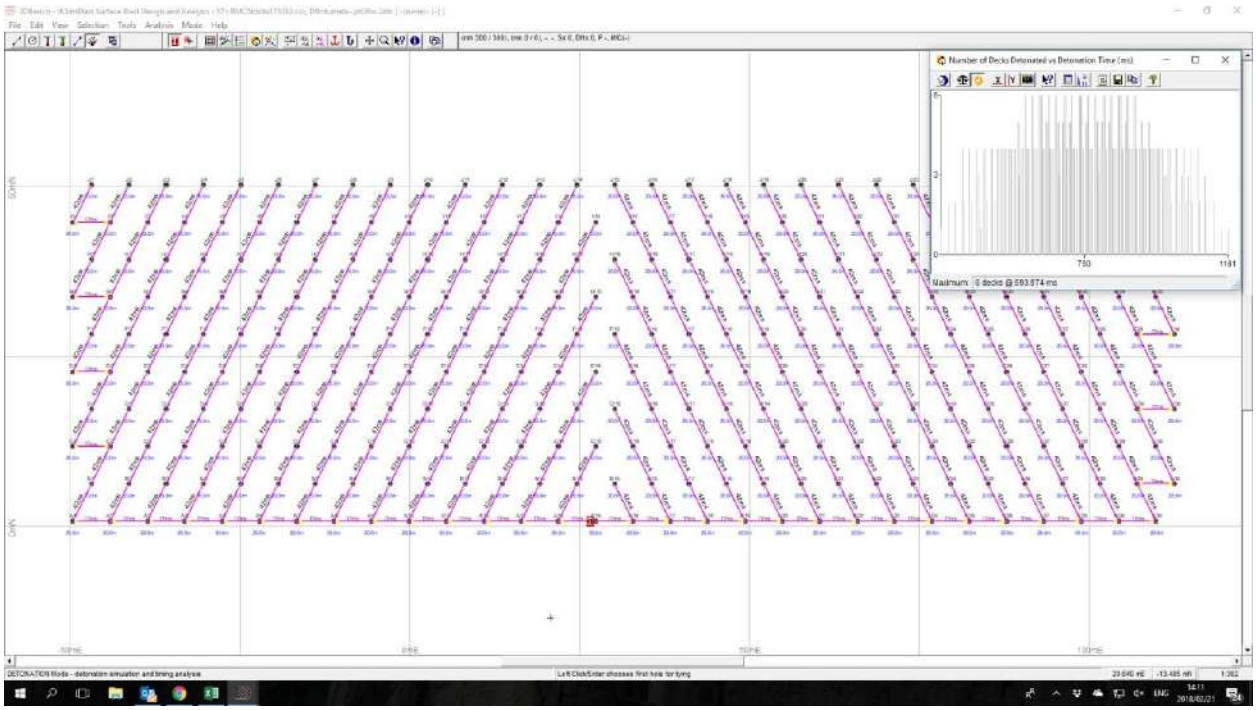


Figure 9: Blast simulation with maximum number of blast holes detonating simultaneously

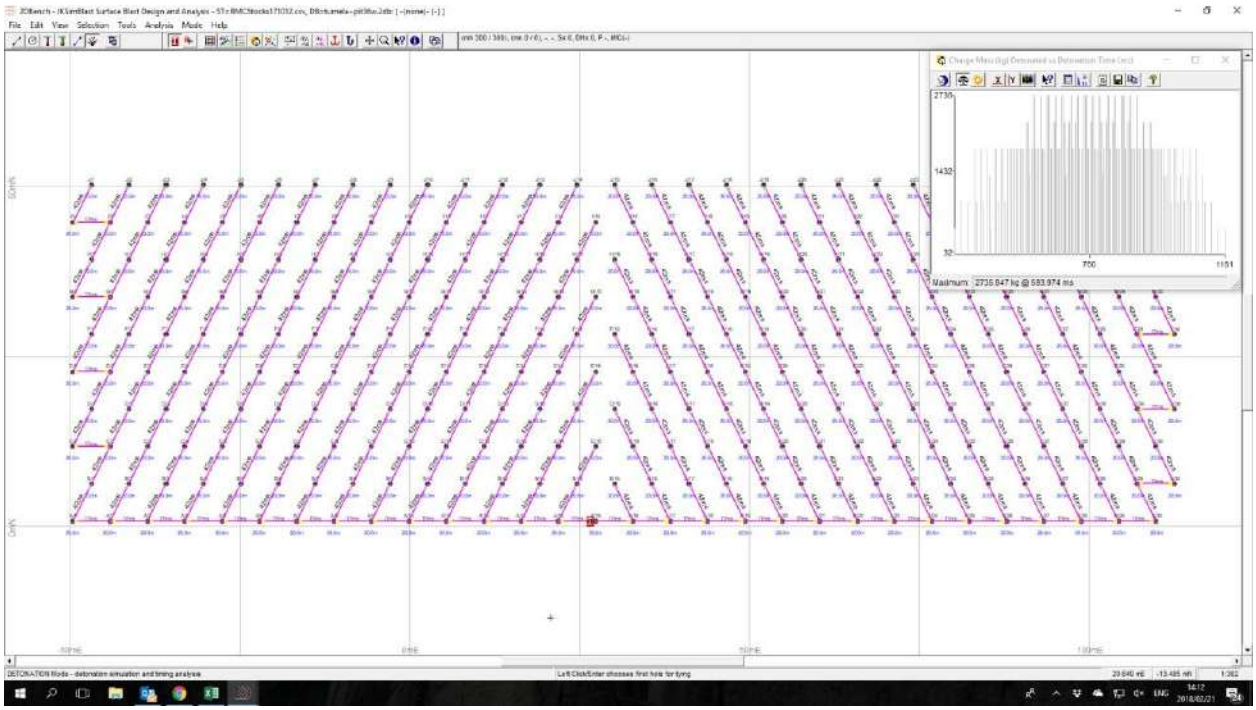


Figure 10: Blast simulation with maximum charge detonating simultaneously

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 172 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. Thus, the maximum mass of explosives detonating at once. The minimum charge relates to 456 kg and the maximum charge relates to 2736 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&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. Structures 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 456 kg and 2736 kg for Pit 1 and Pit 2.

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

No.	Distance (m)	Expected PPV (mm/s) for 456 kg Charge	Expected PPV (mm/s) for 2736 kg Charge
1	50.0	280.8	1231.3
2	100.0	143.8	630.7
3	150.0	45.8	201.0
4	200.0	28.5	125.0
5	250.0	19.7	86.5
6	300.0	14.6	64.0
7	400.0	9.1	39.8
8	500.0	6.3	27.6
9	600.0	4.7	20.4
10	700.0	3.6	15.8
11	800.0	2.9	12.7
12	900.0	2.4	10.5
13	1000.0	2.0	8.8
14	1250.0	1.4	6.1
15	1500.0	1.0	4.5
16	1750.0	0.8	3.5
17	2000.0	0.6	2.8
18	2500.0	0.4	1.9
19	3000.0	0.3	1.4
20	3500.0	0.3	1.1

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 - (5.37)

B = Constant – (-0.79)

The constants for A and B were then selected according to the information as provided in Figure 11 below. Various types of mining operations are expected to yield different results. The information provided in Figure 11 is based on detailed research that was conducted for each of the different types of mining environments. In this report, the data for "Coal Mines (high wall)" 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 11: 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:

$$p_s = 20 \times \log \frac{P}{P_o}$$

Where:

p_s = Air blast level (dB)

P = Air blast level (Pa (mB x 100))
P_o = Reference Pressure (2×10^{-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 456 kg Charge	Air blast (dB) for 2736 kg Charge
1	50.0	135.7	139.8
2	100.0	133.0	137.1
3	150.0	128.2	132.3
4	200.0	126.2	130.3
5	250.0	124.7	128.8
6	300.0	123.5	127.5
7	400.0	121.5	125.6
8	500.0	120.0	124.1
9	600.0	118.7	122.8
10	700.0	117.7	121.8
11	800.0	116.8	120.8
12	900.0	115.9	120.0
13	1000.0	115.2	119.3
14	1250.0	113.7	117.8
15	1500.0	112.5	116.5
16	1750.0	111.4	115.5
17	2000.0	110.5	114.6
18	2500.0	108.9	113.1
19	3000.0	107.8	111.8
20	3500.0	106.6	110.8

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 the construction phase.

17 Operational Phase: Impact Assessment and Mitigation Measures

The area surrounding the proposed mining areas was reviewed for structures, traffic, roads, human interface, animals interface etc. Various installations and structures were observed. These are listed in Table 5. 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 14.1 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 area. 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 Minimum charge mass per delay – 456 kg – Pit 1

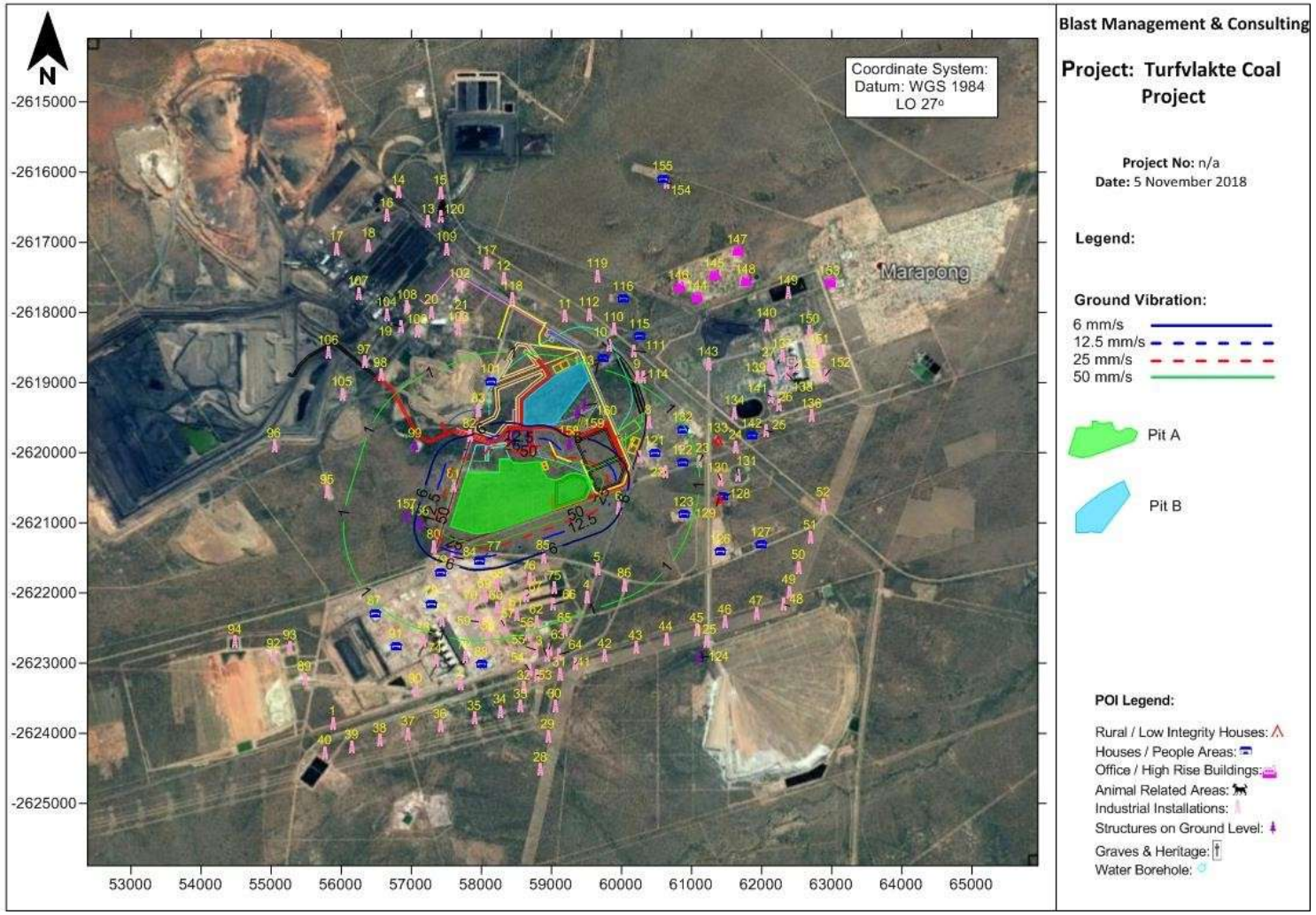


Figure 12: Ground vibration influence from minimum charge for Pit 1 Area

Table 11: Ground vibration evaluation for minimum charge for Pit 1

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Railway Line	150	3270	456	0.3	Acceptable	N/A
2	Railway Line	150	2154	456	0.6	Acceptable	N/A
3	Railway Line	150	1931	456	0.7	Acceptable	N/A
4	Railway Line	150	1329	456	1.3	Acceptable	N/A
5	Bridge	50	1004	456	2.0	Acceptable	N/A
6	Railway Line	150	488	456	6.5	Acceptable	N/A
7	Railway Line	150	750	456	3.2	Acceptable	N/A
8	Railway Line	150	1161	456	1.6	Acceptable	N/A
9	Railway Line	150	1610	456	0.9	Acceptable	N/A
10	Railway Line	150	1889	456	0.7	Acceptable	N/A
11	Railway Line	150	2103	456	0.6	Acceptable	N/A
12	Railway Line	150	2577	456	0.4	Acceptable	N/A
13	Railway Line	150	3541	456	0.2	Acceptable	N/A
14	Railway Line	150	4068	456	0.2	Acceptable	N/A
15	Railway Line	150	3893	456	0.2	Acceptable	N/A
16	Railway Line	150	3834	456	0.2	Acceptable	N/A
17	Railway Line	150	3695	456	0.2	Acceptable	N/A
18	Railway Line	150	3536	456	0.2	Acceptable	N/A
19	Railway Line	150	2293	456	0.5	Acceptable	N/A
20	Railway Line	150	2313	456	0.5	Acceptable	N/A
21	Railway Line	150	2091	456	0.6	Acceptable	N/A
22	Railway Line	150	1054	456	1.8	Acceptable	N/A
23	Railway Line	150	1556	456	1.0	Acceptable	N/A
24	Railway Line	150	2104	456	0.6	Acceptable	N/A
25	Railway Line	150	2582	456	0.4	Acceptable	N/A
26	Railway Line	150	2869	456	0.4	Acceptable	N/A
27	Railway Line	150	3018	456	0.3	Acceptable	N/A
28	Power Lines/Pylons	75	3455	456	0.3	Acceptable	N/A
29	Power Lines/Pylons	75	3022	456	0.3	Acceptable	N/A
30	Power Lines/Pylons	75	2638	456	0.4	Acceptable	N/A
31	Power Lines/Pylons	75	2233	456	0.5	Acceptable	N/A
32	Power Lines/Pylons	75	2267	456	0.5	Acceptable	N/A
33	Power Lines/Pylons	75	2517	456	0.4	Acceptable	N/A
34	Power Lines/Pylons	75	2556	456	0.4	Acceptable	N/A
35	Power Lines/Pylons	75	2629	456	0.4	Acceptable	N/A
36	Power Lines/Pylons	75	2788	456	0.4	Acceptable	N/A
37	Power Lines/Pylons	75	3005	456	0.3	Acceptable	N/A
38	Power Lines/Pylons	75	3212	456	0.3	Acceptable	N/A
39	Power Lines/Pylons	75	3441	456	0.3	Acceptable	N/A
40	Power Lines/Pylons	75	3685	456	0.2	Acceptable	N/A
41	Power Lines/Pylons	75	2169	456	0.6	Acceptable	N/A
42	Power Lines/Pylons	75	2205	456	0.5	Acceptable	N/A
43	Power Lines/Pylons	75	2238	456	0.5	Acceptable	N/A
44	Power Lines/Pylons	75	2302	456	0.5	Acceptable	N/A
45	Power Lines/Pylons	75	2458	456	0.5	Acceptable	N/A

46	Power Lines/Pylons	75	2653	456	0.4	Acceptable	N/A
47	Power Lines/Pylons	75	2928	456	0.3	Acceptable	N/A
48	Power Lines/Pylons	75	3204	456	0.3	Acceptable	N/A
49	Power Lines/Pylons	75	3188	456	0.3	Acceptable	N/A
50	Power Lines/Pylons	75	3184	456	0.3	Acceptable	N/A
51	Power Lines/Pylons	75	3209	456	0.3	Acceptable	N/A
52	Power Lines/Pylons	75	3308	456	0.3	Acceptable	N/A
53	Power Lines/Pylons	75	2150	456	0.6	Acceptable	N/A
54	Power Lines/Pylons	75	2038	456	0.6	Acceptable	N/A
55	Power Lines/Pylons	75	1790	456	0.8	Acceptable	N/A
56	Power Lines/Pylons	75	1556	456	1.0	Acceptable	N/A
57	Power Lines/Pylons	75	1349	456	1.2	Acceptable	N/A
58	Power Lines/Pylons	75	1498	456	1.0	Acceptable	N/A
59	Power Lines/Pylons	75	1252	456	1.4	Acceptable	N/A
60	Power Lines/Pylons	75	1077	456	1.8	Acceptable	N/A
61	Power Lines/Pylons	75	1225	456	1.4	Acceptable	N/A
62	Power Lines/Pylons	75	1418	456	1.1	Acceptable	N/A
63	Power Lines/Pylons	75	1847	456	0.7	Acceptable	N/A
64	Power Lines/Pylons	75	1962	456	0.7	Acceptable	N/A
65	Power Lines/Pylons	75	1667	456	0.9	Acceptable	N/A
66	Power Lines/Pylons	75	1268	456	1.4	Acceptable	N/A
67	Power Lines/Pylons	75	1025	456	1.9	Acceptable	N/A
68	Power Lines/Pylons	75	768	456	3.1	Acceptable	N/A
69	Power Lines/Pylons	75	892	456	2.4	Acceptable	N/A
70	Power Lines/Pylons	75	1055	456	1.8	Acceptable	N/A
71	Medupi Power Station	50	1320	456	1.3	Acceptable	N/A
72	Medupi Power Station	50	1766	456	0.8	Acceptable	N/A
73	Cooling Towers	50	1661	456	0.9	Acceptable	N/A
74	Cooling Towers	50	1891	456	0.7	Acceptable	N/A
75	Water Reservoirs	50	1050	456	1.8	Acceptable	N/A
76	Tailing Dams	25	796	456	2.9	Acceptable	N/A
77	Buildings/Structures	25	381	456	9.8	Acceptable	Unpleasant
78	Buildings/Structures	25	1132	456	1.6	Acceptable	Perceptible
79	Buildings/Structures	25	665	456	3.9	Acceptable	Perceptible
80	Conveyor	150	370	456	10.3	Acceptable	N/A
81	Conveyor	150	125	456	61.7	Acceptable	N/A
82	Bridge	50	520	456	5.9	Acceptable	N/A
83	Conveyor	150	756	456	3.2	Acceptable	N/A
84	D1675 Road	150	401	456	9.1	Acceptable	N/A
85	D1675 Road	150	588	456	4.8	Acceptable	N/A
86	D2649 Road	150	1354	456	1.2	Acceptable	N/A
87	Buildings/Structures	25	1641	456	0.9	Acceptable	Perceptible
88	Buildings/Structures	25	1860	456	0.7	Acceptable	Too Low
89	Conveyor	150	3003	456	0.3	Acceptable	N/A
90	Conveyor	150	2383	456	0.5	Acceptable	N/A
91	Buildings/Structures	25	1875	456	0.7	Acceptable	Too Low
92	Conveyor	150	3120	456	0.3	Acceptable	N/A
93	Dam	50	2860	456	0.4	Acceptable	N/A
94	Dam	50	3483	456	0.3	Acceptable	N/A
95	Explosive Magazines Exxaro	25	1822	456	0.7	Acceptable	N/A
96	Sub Station	25	2743	456	0.4	Acceptable	N/A

97	Exxaro Grootgeluk Mine Activity	200	2156	456	0.6	Acceptable	N/A
98	Mine Buildings/Structures	25	1862	456	0.7	Acceptable	N/A
99	Pan	150	837	456	2.7	Acceptable	N/A
100	Industrial Buildings	50	2134	456	0.6	Acceptable	N/A
101	Building/Structure	25	1119	456	1.7	Acceptable	Perceptible
102	Mine Buildings/Structures	25	2536	456	0.4	Acceptable	N/A
103	Industrial Buildings	50	1942	456	0.7	Acceptable	N/A
104	Water Reservoirs	50	2530	456	0.4	Acceptable	N/A
105	Industrial Buildings/Structures	50	2110	456	0.6	Acceptable	N/A
106	Mine Activity	200	2618	456	0.4	Acceptable	N/A
107	Water Reservoirs	50	2993	456	0.3	Acceptable	N/A
108	Industrial Buildings/Structures	50	2513	456	0.4	Acceptable	N/A
109	Conveyor	150	3088	456	0.3	Acceptable	N/A
110	D2816 Road	150	2119	456	0.6	Acceptable	N/A
111	D2001 Road	150	1916	456	0.7	Acceptable	N/A
112	D2001 Road	150	2215	456	0.5	Acceptable	N/A
113	Manketti Lodge	25	1686	456	0.8	Acceptable	Perceptible
114	Reservoir	50	1644	456	0.9	Acceptable	N/A
115	Buildings/Structures	25	2140	456	0.6	Acceptable	Too Low
116	Buildings/Structures	25	2577	456	0.4	Acceptable	Too Low
117	Sub Station	25	2800	456	0.4	Acceptable	N/A
118	Conveyor	150	2289	456	0.5	Acceptable	N/A
119	Conveyor	150	2773	456	0.4	Acceptable	N/A
120	Dams	50	3558	456	0.2	Acceptable	N/A
121	Buildings/Structures	25	975	456	2.1	Acceptable	Perceptible
122	Buildings/Structures	25	1313	456	1.3	Acceptable	Perceptible
123	Buildings/Structures	25	1379	456	1.2	Acceptable	Perceptible
124	Pan	150	2776	456	0.4	Acceptable	N/A
125	Conveyor	150	2670	456	0.4	Acceptable	N/A
126	Buildings/Structures	25	2059	456	0.6	Acceptable	Too Low
127	Buildings/Structures	25	2569	456	0.4	Acceptable	Too Low
128	Buildings/Structures	25	1875	456	0.7	Acceptable	Too Low
129	Informal Housing	6	1820	456	0.7	Acceptable	Too Low
130	Pivot Irrigation	150	1823	456	0.7	Acceptable	N/A
131	Pivot Irrigation	150	2071	456	0.6	Acceptable	N/A
132	Buildings/Structures	25	1487	456	1.0	Acceptable	Perceptible
133	Informal Housing	6	1883	456	0.7	Acceptable	Too Low
134	Dam	50	2253	456	0.5	Acceptable	N/A
135	Eskom Power Station-Matimba	50	3317	456	0.3	Acceptable	N/A
136	Airfield	150	3264	456	0.3	Acceptable	N/A
137	Cooling Towers	50	3248	456	0.3	Acceptable	N/A
138	Cooling Towers	50	3169	456	0.3	Acceptable	N/A
139	Industrial Buildings/Structures	50	2989	456	0.3	Acceptable	N/A
140	Conveyor	150	3337	456	0.3	Acceptable	N/A
141	Industrial Buildings/Structures	50	2819	456	0.4	Acceptable	N/A
142	Buildings/Structures	25	2364	456	0.5	Acceptable	Too Low
143	Conveyor	150	2355	456	0.5	Acceptable	N/A
144	Marapong Community Buildings	25	3010	456	0.3	Acceptable	Too Low
145	Marapong Community Buildings	25	3408	456	0.3	Acceptable	Too Low
146	Marapong Community Buildings	25	3018	456	0.3	Acceptable	Too Low
147	Marapong Community Buildings	25	3876	456	0.2	Acceptable	Too Low

148	Marapong Community Buildings	25	3593	456	0.2	Acceptable	Too Low
149	Dams	50	3875	456	0.2	Acceptable	N/A
150	Industrial Buildings/Structures	50	3764	456	0.2	Acceptable	N/A
151	Power Lines/Pylons	75	3731	456	0.2	Acceptable	N/A
152	Power Lines/Pylons	75	3644	456	0.2	Acceptable	N/A
153	Marapong Hospital	25	4415	456	0.2	Acceptable	Too Low
154	Dam	50	4329	456	0.2	Acceptable	N/A
155	Buildings/Structures	25	4375	456	0.2	Acceptable	Too Low
156	Pan	150	444	456	7.6	Acceptable	N/A
157	Pan	150	639	456	4.2	Acceptable	N/A
158	Pan	150	426	456	8.2	Acceptable	N/A
159	Pan	150	843	456	2.7	Acceptable	N/A
160	Pan	150	975	456	2.1	Acceptable	N/A

17.1.2 Minimum charge mass per delay – 456 kg – Pit 2

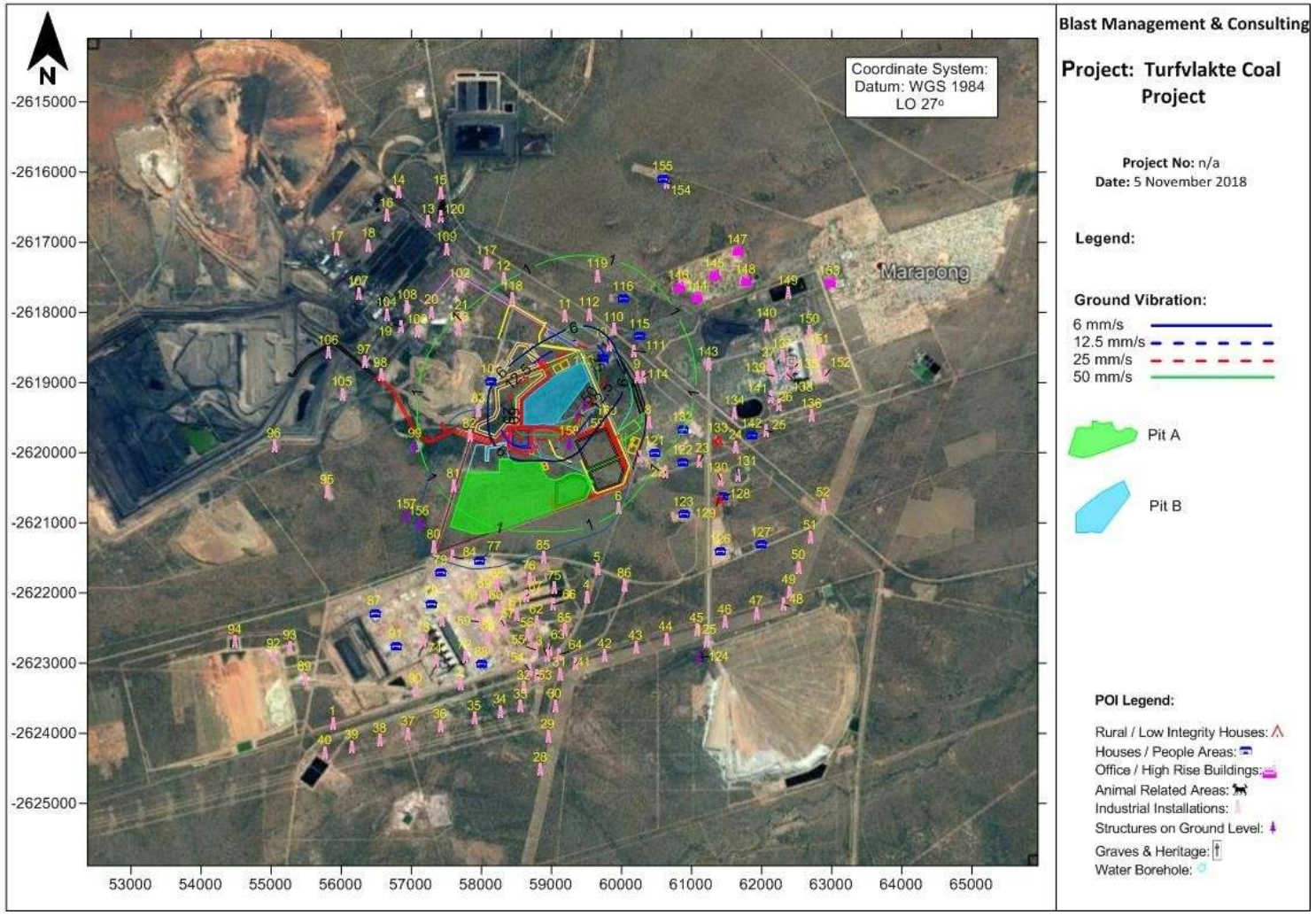


Figure 13: Ground vibration influence from minimum charge for Pit 2 Area

Table 12: Ground vibration evaluation for minimum charge for Pit 2

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Railway Line	150	5063	456	0.1	Acceptable	N/A
2	Railway Line	150	3812	456	0.2	Acceptable	N/A
3	Railway Line	150	3301	456	0.3	Acceptable	N/A
4	Railway Line	150	2502	456	0.4	Acceptable	N/A
5	Bridge	50	2151	456	0.6	Acceptable	N/A
6	Railway Line	150	1508	456	1.0	Acceptable	N/A
7	Railway Line	150	1243	456	1.4	Acceptable	N/A
8	Railway Line	150	1049	456	1.9	Acceptable	N/A
9	Railway Line	150	691	456	3.7	Acceptable	N/A
10	Railway Line	150	457	456	7.3	Acceptable	N/A
11	Railway Line	150	696	456	3.6	Acceptable	N/A
12	Railway Line	150	1574	456	0.9	Acceptable	N/A
13	Railway Line	150	2850	456	0.4	Acceptable	N/A
14	Railway Line	150	3433	456	0.3	Acceptable	N/A
15	Railway Line	150	3085	456	0.3	Acceptable	N/A
16	Railway Line	150	3282	456	0.3	Acceptable	N/A
17	Railway Line	150	3443	456	0.3	Acceptable	N/A
18	Railway Line	150	3139	456	0.3	Acceptable	N/A
19	Railway Line	150	2061	456	0.6	Acceptable	N/A
20	Railway Line	150	1833	456	0.7	Acceptable	N/A
21	Railway Line	150	1480	456	1.0	Acceptable	N/A
22	Railway Line	150	1676	456	0.9	Acceptable	N/A
23	Railway Line	150	1966	456	0.7	Acceptable	N/A
24	Railway Line	150	2314	456	0.5	Acceptable	N/A
25	Railway Line	150	2637	456	0.4	Acceptable	N/A
26	Railway Line	150	2730	456	0.4	Acceptable	N/A
27	Railway Line	150	2580	456	0.4	Acceptable	N/A
28	Power Lines/Pylons	75	4917	456	0.1	Acceptable	N/A
29	Power Lines/Pylons	75	4443	456	0.2	Acceptable	N/A
30	Power Lines/Pylons	75	4007	456	0.2	Acceptable	N/A
31	Power Lines/Pylons	75	3556	456	0.2	Acceptable	N/A
32	Power Lines/Pylons	75	3753	456	0.2	Acceptable	N/A
33	Power Lines/Pylons	75	4017	456	0.2	Acceptable	N/A
34	Power Lines/Pylons	75	4107	456	0.2	Acceptable	N/A
35	Power Lines/Pylons	75	4248	456	0.2	Acceptable	N/A
36	Power Lines/Pylons	75	4465	456	0.2	Acceptable	N/A
37	Power Lines/Pylons	75	4710	456	0.2	Acceptable	N/A
38	Power Lines/Pylons	75	4954	456	0.1	Acceptable	N/A
39	Power Lines/Pylons	75	5213	456	0.1	Acceptable	N/A
40	Power Lines/Pylons	75	5474	456	0.1	Acceptable	N/A
41	Power Lines/Pylons	75	3424	456	0.3	Acceptable	N/A
42	Power Lines/Pylons	75	3375	456	0.3	Acceptable	N/A
43	Power Lines/Pylons	75	3381	456	0.3	Acceptable	N/A
44	Power Lines/Pylons	75	3441	456	0.3	Acceptable	N/A
45	Power Lines/Pylons	75	3566	456	0.2	Acceptable	N/A

46	Power Lines/Pylons	75	3719	456	0.2	Acceptable	N/A
47	Power Lines/Pylons	75	3939	456	0.2	Acceptable	N/A
48	Power Lines/Pylons	75	4161	456	0.2	Acceptable	N/A
49	Power Lines/Pylons	75	4110	456	0.2	Acceptable	N/A
50	Power Lines/Pylons	75	4007	456	0.2	Acceptable	N/A
51	Power Lines/Pylons	75	3884	456	0.2	Acceptable	N/A
52	Power Lines/Pylons	75	3793	456	0.2	Acceptable	N/A
53	Power Lines/Pylons	75	3585	456	0.2	Acceptable	N/A
54	Power Lines/Pylons	75	3501	456	0.3	Acceptable	N/A
55	Power Lines/Pylons	75	3214	456	0.3	Acceptable	N/A
56	Power Lines/Pylons	75	3004	456	0.3	Acceptable	N/A
57	Power Lines/Pylons	75	2886	456	0.3	Acceptable	N/A
58	Power Lines/Pylons	75	3090	456	0.3	Acceptable	N/A
59	Power Lines/Pylons	75	2886	456	0.3	Acceptable	N/A
60	Power Lines/Pylons	75	2641	456	0.4	Acceptable	N/A
61	Power Lines/Pylons	75	2708	456	0.4	Acceptable	N/A
62	Power Lines/Pylons	75	2813	456	0.4	Acceptable	N/A
63	Power Lines/Pylons	75	3201	456	0.3	Acceptable	N/A
64	Power Lines/Pylons	75	3269	456	0.3	Acceptable	N/A
65	Power Lines/Pylons	75	2933	456	0.3	Acceptable	N/A
66	Power Lines/Pylons	75	2564	456	0.4	Acceptable	N/A
67	Power Lines/Pylons	75	2446	456	0.5	Acceptable	N/A
68	Power Lines/Pylons	75	2330	456	0.5	Acceptable	N/A
69	Power Lines/Pylons	75	2506	456	0.4	Acceptable	N/A
70	Power Lines/Pylons	75	2721	456	0.4	Acceptable	N/A
71	Medupi Power Station	50	3033	456	0.3	Acceptable	N/A
72	Medupi Power Station	50	3425	456	0.3	Acceptable	N/A
73	Cooling Towers	50	3393	456	0.3	Acceptable	N/A
74	Cooling Towers	50	3594	456	0.2	Acceptable	N/A
75	Water Reservoirs	50	2326	456	0.5	Acceptable	N/A
76	Tailing Dams	25	2190	456	0.5	Acceptable	N/A
77	Buildings/Structures	25	2037	456	0.6	Acceptable	Too Low
78	Buildings/Structures	25	2880	456	0.3	Acceptable	Too Low
79	Buildings/Structures	25	2421	456	0.5	Acceptable	Too Low
80	Conveyor	150	2167	456	0.6	Acceptable	N/A
81	Conveyor	150	1331	456	1.2	Acceptable	N/A
82	Bridge	50	793	456	2.9	Acceptable	N/A
83	Conveyor	150	649	456	4.1	Acceptable	N/A
84	D1675 Road	150	2141	456	0.6	Acceptable	N/A
85	D1675 Road	150	1899	456	0.7	Acceptable	N/A
86	D2649 Road	150	2500	456	0.4	Acceptable	N/A
87	Buildings/Structures	25	3435	456	0.3	Acceptable	Too Low
88	Buildings/Structures	25	3471	456	0.3	Acceptable	Too Low
89	Conveyor	150	4789	456	0.2	Acceptable	N/A
90	Conveyor	150	4098	456	0.2	Acceptable	N/A
91	Buildings/Structures	25	3653	456	0.2	Acceptable	Too Low
92	Conveyor	150	4862	456	0.1	Acceptable	N/A
93	Dam	50	4608	456	0.2	Acceptable	N/A
94	Dam	50	5160	456	0.1	Acceptable	N/A
95	Explosive Magazines Exxaro	25	2969	456	0.3	Acceptable	N/A
96	Sub Station	25	3580	456	0.2	Acceptable	N/A

97	Exxaro Grootgeluk Mine Activity	200	2346	456	0.5	Acceptable	N/A
98	Mine Buildings/Structures	25	2081	456	0.6	Acceptable	N/A
99	Pan	150	1585	456	0.9	Acceptable	N/A
100	Industrial Buildings	50	1817	456	0.7	Acceptable	N/A
101	Building/Structure	25	551	456	5.4	Acceptable	Perceptible
102	Mine Buildings/Structures	25	1844	456	0.7	Acceptable	N/A
103	Industrial Buildings	50	1385	456	1.2	Acceptable	N/A
104	Water Reservoirs	50	2315	456	0.5	Acceptable	N/A
105	Industrial Buildings/Structures	50	2602	456	0.4	Acceptable	N/A
106	Mine Activity	200	2876	456	0.4	Acceptable	N/A
107	Water Reservoirs	50	2821	456	0.4	Acceptable	N/A
108	Industrial Buildings/Structures	50	2141	456	0.6	Acceptable	N/A
109	Conveyor	150	2374	456	0.5	Acceptable	N/A
110	D2816 Road	150	653	456	4.0	Acceptable	N/A
111	D2001 Road	150	742	456	3.3	Acceptable	N/A
112	D2001 Road	150	690	456	3.7	Acceptable	N/A
113	Manketti Lodge	25	309	456	13.9	Acceptable	Unpleasant
114	Reservoir	50	779	456	3.0	Acceptable	N/A
115	Buildings/Structures	25	906	456	2.4	Acceptable	Perceptible
116	Buildings/Structures	25	1083	456	1.8	Acceptable	Perceptible
117	Sub Station	25	1882	456	0.7	Acceptable	N/A
118	Conveyor	150	1260	456	1.4	Acceptable	N/A
119	Conveyor	150	1250	456	1.4	Acceptable	N/A
120	Dams	50	2798	456	0.4	Acceptable	N/A
121	Buildings/Structures	25	1385	456	1.2	Acceptable	Perceptible
122	Buildings/Structures	25	1783	456	0.8	Acceptable	Perceptible
123	Buildings/Structures	25	2238	456	0.5	Acceptable	Too Low
124	Pan	150	3900	456	0.2	Acceptable	N/A
125	Conveyor	150	3778	456	0.2	Acceptable	N/A
126	Buildings/Structures	25	2980	456	0.3	Acceptable	Too Low
127	Buildings/Structures	25	3385	456	0.3	Acceptable	Too Low
128	Buildings/Structures	25	2540	456	0.4	Acceptable	Too Low
129	Informal Housing	6	2506	456	0.4	Acceptable	Too Low
130	Pivot Irrigation	150	2362	456	0.5	Acceptable	N/A
131	Pivot Irrigation	150	2526	456	0.4	Acceptable	N/A
132	Buildings/Structures	25	1521	456	1.0	Acceptable	Perceptible
133	Informal Housing	6	2039	456	0.6	Acceptable	Too Low
134	Dam	50	2139	456	0.6	Acceptable	N/A
135	Eskom Power Station-Matimba	50	2944	456	0.3	Acceptable	N/A
136	Airfield	150	3225	456	0.3	Acceptable	N/A
137	Cooling Towers	50	2783	456	0.4	Acceptable	N/A
138	Cooling Towers	50	2824	456	0.4	Acceptable	N/A
139	Industrial Buildings/Structures	50	2638	456	0.4	Acceptable	N/A
140	Conveyor	150	2650	456	0.4	Acceptable	N/A
141	Industrial Buildings/Structures	50	2615	456	0.4	Acceptable	N/A
142	Buildings/Structures	25	2466	456	0.5	Acceptable	Too Low
143	Conveyor	150	1720	456	0.8	Acceptable	N/A
144	Marapong Community Buildings	25	1889	456	0.7	Acceptable	Too Low
145	Marapong Community Buildings	25	2262	456	0.5	Acceptable	Too Low
146	Marapong Community Buildings	25	1753	456	0.8	Acceptable	Perceptible
147	Marapong Community Buildings	25	2729	456	0.4	Acceptable	Too Low

148	Marapong Community Buildings	25	2609	456	0.4	Acceptable	Too Low
149	Dams	50	3094	456	0.3	Acceptable	N/A
150	Industrial Buildings/Structures	50	3220	456	0.3	Acceptable	N/A
151	Power Lines/Pylons	75	3313	456	0.3	Acceptable	N/A
152	Power Lines/Pylons	75	3371	456	0.3	Acceptable	N/A
153	Marapong Hospital	25	3700	456	0.2	Acceptable	Too Low
154	Dam	50	2825	456	0.4	Acceptable	N/A
155	Buildings/Structures	25	2860	456	0.4	Acceptable	Too Low
156	Pan	150	2054	456	0.6	Acceptable	N/A
157	Pan	150	2126	456	0.6	Acceptable	N/A
158	Pan	150	338	456	12.0	Acceptable	N/A
159	Pan	150	173	456	36.4	Acceptable	N/A
160	Pan	150	172	456	36.6	Acceptable	N/A

17.1.3 Maximum charge per delay 2736 kg – Pit 1

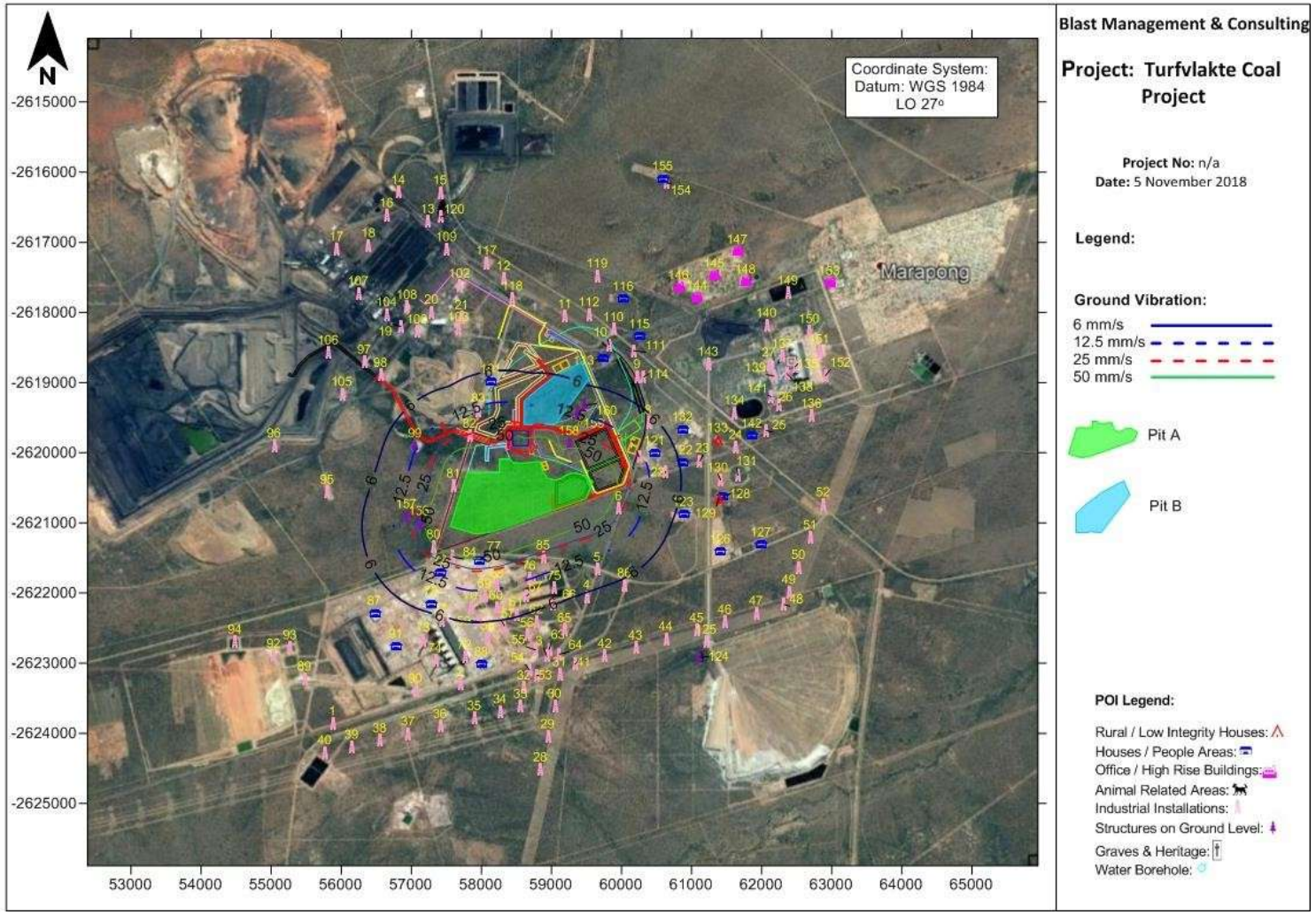


Figure 14: Ground vibration influence from maximum charge for Pit 1 Area

Table 13: Ground vibration evaluation for maximum charge for Pit 1

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Railway Line	150	3270	2736	1.2	Acceptable	N/A
2	Railway Line	150	2154	2736	2.5	Acceptable	N/A
3	Railway Line	150	1931	2736	3.0	Acceptable	N/A
4	Railway Line	150	1329	2736	5.5	Acceptable	N/A
5	Bridge	50	1004	2736	8.7	Acceptable	N/A
6	Railway Line	150	488	2736	28.7	Acceptable	N/A
7	Railway Line	150	750	2736	14.1	Acceptable	N/A
8	Railway Line	150	1161	2736	6.9	Acceptable	N/A
9	Railway Line	150	1610	2736	4.0	Acceptable	N/A
10	Railway Line	150	1889	2736	3.1	Acceptable	N/A
11	Railway Line	150	2103	2736	2.6	Acceptable	N/A
12	Railway Line	150	2577	2736	1.8	Acceptable	N/A
13	Railway Line	150	3541	2736	1.1	Acceptable	N/A
14	Railway Line	150	4068	2736	0.9	Acceptable	N/A
15	Railway Line	150	3893	2736	0.9	Acceptable	N/A
16	Railway Line	150	3834	2736	1.0	Acceptable	N/A
17	Railway Line	150	3695	2736	1.0	Acceptable	N/A
18	Railway Line	150	3536	2736	1.1	Acceptable	N/A
19	Railway Line	150	2293	2736	2.2	Acceptable	N/A
20	Railway Line	150	2313	2736	2.2	Acceptable	N/A
21	Railway Line	150	2091	2736	2.6	Acceptable	N/A
22	Railway Line	150	1054	2736	8.1	Acceptable	N/A
23	Railway Line	150	1556	2736	4.2	Acceptable	N/A
24	Railway Line	150	2104	2736	2.6	Acceptable	N/A
25	Railway Line	150	2582	2736	1.8	Acceptable	N/A
26	Railway Line	150	2869	2736	1.5	Acceptable	N/A
27	Railway Line	150	3018	2736	1.4	Acceptable	N/A
28	Power Lines/Pylons	75	3455	2736	1.1	Acceptable	N/A
29	Power Lines/Pylons	75	3022	2736	1.4	Acceptable	N/A
30	Power Lines/Pylons	75	2638	2736	1.8	Acceptable	N/A
31	Power Lines/Pylons	75	2233	2736	2.3	Acceptable	N/A
32	Power Lines/Pylons	75	2267	2736	2.3	Acceptable	N/A
33	Power Lines/Pylons	75	2517	2736	1.9	Acceptable	N/A
34	Power Lines/Pylons	75	2556	2736	1.9	Acceptable	N/A
35	Power Lines/Pylons	75	2629	2736	1.8	Acceptable	N/A
36	Power Lines/Pylons	75	2788	2736	1.6	Acceptable	N/A
37	Power Lines/Pylons	75	3005	2736	1.4	Acceptable	N/A
38	Power Lines/Pylons	75	3212	2736	1.3	Acceptable	N/A
39	Power Lines/Pylons	75	3441	2736	1.1	Acceptable	N/A
40	Power Lines/Pylons	75	3685	2736	1.0	Acceptable	N/A
41	Power Lines/Pylons	75	2169	2736	2.4	Acceptable	N/A
42	Power Lines/Pylons	75	2205	2736	2.4	Acceptable	N/A
43	Power Lines/Pylons	75	2238	2736	2.3	Acceptable	N/A
44	Power Lines/Pylons	75	2302	2736	2.2	Acceptable	N/A
45	Power Lines/Pylons	75	2458	2736	2.0	Acceptable	N/A

46	Power Lines/Pylons	75	2653	2736	1.8	Acceptable	N/A
47	Power Lines/Pylons	75	2928	2736	1.5	Acceptable	N/A
48	Power Lines/Pylons	75	3204	2736	1.3	Acceptable	N/A
49	Power Lines/Pylons	75	3188	2736	1.3	Acceptable	N/A
50	Power Lines/Pylons	75	3184	2736	1.3	Acceptable	N/A
51	Power Lines/Pylons	75	3209	2736	1.3	Acceptable	N/A
52	Power Lines/Pylons	75	3308	2736	1.2	Acceptable	N/A
53	Power Lines/Pylons	75	2150	2736	2.5	Acceptable	N/A
54	Power Lines/Pylons	75	2038	2736	2.7	Acceptable	N/A
55	Power Lines/Pylons	75	1790	2736	3.4	Acceptable	N/A
56	Power Lines/Pylons	75	1556	2736	4.2	Acceptable	N/A
57	Power Lines/Pylons	75	1349	2736	5.4	Acceptable	N/A
58	Power Lines/Pylons	75	1498	2736	4.5	Acceptable	N/A
59	Power Lines/Pylons	75	1252	2736	6.1	Acceptable	N/A
60	Power Lines/Pylons	75	1077	2736	7.8	Acceptable	N/A
61	Power Lines/Pylons	75	1225	2736	6.3	Acceptable	N/A
62	Power Lines/Pylons	75	1418	2736	4.9	Acceptable	N/A
63	Power Lines/Pylons	75	1847	2736	3.2	Acceptable	N/A
64	Power Lines/Pylons	75	1962	2736	2.9	Acceptable	N/A
65	Power Lines/Pylons	75	1667	2736	3.8	Acceptable	N/A
66	Power Lines/Pylons	75	1268	2736	5.9	Acceptable	N/A
67	Power Lines/Pylons	75	1025	2736	8.4	Acceptable	N/A
68	Power Lines/Pylons	75	768	2736	13.6	Acceptable	N/A
69	Power Lines/Pylons	75	892	2736	10.6	Acceptable	N/A
70	Power Lines/Pylons	75	1055	2736	8.0	Acceptable	N/A
71	Medupi Power Station	50	1320	2736	5.6	Acceptable	N/A
72	Medupi Power Station	50	1766	2736	3.4	Acceptable	N/A
73	Cooling Towers	50	1661	2736	3.8	Acceptable	N/A
74	Cooling Towers	50	1891	2736	3.1	Acceptable	N/A
75	Water Reservoirs	50	1050	2736	8.1	Acceptable	N/A
76	Tailing Dams	25	796	2736	12.8	Acceptable	N/A
77	Buildings/Structures	25	381	2736	43.2	Problematic	Intolerable
78	Buildings/Structures	25	1132	2736	7.2	Acceptable	Unpleasant
79	Buildings/Structures	25	665	2736	17.2	Acceptable	Unpleasant
80	Conveyor	150	370	2736	45.3	Acceptable	N/A
81	Conveyor	150	125	2736	270.4	Problematic	N/A
82	Bridge	50	520	2736	25.9	Acceptable	N/A
83	Conveyor	150	756	2736	13.9	Acceptable	N/A
84	D1675 Road	150	401	2736	39.7	Acceptable	N/A
85	D1675 Road	150	588	2736	21.1	Acceptable	N/A
86	D2649 Road	150	1354	2736	5.3	Acceptable	N/A
87	Buildings/Structures	25	1641	2736	3.9	Acceptable	Perceptible
88	Buildings/Structures	25	1860	2736	3.2	Acceptable	Perceptible
89	Conveyor	150	3003	2736	1.4	Acceptable	N/A
90	Conveyor	150	2383	2736	2.1	Acceptable	N/A
91	Buildings/Structures	25	1875	2736	3.1	Acceptable	Perceptible
92	Conveyor	150	3120	2736	1.3	Acceptable	N/A
93	Dam	50	2860	2736	1.6	Acceptable	N/A
94	Dam	50	3483	2736	1.1	Acceptable	N/A
95	Explosive Magazines Exxaro	25	1822	2736	3.3	Acceptable	N/A
96	Sub Station	25	2743	2736	1.7	Acceptable	N/A

97	Exxaro Grootgeluk Mine Activity	200	2156	2736	2.5	Acceptable	N/A
98	Mine Buildings/Structures	25	1862	2736	3.1	Acceptable	N/A
99	Pan	150	837	2736	11.8	Acceptable	N/A
100	Industrial Buildings	50	2134	2736	2.5	Acceptable	N/A
101	Building/Structure	25	1119	2736	7.3	Acceptable	Unpleasant
102	Mine Buildings/Structures	25	2536	2736	1.9	Acceptable	N/A
103	Industrial Buildings	50	1942	2736	2.9	Acceptable	N/A
104	Water Reservoirs	50	2530	2736	1.9	Acceptable	N/A
105	Industrial Buildings/Structures	50	2110	2736	2.6	Acceptable	N/A
106	Mine Activity	200	2618	2736	1.8	Acceptable	N/A
107	Water Reservoirs	50	2993	2736	1.4	Acceptable	N/A
108	Industrial Buildings/Structures	50	2513	2736	1.9	Acceptable	N/A
109	Conveyor	150	3088	2736	1.4	Acceptable	N/A
110	D2816 Road	150	2119	2736	2.5	Acceptable	N/A
111	D2001 Road	150	1916	2736	3.0	Acceptable	N/A
112	D2001 Road	150	2215	2736	2.4	Acceptable	N/A
113	Manketti Lodge	25	1686	2736	3.7	Acceptable	Perceptible
114	Reservoir	50	1644	2736	3.9	Acceptable	N/A
115	Buildings/Structures	25	2140	2736	2.5	Acceptable	Perceptible
116	Buildings/Structures	25	2577	2736	1.8	Acceptable	Perceptible
117	Sub Station	25	2800	2736	1.6	Acceptable	N/A
118	Conveyor	150	2289	2736	2.2	Acceptable	N/A
119	Conveyor	150	2773	2736	1.6	Acceptable	N/A
120	Dams	50	3558	2736	1.1	Acceptable	N/A
121	Buildings/Structures	25	975	2736	9.2	Acceptable	Unpleasant
122	Buildings/Structures	25	1313	2736	5.6	Acceptable	Unpleasant
123	Buildings/Structures	25	1379	2736	5.2	Acceptable	Perceptible
124	Pan	150	2776	2736	1.6	Acceptable	N/A
125	Conveyor	150	2670	2736	1.7	Acceptable	N/A
126	Buildings/Structures	25	2059	2736	2.7	Acceptable	Perceptible
127	Buildings/Structures	25	2569	2736	1.9	Acceptable	Perceptible
128	Buildings/Structures	25	1875	2736	3.1	Acceptable	Perceptible
129	Informal Housing	6	1820	2736	3.3	Acceptable	Perceptible
130	Pivot Irrigation	150	1823	2736	3.3	Acceptable	N/A
131	Pivot Irrigation	150	2071	2736	2.6	Acceptable	N/A
132	Buildings/Structures	25	1487	2736	4.6	Acceptable	Perceptible
133	Informal Housing	6	1883	2736	3.1	Acceptable	Perceptible
134	Dam	50	2253	2736	2.3	Acceptable	N/A
135	Eskom Power Station-Matimba	50	3317	2736	1.2	Acceptable	N/A
136	Airfield	150	3264	2736	1.2	Acceptable	N/A
137	Cooling Towers	50	3248	2736	1.3	Acceptable	N/A
138	Cooling Towers	50	3169	2736	1.3	Acceptable	N/A
139	Industrial Buildings/Structures	50	2989	2736	1.4	Acceptable	N/A
140	Conveyor	150	3337	2736	1.2	Acceptable	N/A
141	Industrial Buildings/Structures	50	2819	2736	1.6	Acceptable	N/A
142	Buildings/Structures	25	2364	2736	2.1	Acceptable	Perceptible
143	Conveyor	150	2355	2736	2.1	Acceptable	N/A
144	Marapong Community Buildings	25	3010	2736	1.4	Acceptable	Perceptible
145	Marapong Community Buildings	25	3408	2736	1.2	Acceptable	Perceptible
146	Marapong Community Buildings	25	3018	2736	1.4	Acceptable	Perceptible
147	Marapong Community Buildings	25	3876	2736	0.9	Acceptable	Perceptible

148	Marapong Community Buildings	25	3593	2736	1.1	Acceptable	Perceptible
149	Dams	50	3875	2736	0.9	Acceptable	N/A
150	Industrial Buildings/Structures	50	3764	2736	1.0	Acceptable	N/A
151	Power Lines/Pylons	75	3731	2736	1.0	Acceptable	N/A
152	Power Lines/Pylons	75	3644	2736	1.0	Acceptable	N/A
153	Marapong Hospital	25	4415	2736	0.8	Acceptable	Too Low
154	Dam	50	4329	2736	0.8	Acceptable	N/A
155	Buildings/Structures	25	4375	2736	0.8	Acceptable	Perceptible
156	Pan	150	444	2736	33.5	Acceptable	N/A
157	Pan	150	639	2736	18.4	Acceptable	N/A
158	Pan	150	426	2736	35.9	Acceptable	N/A
159	Pan	150	843	2736	11.6	Acceptable	N/A
160	Pan	150	975	2736	9.2	Acceptable	N/A

17.1.4 Maximum charge mass per delay – 2736 kg – Pit 2

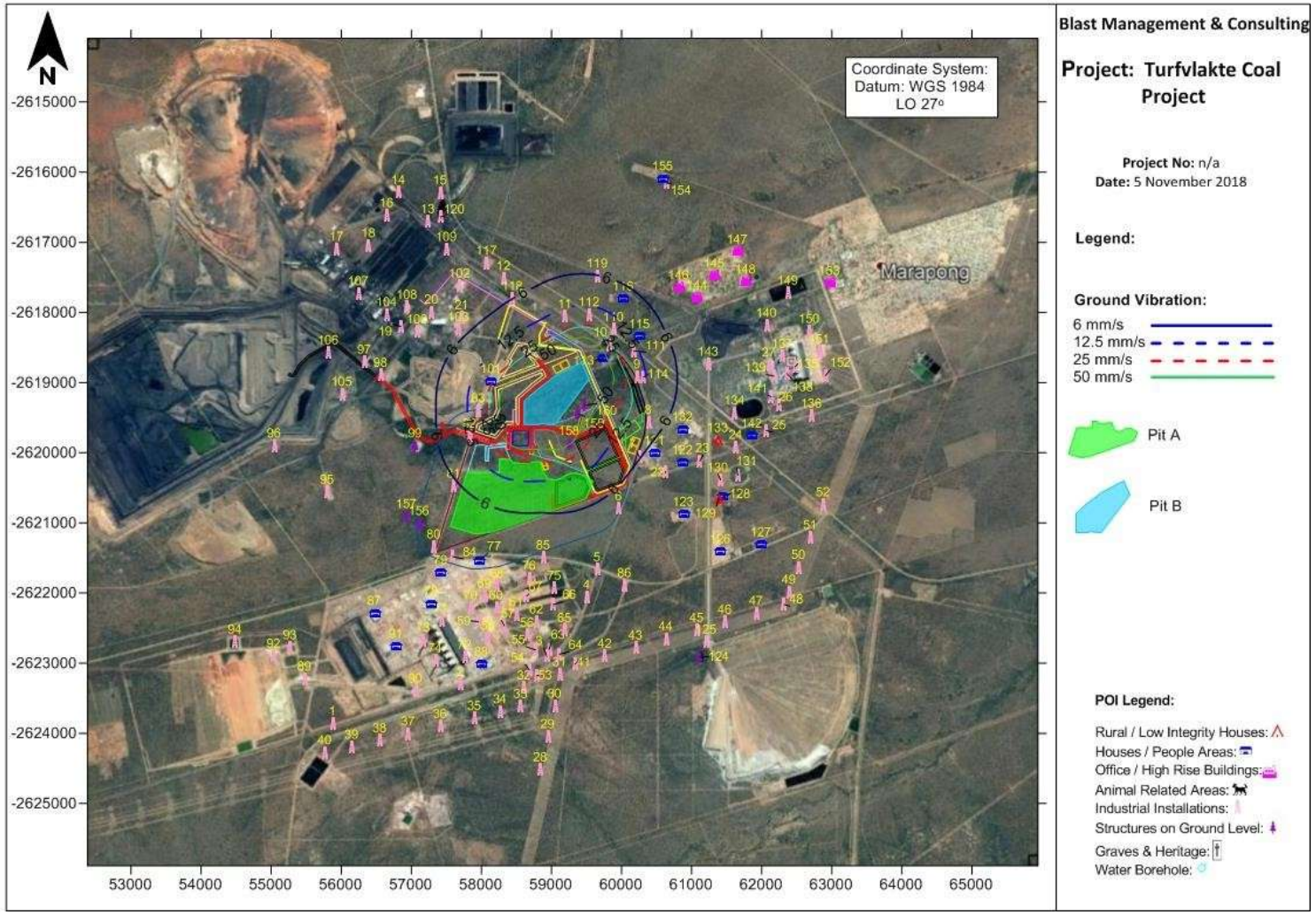


Figure 15: Ground vibration influence from maximum charge for Pit 2 Area

Table 14: Ground vibration evaluation for maximum charge for Pit 2

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Railway Line	150	5063	2736	0.6	Acceptable	N/A
2	Railway Line	150	3812	2736	1.0	Acceptable	N/A
3	Railway Line	150	3301	2736	1.2	Acceptable	N/A
4	Railway Line	150	2502	2736	1.9	Acceptable	N/A
5	Bridge	50	2151	2736	2.5	Acceptable	N/A
6	Railway Line	150	1508	2736	4.5	Acceptable	N/A
7	Railway Line	150	1243	2736	6.1	Acceptable	N/A
8	Railway Line	150	1049	2736	8.1	Acceptable	N/A
9	Railway Line	150	691	2736	16.2	Acceptable	N/A
10	Railway Line	150	457	2736	32.0	Acceptable	N/A
11	Railway Line	150	696	2736	16.0	Acceptable	N/A
12	Railway Line	150	1574	2736	4.2	Acceptable	N/A
13	Railway Line	150	2850	2736	1.6	Acceptable	N/A
14	Railway Line	150	3433	2736	1.1	Acceptable	N/A
15	Railway Line	150	3085	2736	1.4	Acceptable	N/A
16	Railway Line	150	3282	2736	1.2	Acceptable	N/A
17	Railway Line	150	3443	2736	1.1	Acceptable	N/A
18	Railway Line	150	3139	2736	1.3	Acceptable	N/A
19	Railway Line	150	2061	2736	2.7	Acceptable	N/A
20	Railway Line	150	1833	2736	3.2	Acceptable	N/A
21	Railway Line	150	1480	2736	4.6	Acceptable	N/A
22	Railway Line	150	1676	2736	3.7	Acceptable	N/A
23	Railway Line	150	1966	2736	2.9	Acceptable	N/A
24	Railway Line	150	2314	2736	2.2	Acceptable	N/A
25	Railway Line	150	2637	2736	1.8	Acceptable	N/A
26	Railway Line	150	2730	2736	1.7	Acceptable	N/A
27	Railway Line	150	2580	2736	1.8	Acceptable	N/A
28	Power Lines/Pylons	75	4917	2736	0.6	Acceptable	N/A
29	Power Lines/Pylons	75	4443	2736	0.7	Acceptable	N/A
30	Power Lines/Pylons	75	4007	2736	0.9	Acceptable	N/A
31	Power Lines/Pylons	75	3556	2736	1.1	Acceptable	N/A
32	Power Lines/Pylons	75	3753	2736	1.0	Acceptable	N/A
33	Power Lines/Pylons	75	4017	2736	0.9	Acceptable	N/A
34	Power Lines/Pylons	75	4107	2736	0.9	Acceptable	N/A
35	Power Lines/Pylons	75	4248	2736	0.8	Acceptable	N/A
36	Power Lines/Pylons	75	4465	2736	0.7	Acceptable	N/A
37	Power Lines/Pylons	75	4710	2736	0.7	Acceptable	N/A
38	Power Lines/Pylons	75	4954	2736	0.6	Acceptable	N/A
39	Power Lines/Pylons	75	5213	2736	0.6	Acceptable	N/A
40	Power Lines/Pylons	75	5474	2736	0.5	Acceptable	N/A
41	Power Lines/Pylons	75	3424	2736	1.2	Acceptable	N/A
42	Power Lines/Pylons	75	3375	2736	1.2	Acceptable	N/A
43	Power Lines/Pylons	75	3381	2736	1.2	Acceptable	N/A
44	Power Lines/Pylons	75	3441	2736	1.1	Acceptable	N/A
45	Power Lines/Pylons	75	3566	2736	1.1	Acceptable	N/A

46	Power Lines/Pylons	75	3719	2736	1.0	Acceptable	N/A
47	Power Lines/Pylons	75	3939	2736	0.9	Acceptable	N/A
48	Power Lines/Pylons	75	4161	2736	0.8	Acceptable	N/A
49	Power Lines/Pylons	75	4110	2736	0.9	Acceptable	N/A
50	Power Lines/Pylons	75	4007	2736	0.9	Acceptable	N/A
51	Power Lines/Pylons	75	3884	2736	0.9	Acceptable	N/A
52	Power Lines/Pylons	75	3793	2736	1.0	Acceptable	N/A
53	Power Lines/Pylons	75	3585	2736	1.1	Acceptable	N/A
54	Power Lines/Pylons	75	3501	2736	1.1	Acceptable	N/A
55	Power Lines/Pylons	75	3214	2736	1.3	Acceptable	N/A
56	Power Lines/Pylons	75	3004	2736	1.4	Acceptable	N/A
57	Power Lines/Pylons	75	2886	2736	1.5	Acceptable	N/A
58	Power Lines/Pylons	75	3090	2736	1.4	Acceptable	N/A
59	Power Lines/Pylons	75	2886	2736	1.5	Acceptable	N/A
60	Power Lines/Pylons	75	2641	2736	1.8	Acceptable	N/A
61	Power Lines/Pylons	75	2708	2736	1.7	Acceptable	N/A
62	Power Lines/Pylons	75	2813	2736	1.6	Acceptable	N/A
63	Power Lines/Pylons	75	3201	2736	1.3	Acceptable	N/A
64	Power Lines/Pylons	75	3269	2736	1.2	Acceptable	N/A
65	Power Lines/Pylons	75	2933	2736	1.5	Acceptable	N/A
66	Power Lines/Pylons	75	2564	2736	1.9	Acceptable	N/A
67	Power Lines/Pylons	75	2446	2736	2.0	Acceptable	N/A
68	Power Lines/Pylons	75	2330	2736	2.2	Acceptable	N/A
69	Power Lines/Pylons	75	2506	2736	1.9	Acceptable	N/A
70	Power Lines/Pylons	75	2721	2736	1.7	Acceptable	N/A
71	Medupi Power Station	50	3033	2736	1.4	Acceptable	N/A
72	Medupi Power Station	50	3425	2736	1.2	Acceptable	N/A
73	Cooling Towers	50	3393	2736	1.2	Acceptable	N/A
74	Cooling Towers	50	3594	2736	1.1	Acceptable	N/A
75	Water Reservoirs	50	2326	2736	2.2	Acceptable	N/A
76	Tailing Dams	25	2190	2736	2.4	Acceptable	N/A
77	Buildings/Structures	25	2037	2736	2.7	Acceptable	Perceptible
78	Buildings/Structures	25	2880	2736	1.5	Acceptable	Perceptible
79	Buildings/Structures	25	2421	2736	2.0	Acceptable	Perceptible
80	Conveyor	150	2167	2736	2.5	Acceptable	N/A
81	Conveyor	150	1331	2736	5.5	Acceptable	N/A
82	Bridge	50	793	2736	12.9	Acceptable	N/A
83	Conveyor	150	649	2736	17.9	Acceptable	N/A
84	D1675 Road	150	2141	2736	2.5	Acceptable	N/A
85	D1675 Road	150	1899	2736	3.0	Acceptable	N/A
86	D2649 Road	150	2500	2736	1.9	Acceptable	N/A
87	Buildings/Structures	25	3435	2736	1.1	Acceptable	Perceptible
88	Buildings/Structures	25	3471	2736	1.1	Acceptable	Perceptible
89	Conveyor	150	4789	2736	0.7	Acceptable	N/A
90	Conveyor	150	4098	2736	0.9	Acceptable	N/A
91	Buildings/Structures	25	3653	2736	1.0	Acceptable	Perceptible
92	Conveyor	150	4862	2736	0.6	Acceptable	N/A
93	Dam	50	4608	2736	0.7	Acceptable	N/A
94	Dam	50	5160	2736	0.6	Acceptable	N/A
95	Explosive Magazines Exxaro	25	2969	2736	1.5	Acceptable	N/A
96	Sub Station	25	3580	2736	1.1	Acceptable	N/A

97	Exxaro Grootgeluk Mine Activity	200	2346	2736	2.2	Acceptable	N/A
98	Mine Buildings/Structures	25	2081	2736	2.6	Acceptable	N/A
99	Pan	150	1585	2736	4.1	Acceptable	N/A
100	Industrial Buildings	50	1817	2736	3.3	Acceptable	N/A
101	Building/Structure	25	551	2736	23.5	Acceptable	Intolerable
102	Mine Buildings/Structures	25	1844	2736	3.2	Acceptable	N/A
103	Industrial Buildings	50	1385	2736	5.1	Acceptable	N/A
104	Water Reservoirs	50	2315	2736	2.2	Acceptable	N/A
105	Industrial Buildings/Structures	50	2602	2736	1.8	Acceptable	N/A
106	Mine Activity	200	2876	2736	1.5	Acceptable	N/A
107	Water Reservoirs	50	2821	2736	1.6	Acceptable	N/A
108	Industrial Buildings/Structures	50	2141	2736	2.5	Acceptable	N/A
109	Conveyor	150	2374	2736	2.1	Acceptable	N/A
110	D2816 Road	150	653	2736	17.7	Acceptable	N/A
111	D2001 Road	150	742	2736	14.4	Acceptable	N/A
112	D2001 Road	150	690	2736	16.2	Acceptable	N/A
113	Manketti Lodge	25	309	2736	60.9	Problematic	Intolerable
114	Reservoir	50	779	2736	13.3	Acceptable	N/A
115	Buildings/Structures	25	906	2736	10.3	Acceptable	Unpleasant
116	Buildings/Structures	25	1083	2736	7.7	Acceptable	Unpleasant
117	Sub Station	25	1882	2736	3.1	Acceptable	N/A
118	Conveyor	150	1260	2736	6.0	Acceptable	N/A
119	Conveyor	150	1250	2736	6.1	Acceptable	N/A
120	Dams	50	2798	2736	1.6	Acceptable	N/A
121	Buildings/Structures	25	1385	2736	5.1	Acceptable	Perceptible
122	Buildings/Structures	25	1783	2736	3.4	Acceptable	Perceptible
123	Buildings/Structures	25	2238	2736	2.3	Acceptable	Perceptible
124	Pan	150	3900	2736	0.9	Acceptable	N/A
125	Conveyor	150	3778	2736	1.0	Acceptable	N/A
126	Buildings/Structures	25	2980	2736	1.4	Acceptable	Perceptible
127	Buildings/Structures	25	3385	2736	1.2	Acceptable	Perceptible
128	Buildings/Structures	25	2540	2736	1.9	Acceptable	Perceptible
129	Informal Housing	6	2506	2736	1.9	Acceptable	Perceptible
130	Pivot Irrigation	150	2362	2736	2.1	Acceptable	N/A
131	Pivot Irrigation	150	2526	2736	1.9	Acceptable	N/A
132	Buildings/Structures	25	1521	2736	4.4	Acceptable	Perceptible
133	Informal Housing	6	2039	2736	2.7	Acceptable	Perceptible
134	Dam	50	2139	2736	2.5	Acceptable	N/A
135	Eskom Power Station-Matimba	50	2944	2736	1.5	Acceptable	N/A
136	Airfield	150	3225	2736	1.3	Acceptable	N/A
137	Cooling Towers	50	2783	2736	1.6	Acceptable	N/A
138	Cooling Towers	50	2824	2736	1.6	Acceptable	N/A
139	Industrial Buildings/Structures	50	2638	2736	1.8	Acceptable	N/A
140	Conveyor	150	2650	2736	1.8	Acceptable	N/A
141	Industrial Buildings/Structures	50	2615	2736	1.8	Acceptable	N/A
142	Buildings/Structures	25	2466	2736	2.0	Acceptable	Perceptible
143	Conveyor	150	1720	2736	3.6	Acceptable	N/A
144	Marapong Community Buildings	25	1889	2736	3.1	Acceptable	Perceptible
145	Marapong Community Buildings	25	2262	2736	2.3	Acceptable	Perceptible
146	Marapong Community Buildings	25	1753	2736	3.5	Acceptable	Perceptible
147	Marapong Community Buildings	25	2729	2736	1.7	Acceptable	Perceptible

148	Marapong Community Buildings	25	2609	2736	1.8	Acceptable	Perceptible
149	Dams	50	3094	2736	1.4	Acceptable	N/A
150	Industrial Buildings/Structures	50	3220	2736	1.3	Acceptable	N/A
151	Power Lines/Pylons	75	3313	2736	1.2	Acceptable	N/A
152	Power Lines/Pylons	75	3371	2736	1.2	Acceptable	N/A
153	Marapong Hospital	25	3700	2736	1.0	Acceptable	Perceptible
154	Dam	50	2825	2736	1.6	Acceptable	N/A
155	Buildings/Structures	25	2860	2736	1.6	Acceptable	Perceptible
156	Pan	150	2054	2736	2.7	Acceptable	N/A
157	Pan	150	2126	2736	2.5	Acceptable	N/A
158	Pan	150	338	2736	52.5	Acceptable	N/A
159	Pan	150	173	2736	159.4	Problematic	N/A
160	Pan	150	172	2736	160.3	Problematic	N/A

17.2 Summary of ground vibration levels

Theopencast operation was evaluated for expectedlevels ofground vibration from future blasting operations. Review of the site and the surrounding installations / houses / buildings showed that structures vary in distances from the pit areas for Pit 1 and Pit 2. The influences will also vary with distance from the pit areas. The model used for evaluation does indicate significant levels. It will be imperative to ensure that a monitoring program is done to confirm levels of ground vibration to ensure that ground vibration levels are not exceeded.

The evaluation considered a distance up to 3500 m from the pit areas. The distances between structures and the pit area is a contributing factor to the levels of ground vibration expected and the subsequent possible influences. The different charge masses evaluated provides different levels of ground vibration. In view of the maximum charge specific attention will need to be given to specific areas. The minimum charge used indicated no POI's of concern in relation to possible structural damage.

The closest structures observed are the conveyor, pans, building/structures and Manketti Lodge for Pit 1 and Pit 2. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human perception. The ground vibration levels predicted ranged between 0.5 mm/s and 270.4 mm/s for structures surrounding the open pit areas.

The nearest public structures are located 309 m from the pit boundaries. Ground vibration level predicted at these structures where people may be present is 60.9 mm/s. In view of this specific mitigations will be required.

Pit 1 is closest to the industrial infrastructures such as the roads, bridges, conveyor belt and the new Medupi power station infrastructure. Levels at these infrastructures is higher than limits and will require specific mitigation. Blasting operations in the southwestern side of Pit 1 will need to

consider the Medupi infrastructure and will require negotiations with management from the power station.
Pit 2 has the pans and Manketti lodge as closest infrastructure. Ground vibration will not have specific influence on the pans, though the pans are close to Pit 2. The Manketti lodge is located 309 m from Pit 2. Predicted levels are greater than limits for surface infrastructure and mitigation of blasting operations will be required.

On a human perception scale thirteen POI's were identified where vibration levels may be perceptible and higher for the minimum charge and twenty-seven POI's for the maximum charge. The planned maximum charge evaluated showed that it could be problematic at the building structures at Pit 1 area (POI 77) and the Building/Structures (POI 101) and Manketti Lodge (POI 113) at the Pit 2 area in terms of potential structural damage and human perception. Perceptible levels of vibration that may be experienced up to 4374 m, unpleasant up to 1312 m and intolerable up to 551 m.

Mitigation of ground vibration was considered and discussed in Section 17.12. A detail inspection of the area and accurate identification of structures will also need to 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 4374 m people may experience levels of ground vibration as perceptible. At 1312 m and closer the perception of ground vibration could be unpleasant. Closer than 551 m the levels will be intolerable and generally greater than limits applied for structures in the areas.

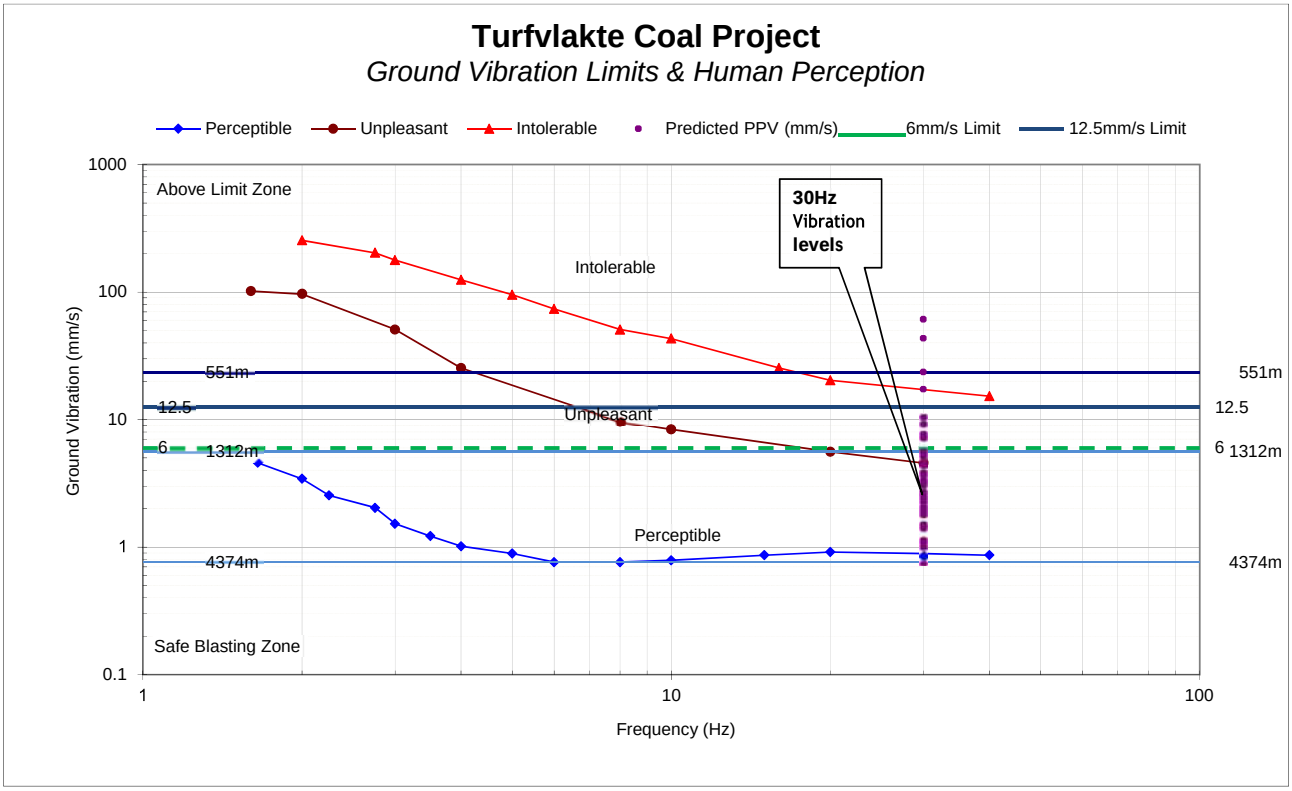


Figure 16: The effect of ground vibration with human perception and vibration limits

17.4 Vibration impact on roads

The D1675, D2001, D2649 and D2816 roads are in the vicinity of the project area and needs to be considered. These district roads are at closest point to Pit 1 at 401 m (D1675) and Pit 2 at 1899 m (D1675), Pit 1 at 1916 m (D2001) and Pit 2 at 690 m (D2001), Pit 1 at 1354 m (D2649) and Pit 2 at 2500 m (D2649), Pit 1 at 2119 m (D2816) and Pit 2 at 653 m (D2816) in the vicinity of the project area. No specific actions are required for any of these roads but there may be people and animals on these routes and will require careful planning to main safe blasting radius. Ground vibration levels calculated is expected to yield levels within acceptable limits for all of these roads.

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 communities and roads that are within the evaluated area of influence. There are no formal community settlements within 500 m but farmsteads are found within 500 m from the Pit 1 area. The houses are located such that levels of ground vibration predicted could be perceived as intolerable and could be problematic.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 4374 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 1783 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 551 m.

The importance of good public relations cannot be under stressed. 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 informal building style 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 Minimum charge mass per delay – 456 kg – Pit 1

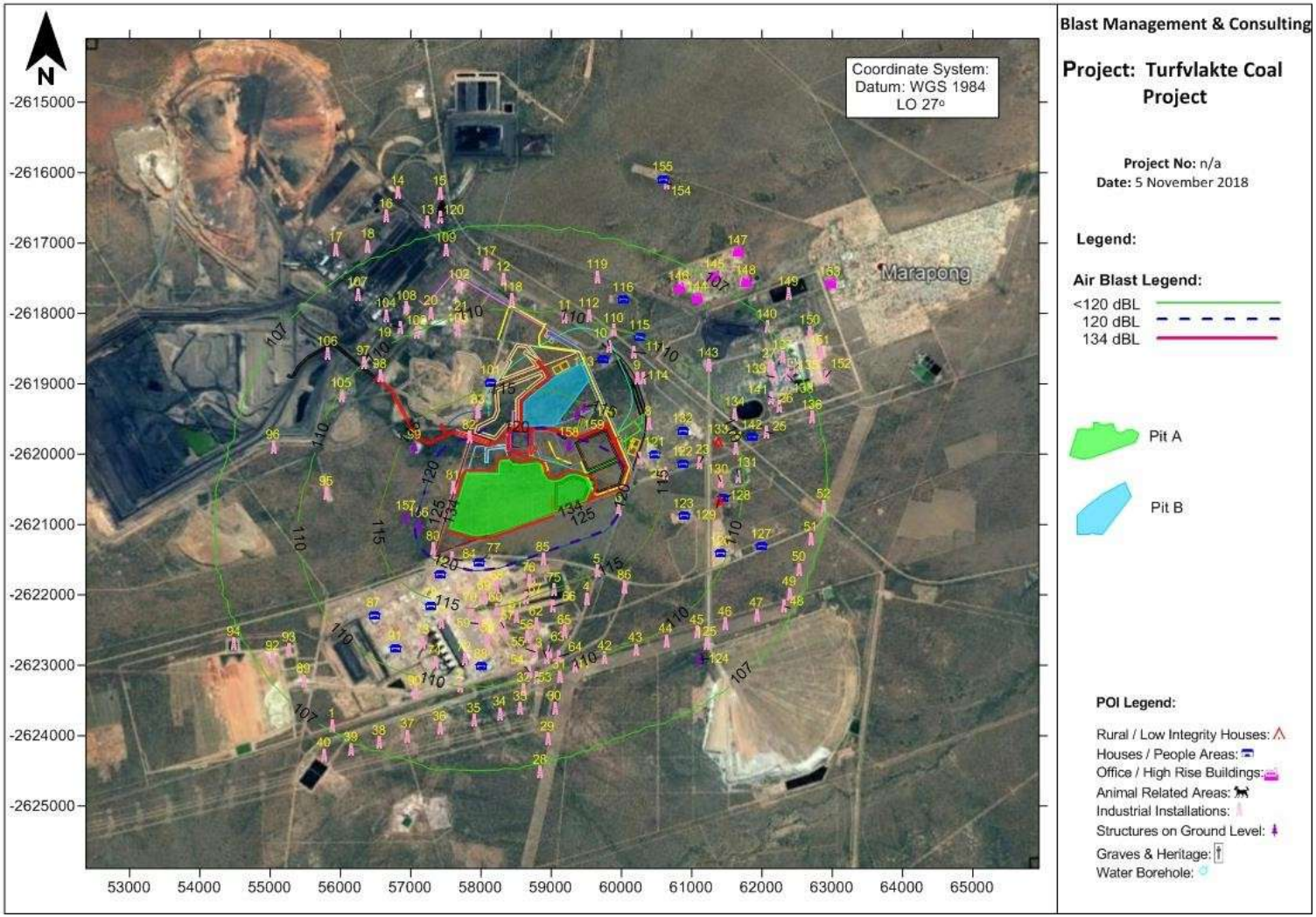


Figure 17: Air blast influence from minimum charge for Pit 1 Area

Air blast evaluation for minimum charge for Pit 1

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Railway Line	3270	107.2	N/A
2	Railway Line	2154	110.0	N/A
3	Railway Line	1931	110.8	N/A
4	Railway Line	1329	113.3	N/A
5	Bridge	1004	115.2	N/A
6	Railway Line	488	120.1	N/A
7	Railway Line	750	117.2	N/A
8	Railway Line	1161	114.2	N/A
9	Railway Line	1610	111.9	N/A
10	Railway Line	1889	110.9	N/A
11	Railway Line	2103	110.1	N/A
12	Railway Line	2577	108.8	N/A
13	Railway Line	3541	106.6	N/A
14	Railway Line	4068	105.6	N/A
15	Railway Line	3893	106.0	N/A
16	Railway Line	3834	106.0	N/A
17	Railway Line	3695	106.2	N/A
18	Railway Line	3536	106.6	N/A
19	Railway Line	2293	109.5	N/A
20	Railway Line	2313	109.5	N/A
21	Railway Line	2091	110.2	N/A
22	Railway Line	1054	114.9	N/A
23	Railway Line	1556	112.3	N/A
24	Railway Line	2104	110.1	N/A
25	Railway Line	2582	108.8	N/A
26	Railway Line	2869	108.0	N/A
27	Railway Line	3018	107.6	N/A
28	Power Lines/Pylons	3455	106.8	N/A
29	Power Lines/Pylons	3022	107.6	N/A
30	Power Lines/Pylons	2638	108.6	N/A
31	Power Lines/Pylons	2233	109.7	N/A
32	Power Lines/Pylons	2267	109.7	N/A
33	Power Lines/Pylons	2517	108.9	N/A
34	Power Lines/Pylons	2556	108.8	N/A
35	Power Lines/Pylons	2629	108.6	N/A
36	Power Lines/Pylons	2788	108.3	N/A
37	Power Lines/Pylons	3005	107.8	N/A
38	Power Lines/Pylons	3212	107.2	N/A
39	Power Lines/Pylons	3441	106.8	N/A
40	Power Lines/Pylons	3685	106.2	N/A

41	Power Lines/Pylons	2169	110.0	N/A
42	Power Lines/Pylons	2205	109.8	N/A
43	Power Lines/Pylons	2238	109.7	N/A
44	Power Lines/Pylons	2302	109.5	N/A
45	Power Lines/Pylons	2458	109.1	N/A
46	Power Lines/Pylons	2653	108.6	N/A
47	Power Lines/Pylons	2928	108.0	N/A
48	Power Lines/Pylons	3204	107.2	N/A
49	Power Lines/Pylons	3188	107.2	N/A
50	Power Lines/Pylons	3184	107.4	N/A
51	Power Lines/Pylons	3209	107.2	N/A
52	Power Lines/Pylons	3308	107.0	N/A
53	Power Lines/Pylons	2150	110.0	N/A
54	Power Lines/Pylons	2038	110.4	N/A
55	Power Lines/Pylons	1790	111.2	N/A
56	Power Lines/Pylons	1556	112.1	N/A
57	Power Lines/Pylons	1349	113.2	N/A
58	Power Lines/Pylons	1498	112.5	N/A
59	Power Lines/Pylons	1252	113.7	N/A
60	Power Lines/Pylons	1077	114.7	N/A
61	Power Lines/Pylons	1225	113.8	N/A
62	Power Lines/Pylons	1418	112.9	N/A
63	Power Lines/Pylons	1847	111.0	N/A
64	Power Lines/Pylons	1962	110.6	N/A
65	Power Lines/Pylons	1667	111.7	N/A
66	Power Lines/Pylons	1268	113.6	N/A
67	Power Lines/Pylons	1025	115.0	N/A
68	Power Lines/Pylons	768	117.0	N/A
69	Power Lines/Pylons	892	116.0	N/A
70	Power Lines/Pylons	1055	114.9	N/A
71	Medupi Power Station	1320	113.3	N/A
72	Medupi Power Station	1766	111.4	N/A
73	Cooling Towers	1661	111.7	N/A
74	Cooling Towers	1891	110.9	N/A
75	Water Reservoirs	1050	114.9	N/A
76	Tailing Dams	796	116.8	N/A
77	Buildings/Structures	381	121.8	Complaint
78	Buildings/Structures	1132	114.4	Acceptable
79	Buildings/Structures	665	118.0	Acceptable
80	Conveyor	370	122.0	N/A
81	Conveyor	125	129.4	N/A
82	Bridge	520	119.7	N/A
83	Conveyor	756	117.1	N/A
84	D1675 Road	401	121.5	N/A
85	D1675 Road	588	118.8	N/A

86	D2649 Road	1354	113.2	N/A
87	Buildings/Structures	1641	111.8	Acceptable
88	Buildings/Structures	1860	111.0	Acceptable
89	Conveyor	3003	107.8	N/A
90	Conveyor	2383	109.2	N/A
91	Buildings/Structures	1875	110.9	Acceptable
92	Conveyor	3120	107.4	N/A
93	Dam	2860	108.1	N/A
94	Dam	3483	106.6	N/A
95	Explosive Magazines Exxaro	1822	111.1	N/A
96	Sub Station	2743	108.3	N/A
97	Exxaro Grootgeluk Mine Activity	2156	110.0	N/A
98	Mine Buildings/Structures	1862	111.0	N/A
99	Pan	837	116.5	N/A
100	Industrial Buildings	2134	110.1	N/A
101	Building/Structure	1119	114.5	Acceptable
102	Mine Buildings/Structures	2536	108.9	N/A
103	Industrial Buildings	1942	110.6	N/A
104	Water Reservoirs	2530	108.9	N/A
105	Industrial Buildings/Structures	2110	110.1	N/A
106	Mine Activity	2618	108.6	N/A
107	Water Reservoirs	2993	107.8	N/A
108	Industrial Buildings/Structures	2513	108.9	N/A
109	Conveyor	3088	107.6	N/A
110	D2816 Road	2119	110.1	N/A
111	D2001 Road	1916	110.8	N/A
112	D2001 Road	2215	109.8	N/A
113	Manketti Lodge	1686	111.7	Acceptable
114	Reservoir	1644	111.8	N/A
115	Buildings/Structures	2140	110.0	Acceptable
116	Buildings/Structures	2577	108.8	Acceptable
117	Sub Station	2800	108.1	N/A
118	Conveyor	2289	109.5	N/A
119	Conveyor	2773	108.3	N/A
120	Dams	3558	106.6	N/A
121	Buildings/Structures	975	115.4	Acceptable
122	Buildings/Structures	1313	113.3	Acceptable
123	Buildings/Structures	1379	113.1	Acceptable
124	Pan	2776	108.3	N/A
125	Conveyor	2670	108.5	N/A
126	Buildings/Structures	2059	110.2	Acceptable
127	Buildings/Structures	2569	108.8	Acceptable
128	Buildings/Structures	1875	110.9	Acceptable
129	Informal Housing	1820	111.1	Acceptable
130	Pivot Irrigation	1823	111.1	N/A

131	Pivot Irrigation	2071	110.2	N/A
132	Buildings/Structures	1487	112.5	Acceptable
133	Informal Housing	1883	110.9	Acceptable
134	Dam	2253	109.7	N/A
135	Eskom Power Station-Matimba	3317	107.0	N/A
136	Airfield	3264	107.2	N/A
137	Cooling Towers	3248	107.2	N/A
138	Cooling Towers	3169	107.4	N/A
139	Industrial Buildings/Structures	2989	107.8	N/A
140	Conveyor	3337	107.0	N/A
141	Industrial Buildings/Structures	2819	108.1	N/A
142	Buildings/Structures	2364	109.4	Acceptable
143	Conveyor	2355	109.4	N/A
144	Marapong Community Buildings	3010	107.8	Acceptable
145	Marapong Community Buildings	3408	106.8	Acceptable
146	Marapong Community Buildings	3018	107.6	Acceptable
147	Marapong Community Buildings	3876	106.0	Acceptable
148	Marapong Community Buildings	3593	106.4	Acceptable
149	Dams	3875	106.0	N/A
150	Industrial Buildings/Structures	3764	106.2	N/A
151	Power Lines/Pylons	3731	106.2	N/A
152	Power Lines/Pylons	3644	106.4	N/A
153	Marapong Hospital	4415	105.1	Acceptable
154	Dam	4329	105.3	N/A
155	Buildings/Structures	4375	105.1	Acceptable
156	Pan	444	120.7	N/A
157	Pan	639	118.3	N/A
158	Pan	426	121.1	N/A
159	Pan	843	116.4	N/A
160	Pan	975	115.4	N/A

17.7.2 Minimum charge mass per delay – 456 kg – Pit 2

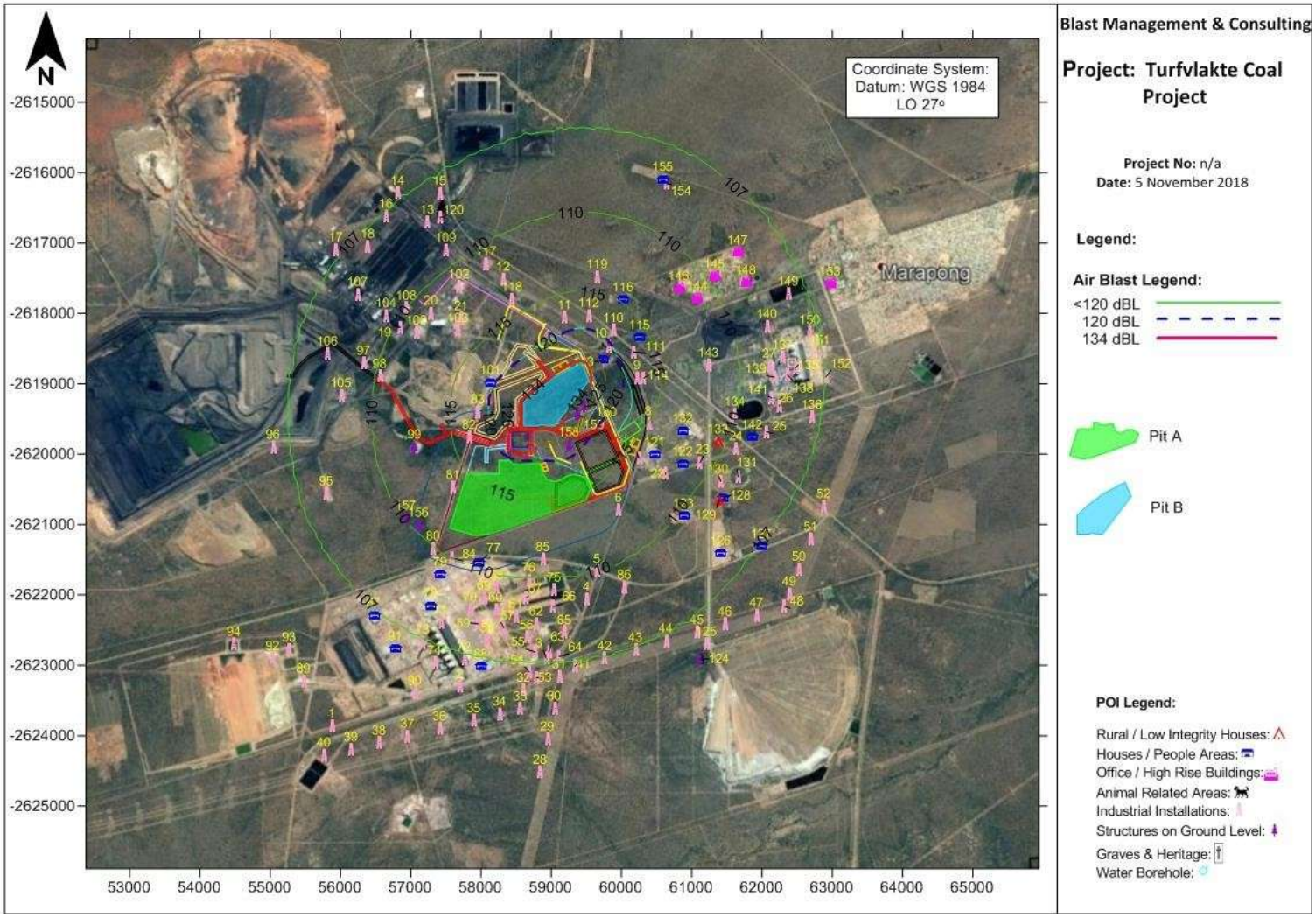


Figure 18: Air blast influence from minimum charge for Pit 2 Area

Table 16: Air blast evaluation for minimum charge for Pit 2

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Railway Line	5063	104.1	N/A
2	Railway Line	3812	106.0	N/A
3	Railway Line	3301	107.0	N/A
4	Railway Line	2502	108.9	N/A
5	Bridge	2151	110.0	N/A
6	Railway Line	1508	112.5	N/A
7	Railway Line	1243	113.7	N/A
8	Railway Line	1049	114.9	N/A
9	Railway Line	691	117.7	N/A
10	Railway Line	457	120.6	N/A
11	Railway Line	696	117.7	N/A
12	Railway Line	1574	112.1	N/A
13	Railway Line	2850	108.1	N/A
14	Railway Line	3433	106.8	N/A
15	Railway Line	3085	107.6	N/A
16	Railway Line	3282	107.0	N/A
17	Railway Line	3443	106.8	N/A
18	Railway Line	3139	107.4	N/A
19	Railway Line	2061	110.2	N/A
20	Railway Line	1833	111.1	N/A
21	Railway Line	1480	112.6	N/A
22	Railway Line	1676	111.7	N/A
23	Railway Line	1966	110.6	N/A
24	Railway Line	2314	109.5	N/A
25	Railway Line	2637	108.6	N/A
26	Railway Line	2730	108.3	N/A
27	Railway Line	2580	108.8	N/A
28	Power Lines/Pylons	4917	104.3	N/A
29	Power Lines/Pylons	4443	105.1	N/A
30	Power Lines/Pylons	4007	105.8	N/A
31	Power Lines/Pylons	3556	106.6	N/A
32	Power Lines/Pylons	3753	106.2	N/A
33	Power Lines/Pylons	4017	105.8	N/A
34	Power Lines/Pylons	4107	105.6	N/A
35	Power Lines/Pylons	4248	105.3	N/A
36	Power Lines/Pylons	4465	105.1	N/A
37	Power Lines/Pylons	4710	104.6	N/A
38	Power Lines/Pylons	4954	104.3	N/A
39	Power Lines/Pylons	5213	104.1	N/A
40	Power Lines/Pylons	5474	103.5	N/A

41	Power Lines/Pylons	3424	106.8	N/A
42	Power Lines/Pylons	3375	106.8	N/A
43	Power Lines/Pylons	3381	106.8	N/A
44	Power Lines/Pylons	3441	106.8	N/A
45	Power Lines/Pylons	3566	106.6	N/A
46	Power Lines/Pylons	3719	106.2	N/A
47	Power Lines/Pylons	3939	105.8	N/A
48	Power Lines/Pylons	4161	105.6	N/A
49	Power Lines/Pylons	4110	105.6	N/A
50	Power Lines/Pylons	4007	105.8	N/A
51	Power Lines/Pylons	3884	106.0	N/A
52	Power Lines/Pylons	3793	106.2	N/A
53	Power Lines/Pylons	3585	106.4	N/A
54	Power Lines/Pylons	3501	106.6	N/A
55	Power Lines/Pylons	3214	107.2	N/A
56	Power Lines/Pylons	3004	107.8	N/A
57	Power Lines/Pylons	2886	108.0	N/A
58	Power Lines/Pylons	3090	107.6	N/A
59	Power Lines/Pylons	2886	108.0	N/A
60	Power Lines/Pylons	2641	108.6	N/A
61	Power Lines/Pylons	2708	108.5	N/A
62	Power Lines/Pylons	2813	108.1	N/A
63	Power Lines/Pylons	3201	107.2	N/A
64	Power Lines/Pylons	3269	107.2	N/A
65	Power Lines/Pylons	2933	108.0	N/A
66	Power Lines/Pylons	2564	108.8	N/A
67	Power Lines/Pylons	2446	109.1	N/A
68	Power Lines/Pylons	2330	109.4	N/A
69	Power Lines/Pylons	2506	108.9	N/A
70	Power Lines/Pylons	2721	108.5	N/A
71	Medupi Power Station	3033	107.6	N/A
72	Medupi Power Station	3425	106.8	N/A
73	Cooling Towers	3393	106.8	N/A
74	Cooling Towers	3594	106.4	N/A
75	Water Reservoirs	2326	109.4	N/A
76	Tailing Dams	2190	109.8	N/A
77	Buildings/Structures	2037	110.4	Acceptable
78	Buildings/Structures	2880	108.0	Acceptable
79	Buildings/Structures	2421	109.2	Acceptable
80	Conveyor	2167	110.0	N/A
81	Conveyor	1331	113.3	N/A
82	Bridge	793	116.8	N/A
83	Conveyor	649	118.2	N/A
84	D1675 Road	2141	110.0	N/A
85	D1675 Road	1899	110.9	N/A

86	D2649 Road	2500	108.9	N/A
87	Buildings/Structures	3435	106.8	Acceptable
88	Buildings/Structures	3471	106.6	Acceptable
89	Conveyor	4789	104.6	N/A
90	Conveyor	4098	105.6	N/A
91	Buildings/Structures	3653	106.4	Acceptable
92	Conveyor	4862	104.3	N/A
93	Dam	4608	104.9	N/A
94	Dam	5160	104.1	N/A
95	Explosive Magazines Exxaro	2969	107.8	N/A
96	Sub Station	3580	106.4	N/A
97	Exxaro Grootgeluk Mine Activity	2346	109.4	N/A
98	Mine Buildings/Structures	2081	110.2	N/A
99	Pan	1585	112.0	N/A
100	Industrial Buildings	1817	111.1	N/A
101	Building/Structure	551	119.3	Acceptable
102	Mine Buildings/Structures	1844	111.0	N/A
103	Industrial Buildings	1385	113.0	N/A
104	Water Reservoirs	2315	109.5	N/A
105	Industrial Buildings/Structures	2602	108.6	N/A
106	Mine Activity	2876	108.0	N/A
107	Water Reservoirs	2821	108.1	N/A
108	Industrial Buildings/Structures	2141	110.0	N/A
109	Conveyor	2374	109.4	N/A
110	D2816 Road	653	118.1	N/A
111	D2001 Road	742	117.3	N/A
112	D2001 Road	690	117.7	N/A
113	Manketti Lodge	309	123.3	Complaint
114	Reservoir	779	116.9	N/A
115	Buildings/Structures	906	115.9	Acceptable
116	Buildings/Structures	1083	114.6	Acceptable
117	Sub Station	1882	110.9	N/A
118	Conveyor	1260	113.6	N/A
119	Conveyor	1250	113.7	N/A
120	Dams	2798	108.1	N/A
121	Buildings/Structures	1385	113.0	Acceptable
122	Buildings/Structures	1783	111.2	Acceptable
123	Buildings/Structures	2238	109.7	Acceptable
124	Pan	3900	106.0	N/A
125	Conveyor	3778	106.2	N/A
126	Buildings/Structures	2980	107.8	Acceptable
127	Buildings/Structures	3385	106.8	Acceptable
128	Buildings/Structures	2540	108.9	Acceptable
129	Informal Housing	2506	108.9	Acceptable
130	Pivot Irrigation	2362	109.4	N/A

131	Pivot Irrigation	2526	108.9	N/A
132	Buildings/Structures	1521	112.4	Acceptable
133	Informal Housing	2039	110.4	Acceptable
134	Dam	2139	110.0	N/A
135	Eskom Power Station-Matimba	2944	107.8	N/A
136	Airfield	3225	107.2	N/A
137	Cooling Towers	2783	108.3	N/A
138	Cooling Towers	2824	108.1	N/A
139	Industrial Buildings/Structures	2638	108.6	N/A
140	Conveyor	2650	108.6	N/A
141	Industrial Buildings/Structures	2615	108.6	N/A
142	Buildings/Structures	2466	109.1	Acceptable
143	Conveyor	1720	111.5	N/A
144	Marapong Community Buildings	1889	110.9	Acceptable
145	Marapong Community Buildings	2262	109.7	Acceptable
146	Marapong Community Buildings	1753	111.4	Acceptable
147	Marapong Community Buildings	2729	108.3	Acceptable
148	Marapong Community Buildings	2609	108.6	Acceptable
149	Dams	3094	107.6	N/A
150	Industrial Buildings/Structures	3220	107.2	N/A
151	Power Lines/Pylons	3313	107.0	N/A
152	Power Lines/Pylons	3371	106.8	N/A
153	Marapong Hospital	3700	106.2	Acceptable
154	Dam	2825	108.1	N/A
155	Buildings/Structures	2860	108.1	Acceptable
156	Pan	2054	110.4	N/A
157	Pan	2126	110.1	N/A
158	Pan	338	122.6	N/A
159	Pan	173	127.3	N/A
160	Pan	172	127.3	N/A

17.7.3 Maximum charge per delay 2736 kg – Pit 1

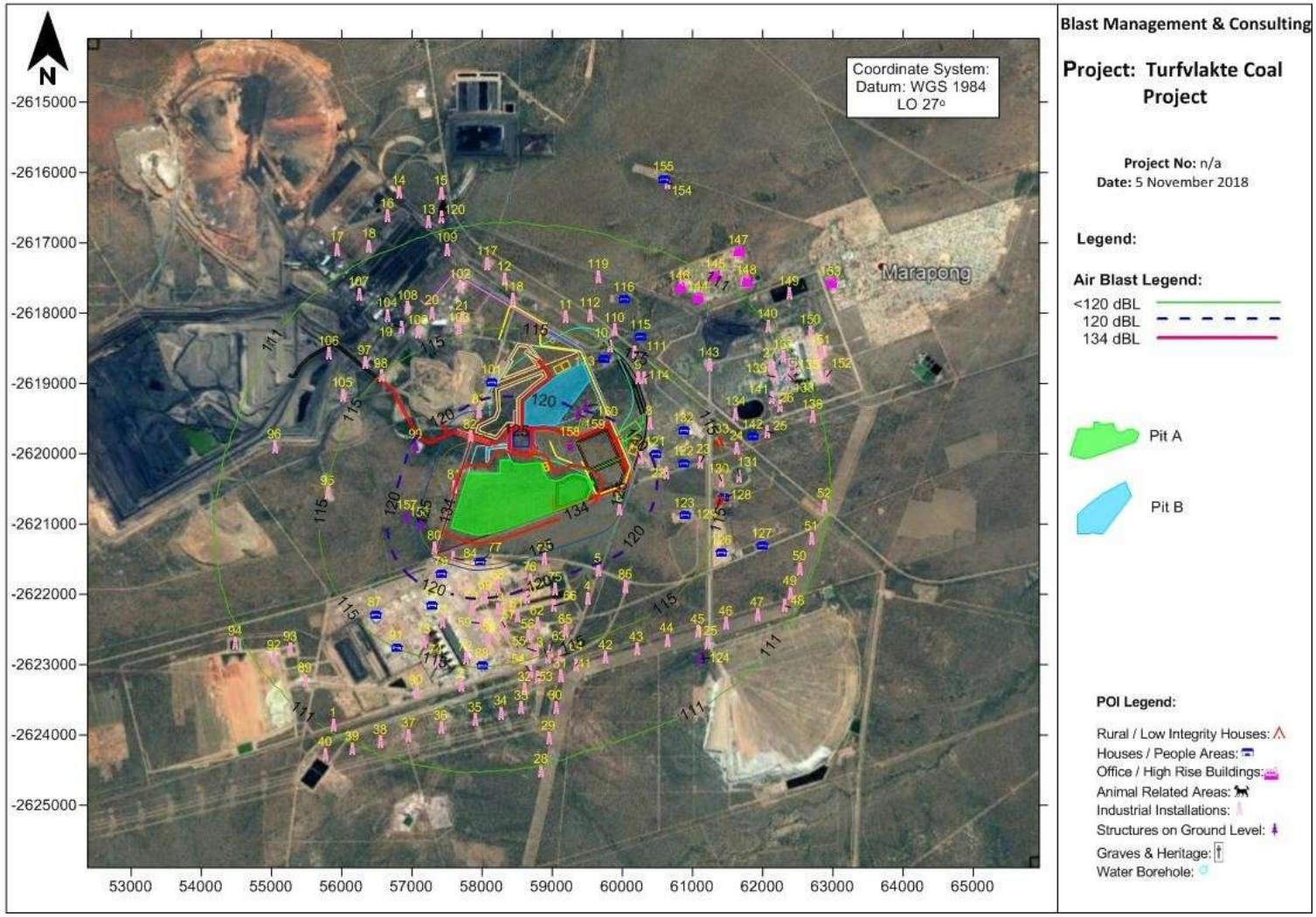


Figure 19: Air blast influence from maximum charge for Pit 1 Area

Table 17: Air blast influence from maximum charge for Pit 1 Area

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Railway Line	3270	111.2	N/A
2	Railway Line	2154	114.1	N/A
3	Railway Line	1931	114.8	N/A
4	Railway Line	1329	117.4	N/A
5	Bridge	1004	119.3	N/A
6	Railway Line	488	124.2	N/A
7	Railway Line	750	121.3	N/A
8	Railway Line	1161	118.3	N/A
9	Railway Line	1610	116.1	N/A
10	Railway Line	1889	115.0	N/A
11	Railway Line	2103	114.2	N/A
12	Railway Line	2577	112.9	N/A
13	Railway Line	3541	110.6	N/A
14	Railway Line	4068	109.7	N/A
15	Railway Line	3893	110.0	N/A
16	Railway Line	3834	110.1	N/A
17	Railway Line	3695	110.4	N/A
18	Railway Line	3536	110.6	N/A
19	Railway Line	2293	113.6	N/A
20	Railway Line	2313	113.5	N/A
21	Railway Line	2091	114.2	N/A
22	Railway Line	1054	118.9	N/A
23	Railway Line	1556	116.3	N/A
24	Railway Line	2104	114.2	N/A
25	Railway Line	2582	112.9	N/A
26	Railway Line	2869	112.1	N/A
27	Railway Line	3018	111.7	N/A
28	Power Lines/Pylons	3455	110.9	N/A
29	Power Lines/Pylons	3022	111.7	N/A
30	Power Lines/Pylons	2638	112.7	N/A
31	Power Lines/Pylons	2233	113.8	N/A
32	Power Lines/Pylons	2267	113.7	N/A
33	Power Lines/Pylons	2517	113.0	N/A
34	Power Lines/Pylons	2556	112.9	N/A
35	Power Lines/Pylons	2629	112.7	N/A
36	Power Lines/Pylons	2788	112.3	N/A
37	Power Lines/Pylons	3005	111.8	N/A
38	Power Lines/Pylons	3212	111.4	N/A
39	Power Lines/Pylons	3441	110.9	N/A
40	Power Lines/Pylons	3685	110.4	N/A

41	Power Lines/Pylons	2169	114.0	N/A
42	Power Lines/Pylons	2205	113.9	N/A
43	Power Lines/Pylons	2238	113.8	N/A
44	Power Lines/Pylons	2302	113.6	N/A
45	Power Lines/Pylons	2458	113.2	N/A
46	Power Lines/Pylons	2653	112.7	N/A
47	Power Lines/Pylons	2928	111.9	N/A
48	Power Lines/Pylons	3204	111.4	N/A
49	Power Lines/Pylons	3188	111.4	N/A
50	Power Lines/Pylons	3184	111.4	N/A
51	Power Lines/Pylons	3209	111.4	N/A
52	Power Lines/Pylons	3308	111.1	N/A
53	Power Lines/Pylons	2150	114.1	N/A
54	Power Lines/Pylons	2038	114.4	N/A
55	Power Lines/Pylons	1790	115.3	N/A
56	Power Lines/Pylons	1556	116.3	N/A
57	Power Lines/Pylons	1349	117.3	N/A
58	Power Lines/Pylons	1498	116.5	N/A
59	Power Lines/Pylons	1252	117.8	N/A
60	Power Lines/Pylons	1077	118.8	N/A
61	Power Lines/Pylons	1225	117.9	N/A
62	Power Lines/Pylons	1418	116.9	N/A
63	Power Lines/Pylons	1847	115.1	N/A
64	Power Lines/Pylons	1962	114.7	N/A
65	Power Lines/Pylons	1667	115.8	N/A
66	Power Lines/Pylons	1268	117.7	N/A
67	Power Lines/Pylons	1025	119.1	N/A
68	Power Lines/Pylons	768	121.1	N/A
69	Power Lines/Pylons	892	120.1	N/A
70	Power Lines/Pylons	1055	118.9	N/A
71	Medupi Power Station	1320	117.4	N/A
72	Medupi Power Station	1766	115.4	N/A
73	Cooling Towers	1661	115.8	N/A
74	Cooling Towers	1891	115.0	N/A
75	Water Reservoirs	1050	119.0	N/A
76	Tailing Dams	796	120.9	N/A
77	Buildings/Structures	381	125.9	Complaint
78	Buildings/Structures	1132	118.4	Acceptable
79	Buildings/Structures	665	122.1	Complaint
80	Conveyor	370	126.1	N/A
81	Conveyor	125	133.5	N/A
82	Bridge	520	123.8	N/A
83	Conveyor	756	121.2	N/A
84	D1675 Road	401	125.6	N/A
85	D1675 Road	588	123.0	N/A

86	D2649 Road	1354	117.2	N/A
87	Buildings/Structures	1641	115.9	Acceptable
88	Buildings/Structures	1860	115.0	Acceptable
89	Conveyor	3003	111.8	N/A
90	Conveyor	2383	113.3	N/A
91	Buildings/Structures	1875	115.0	Acceptable
92	Conveyor	3120	111.5	N/A
93	Dam	2860	112.1	N/A
94	Dam	3483	110.8	N/A
95	Explosive Magazines Exxaro	1822	115.2	N/A
96	Sub Station	2743	112.4	N/A
97	Exxaro Grootgeluk Mine Activity	2156	114.1	N/A
98	Mine Buildings/Structures	1862	115.0	N/A
99	Pan	837	120.5	N/A
100	Industrial Buildings	2134	114.2	N/A
101	Building/Structure	1119	118.5	Acceptable
102	Mine Buildings/Structures	2536	113.0	N/A
103	Industrial Buildings	1942	114.7	N/A
104	Water Reservoirs	2530	113.0	N/A
105	Industrial Buildings/Structures	2110	114.2	N/A
106	Mine Activity	2618	112.8	N/A
107	Water Reservoirs	2993	111.8	N/A
108	Industrial Buildings/Structures	2513	113.0	N/A
109	Conveyor	3088	111.6	N/A
110	D2816 Road	2119	114.2	N/A
111	D2001 Road	1916	114.9	N/A
112	D2001 Road	2215	113.9	N/A
113	Manketti Lodge	1686	115.7	Acceptable
114	Reservoir	1644	115.9	N/A
115	Buildings/Structures	2140	114.1	Acceptable
116	Buildings/Structures	2577	112.9	Acceptable
117	Sub Station	2800	112.3	N/A
118	Conveyor	2289	113.6	N/A
119	Conveyor	2773	112.4	N/A
120	Dams	3558	110.6	N/A
121	Buildings/Structures	975	119.5	Acceptable
122	Buildings/Structures	1313	117.4	Acceptable
123	Buildings/Structures	1379	117.1	Acceptable
124	Pan	2776	112.4	N/A
125	Conveyor	2670	112.6	N/A
126	Buildings/Structures	2059	114.4	Acceptable
127	Buildings/Structures	2569	112.9	Acceptable
128	Buildings/Structures	1875	115.0	Acceptable
129	Informal Housing	1820	115.2	Acceptable
130	Pivot Irrigation	1823	115.2	N/A

131	Pivot Irrigation	2071	114.3	N/A
132	Buildings/Structures	1487	116.6	Acceptable
133	Informal Housing	1883	115.0	Acceptable
134	Dam	2253	113.7	N/A
135	Eskom Power Station-Matimba	3317	111.1	N/A
136	Airfield	3264	111.2	N/A
137	Cooling Towers	3248	111.2	N/A
138	Cooling Towers	3169	111.5	N/A
139	Industrial Buildings/Structures	2989	111.8	N/A
140	Conveyor	3337	111.1	N/A
141	Industrial Buildings/Structures	2819	112.3	N/A
142	Buildings/Structures	2364	113.4	Acceptable
143	Conveyor	2355	113.4	N/A
144	Marapong Community Buildings	3010	111.8	Acceptable
145	Marapong Community Buildings	3408	110.9	Acceptable
146	Marapong Community Buildings	3018	111.7	Acceptable
147	Marapong Community Buildings	3876	110.1	Acceptable
148	Marapong Community Buildings	3593	110.6	Acceptable
149	Dams	3875	110.1	N/A
150	Industrial Buildings/Structures	3764	110.2	N/A
151	Power Lines/Pylons	3731	110.4	N/A
152	Power Lines/Pylons	3644	110.5	N/A
153	Marapong Hospital	4415	109.1	Acceptable
154	Dam	4329	109.2	N/A
155	Buildings/Structures	4375	109.2	Acceptable
156	Pan	444	124.9	N/A
157	Pan	639	122.4	N/A
158	Pan	426	125.2	N/A
159	Pan	843	120.5	N/A
160	Pan	975	119.5	N/A

17.7.4 Maximum charge per delay 2736 kg – Pit 2

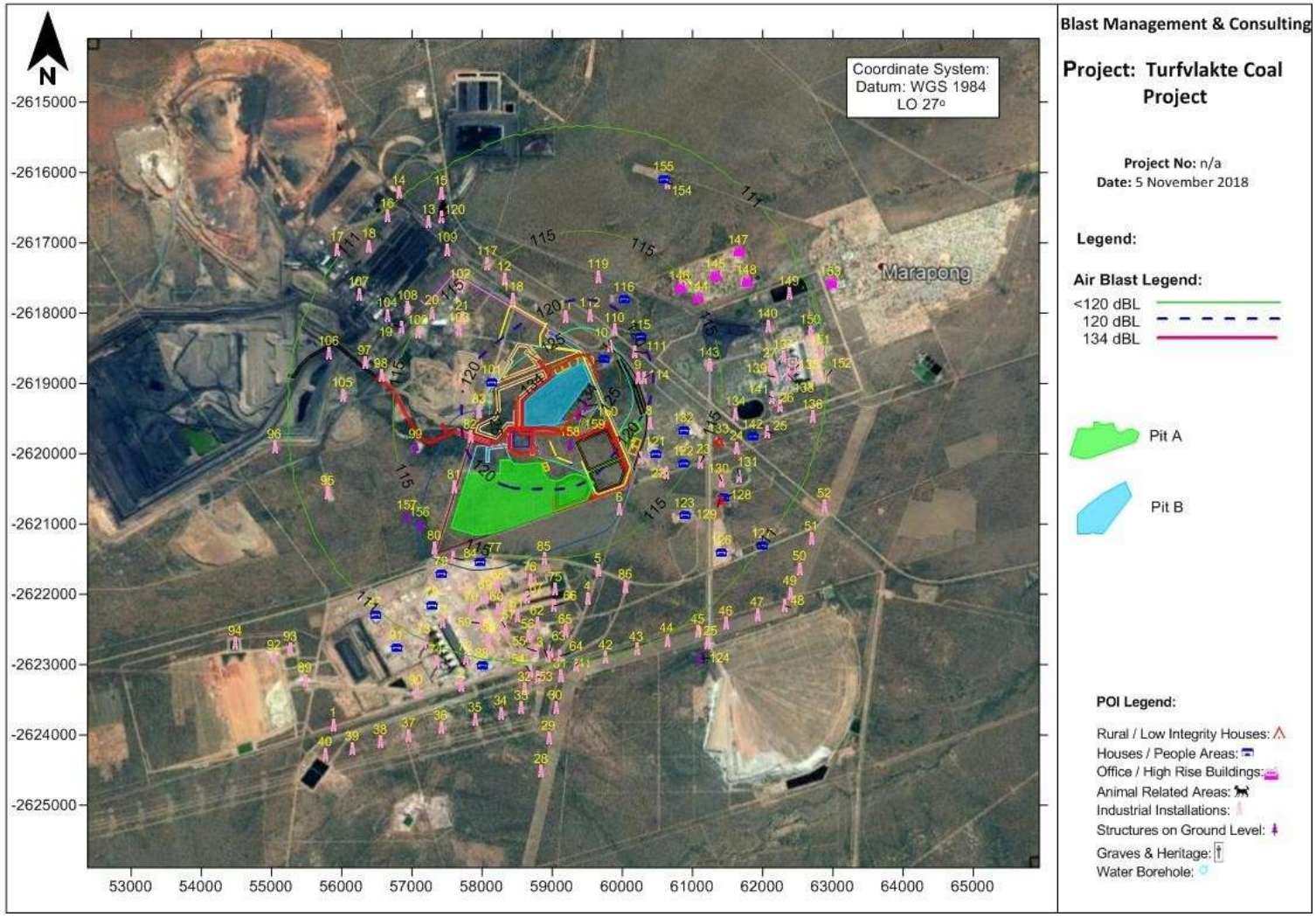


Figure 20: Air blast influence from maximum charge for Pit 2 Area

Table 18: Air blast evaluation for maximum charge for Pit 2

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Railway Line	5063	108.3	N/A
2	Railway Line	3812	110.1	N/A
3	Railway Line	3301	111.1	N/A
4	Railway Line	2502	113.1	N/A
5	Bridge	2151	114.1	N/A
6	Railway Line	1508	116.5	N/A
7	Railway Line	1243	117.8	N/A
8	Railway Line	1049	119.0	N/A
9	Railway Line	691	121.8	N/A
10	Railway Line	457	124.7	N/A
11	Railway Line	696	121.8	N/A
12	Railway Line	1574	116.2	N/A
13	Railway Line	2850	112.1	N/A
14	Railway Line	3433	110.9	N/A
15	Railway Line	3085	111.6	N/A
16	Railway Line	3282	111.1	N/A
17	Railway Line	3443	110.9	N/A
18	Railway Line	3139	111.5	N/A
19	Railway Line	2061	114.3	N/A
20	Railway Line	1833	115.2	N/A
21	Railway Line	1480	116.7	N/A
22	Railway Line	1676	115.8	N/A
23	Railway Line	1966	114.6	N/A
24	Railway Line	2314	113.5	N/A
25	Railway Line	2637	112.7	N/A
26	Railway Line	2730	112.5	N/A
27	Railway Line	2580	112.9	N/A
28	Power Lines/Pylons	4917	108.5	N/A
29	Power Lines/Pylons	4443	109.1	N/A
30	Power Lines/Pylons	4007	109.8	N/A
31	Power Lines/Pylons	3556	110.6	N/A
32	Power Lines/Pylons	3753	110.2	N/A
33	Power Lines/Pylons	4017	109.8	N/A
34	Power Lines/Pylons	4107	109.7	N/A
35	Power Lines/Pylons	4248	109.4	N/A
36	Power Lines/Pylons	4465	109.1	N/A
37	Power Lines/Pylons	4710	108.8	N/A
38	Power Lines/Pylons	4954	108.5	N/A
39	Power Lines/Pylons	5213	108.0	N/A
40	Power Lines/Pylons	5474	107.8	N/A

41	Power Lines/Pylons	3424	110.9	N/A
42	Power Lines/Pylons	3375	111.0	N/A
43	Power Lines/Pylons	3381	111.0	N/A
44	Power Lines/Pylons	3441	110.9	N/A
45	Power Lines/Pylons	3566	110.6	N/A
46	Power Lines/Pylons	3719	110.4	N/A
47	Power Lines/Pylons	3939	110.0	N/A
48	Power Lines/Pylons	4161	109.5	N/A
49	Power Lines/Pylons	4110	109.7	N/A
50	Power Lines/Pylons	4007	109.8	N/A
51	Power Lines/Pylons	3884	110.1	N/A
52	Power Lines/Pylons	3793	110.2	N/A
53	Power Lines/Pylons	3585	110.6	N/A
54	Power Lines/Pylons	3501	110.8	N/A
55	Power Lines/Pylons	3214	111.4	N/A
56	Power Lines/Pylons	3004	111.8	N/A
57	Power Lines/Pylons	2886	112.0	N/A
58	Power Lines/Pylons	3090	111.6	N/A
59	Power Lines/Pylons	2886	112.0	N/A
60	Power Lines/Pylons	2641	112.7	N/A
61	Power Lines/Pylons	2708	112.5	N/A
62	Power Lines/Pylons	2813	112.3	N/A
63	Power Lines/Pylons	3201	111.4	N/A
64	Power Lines/Pylons	3269	111.2	N/A
65	Power Lines/Pylons	2933	111.9	N/A
66	Power Lines/Pylons	2564	112.9	N/A
67	Power Lines/Pylons	2446	113.2	N/A
68	Power Lines/Pylons	2330	113.5	N/A
69	Power Lines/Pylons	2506	113.1	N/A
70	Power Lines/Pylons	2721	112.5	N/A
71	Medupi Power Station	3033	111.7	N/A
72	Medupi Power Station	3425	110.9	N/A
73	Cooling Towers	3393	111.0	N/A
74	Cooling Towers	3594	110.6	N/A
75	Water Reservoirs	2326	113.5	N/A
76	Tailing Dams	2190	114.0	N/A
77	Buildings/Structures	2037	114.4	Acceptable
78	Buildings/Structures	2880	112.0	Acceptable
79	Buildings/Structures	2421	113.3	Acceptable
80	Conveyor	2167	114.0	N/A
81	Conveyor	1331	117.3	N/A
82	Bridge	793	120.9	N/A
83	Conveyor	649	122.3	N/A
84	D1675 Road	2141	114.1	N/A
85	D1675 Road	1899	114.9	N/A

86	D2649 Road	2500	113.1	N/A
87	Buildings/Structures	3435	110.9	Acceptable
88	Buildings/Structures	3471	110.8	Acceptable
89	Conveyor	4789	108.6	N/A
90	Conveyor	4098	109.7	N/A
91	Buildings/Structures	3653	110.5	Acceptable
92	Conveyor	4862	108.5	N/A
93	Dam	4608	108.9	N/A
94	Dam	5160	108.1	N/A
95	Explosive Magazines Exxaro	2969	111.8	N/A
96	Sub Station	3580	110.6	N/A
97	Exxaro Grootgeluk Mine Activity	2346	113.4	N/A
98	Mine Buildings/Structures	2081	114.3	N/A
99	Pan	1585	116.1	N/A
100	Industrial Buildings	1817	115.2	N/A
101	Building/Structure	551	123.4	Complaint
102	Mine Buildings/Structures	1844	115.1	N/A
103	Industrial Buildings	1385	117.1	N/A
104	Water Reservoirs	2315	113.5	N/A
105	Industrial Buildings/Structures	2602	112.8	N/A
106	Mine Activity	2876	112.0	N/A
107	Water Reservoirs	2821	112.3	N/A
108	Industrial Buildings/Structures	2141	114.1	N/A
109	Conveyor	2374	113.3	N/A
110	D2816 Road	653	122.2	N/A
111	D2001 Road	742	121.4	N/A
112	D2001 Road	690	121.8	N/A
113	Manketti Lodge	309	127.3	Complaint
114	Reservoir	779	121.0	N/A
115	Buildings/Structures	906	120.0	Acceptable
116	Buildings/Structures	1083	118.7	Acceptable
117	Sub Station	1882	115.0	N/A
118	Conveyor	1260	117.7	N/A
119	Conveyor	1250	117.8	N/A
120	Dams	2798	112.3	N/A
121	Buildings/Structures	1385	117.1	Acceptable
122	Buildings/Structures	1783	115.3	Acceptable
123	Buildings/Structures	2238	113.8	Acceptable
124	Pan	3900	110.0	N/A
125	Conveyor	3778	110.2	N/A
126	Buildings/Structures	2980	111.8	Acceptable
127	Buildings/Structures	3385	111.0	Acceptable
128	Buildings/Structures	2540	113.0	Acceptable
129	Informal Housing	2506	113.1	Acceptable
130	Pivot Irrigation	2362	113.4	N/A

131	Pivot Irrigation	2526	113.0	N/A
132	Buildings/Structures	1521	116.5	Acceptable
133	Informal Housing	2039	114.4	Acceptable
134	Dam	2139	114.1	N/A
135	Eskom Power Station-Matimba	2944	111.9	N/A
136	Airfield	3225	111.4	N/A
137	Cooling Towers	2783	112.4	N/A
138	Cooling Towers	2824	112.3	N/A
139	Industrial Buildings/Structures	2638	112.7	N/A
140	Conveyor	2650	112.7	N/A
141	Industrial Buildings/Structures	2615	112.8	N/A
142	Buildings/Structures	2466	113.2	Acceptable
143	Conveyor	1720	115.6	N/A
144	Marapong Community Buildings	1889	115.0	Acceptable
145	Marapong Community Buildings	2262	113.7	Acceptable
146	Marapong Community Buildings	1753	115.5	Acceptable
147	Marapong Community Buildings	2729	112.5	Acceptable
148	Marapong Community Buildings	2609	112.8	Acceptable
149	Dams	3094	111.6	N/A
150	Industrial Buildings/Structures	3220	111.4	N/A
151	Power Lines/Pylons	3313	111.1	N/A
152	Power Lines/Pylons	3371	111.0	N/A
153	Marapong Hospital	3700	110.4	Acceptable
154	Dam	2825	112.3	N/A
155	Buildings/Structures	2860	112.1	Acceptable
156	Pan	2054	114.4	N/A
157	Pan	2126	114.2	N/A
158	Pan	338	126.7	N/A
159	Pan	173	131.3	N/A
160	Pan	172	131.4	N/A

17.8 Summary of findings for air blast

Review of the air blast levels indicates some concerns for opencast blasting. Air blast predicted for the maximum charge ranges between 107.8 and 133.5 dB for all the POI's for both Pit 1 and Pit 2 considered. This includes the nearest points such as the Buildings/Structures and the pans located next to Pit 2. These levels may contribute to effects such as rattling of roofs or door or windows. The closest structures at Pit 1 is located 381 m from pit edge and is certain to raise concerns and complaints from air blast. Pit 2 have the Manketti Lodge closest at 309 m. Levels expected is certain to raise concerns and complaints. Minimum charge predictions identified one POI at Pit 1 and one POI at Pit 2 could experience levels of air blast that could lead to complaints. Maximum charge predictions indicate that the same POI's could experience air blast that could lead to

complaints. Levels predicted are however less than the 134 dB limit currently applied in south Africa.

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 118 m and closer to pit boundaries. Infrastructure at all pit areas such as roads is 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 pits are located such that "free blasting" – meaning no controls on blast preparation – will not be possible.

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 21 shows the results from the ISEE calculations for fly rock range based on a 172 mm diameter blast hole and 4.3 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 305 m. The absolute minimum unsafe zone is then the 305 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 22 shows the area around Pit 1 and Pit 2 that incorporates the 305 m unsafe zone.

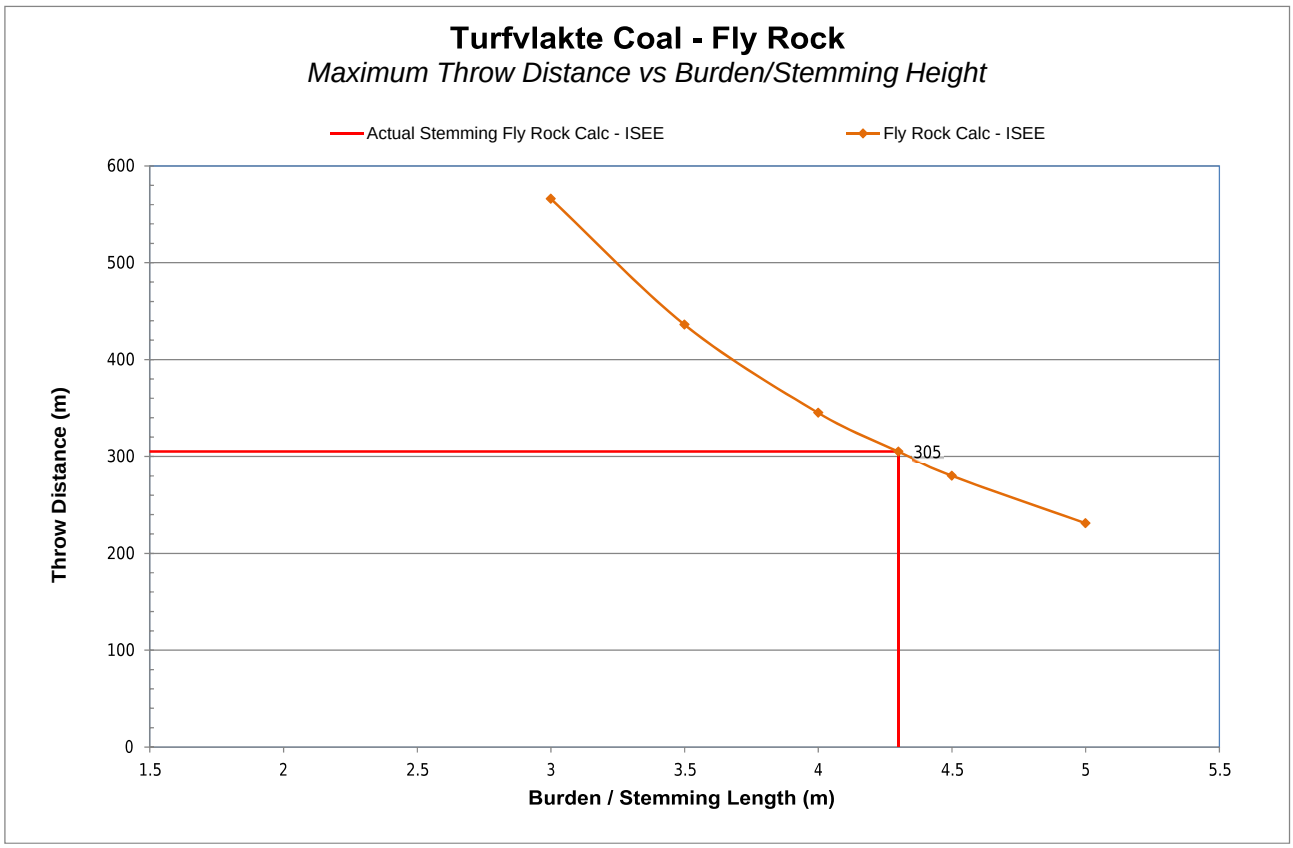


Figure 21: Fly rock prediction calculation

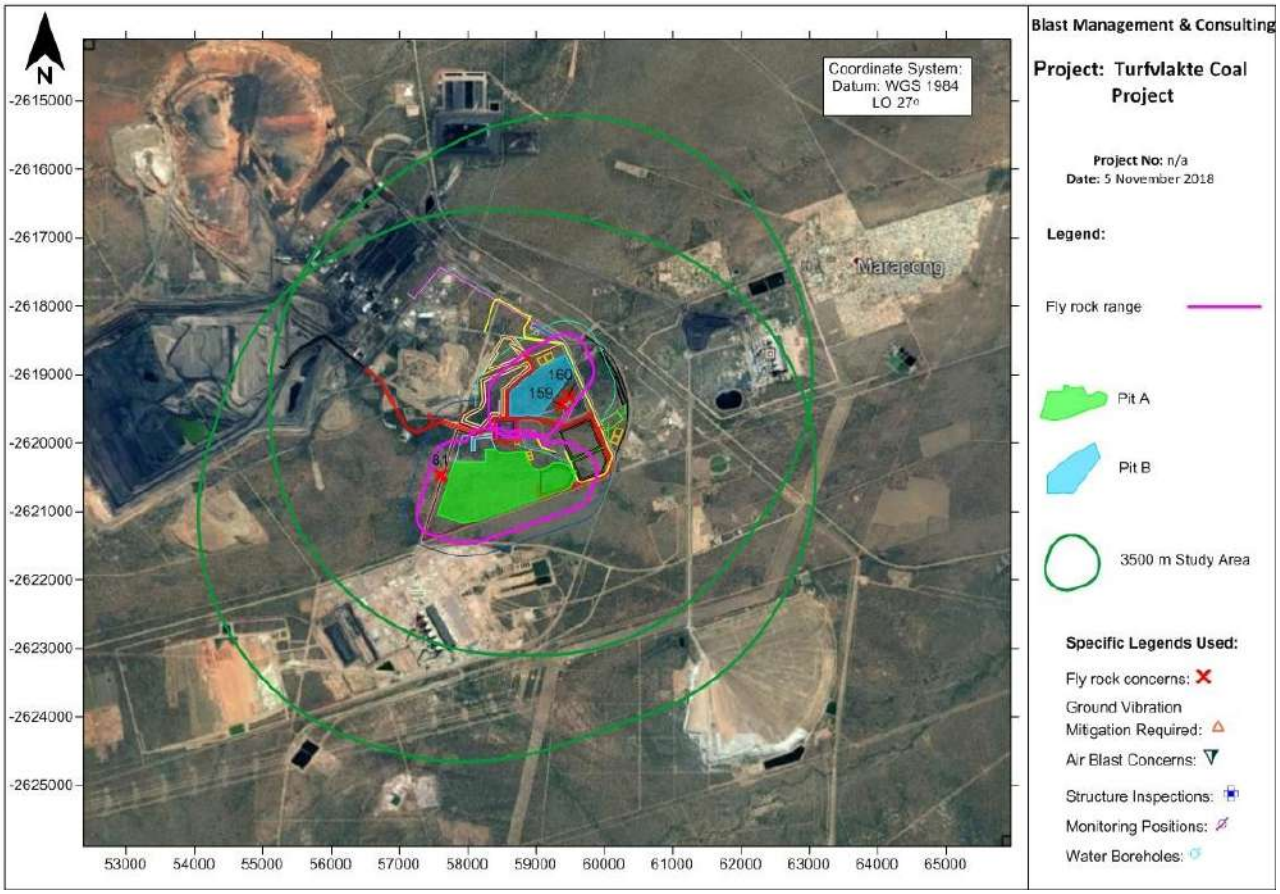


Figure 22: Predicted Fly Rock Exclusion Zone for Pit 1 and Pit 2

Review of the calculated unsafe zone showed three POI's for Pit 1 and Pit 2 are within the unsafe zone. This includes mainly the Conveyor and Pans. A single POI may represent multiple structures in the area of POI. Table 19 below shows the POI's of concern and coordinates.

Table 19: Fly rock concern POI's

Tag	Description	Y	X
81	Conveyor	-57608.62	2620471.60
159	Pan	-59378.44	2619444.34
160	Pan	-59470.44	2619321.67

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.

17.11 Potential Environmental Impact Assessment: Operational Phase

The following is the impact assessment of the various concerns covered by this report. The matrix below in Table 20 was used for analysis and evaluation of aspects discussed in this report. The outcome of the analysis is provided in Table 21 with before mitigation and after mitigation. This risk assessment is a one-sided analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation.

Assessment Methodology

The impact significance rating process serves two purposes: firstly, it helps to highlight the critical impacts requiring consideration in the management and approval process; secondly, it shows the primary impact characteristics, as defined above, used to evaluate impact significance.

The impact significance rating system is presented in Table 20 and involves three parts:

Part A: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale/ population and duration;

Part B: Use the matrix to determine a rating for impact consequence based on the definitions identified in Part A; and

Part C: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence.

Table 20: Significance Rating Methodology

PART A: DEFINING CONSEQUENCE IN TERMS OF MAGNITUDE, DURATION AND SPATIAL SCALE *Use these definitions to define the consequence in Part B*		
Impact characteristics	**Definition**	**Criteria**
MAGNITUDE	Major -	Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded
	Moderate -	Moderate/measurable deterioration or harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded
	Minor -	Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded

	Minor +	Minor improvement; change not measurable; or threshold never exceeded
	Moderate +	Moderate improvement; within or better than the threshold; or no observed reaction
	Major +	Substantial improvement; within or better than the threshold; or favourable publicity
SPATIAL SCALE OR POPULATION	Site or local	Site specific or confined to the immediate project area
	Regional	May be defined in various ways, e.g. cadastral, catchment, topographic
	National/ International	Nationally or beyond
DURATION	Short term	Up to 18 months.
	Medium term	18 months to 5 years
	Long term	Longer than 5 years

PART B: DETERMINING CONSEQUENCE RATING

Rate consequence based on definition of magnitude, spatial extent and duration

			SPATIAL SCALE/POPULATION		
			Site or Local	**Regional**	**National/ International**
MAGNITUDE					
Minor	**DURATION**	**Long term**	Medium	Medium	High
		Medium term	Low	Low	Medium
		Short term	Low	Low	Medium
Moderate	**DURATION**	**Long term**	Medium	High	High
		Medium term	Medium	Medium	High
		Short term	Low	Medium	Medium
Major	**DURATION**	**Long term**	High	High	High
		Medium term	Medium	Medium	High
		Short term	Medium	Medium	High

PART C: DETERMINING SIGNIFICANCE RATING *Rate significance based on consequence and probability*				
		CONSEQUENCE		
		Low	**Medium**	**High**
PROBABILITY (of exposure to impacts)	**Definite**	Medium	Medium	High
	Possible	Low	Medium	High
	Unlikely	Low	Low	Medium

17.11.1 Assessment

Table 21: Impact Assessment Outcome

No.	Affected Environment	Activity	Impact Description	BEFORE MITIGATION						Cumulative Impact	Mitigation measures / Recommendations	AFTER MITIGATION					
				Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE			Magnitude	Duration	Spatial Scale	Consequence	Probability	SIGNIFICANCE
	Construction																
1	None						-		-	-							
	Operation																
40	Neighbouring areas	Blasting	Ground vibration Impact on houses and structures	*Major -*	*Long Term > 5 years*	*Site or Local*	High	*Definite*	High	-	Reduce charge mass per delay, changed or re-define blast design, review pit area to be blasted	*Minor -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
41	Neighbouring areas	Blasting	Ground vibration impact on industrial surface Infrastructure	*Minor -*	*Long Term > 5 years*	*Site or Local*	Medium	*Definite*	Medium	-	Reduce charge mass per delay, changed or re-define blast design, review pit area to be blasted	*Minor -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
42	Neighbouring areas	Blasting	Ground vibration impact on roads and road structures	*Major -*	*Long Term > 5 years*	*Site or Local*	High	*Definite*	High	-	Reduce charge mass per delay, changed or re-define blast design, review pit area to be blasted	*Minor -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
43	Neighbouring areas	Blasting	Air blast Impact on houses and structures	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Definite*	Medium	-	Stemming control and audit, use proper stemming materials, re-design blasts	*Minor -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
44	Neighbouring areas	Blasting	Air blast impact on industrial surface Infrastructure	*Moderate -*	*Long Term > 5 years*	*Site or Local*	Medium	*Definite*	Medium	-	Stemming control and audit, use proper stemming materials, re-design blasts	*Minor -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low

45	Neighbouring areas	Blasting	Air blast impact on roads and road structures	-	*Long Term > 5 years*	*Site or Local*	-	*Unlikely*	-	-		-	*Long Term > 5 years*	*Site or Local*	-	-	-
46	Neighbouring areas	Blasting	Fly rock impact on houses and structures	-	*Long Term > 5 years*	*Site or Local*	-	*Unlikely*	-	-		-	*Long Term > 5 years*	*Site or Local*	-	-	-
47	Neighbouring areas	Blasting	Fly rock impact on industrial surface Infrastructure	*Major -*	*Long Term > 5 years*	*Site or Local*	High	*Possible*	High	-	Stemming control and audit, use proper stemming materials, re-design blasts	*Minor -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
48	Neighbouring areas	Blasting	Fly rock impact on roads and road structures	*Major -*	*Long Term > 5 years*	*Site or Local*	High	*Possible*	High	-	Stemming control and audit, use proper stemming materials, re-design blasts	*Minor -*	*Long Term > 5 years*	*Site or Local*	Medium	*Unlikely*	Low
	Decommissioning and Closure																
76	None			-	-	-	-	-	-	-		-	-	-	-	-	-
	Post- Closure																
116	None			-	-	-	-	-	-	-		-	-	-	-	-	-

17.12 Mitigations

In review of the evaluations made in this report it is certain that specific mitigation will be required with regards to ground vibration. 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.

Specific impacts are expected at the following POI's identified. Table 22 shows list of POI's that will need to be considered. Figure 23 shows the location of these POI's in relation to the pit areas.

Table 22: Structures at Pit 1 and Pit 2 of the Project Area identified as problematic

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
	Pit 1							
77	Buildings/ Structures	-57977.92	2621532.99	25	381	2736	43.2	Problematic
81	Conveyor	-57608.62	2620471.60	150	125	2736	270.4	Problematic
	Pit 2							
113	Manketti Lodge	-59746.58	2618652.80	25	309	2736	60.9	Problematic
159	Pan	-59378.44	2619444.34	Pan not expected to be influenced by vibration but are close to Pit 2				
160	Pan	-59470.44	2619321.67					

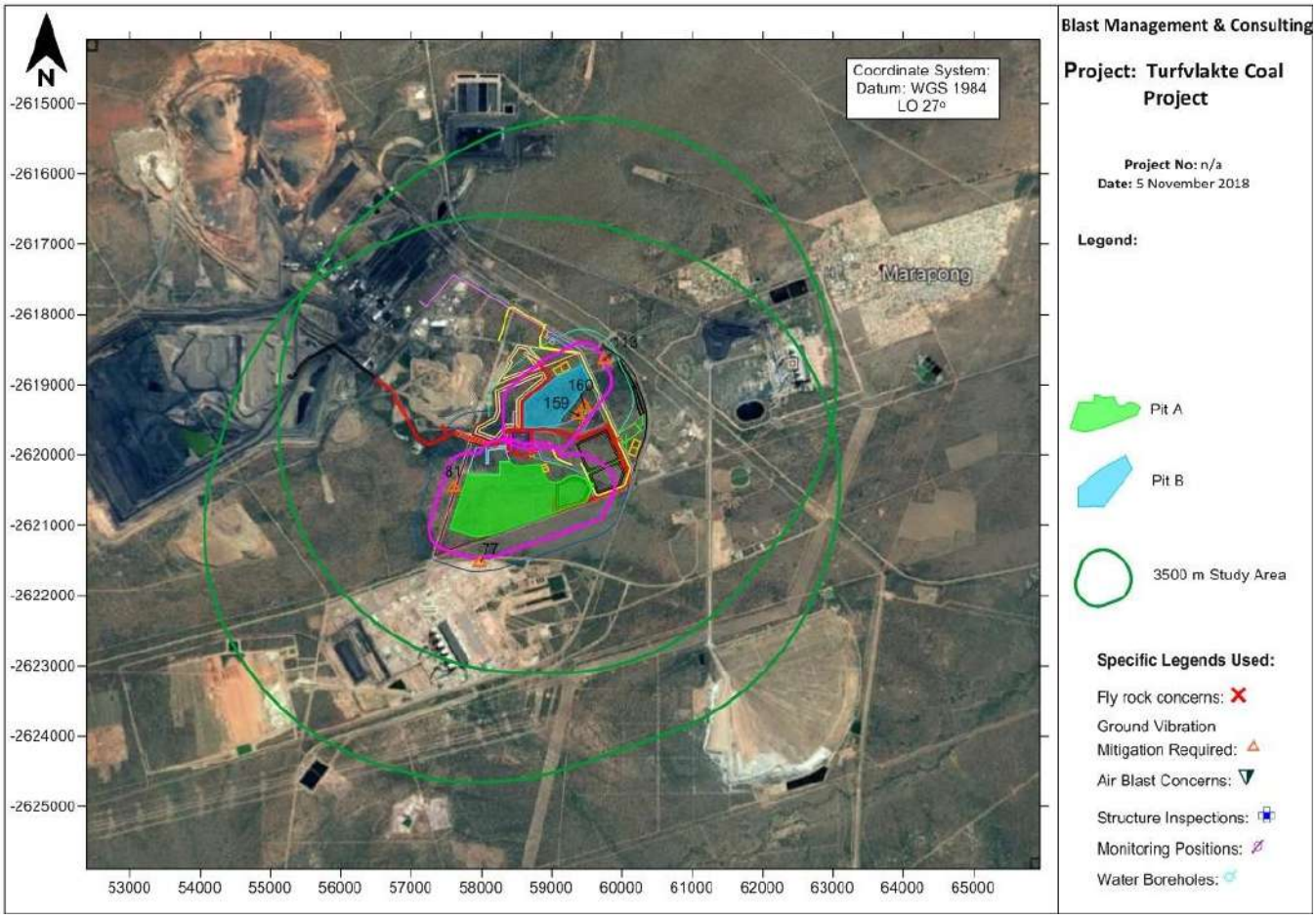


Figure 23: Structures identified at Pit 1 and Pit 2 where ground vibration mitigation will be required.

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

- 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.
- Relocate the POI / acquire the POI of concern – mined owned.

The following Table 23 do show mitigation in the form of maximum charge mass that will be allowed to maintain safe levels of ground vibration and minimum distance between blast and POI required for the maximum charge to yield safe levels of ground vibration.

Table 23: Mitigation measures for ground vibration

Maximum Charge allowed									
Code	**Tag**	**Description**	**Y**	**X**	**Specific Limit (mm/s)**	**Distance (m)**	**Total Mass/Delay (kg)**	**Predicted PPV (mm/s)**	**Structure Response @ 10Hz**
		Pit 1							
POI	77	Buildings/Structures	-57977.92	2621532.99	25	381	1412	25.0	Acceptable
POI	81	Conveyor	-57608.62	2620471.60	150	125	1340	150.0	Acceptable
		Pit 2							
POI	113	Manketti Lodge	-59746.58	2618652.80	25	309	930	25.0	Acceptable
Minimum distance required from maximum charge									
Code	**Tag**	**Description**	**Y**	**X**	**Specific Limit (mm/s)**	**Distance (m)**	**Total Mass/Delay (kg)**	**Predicted PPV (mm/s)**	**Structure Response @ 10Hz**
		Pit 1							
POI	77	Buildings/Structures	-57977.92	2621532.99	25	530	2736	25.0	Acceptable
POI	81	Conveyor	-57608.62	2620471.60	150	179	2736	150.0	Acceptable
		Pit 2							
POI	113	Manketti Lodge	-59746.58	2618652.80	25	530	2736	25.0	Acceptable

18 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.

19 Alternatives (Comparison and Recommendation)

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

20 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.

Most of the above aspects do not require specific locations of monitoring. 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. Proposed positions were selected to indicate the nearest points of interest at which levels of ground vibration and air blast should be within the accepted norms and standards as proposed in this report. The monitoring of ground vibration will also qualify the expected ground vibration and air blast levels and assist in mitigating these aspects properly. This will also contribute to proper relationships with the neighbours.

A minimum of seven monitoring positions were identified for Pit 1 and Pit 2 Some of these points may be applicable to more than one installation. Monitoring positions are indicated in Figure 24 and Table 24 lists the positions with coordinates. These points will need to be re-defined after the first blasts done and the monitoring programme defined.

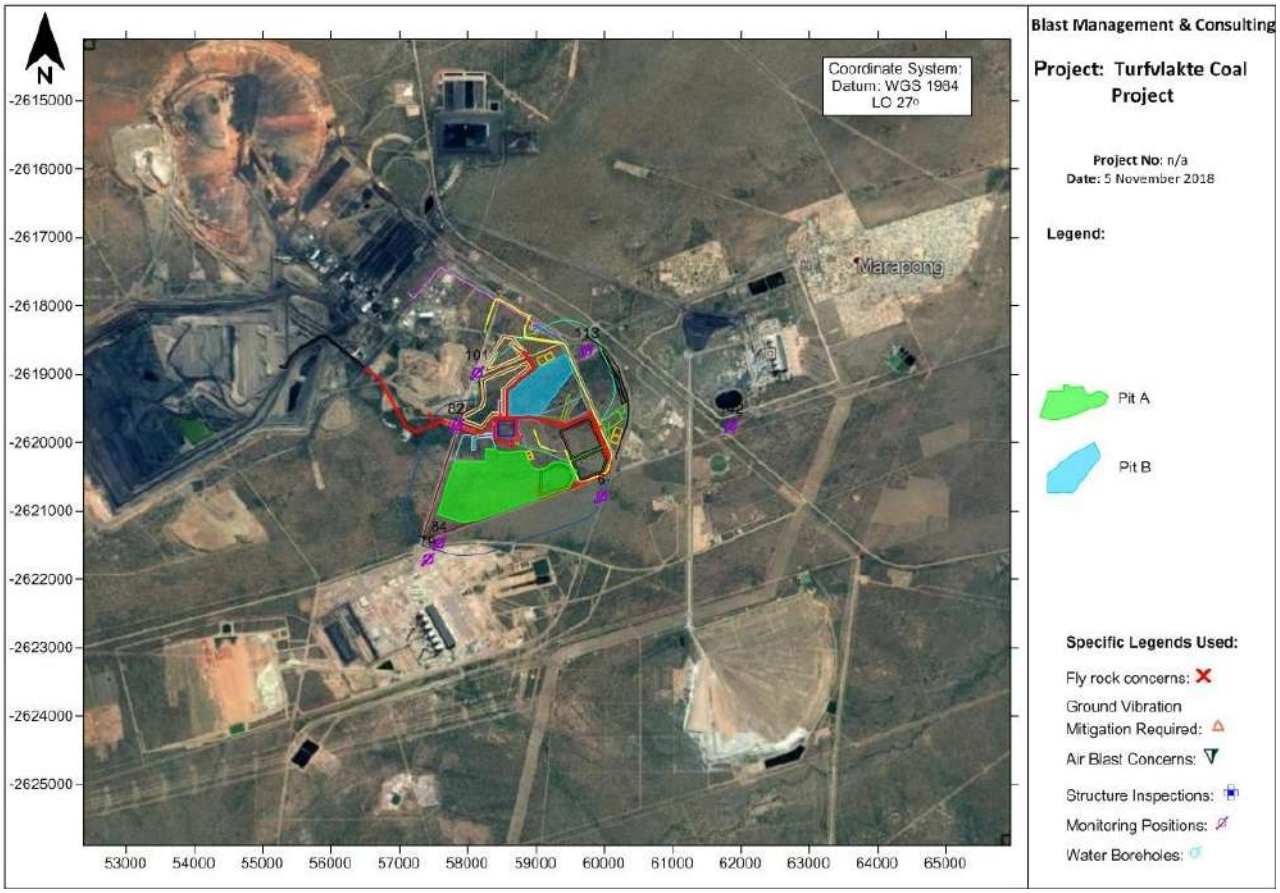


Figure 24: Monitoring Positions suggested for Pit 1 and Pit 2

Table 24: List of possible monitoring positions

Tag	Description	Y	X
6	Railway Line	59965.28	-2620795.47
79	Buildings/Structures	57422.05	-2621705.43
82	Bridge	57836.83	-2619761.73
84	D1675 Road	57595.00	-2621480.66
101	Building/Structure	58141.47	-2618979.14

Tag	Description	Y	X
113	Manketti Lodge	59746.58	-2618652.80
142	Buildings/Structures	61862.18	-2619759.82

21 Recommendations

The following recommendations are proposed.

21.1 Regulatory requirements

Regulatory requirements indicate specific requirements for all non-mining structures and installations within 500 m from the mining operation. POI's at both Pit 1 and Pit 2 are observed within the 500 m. 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. Table 25 shows list of these installations. Figure 25 below shows the 500 m boundary around the Pit 1 and Pit 2 areas. The location of non-mining installations is clearly observed.

Table 25: List of possible installations within the regulatory 500 m

Tag	Description	Y	X
6	Railway Line	-59965.28	2620795.47
10	Railway Line	-59817.77	2618460.97
77	Buildings/Structures	-57977.92	2621532.99
80	Conveyor	-57325.56	2621340.99
81	Conveyor	-57608.62	2620471.60
84	D1675 Road	-57595.00	2621480.66
113	Manketti Lodge	-59746.58	2618652.80
156	Pan	-57115.07	2621003.69
158	Pan	-59256.95	2619864.34
159	Pan	-59378.44	2619444.34
160	Pan	-59470.44	2619321.67

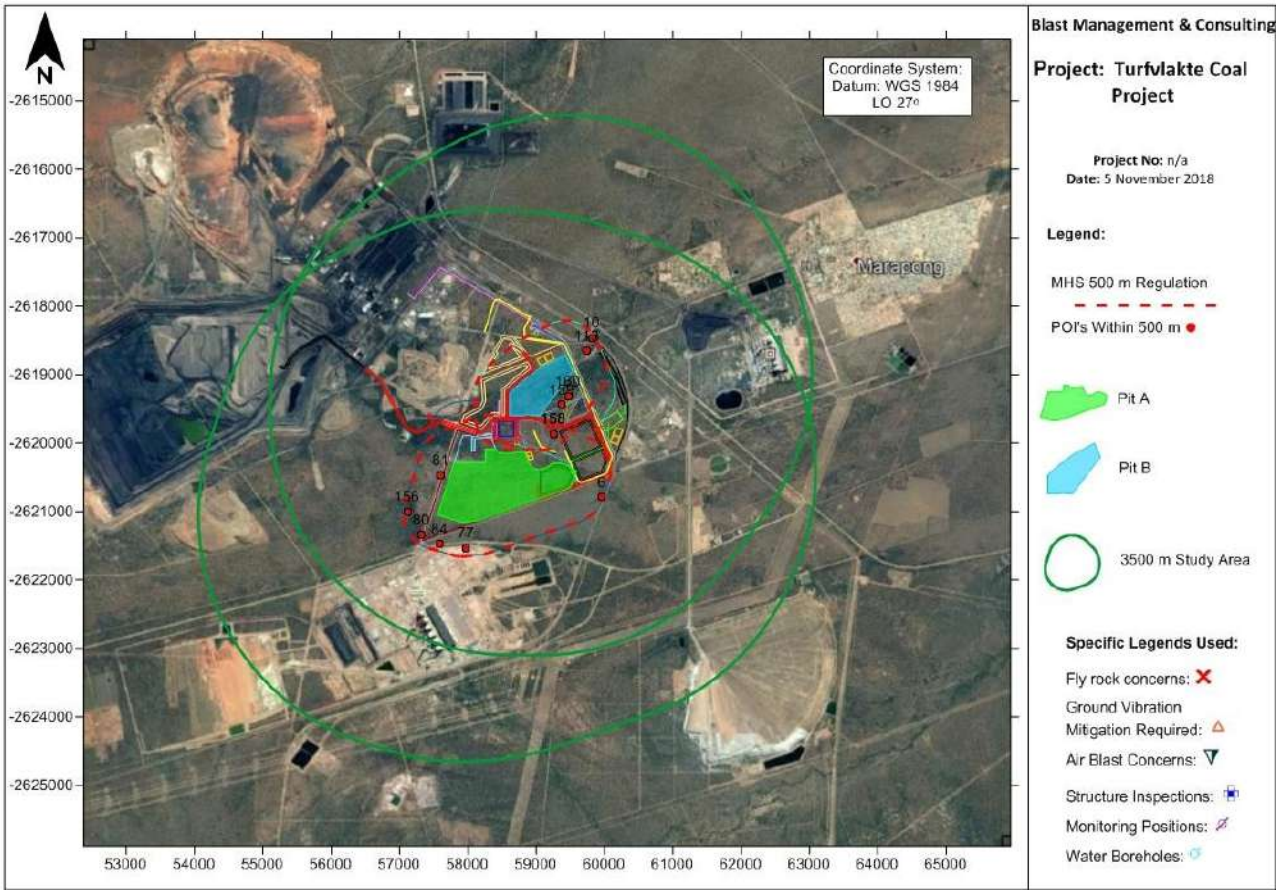


Figure 25: Regulatory 500 m range for Pit 1 and Pit 2

21.2 Blast Designs

Blast designs can be reviewed prior to first blast planned and done. Specific attention can be given to the possible use of electronic initiation rather than conventional timing systems. This will allow for single blast hole firing instead of multiple blast holes. Single blast hole firing will provide single hole firing – thus less charge mass per delay and less influence.

21.3 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.

21.4 Stemming length

The current proposed stemming lengths used provides for some 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 20 and 30 times the blast hole diameter. In cases for better 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.

21.5 Safe blasting distance and evacuation

Calculated minimum safe distance is 305 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.

21.6 Road Closure

There are district roads in the vicinity of the project area to be considered. The D1675 road closest to Pit 1 is located at 401 m and road closure needs to be considered when blasting closer than 500 m from road. There may be smaller roads that are used by the local communities that may not be clearly indicated on maps and should also be considered for closures when blasting is done. During blasting care must be taken to ensure all people and animals cleared to outside the unsafe area as determined by the blaster. No specific actions are required for any of the other roads but there may be people and animals on these routes and will require careful planning to main safe blasting radius.

21.7 Photographic Inspections

The option of photographic survey of all structures up to 1500 m from the pit areas 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 areas. At 1500 m the expected level of ground vibration will be perceptible. Figure 26 shows extent of the range of 1500 m around the Pit 1 and Pit 2 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.

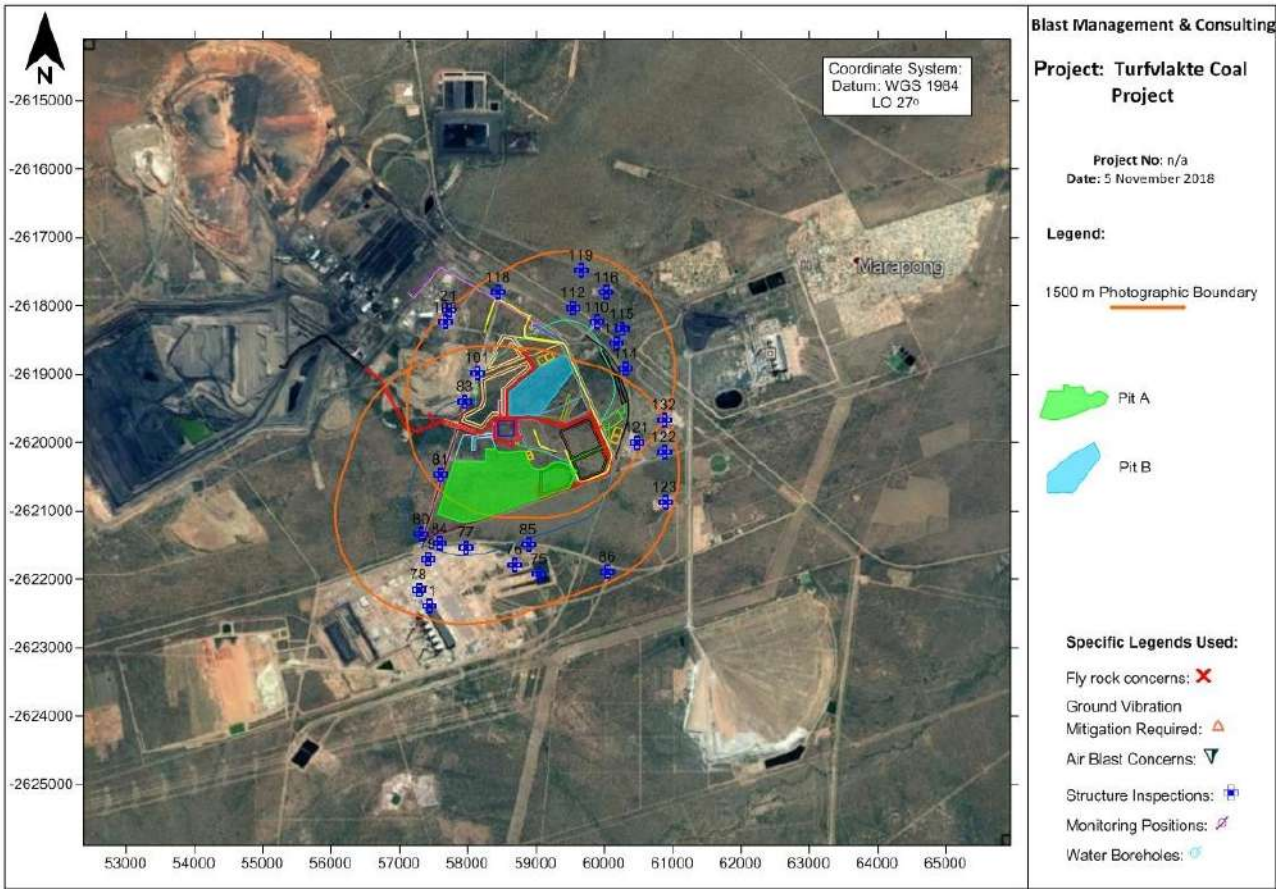


Figure 26: 1500 m area around the Pit 1 and Pit 2 identified for structure inspections.

Table 26: Combined list of structures identified for inspections

Tag	Description	Y	X
21	Railway Line	-57724.34	2618072.60
71	Medupi Power Station	-57431.65	2622390.43
75	Water Reservoirs	-59047.13	2621928.00
76	Tailing Dams	-58687.76	2621786.30
77	Buildings/Structures	-57977.92	2621532.99
78	Buildings/Structures	-57284.09	2622152.11
79	Buildings/Structures	-57422.05	2621705.43
80	Conveyor	-57325.56	2621340.99
81	Conveyor	-57608.62	2620471.60
83	Conveyor	-57962.09	2619399.15
84	D1675 Road	-57595.00	2621480.66
85	D1675 Road	-58885.43	2621495.06
86	D2649 Road	-60045.97	2621891.74
101	Building/Structure	-58141.47	2618979.14

Tag	Description	Y	X
103	Industrial Buildings	-57675.66	2618241.97
110	D2816 Road	-59890.91	2618242.77
111	D2001 Road	-60171.39	2618546.16
112	D2001 Road	-59541.31	2618027.52
114	Reservoir	-60314.01	2618920.85
115	Buildings/Structures	-60262.50	2618342.33
116	Buildings/Structures	-60030.53	2617805.13
118	Conveyor	-58447.32	2617801.36
119	Conveyor	-59658.90	2617479.64
121	Buildings/Structures	-60474.89	2620003.81
122	Buildings/Structures	-60872.99	2620138.16
123	Buildings/Structures	-60886.47	2620875.22
132	Buildings/Structures	-60876.52	2619666.49

21.8 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 27.

Table 27: 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	12.5	
Rural building – Mud houses	6	

21.9 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.

21.10 Third party monitoring

Third party consultation and monitoring should be considered for all ground vibration and air blast monitoring work. This will bring about unbiased evaluation of levels and influence from an independent group. Monitoring could be done using permanent installed stations. Audit functions may also be conducted to assist the mine in maintaining a high level of performance with regards to blast results and the effects related to blasting operations.

21.11 Video monitoring of each blast

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

21.12 Relocation

There are various public houses and installations in close proximity of the pit area. The greatest concerns originate from houses that are located up to 305 m from the pit areas. A relocation program should be considered for all households within this distance. This is a process that will require careful planning and execution.

22 Knowledge Gaps

The data provided from client and information gathered was sufficient to conduct this study. Surface surroundings change continuously and this should be taken into account 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.

23 Conclusion

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed new opencast mining operation. 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.

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 is typical roads (tar and gravel, low cost houses, corrugated iron structures, brick and mortar houses, boreholes and heritage sites.

This project is a greenfield project with no existing blasting operations.

The location of structures around the Pit 1 and Pit 2 areas is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the conveyor, pan, building/structures and Manketti Lodge for Pit 1 and Pit 2. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human perception.

Ground vibration mitigation will be required for these structures. Ground vibrations predicted for all pit areas ranged between low and very high. There are 5 POI's identified for Pit 1 and Pit 2 that is the main concern with regards to ground vibration. There are POI's as close as 309 m from the pit boundary. The expected levels of ground vibration for 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 some concerns for opencast blasting. Maximum air blast levels predicted showed levels less than limit for structures but at levels where complaints can be expected. High levels may contribute to effects such as rattling of roofs or door or windows that could lead to complaints. The current accepted limit on air blast is134dBL. Damagesare 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.

Minimum charge predictions identified that one POI at Pit 1 and one POI at Pit 2 could experience levels of air blast that could lead to complaints. Maximum charge predictions indicate two POI's at Pit 1 and two POI's at Pit 2 that could lead to complaints.

Based on the charges considered it is expected that air blast will be greater than 134 dB at a distance of 117 m and closer to pit boundaries. Minimum and Maximum charge predictions identified that two POI's at Pit 1 and two POI's at Pit 2 could experience levels of air blast that could lead to complaints. Infrastructure at all pit areas such as roads is present but air blast does not have any influence on these installations.

An exclusion zone for safe blasting was also calculated. The exclusion zone was established to be at least 305 m. The use of the normal practice observed in mines of 500 m exclusion zone will include the Conveyor and Pans. The use of minimum 500 m exclusion zone is rather recommended and it will be required that evacuation be negotiated when blasting.

Recommendations were made and should be considered. Specific actions will be required for all pit areas such as Mine Health and Safety Act requirements when blasting is done within 500 m from private structures. Specific blast design that will consider the installations around the pit areas will be needed. Closure of roads during blasting must also be considered.

The pit areas are located such that specific concerns were identified and addressed in the report. The author is however of the opinion that with careful planning of blasting operations and necessary permissions blasting operations will be possible. A changed consideration of blast designs and possible bench levels may be required.

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

24 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.

BM&C 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 BM&C.

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