Blast Management & Consulting

Quality Service on Time

Blast and Vibration Assessment Report

Proposed Palmietkuilen Coal Mining Project

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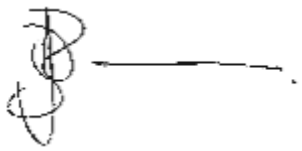
Signed:	
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ii. Study Team Qualifications And Background

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 project applicant. 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 these.

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 7
(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 10
(g)	an identification of any areas to be avoided, including buffers;	Section 10
(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 7
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 8
(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 15
(k)	any mitigation measures for inclusion in the EMPr;	Section 15.15
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 18
(m)	any monitoring requirements for inclusion in the EMPr or	Section 18.11

Legal Requirement		Relevant Section in Specialist study
	environmental authorisation;	
(n)	a reasoned opinion (Environmental Impact Statement)-	Section 20
	as to whether the proposed activity or portions thereof should be authorised; and	Section 20
	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 20
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 11
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Section 11
(q)	any other information requested by the competent authority.	None

v. Document Control:

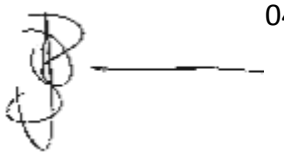
Name	Responsibility	Signature	Date
C Zeeman Blast Management & Consulting	Document Preparation		04/10/2016
JD Zeeman Blast Management & Consulting	Consultant		04/10/2016

Table of Contents

List of Acronyms used in this Report

a and b	Site Constant
ANFO	Ammonium nitrate fuel oil
APP	Air Pressure Pulse
B	Burden (m)
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_s	Air blast level (dB)
P	Air blast level (Pa (mB x 100))
P_o	Reference Pressure (2 x 10^{-5} Pa)
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 per tonne
km	kilometre
kPa	kilopascal
m	metre
m³	metre squared
MJ	Mega Joules
MJ/m³	Mega Joules per cubic meter
MJ/t	Mega Joules per tonne
mB	millibar
mm/s	millimetres per second
mm/s^2	millimetres per second square
ms	milliseconds
Pa	Pascal
ppm	parts per million
psi	pounds per square inch
θ	theta or angle

List of Figures

List of Tables

1 Executive Summary

Pandospan (Pty) Ltd (a subsidiary of the Canyon Group), on behalf of Anglo Operations Pty Limited (AOL), is planning the development of a new open pit coal mining operation on Portions 2 and 9 of the Farm Palmietkuilen 241 IR, near Springs in the Gauteng Province of South Africa. The proposed Project area falls within the Sedibeng District Municipality and borders the Province of Mpumalanga.

Blast Management & Consulting (BM&C) was contracted as part of the Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations on the proposed Palmietkuilen Coal Mining Project located in the Gauteng Province of South Africa. Ground vibration, air blast, fly rock and fumes are some of the aspects resulting from blasting operations. The report concentrates on the possible influences of ground vibration, air blast and fly rock. It intends to provide information, calculations, predictions, possible influences and mitigation of blasting operations for the project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as a 3500 m radius from where blasting will take place. The range of structures observed and considered in this evaluation ranged between industrial structures, farm buildings, power lines and railway lines.

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

There are people and houses at close distances to the project area. The nearest house or building is found at a distance of 101 m from the open pit area. Industrial installations i.e. Power lines and the road are very close to the open pit and can also be found inside the open pit area. Ground vibration mitigation will be required for these structures. Specific attention will be required for adjustments in the blasting operations to ensure expected levels of ground vibration and air blast are within the required limits. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage. There is a possibility that ground vibration may be intolerable at the closest residential houses and Informal housing and unpleasant at the closest chicken farm. Considerations will have to be given to alternative placement or installation of the power lines and road specifically. The ground vibration levels predicted for all installations evaluated surrounding the open pit area ranged between 1.1 mm/s and 4765.4 mm/s. Ground vibration levels at the nearest buildings where people may be present is 375.8 mm/s. These structures considered in the evaluation showed concern for possible damages.

Air blast predicted for the maximum charge ranges between 110.8 and 134.9 dB for all the POI's considered. No specific damages are expected from the levels calculated. Damages are only

expected to occur at levels greater than 134dB. On prediction it is expected that air blast will be greater than 134 dB at a distance of 101 m and closer to the open pit boundary. The nearest buildings are 101 m from the open pit boundary and could be problematic. Air blast that could lead to complaints is however expected to reach distances of 716 m from the pit area. The levels at other private houses or settlements are expected to be within limits and not damaging. Levels at the nearest houses may cause effects such as rattling of roofs or doors and could result in complaints from the owners. Infrastructure such as Power lines and the Road are closer 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 447 m. Normal practice observed in mines is a 500 m exclusion zone. The minimum distance recommended is 447 m. This distance may be greater but not less.

The following recommendations are made and should be considered:

- There are structures and installations within 500 m from the open pit area and specific regulatory authorisations for blasting within 500 m of these installations will be required.
- At time of developing the open pit the blast designs must be reviewed for improvements on the general design used in this report.
- A minimum safe clearance distance of 447 m must be applied.
- Farming activities and travelling on farm roads must be considered when areas are cleared prior to blasting operations.
- Ground vibration limits as recommended and presented should be adhered to.
- The use of a third party to monitor the blasting operations for ground vibration and air blast is recommended.

There is no reason to believe that this operation cannot continue if the recommendations made are adhered to.

Recommendations were made that should be considered, specifically for review of blast designs, monitoring of ground vibration and air blast, safe blasting zones, safe ground vibration and air blast limits, blast designs, blasting times and relocations of infrastructure to be considered.

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

2 Introduction

Pandospan (Pty) Ltd (a subsidiary of the Canyon Group), on behalf of Anglo Operations Pty Limited (AOL), is applying for a Mining Right to mine coal on Portions 1, 2, 4, 9, 13 and 19 of the Farm

Palmietkuilen 241 IR, near Springs in the Gauteng Province of South Africa. The proposed Project area falls within the Sedibeng District Municipality and borders the Province of Mpumalanga.

The applicant is planning the development of a new open pit coal mining operation, located near Springs within the Gauteng Province, to be known as the Palmietkuilen Coal Mining Project. The Project is a greenfields development with the infrastructure based on Portions 2 and 19 of the Farm Palmietkuilen 241 IR.

It is proposed to extract the coal through open pit mining and the current resource is estimated at 125.98 Mt. The life of mine for the project is 53 years including a 2 year ramp-up period. Once the mine has been established a full production rate of 200 000 t / month will be maintained for 51 years.

The proposed infrastructure required on site includes the following:

- Access and haul roads;
- Office blocks;
- Workshops;
- A coal processing plant including a filter press;
- Stockpile areas;
- Pollution control dams;
- Slurry dams;
- A return water dam;
- Storm water trenches and berms; and
- A future development area (to be confirmed).

The establishment of the open pit will lead to the establishment of topsoil, subsoil, and overburden stockpiles. Once coal is extracted it will initially be stored on a Run of Mine (ROM) stockpile before being fed to a processing plant on site which will crush and screen the coal. From there, slurry will be sent to the dense media separator and the remaining solid discard will be placed back into the void. Coal product will be stockpiled on the product stockpile and thereafter transported by truck to the Welgedacht Siding located approximately 2 kilometres (km) from the proposed Project area. The Welgedacht siding is linked to the major rail networks in the area and coal will be transported from there to the relevant markets. Surface water management infrastructure will also be required, thus a pollution control dam will be constructed for all mine-affected water. A slurry dam is also proposed and the slurry will be fed to a Filter Press Plant to extract coal fines to convert into coal “cakes”, which will also be sold as product.

As part of Environmental Impact Assessment (EIA), Blast Management & Consulting (BM&C) was contracted to perform a review of possible impacts from blasting operations for the proposed new

open pit coal mining operation. 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 to outline the expected environmental effects that blasting operations at the Palmietkuilen Coal Mining Project could have on the surrounding environment and to propose specific mitigation measures if 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, project applicant requirements and general indicators in the various appropriate pieces of South African legislation. There is no direct reference in the following acts regarding 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, 1998 (Act No. 107 of 1998) (NEMA)
- Mine Health and Safety Act, 1996 (Act No. 29 of 1996)
- Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA)
- Explosives Act, 2003 (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 a standard for South Africa. Additional restrictions are also considered where necessary. Specifically where structures of lesser integrity is observed i.e. traditional built structures.

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.

- 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 500 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 of the location of blasting operations in relation to surrounding areas according to the regulations from the applicable Acts
- Undertake an impact assessment and identify suitable mitigation measures

5 Study Area

The proposed mining right area is located on Portions 1, 2, 4, 9, 13 and 19 of the Farm Palmietkuilen 241 IR, near Springs in the Gauteng Province of South Africa. The proposed Project area falls within the Sedibeng District Municipality and borders the Province of Mpumalanga. The Project is a greenfields development with the infrastructure based on Portions 2 and 19 of the Farm Palmietkuilen 241 IR at coordinates (Lat/Lon WGS84) 26°15'4.05"S 28°35'3.91"E.

Figure 1 shows a Locality Map of the proposed Project area. Figure 2 shows the Proposed Infrastructure Plan.

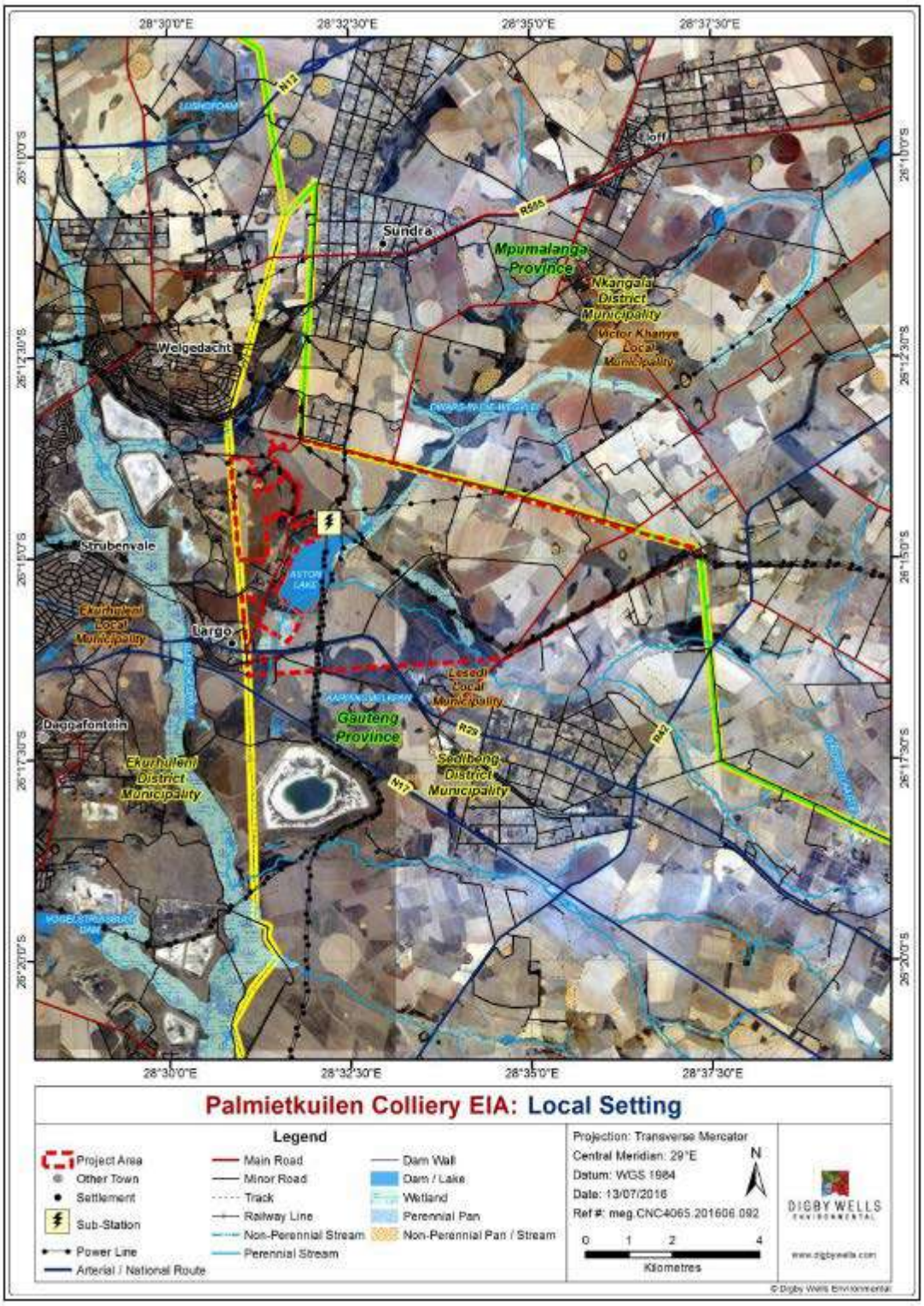


Figure 1: Locality Map of the proposed Project area

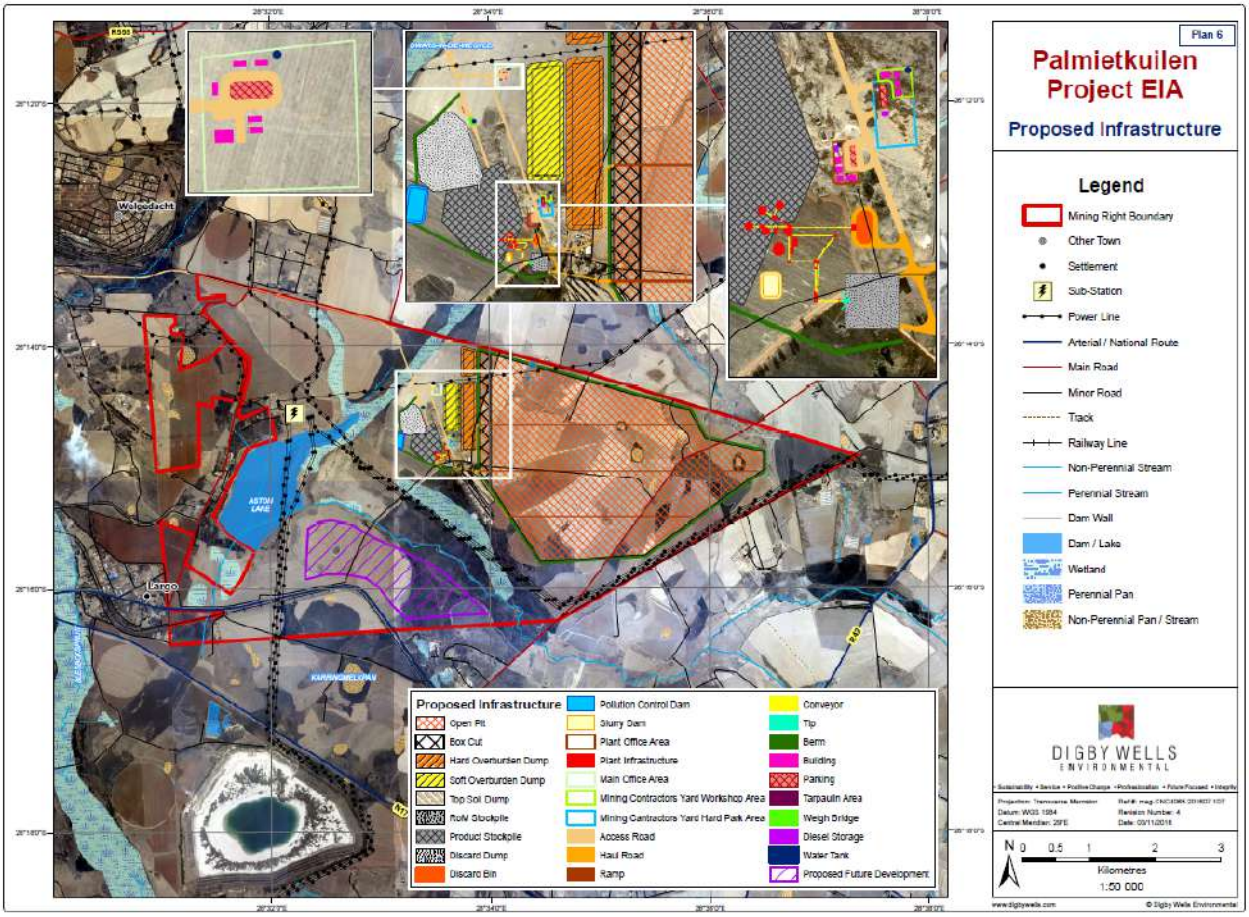


Figure 2: Proposed Infrastructure Plan

6 Methodology

The detailed plan of study consists of the following sections:

- Baseline influence: There are no blasting activities currently being done or no operations yet. The baseline is zero with no specific influence from blasting.
- Identifying surface structures/ installations that are found within reason from the project site. A list of Point of Interests (POI's) were created that will be used for the evaluation.
- Site evaluation: This entails an evaluation of the planned mining, drilling and blasting operations and the possible influences from the blasting operations. The methodology includes the modelling of the expected impacts based on the expected drilling and blasting information provided for the project. Various accepted mathematical equations were applied to determine the attenuation of ground vibration, air blast and fly rock. These values were then calculated over the distance investigated from the site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors gave an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted

levels further gave an indication of the possible mitigation measures to be applied. The possible environmental or social impacts were addressed in the detailed EIA phase investigation.

7 Site Investigation

The site was visited and structure identification was done on 25th October 2016. This site visit was done specifically to get an understanding of the location of the open pit for the project and identifying the structures and installations surrounding the proposed open pit area.

The investigation and evaluation is not season specific. The operations are not season specific.

8 Assumptions and Limitations

The following assumptions have been made:

- The project is a greenfields 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 greenfields 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.

9 Legal Requirements

The protocols applied in this document are based on the author's experience, guidelines elicited by the literature research, project applicant 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 regard 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, 1998 (Act No. 107 of 1998) (NEMA)
- Mine Health and Safety Act, 1996 (Act No. 29 of 1996)

- Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (MPRDA)
- Explosives Act, 2003 (Act No. 15 of 2003)

There are no specific South African standards providing limiting levels regarding ground vibration and air blast. 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. The USBM is well accepted as a standard for South Africa. Additional criteria required by various institutions in South Africa were also taken into consideration, i.e. Eskom, Telkom, Transnet, Rand Water Board, etc. as well as specific limitations regarding traditional built structures where applicable.

In view of the acts consulted the following guidelines and regulations are noted. Only parts of the acts were extracted:

- **Mine Health and Safety Act, 1996 (Act No. 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, 2002 (Act No. 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.

10 Sensitivity of the Project

A review of the project and the surrounding areas is done before any specific analysis is undertaken and sensitivity mapping is undertaken based on typical areas and distance from the proposed shaft area. This sensitivity map uses distances at which 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 decline shaft area.
- An area 500 m to 1500 m around the shaft area can be considered as being a medium sensitive area. In this area, the possibility of impact is still expected, but 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 result in a reaction by surrounding landowners/occupiers.

- An area greater than 1500 m is considered a low sensitivity area. In this area it is relatively certain that influences will be low with low possibility of damages or a reaction by surrounding landowners/occupiers.

Figure 3 shows the sensitivity mapping with the identified POI in the surrounding areas for the Open Pit for the proposed Palmietkuilen Coal Mining Project.

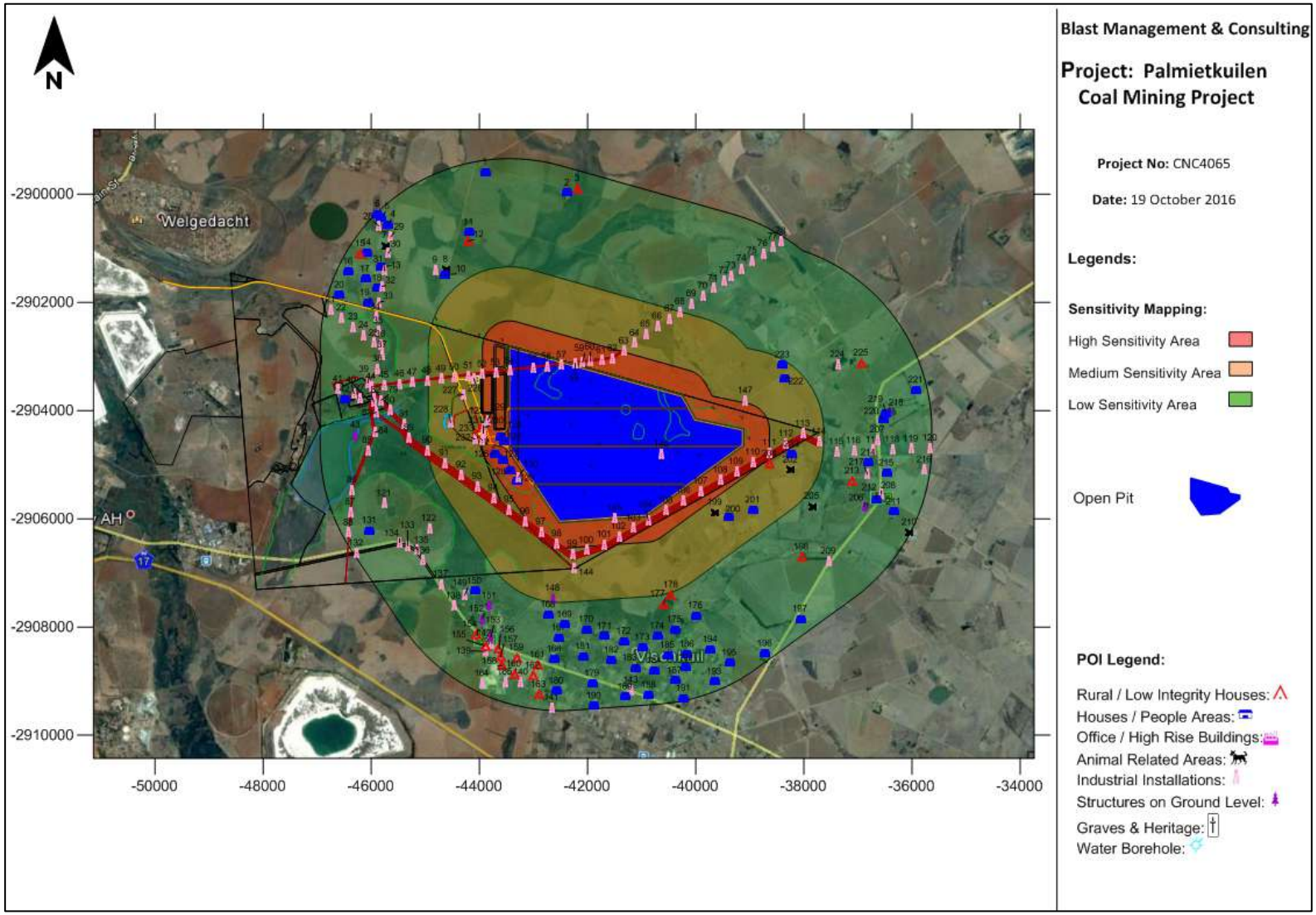


Figure 3: Identified sensitive areas

11 Consultation Process

Digby Wells Environmental as the lead consultant is responsible for the consultation process throughout the EIA. No specific consultation was done by the author with any external parties as part of the study.

12 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 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 standards.

12.1 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 traditional 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 a higher frequency and lower oscillation is synonymous with a 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 to occur.

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 4 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; and
- 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 which are additional criteria that are used by BM&C. 6 mm/s is used for traditional built rural structures and 12.5 mm/s is used for structures that are considered being of lesser structural integrity than brick and mortar structures built according to building regulations.

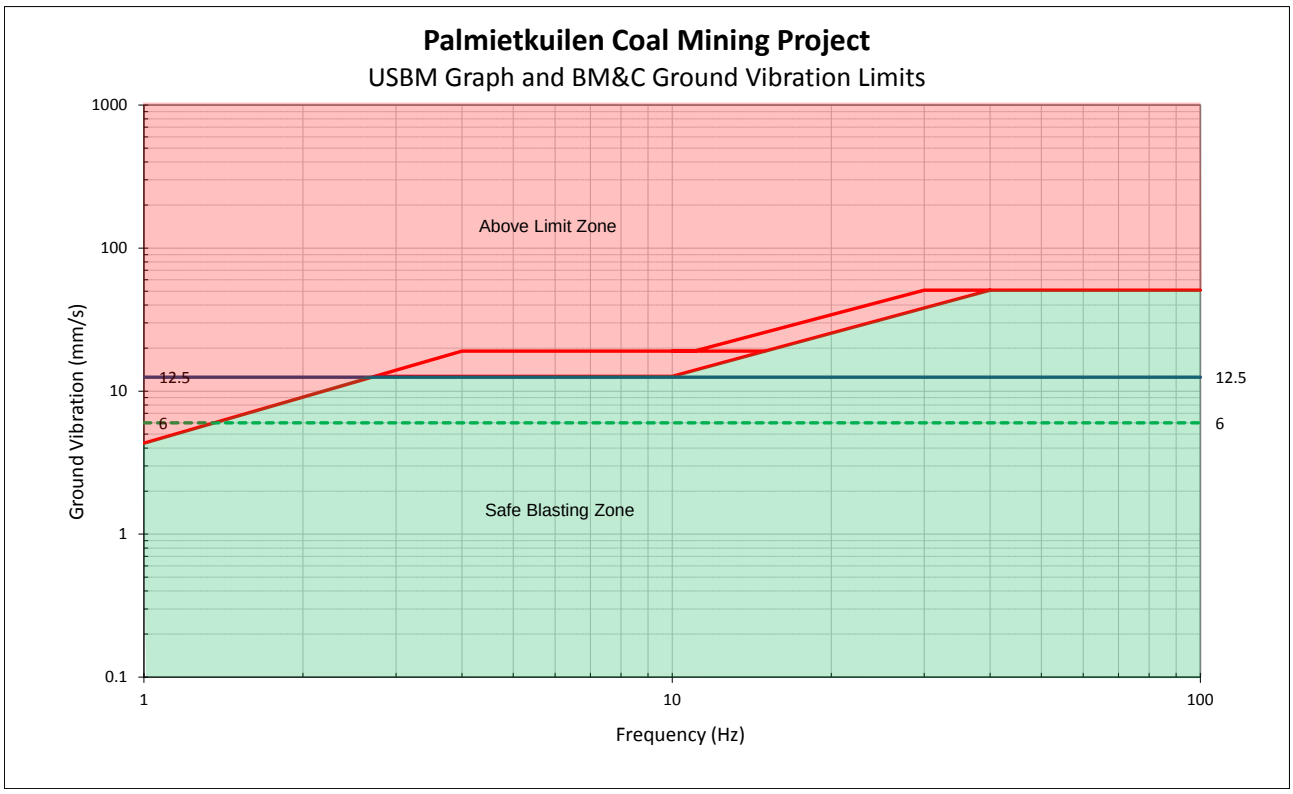


Figure 4: USBM Analysis Graph

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
- 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
- Concrete less than 3 days old: 5 mm/s
- Concrete after 10 days: 200 mm/s

- 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.)
- Waterwells: 50 mm/s

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.
- Traditional 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.

12.2 Ground Vibration Limitations and Human Perceptions

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

Ground vibration is experienced at different levels; 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 5). This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.
Indicated on Figure 5 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 evaluation.

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

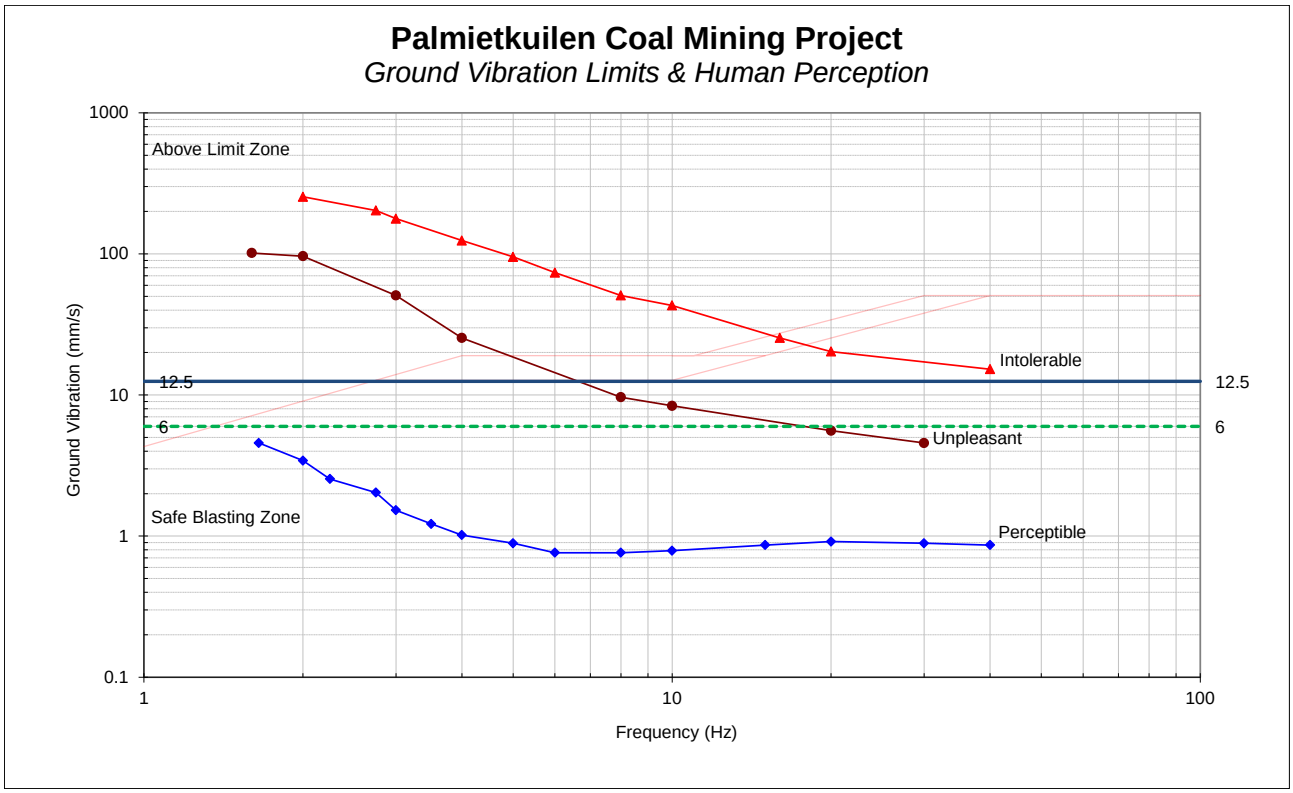


Figure 5: USBM Analysis with Human Perception

12.3 Air Blast Limitations on Structures

Air blast or air-overpressure is a pressure wave generated from the blasting process. Air blast is measured as a 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, 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 134 dBL. 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 135 dB 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.

12.4 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 on structures that startle people will also be reduced, which 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 to the structure.

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

12.5 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 or a decline shaft as in this project. The movement should be in the direction of the free face. The orientation of the blast and expected movement direction is important. Material or elements travelling outside of a planned or expected range would be considered fly rock. Figure 6 shows a schematic representation of the following 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.

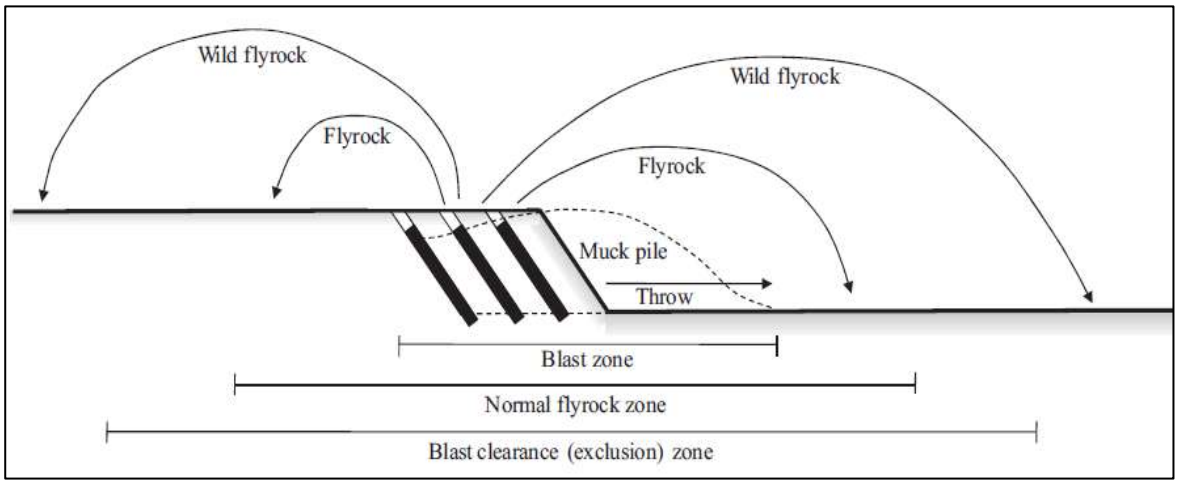


Figure 6: Schematic of fly rock terminology

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.

12.6 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 particularly undesirable. These fumes present themselves as red brown cloud after the blast has detonated. It has been reported that 10 ppm to 20 ppm can be mildly irritating. Exposure to 150 ppm or more (no time period given) has been reported to cause death from pulmonary edema. It has been predicted that there is a 50 % chance of death following exposure to 174 ppm 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.

12.7 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.

12.8 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.

12.9 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 7 below. A typical X crack formations is observed.

Figure 7: Example of blast induced damage.

Observing cracks of this form 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 or else stated was not always applied in the country side when houses were built. 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.

12.10 Blast operations impacts on farm animals

The information and proper study material of the occurrence of blasting operations near farming communities with various animals, wild life areas and wild life in general is limited in exact detail. Some work was done but much related to impact from air blast in nuclear blasts or bombs exploding. This was mainly indication of mid-air detonations occurring and the respective effect. There is not much research done in the field of farm animals or wild live in relation to blasting

operations specifically with regards to social interaction defects or changes or the influence on wellbeing of animals. Information that is available to the author's disposal is summed up in this section. It is certain that these aspects are sensitive and also discussed such that a realistic process and summary can be presented.

Presented here are some personal experiences as observed on projects and work that was found from other researchers in similar fields with regards to farm animal and wild life responses and influences.
Cattle: Cattle seem to be very accommodating with regards to blasting operations. We have seen that for a first time blast, the blast will upset them. Reaction is shown in taking freight and running a short distance – maybe 10 m to 20 m – and then carries on grazing. Second blast they will only lift their heads and carry on grazing. Third blast no specific reaction was shown most of the time.

Chickens: Chickens react to sudden noises. Chickens in a broiler will run into opposite corner of the broiler than the noise source and actually trample each other to death. Chickens in a broiler are considered a problem when blasting is done in close proximity without specific mitigation measures.

House animals: Dogs are sensitive to vibration much more than humans and most probably all animals. Significant vibration levels will have them reacting in barking, getting anxious and possibly running away in opposite direction. One can relate to what typically happens when crackers are fired over Christmas and Guy faux days. Loud noises will certainly have an influence.

Noise affects wildlife differently from humans and the effects of noise on wildlife vary from serious to non-existent in different species and situations. Risk of hearing damage in wildlife is probably greater from exposure to nearby blast noise from bombs and large weapons than from long-lasting exposure to continuous noise or from muzzle blast of small arms fire. Direct physiological effects of noise on wildlife, if present, are difficult to measure in the field. Behavioural effects that might decrease chances of surviving and reproducing could include retreat from favourable habitat near noise sources and reduction of time spent feeding with resulting energy depletion. Serious effects such as decreased reproductive success have apparently been documented in some studies. Decreased responsiveness after repeated noises is frequently observed and usually attributed to habituation. Military and civilian blast noise had no unusual effects (beyond other human-generated noise) on wildlife in most studies, although hearing damage was not an issue in the situations studied and animals were often probably habituated to blasts.

The Animal Research centre at Onderstepoort, South Africa was contacted in the past for information as well but to no prevail as studies in this field does not exist at Onderstepoort. There

has been claims in the past of farmers claiming that the reproductively of pigs were severely hampered due to mining operations but no scientific evidence were presented for this.

A further question on dairy farms is similar that no scientific evidence exists of deterioration of milk production. However previous projects done by BM&C in the vicinity of dairies, it was considered that it is possible that milk production will be hampered when blasting is done during the milking process. In this instance no blasting was allowed prior to milking time. Thus blasting was only done after the daily milking period. This instance the quarry where blasting was done was approximately 800 m away from the dairy.

Work done by Richmond, Damon, Fletcher, Bowen and White considered the effect of air blast on animals from air blast in specific conditions. Animals were tested in shock tubes as well as research from other encompassed into the report. In this research work that was done to define the influence of air blast pressure and the resulting effect on different types and size of animals. Mouse, rabbits, Guinea Pig, hamsters, rat, dog, goat, sheep, cat and cattle were the subjects of this research. The research concentrated on the effect of short duration and long duration pressure pulses, orientation of subject, reflected shock or not and investigated the effect with regards to lethality, lung injury and eardrum rupture. This work was basis for estimates of pressure and possible influence on humans and the required protection of humans in blast situations. Without going into all the detail of the report the following is a summary of the findings. Long duration and fast rising pressure pulses seem to have most influence on the wellbeing of animals. Long duration pressure pulses are also found in the blasting environment. Long duration pressure pulses are defined as pulses beyond 20 msec, and short duration as pulses having duration of less than 5 msec. Lungs are considered the critical organs in such a situation. The release of air bubbles from disrupted alveoli of the lungs into the vascular systems accounted for the rapid deaths. The degree of lung haemorrhage was related to the increase in lung weight and blast dosage. Smaller lung sizes were damaged easier. Larger animals showed threshold of petechial haemorrhage was near 10 psi to 15 psi (68.9476 kPa to 103.421 kPa) at long durations. Ear damage recorded in sheep showed 38% rupture were recorded at 21.4 psi (147.548 kPa) for long durations and severity of damage increased with the intensity of the blast. The following figure (Figure 8) shows the mortality curves for the various animals exposed to long duration pressure pulses.

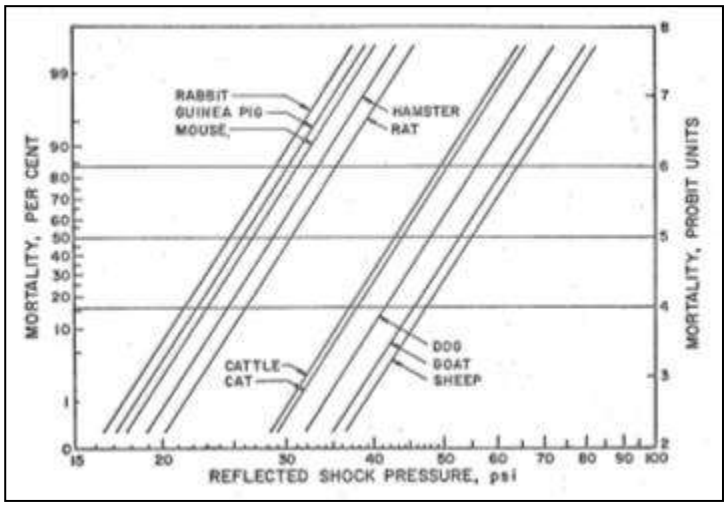


Figure 8: Mortality curve for long duration pressure exposure on animals.

In order to relate to air blast the following Table 3 shows the corresponding air blast level in dB and Pascal. Air blast is measured in Pascal (Pa) but converted to the dB scale for ease of use.

Table 3: Corresponding pressure levels to air blast values in the dB scale.

dB	P (Pa)	kPa	PSI
100.0	2.0	0.002	0.000
120.0	20.0	0.020	0.003
140.0	200.0	0.200	0.029
150.0	632.5	0.632	0.092
155.0	1124.7	1.12	0.163
160.0	2000.0	2.00	0.290
165.0	3556.6	3.56	0.516
170.0	6324.6	6.32	0.917
175.0	11246.8	11.25	1.631
180.0	20000.0	20.00	2.901
185.0	35565.6	35.57	5.158
190.0	63245.6	63.25	9.173
195.0	112468.3	112.47	16.312
200.0	200000.0	200.00	29.008
205.0	355655.9	355.66	51.584
210.0	632455.5	632.46	91.730

Distance between source and receptor will certainly be a major consideration. The greater the distance, the lesser will the effect be of noise or air blast.

13 Baseline Results

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

13.1 Baseline influence

The mine is not operational and do not have any specific influence currently. No specific monitoring was done. The project is not currently active with any blasting operations being done. Baseline data is considered at zero level.

13.2 Structure Profile

As part of the baseline, all possible structures in a possible influence area are identified. The site was reviewed using Google Earth imagery. Information sought during the review was to identify surface structures present in a 3500 m radius from the proposed open pit area, which will require consideration during modelling of blasting operations, e.g. houses, general structures, powerlines, pipelines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the open pit area. The list includes structures and POI within the 3500 m boundary – see Table 4 below. A list of structure locations was required to determine the allowable ground vibration limits and air blast limits. Figure 9 shows an aerial view of the open pit area and surroundings with POIs. The type of POIs identified is grouped into different classes. These classes are indicated as “Classification” in Table 5. The classification used is a BM&C classification and does not relate to any standard or national or international code or practice. Table 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

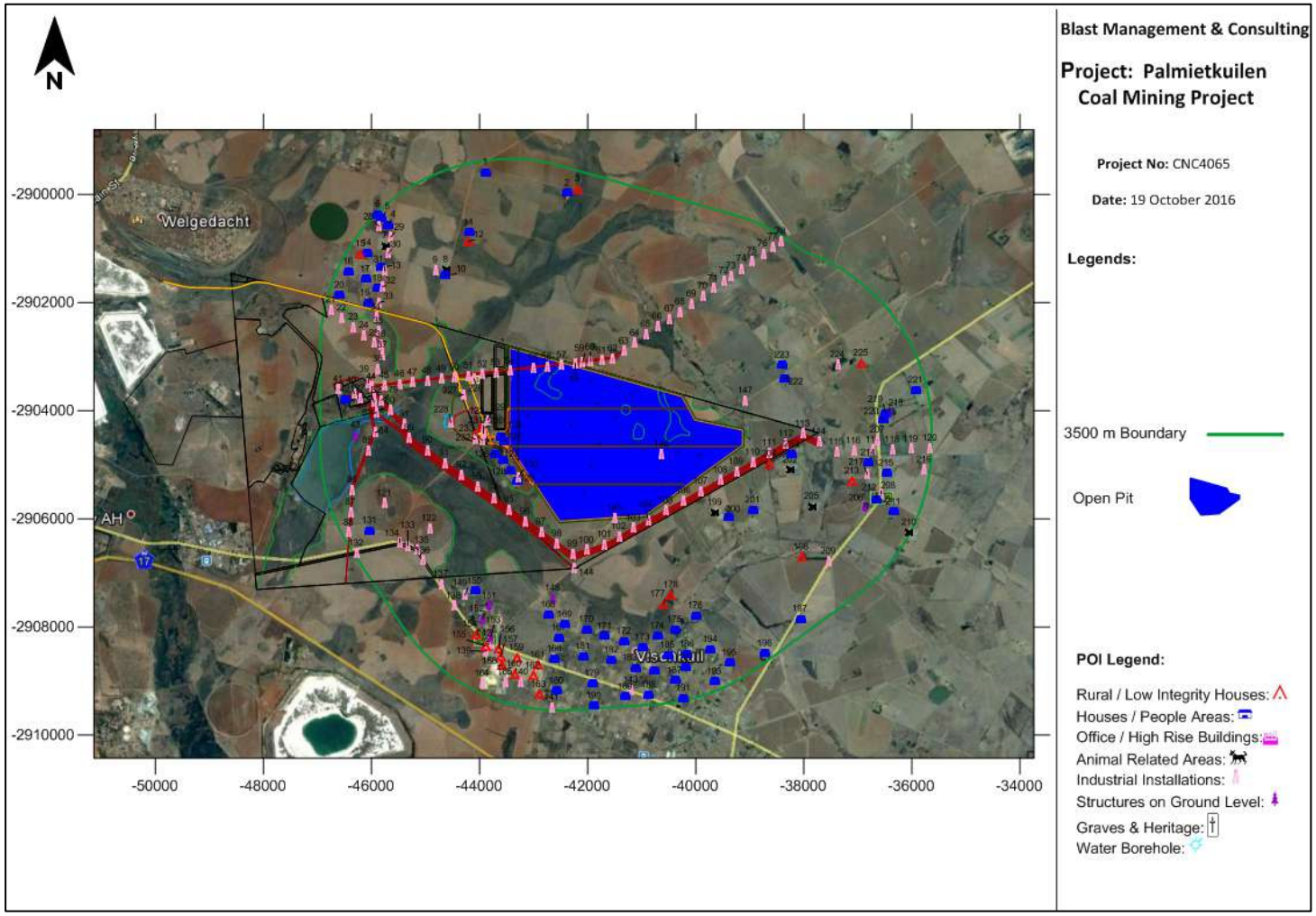


Figure 9: Aerial view and surface plan of the proposed mining area with points of interest identified

Table 5: List of POIs identified (WGS – LO 29°)

Tag	Description	Classification	Y	X
1	Farm Buildings/Structures	2	43886.90	2899587.63
2	Farm Buildings/Structures	2	42372.70	2899973.02
3	Informal Housing	1	42186.81	2899891.39
4	Buildings/Structures	2	45683.23	2900556.23
5	Buildings/Structures	2	45815.19	2900437.83
6	Buildings/Structures	2	45874.45	2900362.32
7	Chicken Farm	4	45743.21	2900945.70
8	Chicken Farm	4	44618.41	2901386.80
9	Grain Silo's	5	44812.00	2901400.66
10	Farm Buildings/Structures	2	44635.97	2901486.09
11	Farm Buildings/Structures	2	44193.87	2900702.34
12	Ruins	1	44208.01	2900865.16
13	Buildings/Structures	2	45810.39	2901346.99
14	Farm Buildings/Structures	2	46079.64	2901075.59
15	Informal Housing	1	46200.53	2901098.83
16	Farm Buildings/Structures	2	46427.43	2901427.35
17	Farm Buildings/Structures	2	46108.01	2901566.40
18	Farm Buildings/Structures	2	45888.39	2901734.40
19	Farm Buildings/Structures	2	46045.67	2902005.34
20	Farm Buildings/Structures	2	46588.33	2901859.98
21	Power lines/Pylons	5	46749.60	2902134.02
22	Power lines/Pylons	5	46551.01	2902284.95
23	Power lines/Pylons	5	46328.78	2902452.18
24	Power lines/Pylons	5	46133.22	2902602.22
25	Power lines/Pylons	5	45946.46	2902747.82
26	Power Distribution Station	5	45955.17	2903776.05
27	Transformers	5	46205.55	2903769.35
28	Power lines/Pylons	5	45862.15	2900584.63
29	Power lines/Pylons	5	45638.22	2900789.87
30	Power lines/Pylons	5	45687.62	2901088.48
31	Power lines/Pylons	5	45748.77	2901415.20
32	Power lines/Pylons	5	45802.32	2901701.31
33	Power lines/Pylons	5	45858.19	2901999.11
34	Power lines/Pylons	5	45912.45	2902270.87
35	Power lines/Pylons	5	45867.84	2902524.18
36	Power lines/Pylons	5	45820.40	2902779.13
37	Power lines/Pylons	5	45788.51	2902969.09
38	Power lines/Pylons	5	45878.35	2903230.72
39	Power lines/Pylons	5	46063.46	2903487.61
40	Power lines/Pylons	5	46321.67	2903682.03
41	Transformers	5	46608.76	2903598.69
42	Buildings/Structures	2	46485.47	2903792.58

Tag	Description	Classification	Y	X
43	Ashton Lake	6	46283.72	2904450.47
44	Power lines/Pylons	5	45996.79	2903556.07
45	Power lines/Pylons	5	45758.27	2903529.91
46	Power lines/Pylons	5	45468.64	2903503.61
47	Power lines/Pylons	5	45238.48	2903475.46
48	Power lines/Pylons	5	44965.49	2903443.81
49	Power lines/Pylons	5	44705.95	2903412.46
50	Power lines/Pylons	5	44454.73	2903384.78
51	Power lines/Pylons	5	44200.63	2903353.24
52	Power lines/Pylons	5	43940.78	2903325.62
53	Power lines/Pylons	5	43698.90	2903298.33
54	Power lines/Pylons (Inside Pit Area)	5	43437.06	2903265.56
55	Power lines/Pylons (Inside Pit Area)	5	43003.64	2903214.25
56	Power lines/Pylons (Inside Pit Area)	5	42753.61	2903183.62
57	Power lines/Pylons (Inside Pit Area)	5	42474.60	2903154.64
58	Power lines/Pylons	5	42227.80	2903125.73
59	Power lines/Pylons	5	42092.19	2903109.90
60	Power lines/Pylons	5	41940.94	2903092.78
61	Power lines/Pylons	5	41742.04	2903069.03
62	Power lines/Pylons	5	41528.88	2903032.26
63	Power lines/Pylons	5	41321.44	2902893.87
64	Power lines/Pylons	5	41121.11	2902747.44
65	Power lines/Pylons	5	40921.85	2902590.98
66	Power lines/Pylons	5	40705.45	2902437.98
67	Power lines/Pylons	5	40476.52	2902303.65
68	Power lines/Pylons	5	40283.06	2902170.56
69	Power lines/Pylons	5	40074.63	2902024.03
70	Power lines/Pylons	5	39863.70	2901877.34
71	Power lines/Pylons	5	39672.48	2901738.23
72	Power lines/Pylons	5	39468.43	2901596.78
73	Power lines/Pylons	5	39335.84	2901508.36
74	Power lines/Pylons	5	39143.62	2901373.39
75	Power lines/Pylons	5	38949.82	2901234.41
76	Power lines/Pylons	5	38752.32	2901099.40
77	Power lines/Pylons	5	38565.65	2900969.77
78	Power lines/Pylons	5	38414.86	2900868.90
79	Power lines/Pylons	5	45821.00	2903807.00
80	Power lines/Pylons	5	45648.66	2903993.03
81	Power lines/Pylons	5	45381.33	2904242.94
82	Power lines/Pylons	5	45953.73	2903845.36
83	Power lines/Pylons	5	45910.47	2904034.61
84	Power lines/Pylons	5	45929.99	2904405.07
85	Power lines/Pylons	5	46066.87	2904734.03
86	Power lines/Pylons	5	46350.93	2905464.26
87	Power lines/Pylons	5	46383.72	2905873.66

Tag	Description	Classification	Y	X
88	Power lines/Pylons	5	46415.02	2906255.64
89	Power lines/Pylons	5	45293.66	2904503.05
90	Power lines/Pylons	5	44954.52	2904736.18
91	Power lines/Pylons	5	44644.35	2904966.42
92	Power lines/Pylons	5	44333.60	2905188.78
93	Power lines/Pylons	5	44035.23	2905401.80
94	Power lines/Pylons	5	43738.69	2905612.63
95	Power lines/Pylons	5	43447.61	2905828.53
96	Power lines/Pylons	5	43150.77	2906044.88
97	Power lines/Pylons	5	42857.62	2906242.95
98	Power lines/Pylons	5	42560.78	2906460.69
99	Power lines/Pylons	5	42275.95	2906652.10
100	Power lines/Pylons	5	42015.52	2906578.29
101	Power lines/Pylons	5	41684.30	2906472.59
102	Power lines/Pylons	5	41419.00	2906328.56
103	Power lines/Pylons	5	41143.97	2906170.45
104	Power lines/Pylons	5	40879.80	2906027.45
105	Power lines/Pylons	5	40550.07	2905844.75
106	Power lines/Pylons	5	40220.96	2905666.69
107	Power lines/Pylons	5	39901.67	2905490.07
108	Power lines/Pylons	5	39536.34	2905281.61
109	Power lines/Pylons	5	39247.42	2905124.84
110	Power lines/Pylons	5	38940.72	2904955.14
111	Power lines/Pylons	5	38628.58	2904778.06
112	Power lines/Pylons	5	38324.19	2904608.62
113	Power lines/Pylons	5	38014.55	2904426.71
114	Power lines/Pylons	5	37716.36	2904574.32
115	Power lines/Pylons	5	37393.00	2904759.62
116	Power lines/Pylons	5	37073.93	2904741.18
117	Power lines/Pylons	5	36709.78	2904726.36
118	Power lines/Pylons	5	36358.36	2904716.64
119	Power lines/Pylons	5	36017.06	2904707.04
120	Power lines/Pylons	5	35659.59	2904691.08
121	Pivot Irrigation	5	45759.44	2905714.07
122	Pivot Irrigation	5	44926.26	2906178.16
123	Informal Housing	1	43944.54	2904312.31
124	Buildings/Structures	2	43597.33	2904482.12
125	Farm Buildings/Structures	2	43546.21	2904565.05
126	Buildings/Structures	2	43706.09	2904794.75
127	Buildings/Structures	2	43554.91	2904915.64
128	Buildings/Structures	2	43431.87	2905099.30
129	Buildings/Structures	2	43296.21	2905293.96
130	Silo	5	43273.42	2905224.33
131	Buildings/Structures	2	46028.45	2906214.69
132	Railway Line	5	46278.12	2906632.64

Tag	Description	Classification	Y	X
133	Railway Line	5	45328.29	2906497.48
134	R29 Road	5	45477.90	2906441.21
135	R29 Road	5	45143.84	2906579.56
136	Railway Line	5	45045.37	2906772.46
137	R29 Road	5	44710.06	2907205.98
138	Railway Line	5	44473.71	2907607.37
139	Railway Line	5	43890.47	2908449.17
140	Railway Line	5	43229.59	2909023.16
141	Railway Line	5	42655.69	2909488.28
142	R29 Road	5	43767.08	2908306.11
143	R29 Road	5	41196.58	2909166.36
144	Road	5	42247.38	2906916.33
145	Road	5	41488.10	2905993.23
146	Road (Inside Pit Area)	5	40626.71	2904805.07
147	Road	5	39076.04	2903816.68
148	Pan	6	42642.94	2907467.95
149	Dam	5	44272.55	2907411.34
150	Buildings/Structures	2	44087.07	2907330.57
151	Pan	6	43811.99	2907609.21
152	Pan	6	43953.64	2907850.43
153	Pan	6	43790.60	2908188.22
154	Informal Housing	1	44046.42	2908149.22
155	Informal Housing	1	43893.28	2908353.07
156	Informal Housing	1	43636.74	2908398.81
157	Informal Housing	1	43608.25	2908551.11
158	Informal Housing	1	43578.28	2908709.00
159	Informal Housing	1	43307.22	2908563.65
160	Informal Housing	1	43354.70	2908872.59
161	Informal Housing	1	42920.36	2908700.74
162	Informal Housing	1	43010.14	2908899.86
163	Informal Housing	1	42902.33	2909247.10
164	Dam	5	43949.41	2909040.97
165	Dam	5	43524.07	2909017.12
166	Buildings/Structures	2	42608.64	2908589.51
167	Farm Buildings/Structures	2	42524.91	2908196.87
168	Buildings/Structures	2	42720.62	2907774.53
169	Farm Buildings/Structures	2	42417.97	2907949.44
170	Farm Buildings/Structures	2	42016.55	2908044.66
171	Farm Buildings/Structures	2	41681.71	2908170.32
172	Farm Buildings/Structures	2	41322.06	2908261.48
173	Farm Buildings/Structures	2	40982.26	2908374.88
174	Farm Buildings/Structures	2	40706.65	2908166.16
175	Farm Buildings/Structures	2	40386.63	2908050.78
176	Farm Buildings/Structures	2	39998.90	2907787.78
177	Informal Housing	1	40599.51	2907582.16

Tag	Description	Classification	Y	X
178	Informal Housing	1	40452.65	2907406.09
179	Farm Buildings/Structures	2	41909.31	2909041.97
180	Farm Buildings/Structures	2	42572.85	2909182.13
181	Farm Buildings/Structures	2	42080.21	2908545.56
182	Buildings/Structures	2	41554.05	2908611.48
183	Buildings/Structures	2	41101.02	2908761.04
184	School	2	40764.78	2908808.43
185	Buildings/Structures	2	40515.88	2908519.61
186	Buildings/Structures	2	40156.50	2908504.63
187	Buildings/Structures	2	40382.23	2908988.03
188	Buildings/Structures	2	40861.20	2909257.87
189	Buildings/Structures	2	41302.86	2909289.30
190	Buildings/Structures	2	41876.37	2909459.01
191	Buildings/Structures	2	40221.98	2909318.17
192	Buildings/Structures	2	40176.46	2908750.38
193	Buildings/Structures	2	39649.74	2909008.61
194	Buildings/Structures	2	39725.00	2908414.43
195	Buildings/Structures	2	39369.40	2908661.06
196	Buildings/Structures	2	38717.01	2908491.35
197	Farm Buildings/Structures	2	38061.98	2907851.67
198	Ruins	1	38036.17	2906702.92
199	Chicken Farm	4	39638.89	2905880.78
200	Farm Buildings/Structures	2	39397.91	2905967.63
201	Farm Buildings/Structures	2	38938.19	2905836.78
202	Chicken Farm	4	38239.73	2905093.23
203	Farm Buildings/Structures	2	38216.70	2904806.23
204	Informal Housing	1	38630.69	2904982.01
205	Chicken Farm	4	37846.35	2905769.14
206	Pan	6	36874.45	2905771.00
207	R42 Road	5	36630.61	2904540.31
208	R42 Road	5	36567.34	2905546.35
209	R42 Road	5	37542.75	2906782.43
210	Chicken Farm	4	36043.81	2906249.37
211	Farm Buildings/Structures	2	36337.08	2905869.24
212	Farm Buildings/Structures	2	36654.18	2905643.57
213	Informal Housing	1	37099.15	2905298.80
214	Farm Buildings/Structures	2	36798.18	2904959.26
215	Farm Buildings/Structures	2	36464.91	2905153.17
216	Reservoir	5	35766.97	2905088.61
217	Reservoir	5	36826.86	2905176.09
218	Pan	6	36394.29	2904036.07
219	Buildings/Structures	2	36482.19	2904055.19
220	Farm Buildings/Structures	2	36531.53	2904168.07
221	Farm Buildings/Structures	2	35921.68	2903619.44
222	Farm Buildings/Structures	2	38355.24	2903415.21

Tag	Description	Classification	Y	X
223	Farm Buildings/Structures	2	38393.82	2903153.24
224	Dam	5	37368.46	2903147.38
225	Ruins	1	36936.72	2903117.43
226	Mine Infrastructure-Mine Office Buildings	5	44108.01	2903408.54
227	Mine Infrastructure-Weigh Bridge	5	44302.37	2903697.90
228	Mine Infrastructure-Pollution Control Dam	5	44532.93	2904219.26
229	Mine Infrastructure-Buildings	5	43845.18	2904174.24
230	Mine Infrastructure-Plant Office	5	43929.25	2904327.83
231	Mine Infrastructure-Plant Infrastructure	5	43929.68	2904419.06
232	Mine Infrastructure-Slurry Dam	5	44079.95	2904527.04
233	Mine Infrastructure-Tip	5	43941.66	2904550.79

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

Table 6 shows photos of the structures found in the area.

Table 6: Structure Profile

Structure Photo	Description
	Ruins

Structure Photo	Description
	Farmstead
	Graveyard
	Power lines

Structure Photo	Description
	Settlement southwest of project
	Settlement structures
	Railway line southwest of project

Structure Photo	Description
	House in Viskuil AH
	House in Viskuil AH
	House in Viskuil AH

Structure Photo	Description
	House in Viskuil AH
	Farming in Viskuil AH
	Industrial Site in Viskuil AH

Structure Photo	Description
	North view of Viskuil AH
	North view of Viskuil AH

Structure Photo	Description
	Small settlement
	Structures

Structure Photo	Description
	Chicken broilers
	Chicken Farm

14 Construction Phase: Blast and Vibration Assessment

No drilling and blasting is anticipated as part of the construction phase. No specific evaluation is required as part of the construction phase.

15 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.

15.1 Mining Method

The coal resource will be mined using open pit methods due to the seemly depth of the coal reserve (between 12 and 60 m below the surface). Bench mining and strip mining techniques are proposed. Bench mining involves the development of an open pit through a series of benches at varying depths while strip mining involves the movement of overburden laterally to an adjacent empty pit where the mineral has already been extracted. The proposed project will include one open pit.

Topsoil and subsoil will be stripped using an excavator and will be stored in separate stockpile areas on the mining area. Drilling and blasting will be employed for the hard overburden or bedrock to expose the coal seams. Once blasted, the hard overburden will be excavated and stockpiled separately for rehabilitation. The mined coal from the open pit will be transported via the haul roads and stored on the Run of Mine (RoM) stockpile area. The coal will be fed into a crushing and washing plant with a conveyor after which the coal product will be temporarily stored at the product stockpile area before being transported to the Welgedacht siding for distribution or directly via truck to the relevant markets. A temporary discard dump containing one year's capacity will be constructed to store discard before being either rewashed or backfilled into mined out areas.

15.2 Ground Vibration and Air Blast Predictions

Explosives are used to break rock through the shock waves and gasses yielded from the explosion. Ground vibration and air blast is a result from blasting activities. Factors influencing ground vibration are the charge mass per delay, distance from the blast, the delay period and the geometry of the blast. These factors are controlled by planned design and proper blast preparation.

An aspect that is not normally considered as pre-operation definable is the effect of air blast. This is mainly due to the fact that air blast is an aspect that can be controlled to a great degree by applying basic rules. Air blast is the direct result from the blast process, although influenced by meteorological conditions, the final blast layout, timing, stemming length, stemming material, accessories used, covered blast or not covered blast etc. all has an influence on the outcome of the result.

The opencast bench mining technique will be employed. The following activities will take place during the operation: Topsoil stripping, Softs stripping, Hards drill and blast, Doze, load and haul blasted hards, Drill and blast coal, Load and haul coal.

This project is a new operation with planned drill and blast designs. The following designs were applied to define expected ground vibration, air blast and fly rock influences and levels. The technical information for designs used is provided Table 7 below.

Table 7: Blast design technical information

Technical Aspect	Overburden(1)	Overburden(2)	Coal	Pre-split
B/H Diameter (mm)	165	141	127	165
Burden (m)	4.5	5	12.7	n/a
Spacing (m)	5	5	12.7	2
Average Depth (m)	18	12	12.7	23.6
P/F Blast hole (kg/m^3)	0.86	0.53	0.05	0.81
Stemming Length (m)	4.13	4.00	5.00	n/a
Explosives Per B/H (incl. Subdrill) (kg)	350	160	112	38
Include SubDrill (Yes/No)	No	No	no	no

The designs reported in Table 3 are expected to be the possible options that can be done. In order to evaluate the possible influence, two charge masses that will span the range of possible charge mass per delay were selected. Considering the option of standard shock tube initiation products to be used for coal and overburden blasts a minimum charge selected consists four times a coal blast hole with 111 kg yielding 448 kg per delay. There is indication of pre-split work that will be done and based on information provided a maximum charge due to pre-split blasting was selected. This charge mass per delay consisted of 70 blast holes initiated with 38 kg yielding a total of 2660 kg. This range of minimum and maximum charge will span various alternatives can may be possible. These charge masses were used for baseline modelling in this report. Applying the above charge masses, various ground vibration calculations were done and considered in this report. Attention is given to limit levels of 6 mm/s, 12.5 mm/s and 25 mm/s.

When 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. In the absence of testing or monitoring standard constants are applied. These constants are applied in equation 1 below.

Equation 1:

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

Where:

PPV = Predicted ground vibration (mm/s)

a = Site constant

b = Site constant

D = Distance (m)

E = Explosive Mass (kg)
General factors applied for the constants a & b are:
a = 1143 and
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.

Predicting the outcome of air blast is considered difficult in most circumstances. There are many variables that have influence on the outcome of air blast. In most cases mainly an indication of typical levels can be obtained. 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:

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

Where:

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

The constants for A and B were then selected according to the information as provided in Figure 10 below. Various types of mining operations are expected to yield different results. The information provided in Figure 10[1] 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.

[1] ISEE Blasters Handbook, 18th Edition, Little, January 2011, Ohio USA

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 10: Proposed prediction equations

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

Equation 3:

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

Where:

p_s = Air blast level (dB)

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

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

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

Based on the designs presented on expected drilling and charging design, Table 8 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. A low charge mass and a maximum charge mass as worst case scenario. The charge masses are 442 kg and 2660 kg.

Table 8: Expected Ground Vibration at Various Distances from Charges Applied in this Study

No.	Distance (m)	Expected PPV (mm/s) for 442 kg Charge	Expected PPV (mm/s) for 2660 kg Charge
1	50.0	273.7	1203.0
2	75.0	140.2	616.2
3	150.0	44.7	196.3
4	200.0	27.8	122.1
5	250.0	19.2	84.5
6	300.0	14.2	62.6
7	400.0	8.9	38.9
8	500.0	6.1	26.9
9	600.0	4.5	19.9
10	700.0	3.5	15.5
11	800.0	2.8	12.4
12	900.0	2.3	10.2
13	1000.0	2.0	8.6
14	1250.0	1.4	5.9
15	1500.0	1.0	4.4
16	1750.0	0.8	3.4
17	2000.0	0.6	2.7
18	2500.0	0.4	1.9
19	3000.0	0.3	1.4
20	3500.0	0.2	1.1

Although above equations 2 & 3 was applied for prediction of air blast levels, additional measures are also recommended to ensure that air blast and associated fly-rock possibilities are minimised as best as possible. As discussed earlier the prediction of air blast is very subjective. Following in Table 9 below is a summary of values predicted according to Equation 2 and Equation 3.

Table 9: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) for 442 kg Charge	Air blast (dB) for 2660 kg Charge
1	50.0	135.7	139.8
2	100.0	132.9	137.0
3	150.0	128.1	132.2
4	200.0	126.2	130.3
5	250.0	124.6	128.7
6	300.0	123.4	127.5
7	400.0	121.4	125.5
8	500.0	119.9	124.0
9	600.0	118.6	122.7
10	700.0	117.6	121.7
11	800.0	116.7	120.7
12	900.0	115.8	120.0

13	1000.0	115.1	119.2
14	1250.0	113.6	117.7
15	1500.0	112.4	116.5
16	1750.0	111.4	115.4
17	2000.0	110.4	114.5
18	2500.0	108.9	113.0
19	3000.0	107.6	111.7
20	3500.0	106.6	110.6

15.3 Review of Expected Ground Vibration

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.

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 open 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 low or negligible possibility of influence.

In evaluation the two different charge mass scenarios is considered with regards to ground vibration and air blast. Review of the charge per blast hole and the possible timing of a blast the two different charge mass of 442 and 2660 kg were selected to ensure proper source coverage.

Ground vibration is calculated and modelled for the open pit area at the minimum and maximum charge mass at specific distances from the open pit area. The charge masses applied are according to blast designs discussed in Section 15.1. 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 open pit 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 applicable for the type of structures observed surrounding the open 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 Complaint on human perception scale is coloured "Mustard"
Vibration levels indicated as Perceptible on human perception scale is coloured "Light Green"
General:
POI's that are found inside the open pit area is coloured "Olive Green"

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

- **Minimum charge mass per delay – 442 kg**

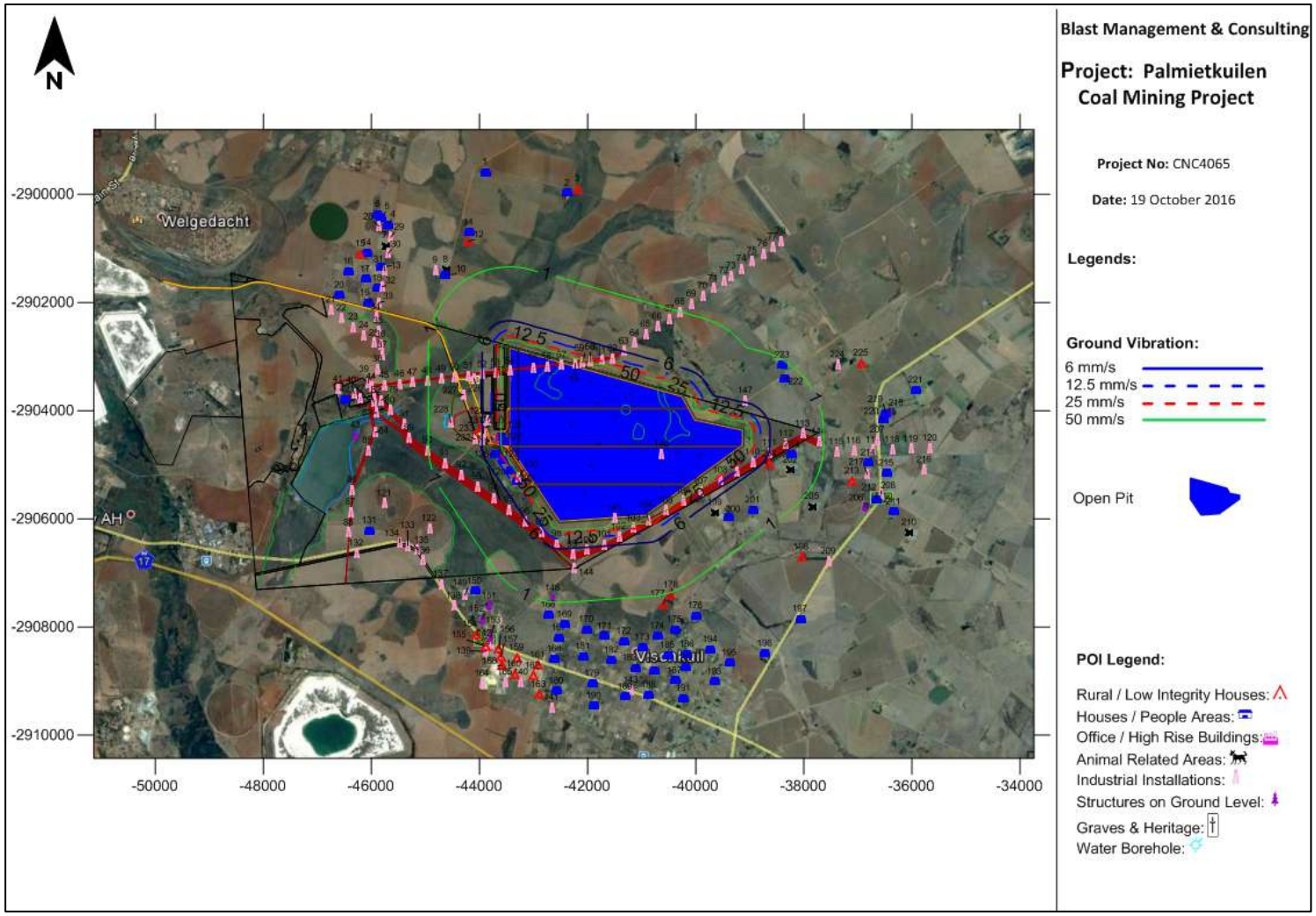


Figure 11: Ground vibration influence from minimum charge for Open Pit Area

Table 10: Ground vibration evaluation for minimum charge for Open Pit Area

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Farm Buildings/Structures	3284	0.3	Acceptable	Too Low
2	Farm Buildings/Structures	3052	0.3	Acceptable	Too Low
3	Informal Housing	3180	0.3	Acceptable	Too Low
4	Buildings/Structures	3199	0.3	Acceptable	Too Low
5	Buildings/Structures	3376	0.3	Acceptable	Too Low
6	Buildings/Structures	3471	0.3	Acceptable	Too Low
7	Chicken Farm	2979	0.3	Acceptable	Too Low
8	Chicken Farm	1869	0.7	Acceptable	Too Low
9	Grain Silo's	1986	0.6	Acceptable	N/A
10	Farm Buildings/Structures	1804	0.7	Acceptable	Too Low
11	Farm Buildings/Structures	2266	0.5	Acceptable	Too Low
12	Ruins	2118	0.6	Acceptable	Too Low
13	Buildings/Structures	2798	0.4	Acceptable	Too Low
14	Farm Buildings/Structures	3172	0.3	Acceptable	Too Low
15	Informal Housing	3260	0.3	Acceptable	Too Low
16	Farm Buildings/Structures	3301	0.3	Acceptable	Too Low
17	Farm Buildings/Structures	2952	0.3	Acceptable	Too Low
18	Farm Buildings/Structures	2682	0.4	Acceptable	Too Low
19	Farm Buildings/Structures	2732	0.4	Acceptable	Too Low
20	Farm Buildings/Structures	3293	0.3	Acceptable	Too Low
21	Power lines/Pylons	3379	0.3	Acceptable	N/A
22	Power lines/Pylons	3155	0.3	Acceptable	N/A
23	Power lines/Pylons	2910	0.3	Acceptable	N/A
24	Power lines/Pylons	2699	0.4	Acceptable	N/A
25	Power lines/Pylons	2503	0.4	Acceptable	N/A
26	Power Distribution Station	2510	0.4	Acceptable	N/A
27	Transformers	2761	0.4	Acceptable	N/A
28	Power lines/Pylons	3307	0.3	Acceptable	N/A
29	Power lines/Pylons	3003	0.3	Acceptable	N/A
30	Power lines/Pylons	2846	0.3	Acceptable	N/A
31	Power lines/Pylons	2709	0.4	Acceptable	N/A
32	Power lines/Pylons	2618	0.4	Acceptable	N/A
33	Power lines/Pylons	2556	0.4	Acceptable	N/A
34	Power lines/Pylons	2533	0.4	Acceptable	N/A
35	Power lines/Pylons	2443	0.4	Acceptable	N/A
36	Power lines/Pylons	2376	0.5	Acceptable	N/A
37	Power lines/Pylons	2344	0.5	Acceptable	N/A
38	Power lines/Pylons	2433	0.5	Acceptable	N/A
39	Power lines/Pylons	2618	0.4	Acceptable	N/A
40	Power lines/Pylons	2877	0.3	Acceptable	N/A
41	Transformers	3164	0.3	Acceptable	N/A
42	Buildings/Structures	3040	0.3	Acceptable	Too Low
43	Ashton Lake	2839	0.3	Acceptable	N/A
44	Power lines/Pylons	2552	0.4	Acceptable	N/A
45	Power lines/Pylons	2313	0.5	Acceptable	N/A

46	Power lines/Pylons	2024	0.6	Acceptable	N/A
47	Power lines/Pylons	1793	0.7	Acceptable	N/A
48	Power lines/Pylons	1520	1.0	Acceptable	N/A
49	Power lines/Pylons	1261	1.3	Acceptable	N/A
50	Power lines/Pylons	1010	1.9	Acceptable	N/A
51	Power lines/Pylons	756	3.1	Acceptable	N/A
52	Power lines/Pylons	496	6.2	Acceptable	N/A
53	Power lines/Pylons	254	18.7	Acceptable	N/A
54	Power lines/Pylons (Inside Pit Area)				
55	Power lines/Pylons (Inside Pit Area)				
56	Power lines/Pylons (Inside Pit Area)				
57	Power lines/Pylons (Inside Pit Area)				
58	Power lines/Pylons	56	227.4	Problematic	N/A
59	Power lines/Pylons	108	76.9	Problematic	N/A
60	Power lines/Pylons	166	37.9	Acceptable	N/A
61	Power lines/Pylons	242	20.3	Acceptable	N/A
62	Power lines/Pylons	335	11.8	Acceptable	N/A
63	Power lines/Pylons	525	5.7	Acceptable	N/A
64	Power lines/Pylons	720	3.4	Acceptable	N/A
65	Power lines/Pylons	925	2.2	Acceptable	N/A
66	Power lines/Pylons	1130	1.6	Acceptable	N/A
67	Power lines/Pylons	1322	1.2	Acceptable	N/A
68	Power lines/Pylons	1502	1.0	Acceptable	N/A
69	Power lines/Pylons	1700	0.8	Acceptable	N/A
70	Power lines/Pylons	1898	0.7	Acceptable	N/A
71	Power lines/Pylons	2084	0.6	Acceptable	N/A
72	Power lines/Pylons	2283	0.5	Acceptable	N/A
73	Power lines/Pylons	2414	0.5	Acceptable	N/A
74	Power lines/Pylons	2616	0.4	Acceptable	N/A
75	Power lines/Pylons	2827	0.4	Acceptable	N/A
76	Power lines/Pylons	3041	0.3	Acceptable	N/A
77	Power lines/Pylons	3248	0.3	Acceptable	N/A
78	Power lines/Pylons	3413	0.3	Acceptable	N/A
79	Power lines/Pylons	2376	0.5	Acceptable	N/A
80	Power lines/Pylons	2204	0.5	Acceptable	N/A
81	Power lines/Pylons	1936	0.7	Acceptable	N/A
82	Power lines/Pylons	2509	0.4	Acceptable	N/A
83	Power lines/Pylons	2465	0.4	Acceptable	N/A
84	Power lines/Pylons	2485	0.4	Acceptable	N/A
85	Power lines/Pylons	2624	0.4	Acceptable	N/A
86	Power lines/Pylons	3016	0.3	Acceptable	N/A
87	Power lines/Pylons	3180	0.3	Acceptable	N/A
88	Power lines/Pylons	3371	0.3	Acceptable	N/A
89	Power lines/Pylons	1849	0.7	Acceptable	N/A
90	Power lines/Pylons	1513	1.0	Acceptable	N/A
91	Power lines/Pylons	1239	1.4	Acceptable	N/A
92	Power lines/Pylons	1034	1.8	Acceptable	N/A
93	Power lines/Pylons	903	2.3	Acceptable	N/A
94	Power lines/Pylons	775	3.0	Acceptable	N/A

95	Power lines/Pylons	654	3.9	Acceptable	N/A
96	Power lines/Pylons	528	5.6	Acceptable	N/A
97	Power lines/Pylons	396	9.0	Acceptable	N/A
98	Power lines/Pylons	420	8.2	Acceptable	N/A
99	Power lines/Pylons	622	4.3	Acceptable	N/A
100	Power lines/Pylons	566	5.0	Acceptable	N/A
101	Power lines/Pylons	484	6.5	Acceptable	N/A
102	Power lines/Pylons	359	10.6	Acceptable	N/A
103	Power lines/Pylons	220	23.7	Acceptable	N/A
104	Power lines/Pylons	107	78.1	Problematic	N/A
105	Power lines/Pylons	152	43.6	Acceptable	N/A
106	Power lines/Pylons	201	27.6	Acceptable	N/A
107	Power lines/Pylons	245	19.9	Acceptable	N/A
108	Power lines/Pylons	291	15.0	Acceptable	N/A
109	Power lines/Pylons	333	12.0	Acceptable	N/A
110	Power lines/Pylons	376	9.8	Acceptable	N/A
111	Power lines/Pylons	529	5.6	Acceptable	N/A
112	Power lines/Pylons	811	2.8	Acceptable	N/A
113	Power lines/Pylons	1120	1.6	Acceptable	N/A
114	Power lines/Pylons	1419	1.1	Acceptable	N/A
115	Power lines/Pylons	1747	0.8	Acceptable	N/A
116	Power lines/Pylons	2064	0.6	Acceptable	N/A
117	Power lines/Pylons	2427	0.5	Acceptable	N/A
118	Power lines/Pylons	2778	0.4	Acceptable	N/A
119	Power lines/Pylons	3119	0.3	Acceptable	N/A
120	Power lines/Pylons	3476	0.2	Acceptable	N/A
121	Pivot Irrigation	2544	0.4	Acceptable	N/A
122	Pivot Irrigation	2076	0.6	Acceptable	N/A
123	Informal Housing	500	6.1	Problematic	Unpleasant
124	Buildings/Structures	153	43.4	Problematic	Intolerable
125	Farm Buildings/Structures	101	85.5	Problematic	Intolerable
126	Buildings/Structures	294	14.7	Acceptable	Unpleasant
127	Buildings/Structures	233	21.5	Acceptable	Intolerable
128	Buildings/Structures	234	21.5	Acceptable	Intolerable
129	Buildings/Structures	230	22.1	Acceptable	Intolerable
130	Silo	172	35.6	Acceptable	N/A
131	Buildings/Structures	3015	0.3	Acceptable	Too Low
132	Railway Line	3451	0.3	Acceptable	N/A
133	Railway Line	2588	0.4	Acceptable	N/A
134	R29 Road	2680	0.4	Acceptable	N/A
135	R29 Road	2480	0.4	Acceptable	N/A
136	Railway Line	2506	0.4	Acceptable	N/A
137	R29 Road	2470	0.4	Acceptable	N/A
138	Railway Line	2507	0.4	Acceptable	N/A
139	Railway Line	2776	0.4	Acceptable	N/A
140	Railway Line	3066	0.3	Acceptable	N/A
141	Railway Line	3447	0.3	Acceptable	N/A
142	R29 Road	2591	0.4	Acceptable	N/A
143	R29 Road	3205	0.3	Acceptable	N/A
144	Road	887	2.4	Acceptable	N/A
145	Road	22	1084.0	Problematic	N/A
146	Road (Inside Pit Area)				

147	Road	544	5.3	Acceptable	N/A
148	Pan	1430	1.1	Acceptable	N/A
149	Dam	2228	0.5	Acceptable	N/A
150	Buildings/Structures	2033	0.6	Acceptable	Too Low
151	Pan	2036	0.6	Acceptable	N/A
152	Pan	2313	0.5	Acceptable	N/A
153	Pan	2500	0.4	Acceptable	N/A
154	Informal Housing	2608	0.4	Acceptable	Too Low
155	Informal Housing	2694	0.4	Acceptable	Too Low
156	Informal Housing	2613	0.4	Acceptable	Too Low
157	Informal Housing	2740	0.4	Acceptable	Too Low
158	Informal Housing	2873	0.3	Acceptable	Too Low
159	Informal Housing	2644	0.4	Acceptable	Too Low
160	Informal Housing	2954	0.3	Acceptable	Too Low
161	Informal Housing	2689	0.4	Acceptable	Too Low
162	Informal Housing	2900	0.3	Acceptable	Too Low
163	Informal Housing	3227	0.3	Acceptable	Too Low
164	Dam	3327	0.3	Acceptable	N/A
165	Dam	3143	0.3	Acceptable	N/A
166	Buildings/Structures	2547	0.4	Acceptable	Too Low
167	Farm Buildings/Structures	2152	0.6	Acceptable	Too Low
168	Buildings/Structures	1744	0.8	Acceptable	Perceptible
169	Farm Buildings/Structures	1907	0.7	Acceptable	Too Low
170	Farm Buildings/Structures	2029	0.6	Acceptable	Too Low
171	Farm Buildings/Structures	2178	0.5	Acceptable	Too Low
172	Farm Buildings/Structures	2294	0.5	Acceptable	Too Low
173	Farm Buildings/Structures	2431	0.5	Acceptable	Too Low
174	Farm Buildings/Structures	2244	0.5	Acceptable	Too Low
175	Farm Buildings/Structures	2186	0.5	Acceptable	Too Low
176	Farm Buildings/Structures	2075	0.6	Acceptable	Too Low
177	Informal Housing	1681	0.8	Acceptable	Perceptible
178	Informal Housing	1548	0.9	Acceptable	Perceptible
179	Farm Buildings/Structures	3031	0.3	Acceptable	Too Low
180	Farm Buildings/Structures	3138	0.3	Acceptable	Too Low
181	Farm Buildings/Structures	2524	0.4	Acceptable	Too Low
182	Buildings/Structures	2627	0.4	Acceptable	Too Low
183	Buildings/Structures	2808	0.4	Acceptable	Too Low
184	School	2878	0.3	Acceptable	Too Low
185	Buildings/Structures	2619	0.4	Acceptable	Too Low
186	Buildings/Structures	2685	0.4	Acceptable	Too Low
187	Buildings/Structures	3103	0.3	Acceptable	Too Low
188	Buildings/Structures	3320	0.3	Acceptable	Too Low
189	Buildings/Structures	3320	0.3	Acceptable	Too Low
190	Buildings/Structures	3450	0.3	Acceptable	Too Low
191	Buildings/Structures	3458	0.3	Acceptable	Too Low
192	Buildings/Structures	2916	0.3	Acceptable	Too Low
193	Buildings/Structures	3331	0.3	Acceptable	Too Low
194	Buildings/Structures	2758	0.4	Acceptable	Too Low
195	Buildings/Structures	3143	0.3	Acceptable	Too Low
196	Buildings/Structures	3370	0.3	Acceptable	Too Low
197	Farm Buildings/Structures	3237	0.3	Acceptable	Too Low
198	Ruins	2322	0.5	Acceptable	Too Low

199	Chicken Farm	716	3.4	Acceptable	Perceptible
200	Farm Buildings/Structures	927	2.2	Acceptable	Perceptible
201	Farm Buildings/Structures	1091	1.7	Acceptable	Perceptible
202	Chicken Farm	1010	1.9	Acceptable	Perceptible
203	Farm Buildings/Structures	936	2.2	Acceptable	Perceptible
204	Informal Housing	617	4.3	Acceptable	Perceptible
205	Chicken Farm	1723	0.8	Acceptable	Perceptible
206	Pan	2534	0.4	Acceptable	N/A
207	R42 Road	2504	0.4	Acceptable	N/A
208	R42 Road	2728	0.4	Acceptable	N/A
209	R42 Road	2676	0.4	Acceptable	N/A
210	Chicken Farm	3492	0.2	Acceptable	Too Low
211	Farm Buildings/Structures	3062	0.3	Acceptable	Too Low
212	Farm Buildings/Structures	2682	0.4	Acceptable	Too Low
213	Informal Housing	2144	0.6	Acceptable	Too Low
214	Farm Buildings/Structures	2361	0.5	Acceptable	Too Low
215	Farm Buildings/Structures	2722	0.4	Acceptable	Too Low
216	Reservoir	3400	0.3	Acceptable	N/A
217	Reservoir	2373	0.5	Acceptable	N/A
218	Pan	2762	0.4	Acceptable	N/A
219	Buildings/Structures	2672	0.4	Acceptable	Too Low
220	Farm Buildings/Structures	2612	0.4	Acceptable	Too Low
221	Farm Buildings/Structures	3301	0.3	Acceptable	Too Low
222	Farm Buildings/Structures	1230	1.4	Acceptable	Perceptible
223	Farm Buildings/Structures	1420	1.1	Acceptable	Perceptible
224	Dam	2150	0.6	Acceptable	N/A
225	Ruins	2533	0.4	Acceptable	Too Low
226	Mine Infrastructure-Mine Office Buildings	663	3.8	Acceptable	N/A
227	Mine Infrastructure-Weigh Bridge	857	2.5	Acceptable	N/A
228	Mine Infrastructure-Pollution Control Dam	1088	1.7	Acceptable	N/A
229	Mine Infrastructure-Buildings	400	8.8	Acceptable	N/A
230	Mine Infrastructure-Plant Office	484	6.5	Acceptable	N/A
231	Mine Infrastructure-Plant Infrastructure	485	6.4	Acceptable	N/A
232	Mine Infrastructure-Slurry Dam	635	4.1	Acceptable	N/A
233	Mine Infrastructure-Tip	497	6.2	Acceptable	N/A

- **Maximum charge per delay – 2660 kg**

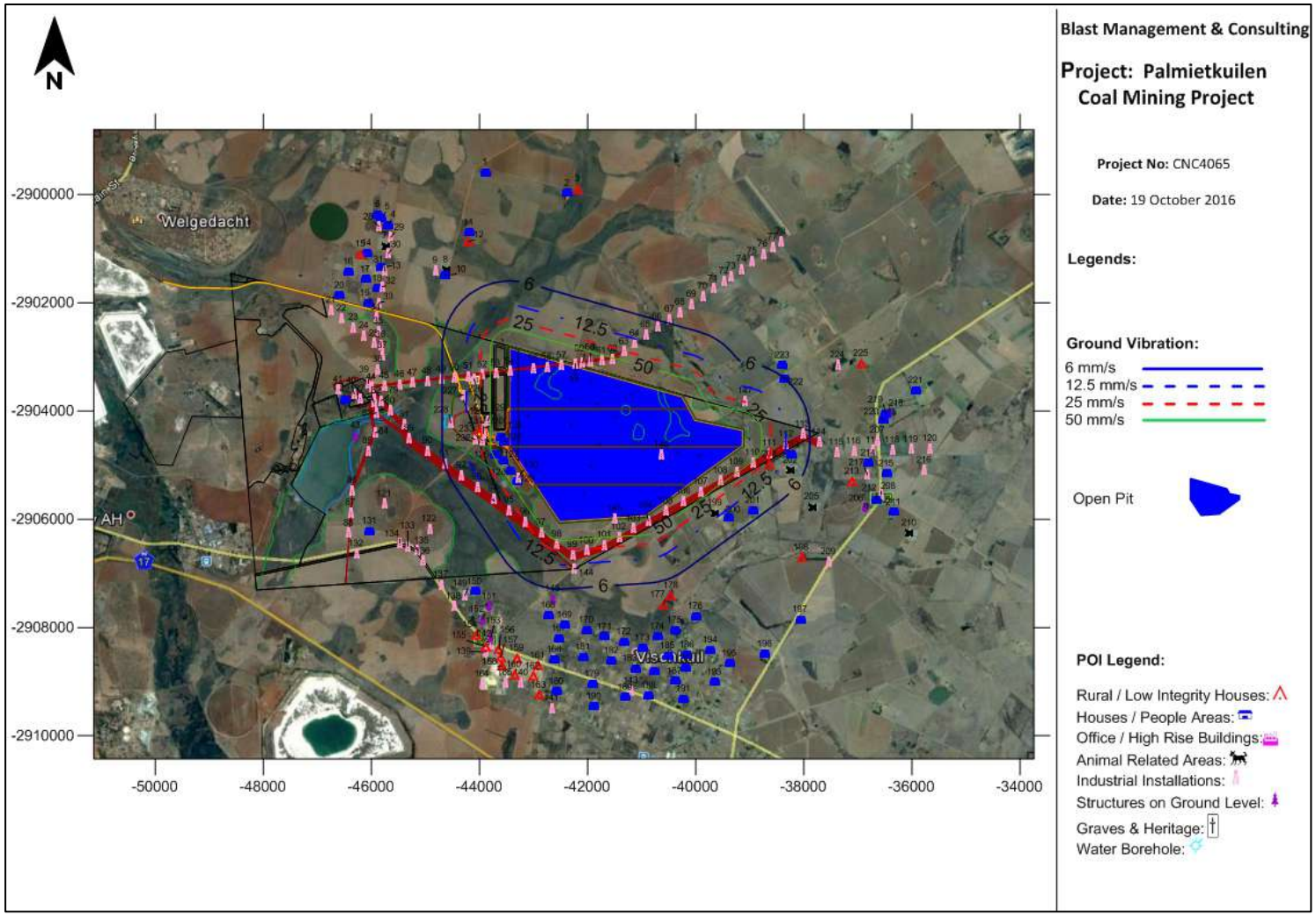


Figure 12: Ground vibration influence from maximum charge for Open Pit Area

Table 11: Ground vibration evaluation for maximum charge for Open Pit Area

Tag	Description	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Farm Buildings/Structures	3284	1.2	Acceptable	Perceptible
2	Farm Buildings/Structures	3052	1.4	Acceptable	Perceptible
3	Informal Housing	3180	1.3	Acceptable	Perceptible
4	Buildings/Structures	3199	1.3	Acceptable	Perceptible
5	Buildings/Structures	3376	1.2	Acceptable	Perceptible
6	Buildings/Structures	3471	1.1	Acceptable	Perceptible
7	Chicken Farm	2979	1.4	Acceptable	Perceptible
8	Chicken Farm	1869	3.1	Acceptable	Perceptible
9	Grain Silo's	1986	2.8	Acceptable	N/A
10	Farm Buildings/Structures	1804	3.2	Acceptable	Perceptible
11	Farm Buildings/Structures	2266	2.2	Acceptable	Perceptible
12	Ruins	2118	2.5	Acceptable	Perceptible
13	Buildings/Structures	2798	1.6	Acceptable	Perceptible
14	Farm Buildings/Structures	3172	1.3	Acceptable	Perceptible
15	Informal Housing	3260	1.2	Acceptable	Perceptible
16	Farm Buildings/Structures	3301	1.2	Acceptable	Perceptible
17	Farm Buildings/Structures	2952	1.4	Acceptable	Perceptible
18	Farm Buildings/Structures	2682	1.7	Acceptable	Perceptible
19	Farm Buildings/Structures	2732	1.6	Acceptable	Perceptible
20	Farm Buildings/Structures	3293	1.2	Acceptable	Perceptible
21	Power lines/Pylons	3379	1.2	Acceptable	N/A
22	Power lines/Pylons	3155	1.3	Acceptable	N/A
23	Power lines/Pylons	2910	1.5	Acceptable	N/A
24	Power lines/Pylons	2699	1.7	Acceptable	N/A
25	Power lines/Pylons	2503	1.9	Acceptable	N/A
26	Power Distribution Station	2510	1.9	Acceptable	N/A
27	Transformers	2761	1.6	Acceptable	N/A
28	Power lines/Pylons	3307	1.2	Acceptable	N/A
29	Power lines/Pylons	3003	1.4	Acceptable	N/A
30	Power lines/Pylons	2846	1.5	Acceptable	N/A
31	Power lines/Pylons	2709	1.7	Acceptable	N/A
32	Power lines/Pylons	2618	1.8	Acceptable	N/A
33	Power lines/Pylons	2556	1.8	Acceptable	N/A
34	Power lines/Pylons	2533	1.9	Acceptable	N/A
35	Power lines/Pylons	2443	2.0	Acceptable	N/A
36	Power lines/Pylons	2376	2.1	Acceptable	N/A
37	Power lines/Pylons	2344	2.1	Acceptable	N/A
38	Power lines/Pylons	2433	2.0	Acceptable	N/A
39	Power lines/Pylons	2618	1.8	Acceptable	N/A
40	Power lines/Pylons	2877	1.5	Acceptable	N/A
41	Transformers	3164	1.3	Acceptable	N/A
42	Buildings/Structures	3040	1.4	Acceptable	Perceptible
43	Ashton Lake	2839	1.5	Acceptable	N/A
44	Power lines/Pylons	2552	1.8	Acceptable	N/A
45	Power lines/Pylons	2313	2.2	Acceptable	N/A

46	Power lines/Pylons	2024	2.7	Acceptable	N/A
47	Power lines/Pylons	1793	3.3	Acceptable	N/A
48	Power lines/Pylons	1520	4.3	Acceptable	N/A
49	Power lines/Pylons	1261	5.9	Acceptable	N/A
50	Power lines/Pylons	1010	8.4	Acceptable	N/A
51	Power lines/Pylons	756	13.6	Acceptable	N/A
52	Power lines/Pylons	496	27.3	Acceptable	N/A
53	Power lines/Pylons	254	82.3	Problematic	N/A
54	Power lines/Pylons (Inside Pit Area)				
55	Power lines/Pylons (Inside Pit Area)				
56	Power lines/Pylons (Inside Pit Area)				
57	Power lines/Pylons (Inside Pit Area)				
58	Power lines/Pylons	56	999.6	Problematic	N/A
59	Power lines/Pylons	108	338.1	Problematic	N/A
60	Power lines/Pylons	166	166.8	Problematic	N/A
61	Power lines/Pylons	242	89.1	Problematic	N/A
62	Power lines/Pylons	335	52.1	Acceptable	N/A
63	Power lines/Pylons	525	24.9	Acceptable	N/A
64	Power lines/Pylons	720	14.8	Acceptable	N/A
65	Power lines/Pylons	925	9.8	Acceptable	N/A
66	Power lines/Pylons	1130	7.0	Acceptable	N/A
67	Power lines/Pylons	1322	5.4	Acceptable	N/A
68	Power lines/Pylons	1502	4.4	Acceptable	N/A
69	Power lines/Pylons	1700	3.6	Acceptable	N/A
70	Power lines/Pylons	1898	3.0	Acceptable	N/A
71	Power lines/Pylons	2084	2.6	Acceptable	N/A
72	Power lines/Pylons	2283	2.2	Acceptable	N/A
73	Power lines/Pylons	2414	2.0	Acceptable	N/A
74	Power lines/Pylons	2616	1.8	Acceptable	N/A
75	Power lines/Pylons	2827	1.5	Acceptable	N/A
76	Power lines/Pylons	3041	1.4	Acceptable	N/A
77	Power lines/Pylons	3248	1.2	Acceptable	N/A
78	Power lines/Pylons	3413	1.1	Acceptable	N/A
79	Power lines/Pylons	2376	2.1	Acceptable	N/A
80	Power lines/Pylons	2204	2.3	Acceptable	N/A
81	Power lines/Pylons	1936	2.9	Acceptable	N/A
82	Power lines/Pylons	2509	1.9	Acceptable	N/A
83	Power lines/Pylons	2465	1.9	Acceptable	N/A
84	Power lines/Pylons	2485	1.9	Acceptable	N/A
85	Power lines/Pylons	2624	1.7	Acceptable	N/A
86	Power lines/Pylons	3016	1.4	Acceptable	N/A
87	Power lines/Pylons	3180	1.3	Acceptable	N/A
88	Power lines/Pylons	3371	1.2	Acceptable	N/A
89	Power lines/Pylons	1849	3.1	Acceptable	N/A
90	Power lines/Pylons	1513	4.3	Acceptable	N/A
91	Power lines/Pylons	1239	6.0	Acceptable	N/A
92	Power lines/Pylons	1034	8.1	Acceptable	N/A
93	Power lines/Pylons	903	10.2	Acceptable	N/A
94	Power lines/Pylons	775	13.1	Acceptable	N/A
95	Power lines/Pylons	654	17.3	Acceptable	N/A
96	Power lines/Pylons	528	24.6	Acceptable	N/A
97	Power lines/Pylons	396	39.6	Acceptable	N/A

98	Power lines/Pylons	420	35.9	Acceptable	N/A
99	Power lines/Pylons	622	18.8	Acceptable	N/A
100	Power lines/Pylons	566	21.9	Acceptable	N/A
101	Power lines/Pylons	484	28.4	Acceptable	N/A
102	Power lines/Pylons	359	46.5	Acceptable	N/A
103	Power lines/Pylons	220	104.1	Problematic	N/A
104	Power lines/Pylons	107	343.1	Problematic	N/A
105	Power lines/Pylons	152	191.9	Problematic	N/A
106	Power lines/Pylons	201	121.4	Problematic	N/A
107	Power lines/Pylons	245	87.4	Problematic	N/A
108	Power lines/Pylons	291	65.9	Acceptable	N/A
109	Power lines/Pylons	333	52.6	Acceptable	N/A
110	Power lines/Pylons	376	43.1	Acceptable	N/A
111	Power lines/Pylons	529	24.6	Acceptable	N/A
112	Power lines/Pylons	811	12.1	Acceptable	N/A
113	Power lines/Pylons	1120	7.1	Acceptable	N/A
114	Power lines/Pylons	1419	4.8	Acceptable	N/A
115	Power lines/Pylons	1747	3.4	Acceptable	N/A
116	Power lines/Pylons	2064	2.6	Acceptable	N/A
117	Power lines/Pylons	2427	2.0	Acceptable	N/A
118	Power lines/Pylons	2778	1.6	Acceptable	N/A
119	Power lines/Pylons	3119	1.3	Acceptable	N/A
120	Power lines/Pylons	3476	1.1	Acceptable	N/A
121	Pivot Irrigation	2544	1.8	Acceptable	N/A
122	Pivot Irrigation	2076	2.6	Acceptable	N/A
123	Informal Housing	500	27.0	Problematic	Intolerable
124	Buildings/Structures	153	190.9	Problematic	Intolerable
125	Farm Buildings/Structures	101	375.8	Problematic	Intolerable
126	Buildings/Structures	294	64.7	Problematic	Intolerable
127	Buildings/Structures	233	94.7	Problematic	Intolerable
128	Buildings/Structures	234	94.4	Problematic	Intolerable
129	Buildings/Structures	230	97.1	Problematic	Intolerable
130	Silo	172	156.3	Problematic	N/A
131	Buildings/Structures	3015	1.4	Acceptable	Perceptible
132	Railway Line	3451	1.1	Acceptable	N/A
133	Railway Line	2588	1.8	Acceptable	N/A
134	R29 Road	2680	1.7	Acceptable	N/A
135	R29 Road	2480	1.9	Acceptable	N/A
136	Railway Line	2506	1.9	Acceptable	N/A
137	R29 Road	2470	1.9	Acceptable	N/A
138	Railway Line	2507	1.9	Acceptable	N/A
139	Railway Line	2776	1.6	Acceptable	N/A
140	Railway Line	3066	1.4	Acceptable	N/A
141	Railway Line	3447	1.1	Acceptable	N/A
142	R29 Road	2591	1.8	Acceptable	N/A
143	R29 Road	3205	1.3	Acceptable	N/A
144	Road	887	10.5	Acceptable	N/A
145	Road	22	4765.4	Problematic	N/A
146	Road (Inside Pit Area)				
147	Road	544	23.4	Acceptable	N/A
148	Pan	1430	4.8	Acceptable	N/A
149	Dam	2228	2.3	Acceptable	N/A

150	Buildings/Structures	2033	2.7	Acceptable	Perceptible
151	Pan	2036	2.7	Acceptable	N/A
152	Pan	2313	2.2	Acceptable	N/A
153	Pan	2500	1.9	Acceptable	N/A
154	Informal Housing	2608	1.8	Acceptable	Perceptible
155	Informal Housing	2694	1.7	Acceptable	Perceptible
156	Informal Housing	2613	1.8	Acceptable	Perceptible
157	Informal Housing	2740	1.6	Acceptable	Perceptible
158	Informal Housing	2873	1.5	Acceptable	Perceptible
159	Informal Housing	2644	1.7	Acceptable	Perceptible
160	Informal Housing	2954	1.4	Acceptable	Perceptible
161	Informal Housing	2689	1.7	Acceptable	Perceptible
162	Informal Housing	2900	1.5	Acceptable	Perceptible
163	Informal Housing	3227	1.2	Acceptable	Perceptible
164	Dam	3327	1.2	Acceptable	N/A
165	Dam	3143	1.3	Acceptable	N/A
166	Buildings/Structures	2547	1.8	Acceptable	Perceptible
167	Farm Buildings/Structures	2152	2.4	Acceptable	Perceptible
168	Buildings/Structures	1744	3.4	Acceptable	Perceptible
169	Farm Buildings/Structures	1907	3.0	Acceptable	Perceptible
170	Farm Buildings/Structures	2029	2.7	Acceptable	Perceptible
171	Farm Buildings/Structures	2178	2.4	Acceptable	Perceptible
172	Farm Buildings/Structures	2294	2.2	Acceptable	Perceptible
173	Farm Buildings/Structures	2431	2.0	Acceptable	Perceptible
174	Farm Buildings/Structures	2244	2.3	Acceptable	Perceptible
175	Farm Buildings/Structures	2186	2.4	Acceptable	Perceptible
176	Farm Buildings/Structures	2075	2.6	Acceptable	Perceptible
177	Informal Housing	1681	3.6	Acceptable	Perceptible
178	Informal Housing	1548	4.2	Acceptable	Perceptible
179	Farm Buildings/Structures	3031	1.4	Acceptable	Perceptible
180	Farm Buildings/Structures	3138	1.3	Acceptable	Perceptible
181	Farm Buildings/Structures	2524	1.9	Acceptable	Perceptible
182	Buildings/Structures	2627	1.7	Acceptable	Perceptible
183	Buildings/Structures	2808	1.6	Acceptable	Perceptible
184	School	2878	1.5	Acceptable	Perceptible
185	Buildings/Structures	2619	1.8	Acceptable	Perceptible
186	Buildings/Structures	2685	1.7	Acceptable	Perceptible
187	Buildings/Structures	3103	1.3	Acceptable	Perceptible
188	Buildings/Structures	3320	1.2	Acceptable	Perceptible
189	Buildings/Structures	3320	1.2	Acceptable	Perceptible
190	Buildings/Structures	3450	1.1	Acceptable	Perceptible
191	Buildings/Structures	3458	1.1	Acceptable	Perceptible
192	Buildings/Structures	2916	1.5	Acceptable	Perceptible
193	Buildings/Structures	3331	1.2	Acceptable	Perceptible
194	Buildings/Structures	2758	1.6	Acceptable	Perceptible
195	Buildings/Structures	3143	1.3	Acceptable	Perceptible
196	Buildings/Structures	3370	1.2	Acceptable	Perceptible
197	Farm Buildings/Structures	3237	1.2	Acceptable	Perceptible
198	Ruins	2322	2.1	Acceptable	Perceptible
199	Chicken Farm	716	14.9	Acceptable	Unpleasant
200	Farm Buildings/Structures	927	9.7	Acceptable	Unpleasant
201	Farm Buildings/Structures	1091	7.4	Acceptable	Unpleasant

202	Chicken Farm	1010	8.4	Acceptable	Unpleasant
203	Farm Buildings/Structures	936	9.6	Acceptable	Unpleasant
204	Informal Housing	617	19.0	Problematic	Unpleasant
205	Chicken Farm	1723	3.5	Acceptable	Perceptible
206	Pan	2534	1.9	Acceptable	N/A
207	R42 Road	2504	1.9	Acceptable	N/A
208	R42 Road	2728	1.6	Acceptable	N/A
209	R42 Road	2676	1.7	Acceptable	N/A
210	Chicken Farm	3492	1.1	Acceptable	Perceptible
211	Farm Buildings/Structures	3062	1.4	Acceptable	Perceptible
212	Farm Buildings/Structures	2682	1.7	Acceptable	Perceptible
213	Informal Housing	2144	2.4	Acceptable	Perceptible
214	Farm Buildings/Structures	2361	2.1	Acceptable	Perceptible
215	Farm Buildings/Structures	2722	1.6	Acceptable	Perceptible
216	Reservoir	3400	1.1	Acceptable	N/A
217	Reservoir	2373	2.1	Acceptable	N/A
218	Pan	2762	1.6	Acceptable	N/A
219	Buildings/Structures	2672	1.7	Acceptable	Perceptible
220	Farm Buildings/Structures	2612	1.8	Acceptable	Perceptible
221	Farm Buildings/Structures	3301	1.2	Acceptable	Perceptible
222	Farm Buildings/Structures	1230	6.1	Acceptable	Unpleasant
223	Farm Buildings/Structures	1420	4.8	Acceptable	Perceptible
224	Dam	2150	2.4	Acceptable	N/A
225	Ruins	2533	1.9	Acceptable	Perceptible
226	Mine Infrastructure-Mine Office Buildings	663	16.9	Acceptable	N/A
227	Mine Infrastructure-Weigh Bridge	857	11.1	Acceptable	N/A
228	Mine Infrastructure-Pollution Control Dam	1088	7.5	Acceptable	N/A
229	Mine Infrastructure-Buildings	400	38.9	Problematic	N/A
230	Mine Infrastructure-Plant Office	484	28.4	Problematic	N/A
231	Mine Infrastructure-Plant Infrastructure	485	28.4	Problematic	N/A
232	Mine Infrastructure-Slurry Dam	635	18.2	Acceptable	N/A

15.4 Summary of Ground Vibration Levels

The Open Pit operations were evaluated for expected levels of ground vibration from future blasting operations. Review of the sites and the surrounding installations / houses / buildings / mine infrastructure showed that structures vary in distances from the open pit area. The evaluation considered a distance up to 3500 m from the mining area.

The distances between structures and the open pit area is the main contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated that levels of ground vibration will change as well. In view of the maximum charge specific attention will need to be given to specific areas.

Review of the site shows power lines that pass through the northern part of the open pit as well as the road that runs through the pit area on the southern side. Currently it is uncertain if the power lines or the road will be relocated.

The closest structures to the open pit area are the road, power lines, mine infrastructure and buildings/structures. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human perception.

The nearest public houses are located 101 m from the open pit boundary. The ground vibration levels predicted ranged between 1.1 mm/s and 4765.4 mm/s for structures surrounding the open pit area. Ground vibration levels at the nearest buildings where people may be present is 375.8 mm/s. The nearest structures considered in the evaluation showed concerns for possible damages and the levels of ground vibration could be experienced as intolerable. The levels predicted also show low levels of ground vibration that could be experienced as intolerable at the maximum charge on the human perception scale at the houses further away from the pit area.

There are structures that are better built and some that are of lesser quality integrity. Only a detailed survey will pin point exactly what type of structure is found where.

In view of the above it is believed that specific mitigations will be required near POIs that have been identified as possible concerns such as possible relocation of relevant households.

15.5 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 13 below). Data applicable to human response only is plotted. The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. From Figure 13 it can be seen that the ground vibration levels predicted is expected to be greater than the perceptible level but mostly less than the unpleasant level. These POI’s are found in a distance range between 3470 m and 1548 m from the pit boundary. POI’s identified close to the pit area is expected to experience ground vibration levels as intolerable. These installations are found up to distances of 715 m. POI’s closer to the pit area could be influenced more aggressively.

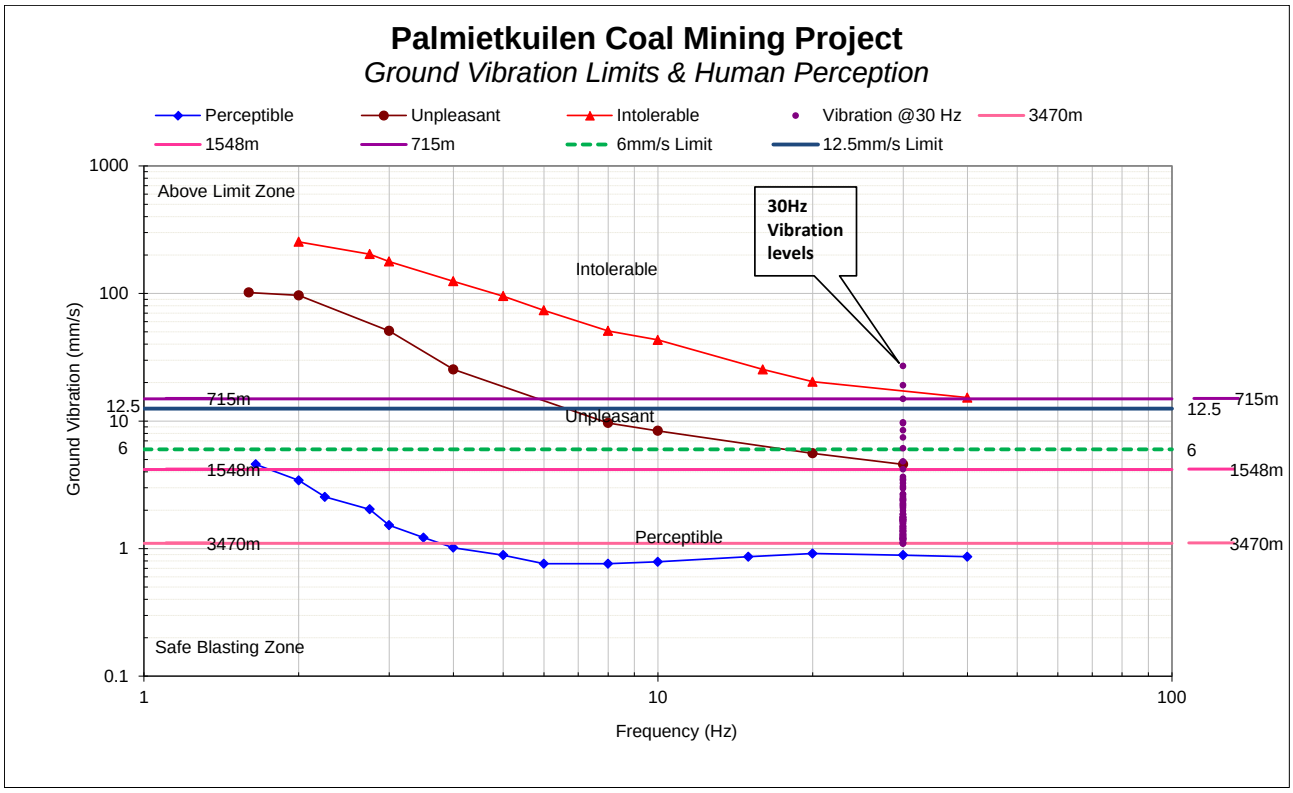


Figure 13: The effect of ground vibration with human perception and vibration limits

15.6 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 structures in close proximity of the pit area. Structures are in some cases right next to the pit area and in some cases within the pit areas.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 3470 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 1793 m. Within these distance ranges there are a significant number of houses. The anticipated ground vibration levels are certain to have possibility of upsetting the adjacent communities. Intolerable levels are expected up to a distance of 715 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.

15.7 Cracking of houses and consequent devaluation

The structures found in the areas of concern ranges from informal building style to brick and mortar structures, industrial structures and various types of roads. There are various villages and houses 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.
Some of the structures i.e. corrugated iron structures are relatively safe from ground vibrations but brick and mortar or traditional built houses or houses in poor state should be considered.
The presence of general vertical cracks, horizontal and diagonal cracks that are found in typical brick 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.
Review of structures, distance from pit area and the expected levels of ground vibration from maximum charge, the problematic indicators identified structures up to a distance of 617 m. The structures within this range could possibly be influenced. This distance is reduced to 500m for minimum charge applied.

The proposed limits as applied in this document i.e. 6 mm/s, 12.5 mm/s and 25 mm/s is 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. Mitigation measures will be required to manage the levels of ground vibration.

15.8 Vibration Impact on Roads

Two provincial roads (R29 and R42) are in the vicinity of the project area and needs to be considered. These provincial roads are at closest points for the R29 at 2470 m and the R42 at 2504 m in the vicinity of the project area. No specific actions are required for these roads.
There are gravel roads that link the different farming areas. These routes are specifically of concern when blasting is done. There may be people and animals on these routes and will require careful planning to main safe blasting radius.
The road on the southern side is running through the planned opencast area. Re-routing of this road will be required.

15.9 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 decline shaft 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 dBL.
    - "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 dBL.
    - "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 the shaft areas. 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 open pit area is coloured "Olive Green"

- **Minimum charge per delay - 442 kg**

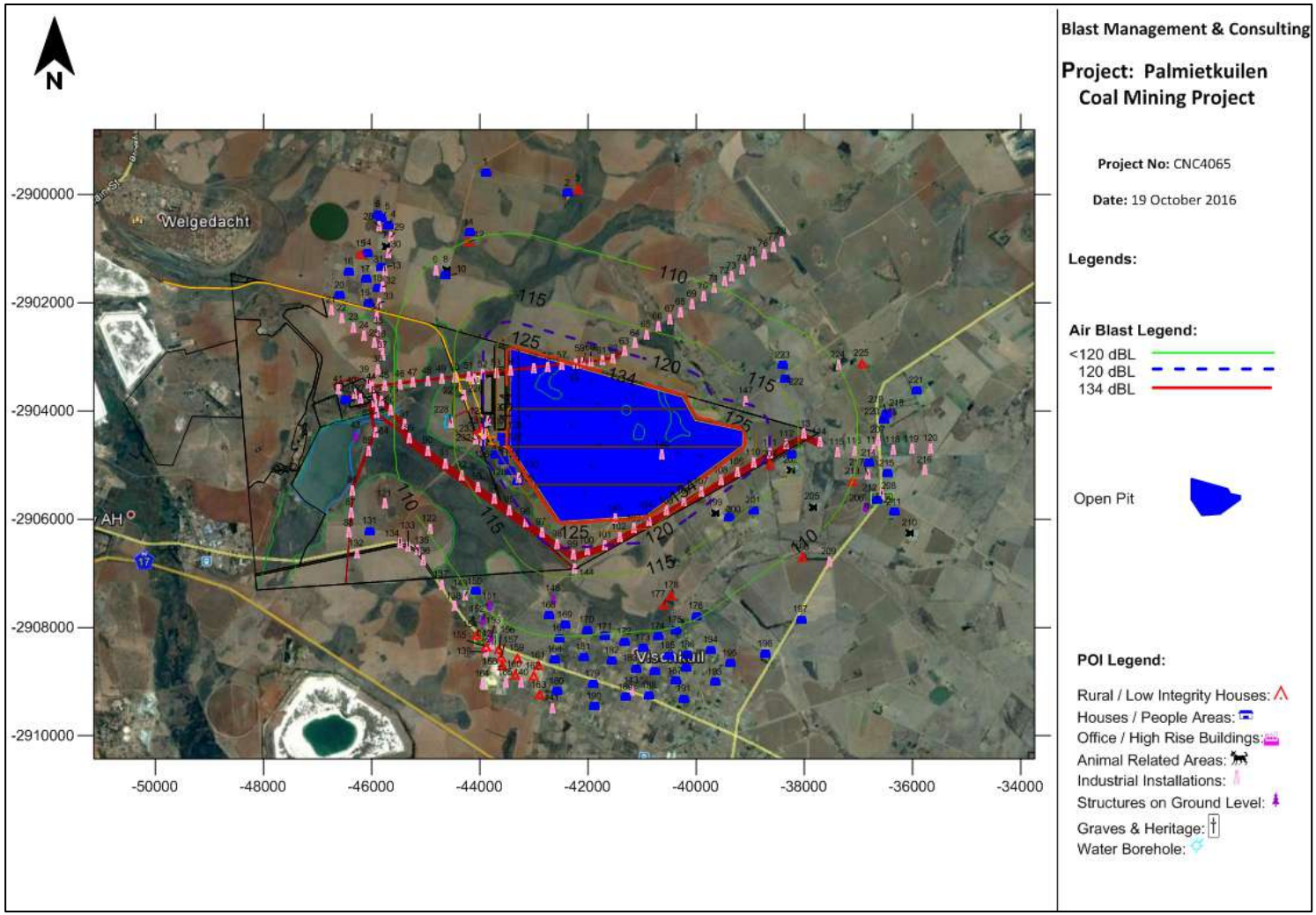


Figure 14: Air blast influence from minimum charge for Open Pit Area

Table 12: Air blast evaluation for minimum charge for Open Pit Area

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Farm Buildings/Structures	3284	107.0	Acceptable
2	Farm Buildings/Structures	3052	107.6	Acceptable
3	Informal Housing	3180	107.2	Acceptable
4	Buildings/Structures	3199	107.2	Acceptable
5	Buildings/Structures	3376	106.8	Acceptable
6	Buildings/Structures	3471	106.6	Acceptable
7	Chicken Farm	2979	107.8	Acceptable
8	Chicken Farm	1869	110.9	Acceptable
9	Grain Silo's	1986	110.5	N/A
10	Farm Buildings/Structures	1804	111.1	Acceptable
11	Farm Buildings/Structures	2266	109.5	Acceptable
12	Ruins	2118	110.0	Acceptable
13	Buildings/Structures	2798	108.1	Acceptable
14	Farm Buildings/Structures	3172	107.2	Acceptable
15	Informal Housing	3260	107.0	Acceptable
16	Farm Buildings/Structures	3301	107.0	Acceptable
17	Farm Buildings/Structures	2952	107.8	Acceptable
18	Farm Buildings/Structures	2682	108.5	Acceptable
19	Farm Buildings/Structures	2732	108.3	Acceptable
20	Farm Buildings/Structures	3293	107.0	Acceptable
21	Power lines/Pylons	3379	106.8	N/A
22	Power lines/Pylons	3155	107.2	N/A
23	Power lines/Pylons	2910	107.8	N/A
24	Power lines/Pylons	2699	108.3	N/A
25	Power lines/Pylons	2503	108.9	N/A
26	Power Distribution Station	2510	108.9	N/A
27	Transformers	2761	108.3	N/A
28	Power lines/Pylons	3307	107.0	N/A
29	Power lines/Pylons	3003	107.6	N/A
30	Power lines/Pylons	2846	108.0	N/A
31	Power lines/Pylons	2709	108.3	N/A
32	Power lines/Pylons	2618	108.6	N/A
33	Power lines/Pylons	2556	108.8	N/A
34	Power lines/Pylons	2533	108.8	N/A
35	Power lines/Pylons	2443	109.1	N/A
36	Power lines/Pylons	2376	109.2	N/A
37	Power lines/Pylons	2344	109.4	N/A
38	Power lines/Pylons	2433	109.1	N/A
39	Power lines/Pylons	2618	108.6	N/A
40	Power lines/Pylons	2877	108.0	N/A
41	Transformers	3164	107.2	N/A
42	Buildings/Structures	3040	107.6	Acceptable
43	Ashton Lake	2839	108.0	N/A
44	Power lines/Pylons	2552	108.8	N/A
45	Power lines/Pylons	2313	109.4	N/A

46	Power lines/Pylons	2024	110.4	N/A
47	Power lines/Pylons	1793	111.1	N/A
48	Power lines/Pylons	1520	112.3	N/A
49	Power lines/Pylons	1261	113.5	N/A
50	Power lines/Pylons	1010	115.1	N/A
51	Power lines/Pylons	756	117.1	N/A
52	Power lines/Pylons	496	120.0	N/A
53	Power lines/Pylons	254	124.5	N/A
54	Power lines/Pylons (Inside Pit Area)			N/A
55	Power lines/Pylons (Inside Pit Area)			N/A
56	Power lines/Pylons (Inside Pit Area)			N/A
57	Power lines/Pylons (Inside Pit Area)			N/A
58	Power lines/Pylons	56	134.9	N/A
59	Power lines/Pylons	108	130.4	N/A
60	Power lines/Pylons	166	127.5	N/A
61	Power lines/Pylons	242	124.9	N/A
62	Power lines/Pylons	335	122.6	N/A
63	Power lines/Pylons	525	119.6	N/A
64	Power lines/Pylons	720	117.4	N/A
65	Power lines/Pylons	925	115.7	N/A
66	Power lines/Pylons	1130	114.3	N/A
67	Power lines/Pylons	1322	113.3	N/A
68	Power lines/Pylons	1502	112.4	N/A
69	Power lines/Pylons	1700	111.5	N/A
70	Power lines/Pylons	1898	110.8	N/A
71	Power lines/Pylons	2084	110.1	N/A
72	Power lines/Pylons	2283	109.5	N/A
73	Power lines/Pylons	2414	109.1	N/A
74	Power lines/Pylons	2616	108.6	N/A
75	Power lines/Pylons	2827	108.1	N/A
76	Power lines/Pylons	3041	107.6	N/A
77	Power lines/Pylons	3248	107.0	N/A
78	Power lines/Pylons	3413	106.8	N/A
79	Power lines/Pylons	2376	109.2	N/A
80	Power lines/Pylons	2204	109.8	N/A
81	Power lines/Pylons	1936	110.6	N/A
82	Power lines/Pylons	2509	108.9	N/A
83	Power lines/Pylons	2465	108.9	N/A
84	Power lines/Pylons	2485	108.9	N/A
85	Power lines/Pylons	2624	108.6	N/A
86	Power lines/Pylons	3016	107.6	N/A
87	Power lines/Pylons	3180	107.2	N/A
88	Power lines/Pylons	3371	106.8	N/A
89	Power lines/Pylons	1849	111.0	N/A
90	Power lines/Pylons	1513	112.4	N/A
91	Power lines/Pylons	1239	113.7	N/A
92	Power lines/Pylons	1034	114.9	N/A
93	Power lines/Pylons	903	115.8	N/A
94	Power lines/Pylons	775	116.9	N/A
95	Power lines/Pylons	654	118.1	N/A
96	Power lines/Pylons	528	119.5	N/A
97	Power lines/Pylons	396	121.5	N/A

98	Power lines/Pylons	420	121.1	N/A
99	Power lines/Pylons	622	118.4	N/A
100	Power lines/Pylons	566	119.0	N/A
101	Power lines/Pylons	484	120.1	N/A
102	Power lines/Pylons	359	122.1	N/A
103	Power lines/Pylons	220	125.5	N/A
104	Power lines/Pylons	107	130.5	N/A
105	Power lines/Pylons	152	128.0	N/A
106	Power lines/Pylons	201	126.1	N/A
107	Power lines/Pylons	245	124.8	N/A
108	Power lines/Pylons	291	123.6	N/A
109	Power lines/Pylons	333	122.7	N/A
110	Power lines/Pylons	376	121.8	N/A
111	Power lines/Pylons	529	119.5	N/A
112	Power lines/Pylons	811	116.6	N/A
113	Power lines/Pylons	1120	114.4	N/A
114	Power lines/Pylons	1419	112.8	N/A
115	Power lines/Pylons	1747	111.4	N/A
116	Power lines/Pylons	2064	110.2	N/A
117	Power lines/Pylons	2427	109.1	N/A
118	Power lines/Pylons	2778	108.1	N/A
119	Power lines/Pylons	3119	107.4	N/A
120	Power lines/Pylons	3476	106.6	N/A
121	Pivot Irrigation	2544	108.8	N/A
122	Pivot Irrigation	2076	110.1	N/A
123	Informal Housing	500	119.9	Acceptable
124	Buildings/Structures	153	128.0	Complaint
125	Farm Buildings/Structures	101	130.8	Complaint
126	Buildings/Structures	294	123.5	Complaint
127	Buildings/Structures	233	125.1	Complaint
128	Buildings/Structures	234	125.1	Complaint
129	Buildings/Structures	230	125.2	Complaint
130	Silo	172	127.2	N/A
131	Buildings/Structures	3015	107.6	Acceptable
132	Railway Line	3451	106.6	N/A
133	Railway Line	2588	108.6	N/A
134	R29 Road	2680	108.5	N/A
135	R29 Road	2480	108.9	N/A
136	Railway Line	2506	108.9	N/A
137	R29 Road	2470	108.9	N/A
138	Railway Line	2507	108.9	N/A
139	Railway Line	2776	108.1	N/A
140	Railway Line	3066	107.6	N/A
141	Railway Line	3447	106.6	N/A
142	R29 Road	2591	108.6	N/A
143	R29 Road	3205	107.2	N/A
144	Road	887	116.0	N/A
145	Road	22	141.4	N/A
146	Road (Inside Pit Area)			N/A
147	Road	544	119.3	N/A
148	Pan	1430	112.7	N/A
149	Dam	2228	109.7	N/A

150	Buildings/Structures	2033	110.4	Acceptable
151	Pan	2036	110.2	N/A
152	Pan	2313	109.4	N/A
153	Pan	2500	108.9	N/A
154	Informal Housing	2608	108.6	Acceptable
155	Informal Housing	2694	108.5	Acceptable
156	Informal Housing	2613	108.6	Acceptable
157	Informal Housing	2740	108.3	Acceptable
158	Informal Housing	2873	108.0	Acceptable
159	Informal Housing	2644	108.5	Acceptable
160	Informal Housing	2954	107.8	Acceptable
161	Informal Housing	2689	108.5	Acceptable
162	Informal Housing	2900	108.0	Acceptable
163	Informal Housing	3227	107.2	Acceptable
164	Dam	3327	107.0	N/A
165	Dam	3143	107.4	N/A
166	Buildings/Structures	2547	108.8	Acceptable
167	Farm Buildings/Structures	2152	110.0	Acceptable
168	Buildings/Structures	1744	111.4	Acceptable
169	Farm Buildings/Structures	1907	110.8	Acceptable
170	Farm Buildings/Structures	2029	110.4	Acceptable
171	Farm Buildings/Structures	2178	109.8	Acceptable
172	Farm Buildings/Structures	2294	109.5	Acceptable
173	Farm Buildings/Structures	2431	109.1	Acceptable
174	Farm Buildings/Structures	2244	109.7	Acceptable
175	Farm Buildings/Structures	2186	109.8	Acceptable
176	Farm Buildings/Structures	2075	110.1	Acceptable
177	Informal Housing	1681	111.6	Acceptable
178	Informal Housing	1548	112.1	Acceptable
179	Farm Buildings/Structures	3031	107.6	Acceptable
180	Farm Buildings/Structures	3138	107.4	Acceptable
181	Farm Buildings/Structures	2524	108.8	Acceptable
182	Buildings/Structures	2627	108.6	Acceptable
183	Buildings/Structures	2808	108.1	Acceptable
184	School	2878	108.0	Acceptable
185	Buildings/Structures	2619	108.6	Acceptable
186	Buildings/Structures	2685	108.5	Acceptable
187	Buildings/Structures	3103	107.4	Acceptable
188	Buildings/Structures	3320	107.0	Acceptable
189	Buildings/Structures	3320	107.0	Acceptable
190	Buildings/Structures	3450	106.6	Acceptable
191	Buildings/Structures	3458	106.6	Acceptable
192	Buildings/Structures	2916	107.8	Acceptable
193	Buildings/Structures	3331	107.0	Acceptable
194	Buildings/Structures	2758	108.3	Acceptable
195	Buildings/Structures	3143	107.4	Acceptable
196	Buildings/Structures	3370	106.8	Acceptable
197	Farm Buildings/Structures	3237	107.2	Acceptable
198	Ruins	2322	109.4	Acceptable
199	Chicken Farm	716	117.4	Acceptable
200	Farm Buildings/Structures	927	115.6	Acceptable
201	Farm Buildings/Structures	1091	114.6	Acceptable

202	Chicken Farm	1010	115.1	Acceptable
203	Farm Buildings/Structures	936	115.6	Acceptable
204	Informal Housing	617	118.4	Acceptable
205	Chicken Farm	1723	111.5	Acceptable
206	Pan	2534	108.8	N/A
207	R42 Road	2504	108.9	N/A
208	R42 Road	2728	108.3	N/A
209	R42 Road	2676	108.5	N/A
210	Chicken Farm	3492	106.6	Acceptable
211	Farm Buildings/Structures	3062	107.6	Acceptable
212	Farm Buildings/Structures	2682	108.5	Acceptable
213	Informal Housing	2144	110.0	Acceptable
214	Farm Buildings/Structures	2361	109.2	Acceptable
215	Farm Buildings/Structures	2722	108.3	Acceptable
216	Reservoir	3400	106.8	N/A
217	Reservoir	2373	109.2	N/A
218	Pan	2762	108.3	N/A
219	Buildings/Structures	2672	108.5	Acceptable
220	Farm Buildings/Structures	2612	108.6	Acceptable
221	Farm Buildings/Structures	3301	107.0	Acceptable
222	Farm Buildings/Structures	1230	113.7	Acceptable
223	Farm Buildings/Structures	1420	112.8	Acceptable
224	Dam	2150	110.0	N/A
225	Ruins	2533	108.8	Acceptable
226	Mine Infrastructure-Mine Office Buildings	663	118.0	N/A
227	Mine Infrastructure-Weigh Bridge	857	116.2	N/A
228	Mine Infrastructure-Pollution Control Dam	1088	114.6	N/A
229	Mine Infrastructure-Buildings	400	121.4	N/A
230	Mine Infrastructure-Plant Office	484	120.1	N/A
231	Mine Infrastructure-Plant Infrastructure	485	120.1	N/A
232	Mine Infrastructure-Slurry Dam	635	118.3	N/A
233	Mine Infrastructure-Tip	497	119.9	N/A

- **Maximum charge per delay - 2660 kg**

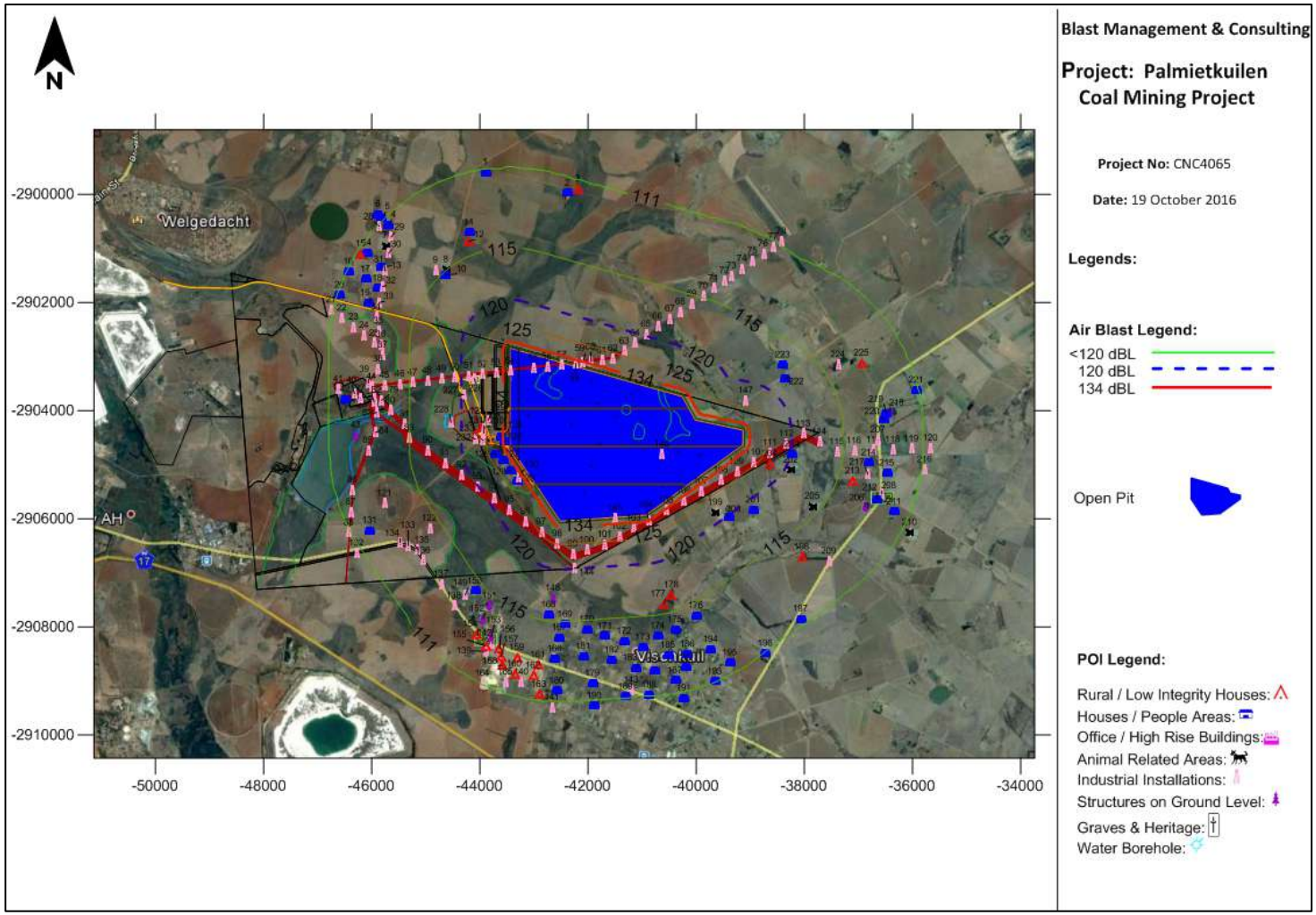


Figure 15: Air blast influence from maximum charge for Open Pit Area

Table 13: Air blast evaluation for maximum charge for Open Pit Area

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Farm Buildings/Structures	3284	111.1	Acceptable
2	Farm Buildings/Structures	3052	111.6	Acceptable
3	Informal Housing	3180	111.4	Acceptable
4	Buildings/Structures	3199	111.2	Acceptable
5	Buildings/Structures	3376	110.9	Acceptable
6	Buildings/Structures	3471	110.8	Acceptable
7	Chicken Farm	2979	111.8	Acceptable
8	Chicken Farm	1869	115.0	Acceptable
9	Grain Silo's	1986	114.6	N/A
10	Farm Buildings/Structures	1804	115.2	Acceptable
11	Farm Buildings/Structures	2266	113.6	Acceptable
12	Ruins	2118	114.2	Acceptable
13	Buildings/Structures	2798	112.3	Acceptable
14	Farm Buildings/Structures	3172	111.4	Acceptable
15	Informal Housing	3260	111.1	Acceptable
16	Farm Buildings/Structures	3301	111.1	Acceptable
17	Farm Buildings/Structures	2952	111.8	Acceptable
18	Farm Buildings/Structures	2682	112.5	Acceptable
19	Farm Buildings/Structures	2732	112.4	Acceptable
20	Farm Buildings/Structures	3293	111.1	Acceptable
21	Power lines/Pylons	3379	110.9	N/A
22	Power lines/Pylons	3155	111.4	N/A
23	Power lines/Pylons	2910	111.9	N/A
24	Power lines/Pylons	2699	112.5	N/A
25	Power lines/Pylons	2503	113.0	N/A
26	Power Distribution Station	2510	113.0	N/A
27	Transformers	2761	112.3	N/A
28	Power lines/Pylons	3307	111.1	N/A
29	Power lines/Pylons	3003	111.7	N/A
30	Power lines/Pylons	2846	112.0	N/A
31	Power lines/Pylons	2709	112.5	N/A
32	Power lines/Pylons	2618	112.7	N/A
33	Power lines/Pylons	2556	112.9	N/A
34	Power lines/Pylons	2533	112.9	N/A
35	Power lines/Pylons	2443	113.2	N/A
36	Power lines/Pylons	2376	113.3	N/A
37	Power lines/Pylons	2344	113.4	N/A
38	Power lines/Pylons	2433	113.2	N/A
39	Power lines/Pylons	2618	112.7	N/A
40	Power lines/Pylons	2877	112.0	N/A
41	Transformers	3164	111.4	N/A
42	Buildings/Structures	3040	111.6	Acceptable
43	Ashton Lake	2839	112.1	N/A
44	Power lines/Pylons	2552	112.9	N/A
45	Power lines/Pylons	2313	113.5	N/A

46	Power lines/Pylons	2024	114.4	N/A
47	Power lines/Pylons	1793	115.3	N/A
48	Power lines/Pylons	1520	116.4	N/A
49	Power lines/Pylons	1261	117.7	N/A
50	Power lines/Pylons	1010	119.2	N/A
51	Power lines/Pylons	756	121.2	N/A
52	Power lines/Pylons	496	124.1	N/A
53	Power lines/Pylons	254	128.6	N/A
54	Power lines/Pylons (Inside Pit Area)			N/A
55	Power lines/Pylons (Inside Pit Area)			N/A
56	Power lines/Pylons (Inside Pit Area)			N/A
57	Power lines/Pylons (Inside Pit Area)			N/A
58	Power lines/Pylons	56	139.0	N/A
59	Power lines/Pylons	108	134.5	N/A
60	Power lines/Pylons	166	131.6	N/A
61	Power lines/Pylons	242	129.0	N/A
62	Power lines/Pylons	335	126.7	N/A
63	Power lines/Pylons	525	123.7	N/A
64	Power lines/Pylons	720	121.5	N/A
65	Power lines/Pylons	925	119.8	N/A
66	Power lines/Pylons	1130	118.4	N/A
67	Power lines/Pylons	1322	117.3	N/A
68	Power lines/Pylons	1502	116.5	N/A
69	Power lines/Pylons	1700	115.6	N/A
70	Power lines/Pylons	1898	114.9	N/A
71	Power lines/Pylons	2084	114.2	N/A
72	Power lines/Pylons	2283	113.6	N/A
73	Power lines/Pylons	2414	113.3	N/A
74	Power lines/Pylons	2616	112.7	N/A
75	Power lines/Pylons	2827	112.1	N/A
76	Power lines/Pylons	3041	111.6	N/A
77	Power lines/Pylons	3248	111.2	N/A
78	Power lines/Pylons	3413	110.9	N/A
79	Power lines/Pylons	2376	113.3	N/A
80	Power lines/Pylons	2204	113.8	N/A
81	Power lines/Pylons	1936	114.7	N/A
82	Power lines/Pylons	2509	113.0	N/A
83	Power lines/Pylons	2465	113.1	N/A
84	Power lines/Pylons	2485	113.1	N/A
85	Power lines/Pylons	2624	112.7	N/A
86	Power lines/Pylons	3016	111.7	N/A
87	Power lines/Pylons	3180	111.4	N/A
88	Power lines/Pylons	3371	110.9	N/A
89	Power lines/Pylons	1849	115.0	N/A
90	Power lines/Pylons	1513	116.4	N/A
91	Power lines/Pylons	1239	117.8	N/A
92	Power lines/Pylons	1034	119.0	N/A
93	Power lines/Pylons	903	120.0	N/A
94	Power lines/Pylons	775	121.0	N/A
95	Power lines/Pylons	654	122.1	N/A
96	Power lines/Pylons	528	123.6	N/A
97	Power lines/Pylons	396	125.6	N/A

98	Power lines/Pylons	420	125.2	N/A
99	Power lines/Pylons	622	122.5	N/A
100	Power lines/Pylons	566	123.1	N/A
101	Power lines/Pylons	484	124.2	N/A
102	Power lines/Pylons	359	126.3	N/A
103	Power lines/Pylons	220	129.6	N/A
104	Power lines/Pylons	107	134.6	N/A
105	Power lines/Pylons	152	132.1	N/A
106	Power lines/Pylons	201	130.2	N/A
107	Power lines/Pylons	245	128.9	N/A
108	Power lines/Pylons	291	127.7	N/A
109	Power lines/Pylons	333	126.8	N/A
110	Power lines/Pylons	376	125.9	N/A
111	Power lines/Pylons	529	123.6	N/A
112	Power lines/Pylons	811	120.7	N/A
113	Power lines/Pylons	1120	118.5	N/A
114	Power lines/Pylons	1419	116.8	N/A
115	Power lines/Pylons	1747	115.4	N/A
116	Power lines/Pylons	2064	114.3	N/A
117	Power lines/Pylons	2427	113.2	N/A
118	Power lines/Pylons	2778	112.3	N/A
119	Power lines/Pylons	3119	111.5	N/A
120	Power lines/Pylons	3476	110.8	N/A
121	Pivot Irrigation	2544	112.9	N/A
122	Pivot Irrigation	2076	114.2	N/A
123	Informal Housing	500	124.0	Complaint
124	Buildings/Structures	153	132.1	Complaint
125	Farm Buildings/Structures	101	134.9	Problematic
126	Buildings/Structures	294	127.6	Complaint
127	Buildings/Structures	233	129.2	Complaint
128	Buildings/Structures	234	129.2	Complaint
129	Buildings/Structures	230	129.3	Complaint
130	Silo	172	131.3	N/A
131	Buildings/Structures	3015	111.7	Acceptable
132	Railway Line	3451	110.8	N/A
133	Railway Line	2588	112.8	N/A
134	R29 Road	2680	112.5	N/A
135	R29 Road	2480	113.1	N/A
136	Railway Line	2506	113.0	N/A
137	R29 Road	2470	113.1	N/A
138	Railway Line	2507	113.0	N/A
139	Railway Line	2776	112.3	N/A
140	Railway Line	3066	111.6	N/A
141	Railway Line	3447	110.8	N/A
142	R29 Road	2591	112.8	N/A
143	R29 Road	3205	111.2	N/A
144	Road	887	120.0	N/A
145	Road	22	145.5	N/A
146	Road (Inside Pit Area)			N/A
147	Road	544	123.4	N/A
148	Pan	1430	116.8	N/A
149	Dam	2228	113.8	N/A

150	Buildings/Structures	2033	114.4	Acceptable
151	Pan	2036	114.4	N/A
152	Pan	2313	113.5	N/A
153	Pan	2500	113.0	N/A
154	Informal Housing	2608	112.7	Acceptable
155	Informal Housing	2694	112.5	Acceptable
156	Informal Housing	2613	112.7	Acceptable
157	Informal Housing	2740	112.4	Acceptable
158	Informal Housing	2873	112.0	Acceptable
159	Informal Housing	2644	112.6	Acceptable
160	Informal Housing	2954	111.8	Acceptable
161	Informal Housing	2689	112.5	Acceptable
162	Informal Housing	2900	111.9	Acceptable
163	Informal Housing	3227	111.2	Acceptable
164	Dam	3327	111.0	N/A
165	Dam	3143	111.4	N/A
166	Buildings/Structures	2547	112.9	Acceptable
167	Farm Buildings/Structures	2152	114.0	Acceptable
168	Buildings/Structures	1744	115.4	Acceptable
169	Farm Buildings/Structures	1907	114.8	Acceptable
170	Farm Buildings/Structures	2029	114.4	Acceptable
171	Farm Buildings/Structures	2178	113.9	Acceptable
172	Farm Buildings/Structures	2294	113.5	Acceptable
173	Farm Buildings/Structures	2431	113.2	Acceptable
174	Farm Buildings/Structures	2244	113.7	Acceptable
175	Farm Buildings/Structures	2186	113.9	Acceptable
176	Farm Buildings/Structures	2075	114.2	Acceptable
177	Informal Housing	1681	115.7	Acceptable
178	Informal Housing	1548	116.3	Acceptable
179	Farm Buildings/Structures	3031	111.7	Acceptable
180	Farm Buildings/Structures	3138	111.5	Acceptable
181	Farm Buildings/Structures	2524	112.9	Acceptable
182	Buildings/Structures	2627	112.7	Acceptable
183	Buildings/Structures	2808	112.1	Acceptable
184	School	2878	112.0	Acceptable
185	Buildings/Structures	2619	112.7	Acceptable
186	Buildings/Structures	2685	112.5	Acceptable
187	Buildings/Structures	3103	111.5	Acceptable
188	Buildings/Structures	3320	111.0	Acceptable
189	Buildings/Structures	3320	111.0	Acceptable
190	Buildings/Structures	3450	110.8	Acceptable
191	Buildings/Structures	3458	110.8	Acceptable
192	Buildings/Structures	2916	111.9	Acceptable
193	Buildings/Structures	3331	111.0	Acceptable
194	Buildings/Structures	2758	112.3	Acceptable
195	Buildings/Structures	3143	111.4	Acceptable
196	Buildings/Structures	3370	110.9	Acceptable
197	Farm Buildings/Structures	3237	111.2	Acceptable
198	Ruins	2322	113.4	Acceptable
199	Chicken Farm	716	121.5	Complaint
200	Farm Buildings/Structures	927	119.7	Acceptable
201	Farm Buildings/Structures	1091	118.6	Acceptable

202	Chicken Farm	1010	119.2	Acceptable
203	Farm Buildings/Structures	936	119.7	Acceptable
204	Informal Housing	617	122.5	Complaint
205	Chicken Farm	1723	115.5	Acceptable
206	Pan	2534	112.9	N/A
207	R42 Road	2504	113.0	N/A
208	R42 Road	2728	112.4	N/A
209	R42 Road	2676	112.5	N/A
210	Chicken Farm	3492	110.8	Acceptable
211	Farm Buildings/Structures	3062	111.6	Acceptable
212	Farm Buildings/Structures	2682	112.5	Acceptable
213	Informal Housing	2144	114.1	Acceptable
214	Farm Buildings/Structures	2361	113.3	Acceptable
215	Farm Buildings/Structures	2722	112.4	Acceptable
216	Reservoir	3400	110.9	N/A
217	Reservoir	2373	113.3	N/A
218	Pan	2762	112.3	N/A
219	Buildings/Structures	2672	112.6	Acceptable
220	Farm Buildings/Structures	2612	112.7	Acceptable
221	Farm Buildings/Structures	3301	111.1	Acceptable
222	Farm Buildings/Structures	1230	117.8	Acceptable
223	Farm Buildings/Structures	1420	116.8	Acceptable
224	Dam	2150	114.0	N/A
225	Ruins	2533	112.9	Acceptable
226	Mine Infrastructure-Mine Office Buildings	663	122.0	N/A
227	Mine Infrastructure-Weigh Bridge	857	120.3	N/A
228	Mine Infrastructure-Pollution Control Dam	1088	118.6	N/A
229	Mine Infrastructure-Buildings	400	125.5	N/A
230	Mine Infrastructure-Plant Office	484	124.2	N/A
231	Mine Infrastructure-Plant Infrastructure	485	124.2	N/A
232	Mine Infrastructure-Slurry Dam	635	122.3	N/A
233	Mine Infrastructure-Tip	497	124.0	N/A

15.10 Summary of Findings for Air Blast

Review of the air blast levels indicates a reduced possibility of damage concerns but more complaint concerns than with ground vibration. Air blast predicted for the maximum charge ranges between 110.8 and 134.9 dB for all the POI's considered. This includes the nearest points such as the Farm House Buildings and Informal Housing. These levels may contribute to effects such as rattling of roofs or door or windows but are not expected to be damaging. As indicated above, there is a high probability that influence that could lead to complaints. The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. On maximum charge prediction it is expected that air blast will be greater than 134 dB at a distance of 108 m and closer to the open pit boundary. There is one private structure in this area that are of concern. All other private structures are further away. The nearest buildings are 101 m from the open pit boundary. Evaluation shows that POI's were identified up to a distance of 716 m

where possible complaints may be expected. Power lines and the Road are closer but air blast does not have any influence on these installations.

Complaints from air blast are normally based on the actual effects that are experienced due to rattling of roof, windows, doors etc. These effects could startle people and raise concern of possible damage.

The calculations for air blast are based on the use of basic rules for stemming length and stemming material. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The project area is located such that “free blasting” – meaning no controls on blast preparation – will not be possible. Controls will be required.

15.11 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 or within the safe boundary. The safe boundary may be anything between 10 m or 1000 m. A general safe boundary is normally considered to be a radius of 500 m or greater from the blast; but needs to be qualified and determined as best possible.

Calculations are 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 16 shows the results from the ISEE calculations for fly rock range based on a 165 mm diameter blast hole and 3.3 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 447 m. The absolute minimum unsafe zone is then the 447 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 there of can never be eliminated. Figure 17 shows the area around the open pit that incorporates the 447 m unsafe zone.

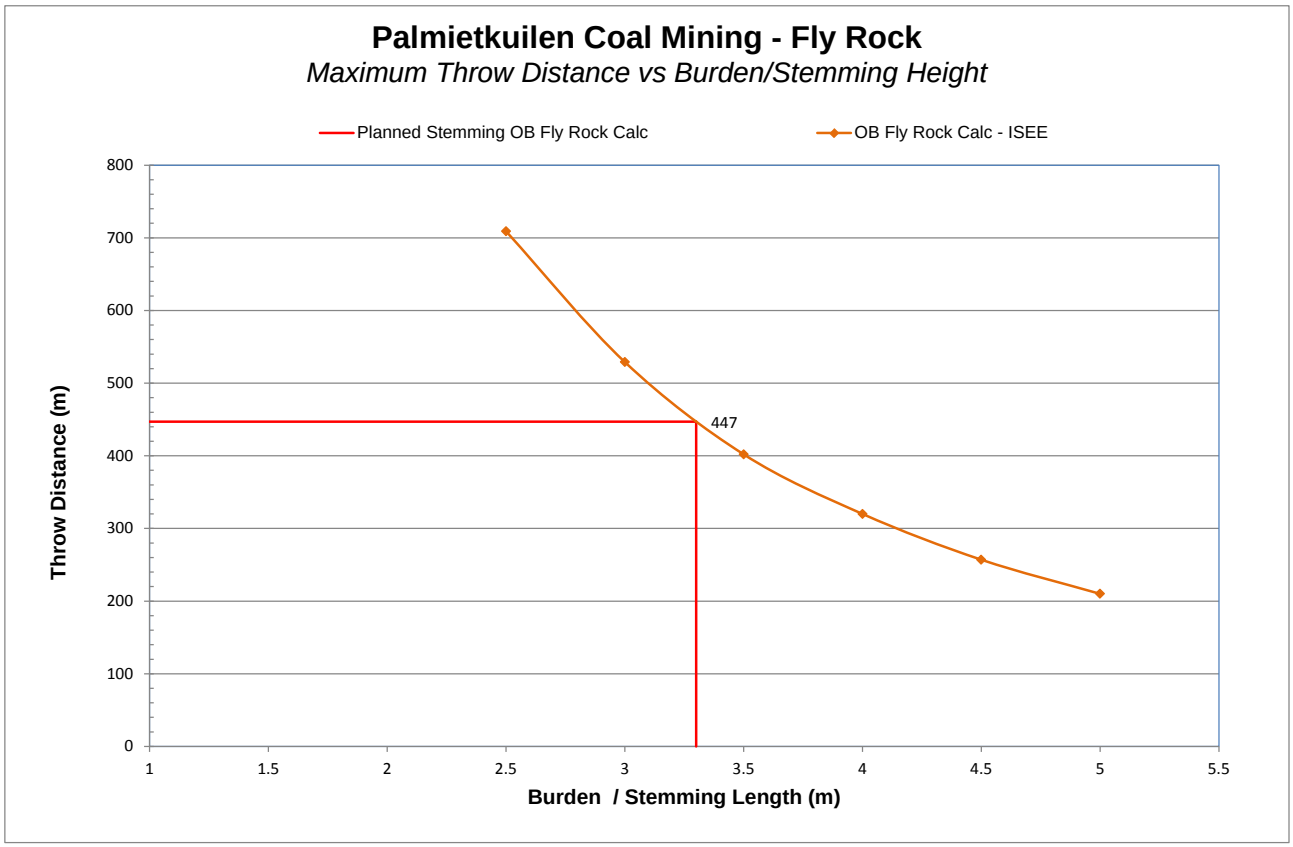


Figure 16: Fly rock prediction calculation

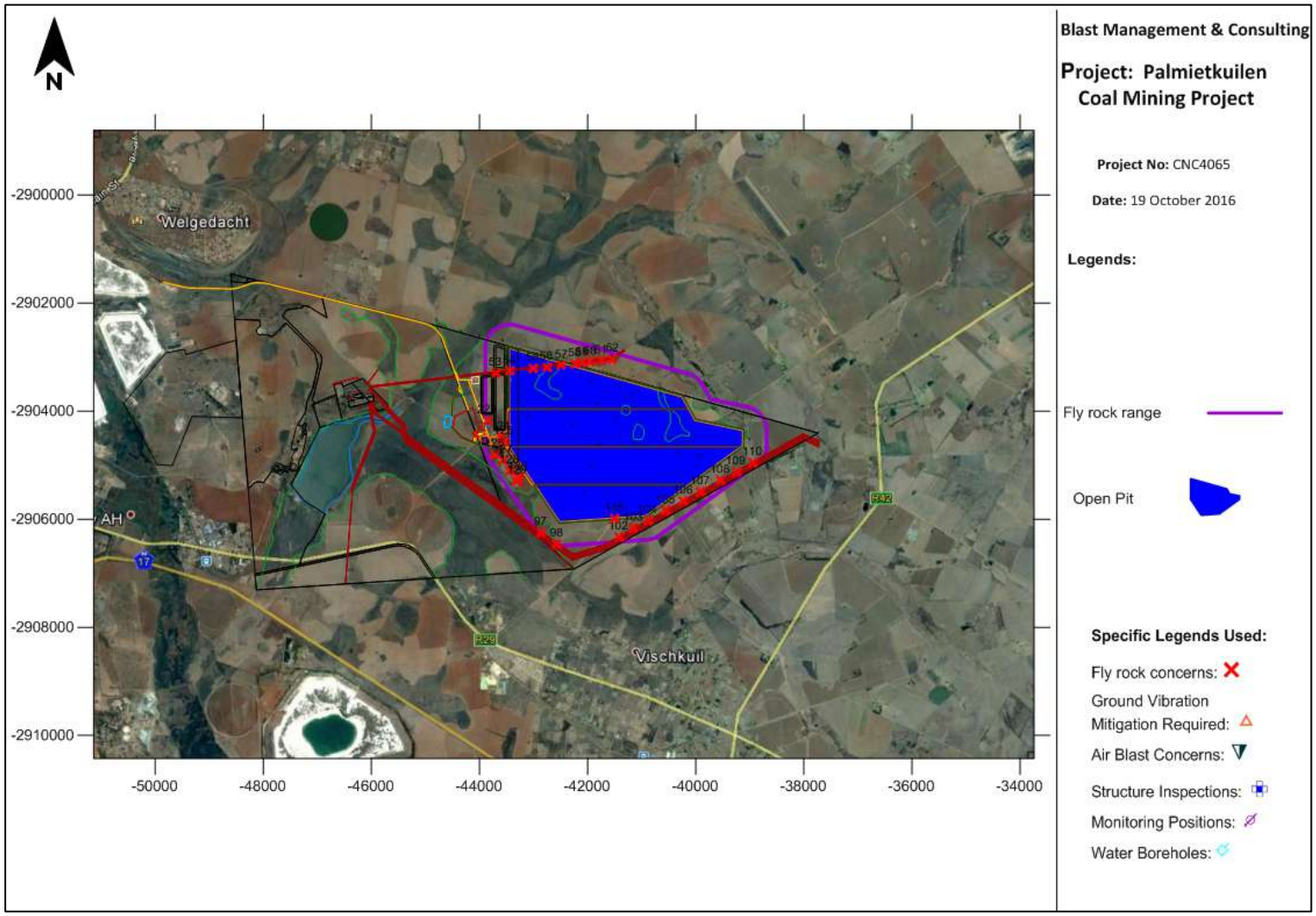


Figure 17: Predicted Fly rock Exclusion Zone for Open Pit Area

Review of the calculated safe boundary showed thirty POI's within the unsafe zone for the open pit area within the unsafe zone. This includes mainly the Power lines, closest building/structures and road. Table 14 below shows the POI's of concern and coordinates.

Table 14: Fly rock concern POI's

Tag	Description	Y	X
53	Power lines/Pylons	43698.90	2903298.33
54	Power lines/Pylons (Inside Pit Area)	43437.06	2903265.56
55	Power lines/Pylons (Inside Pit Area)	43003.64	2903214.25
56	Power lines/Pylons (Inside Pit Area)	42753.61	2903183.62
57	Power lines/Pylons (Inside Pit Area)	42474.60	2903154.64
58	Power lines/Pylons	42227.80	2903125.73
59	Power lines/Pylons	42092.19	2903109.90
60	Power lines/Pylons	41940.94	2903092.78
61	Power lines/Pylons	41742.04	2903069.03
62	Power lines/Pylons	41528.88	2903032.26
97	Power lines/Pylons	42857.62	2906242.95
98	Power lines/Pylons	42560.78	2906460.69
102	Power lines/Pylons	41419.00	2906328.56
103	Power lines/Pylons	41143.97	2906170.45
104	Power lines/Pylons	40879.80	2906027.45
105	Power lines/Pylons	40550.07	2905844.75
106	Power lines/Pylons	40220.96	2905666.69
107	Power lines/Pylons	39901.67	2905490.07
108	Power lines/Pylons	39536.34	2905281.61
109	Power lines/Pylons	39247.42	2905124.84
110	Power lines/Pylons	38940.72	2904955.14
124	Buildings/Structures	43597.33	2904482.12
125	Farm Buildings/Structures	43546.21	2904565.05
126	Buildings/Structures	43706.09	2904794.75
127	Buildings/Structures	43554.91	2904915.64
128	Buildings/Structures	43431.87	2905099.30
129	Buildings/Structures	43296.21	2905293.96
130	Silo	43273.42	2905224.33
145	Road	41488.10	2905993.23
229	Mine Infrastructure-Buildings	43845.18	2904174.24

15.12 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 11.6. 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.

15.13 Water Borehole Influence

No specific water boreholes were considered. It is uncertain at this stage if there are any domestic or agricultural boreholes within close proximity of the pit area.

15.14 Environmental Impact Assessment

The impact rating process is designed to provide a numerical rating of the various environmental impacts identified by use of the Input-Output model. As discussed above, it has to be stressed that the purpose of the EIA process is not to provide an incontrovertible rating of the significance of various aspects, but rather to provide a structured, traceable and defendable methodology of rating the relative significance of impacts in a specific context. This will give the project applicant a greater understanding of the impacts of his project and the issues which need to be addressed by mitigation. It will also give the regulators information on which to base their decisions.

Details of the impact assessment methodology used to determine the significance of physical, bio-physical and socio-economic impacts are provided below.

The significance rating process follows the established impact/risk assessment formula:

Significance = Consequence x Probability x Nature
Where Consequence = Intensity + Extent + Duration
And Probability = Likelihood of an impact occurring
And Nature = Positive (+1) or negative (-1) impact

Note: In the formula for calculating consequence, the type of impact is multiplied by +1 for positive impacts and -1 for negative impacts

The matrix calculates the rating out of 147, whereby Intensity, Extent, Duration and Probability are each rated out of seven as indicated in Table 15. The weight assigned to the various parameters is then multiplied by +1 for positive and -1 for negative impacts.

Impacts are rated prior to mitigation and again after consideration of the mitigation measure proposed in this report. The significance of an impact is then determined and categorised into one of eight categories, as indicated in Table 16, which is extracted from Table 15. The description of the significance ratings is discussed in Table 17.

It is important to note that the pre-mitigation rating takes into consideration the activity as proposed, i.e. there may already be certain types of mitigation measures included in the design (for example due to legal requirements). If the potential impact is still considered too high, additional mitigation measures are proposed.

Table 15: Impact Assessment Parameter Ratings

Rating	Intensity/Replace ability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature=-1)	**Positive Impacts (Nature=+1)**			
7	Irreplaceable loss or damage to biological or physical resources or highly sensitive environments. Irreplaceable damage to highly sensitive cultural/social resources.	Noticeable, on-going natural and / or social benefits which have improved the overall conditions of the baseline.	International The effect will occur across international borders.	Permanent: The impact is irreversible, even with management, and will remain after the life of the project.	Definite: There are sound scientific reasons to expect that the impact will definitely occur. >80% probability.
6	Irreplaceable loss or damage to biological or physical resources or moderate to highly sensitive environments. Irreplaceable damage to cultural/social resources of moderate to highly sensitivity.	Great improvement to the overall conditions of a large percentage of the baseline.	National Will affect the entire country.	Beyond project life: The impact will remain for some time after the life of the project and is potentially irreversible even with management.	Almost certain / Highly probable: It is most likely that the impact will occur. <80% probability.
5	Serious loss and/or damage to physical or biological resources or highly sensitive environments, limiting ecosystem function. Very serious widespread social impacts.	On –going and widespread benefits to local communities and natural features of the landscape.	Province / Region Will affect the entire province or region.	Project Life (>15 years): The impact will cease after the operational life span of the project and can be reversed with sufficient management.	Likely: The impact may occur. <65% probability.

Rating	Intensity/Replace ability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature=-1)	**Positive Impacts (Nature=+1)**			
	Irreparable damage to highly valued items.				
4	Serious loss and/or damage to physical or biological resources or moderately sensitive environments, limiting ecosystem function. On-going serious social issues. Significant damage to structures / items of cultural significance.	Average to intense natural and / or social benefits to some elements of the baseline.	Municipal Area Will affect the whole municipal area	Long term: 6-15 years and impact can be reversed with management.	Probable: Has occurred here or elsewhere and could therefore occur. <50% probability.
3	Moderate loss and/or damage to biological or physical resources of low to moderately sensitive environments and, limiting ecosystem function. On-going social issues. Damage to items of cultural significance.	Average, on-going positive benefits, not widespread but felt by some elements of the baseline.	Local Local extending only as far as the development site area.	Medium term: 1-5 years and impact can be reversed with minimal management.	Unlikely: Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur. <25% probability.
2	Minor loss and/or effects to biological or physical resources of low sensitive environments, not	Low positive impacts experience by a small percentage of the baseline.	Limited Limited to the site and its immediate surroundings.	Short term: Less than 1 year and is reversible.	Rare / improbable: Conceivable, but only in extreme circumstances. The possibility of the impact materialising is very low as a result of design, historic experience or implementation of adequate mitigation

Rating	Intensity/Replace ability		Extent	Duration/Reversibility	Probability
	Negative Impacts (Nature=-1)	**Positive Impacts (Nature=+1)**			
	affecting ecosystem functioning. Minor medium-term social impacts on local population. Mostly repairable. Cultural functions and processes not affected.				measures. <10% probability.
1	Minimal to no loss and/or effect to biological or physical resources, not affecting ecosystem functioning. Minimal social impacts, low-level repairable damage to commonplace structures.	Some low-level natural and / or social benefits felt by a very small percentage of the baseline.	Very limited/Isolated Limited to specific isolated parts of the site.	Immediate: Less than 1 month and is completely reversible without management	Highly unlikely / None: Expected never to happen. <1% probability.

Table 16: Probability/Consequence Matrix

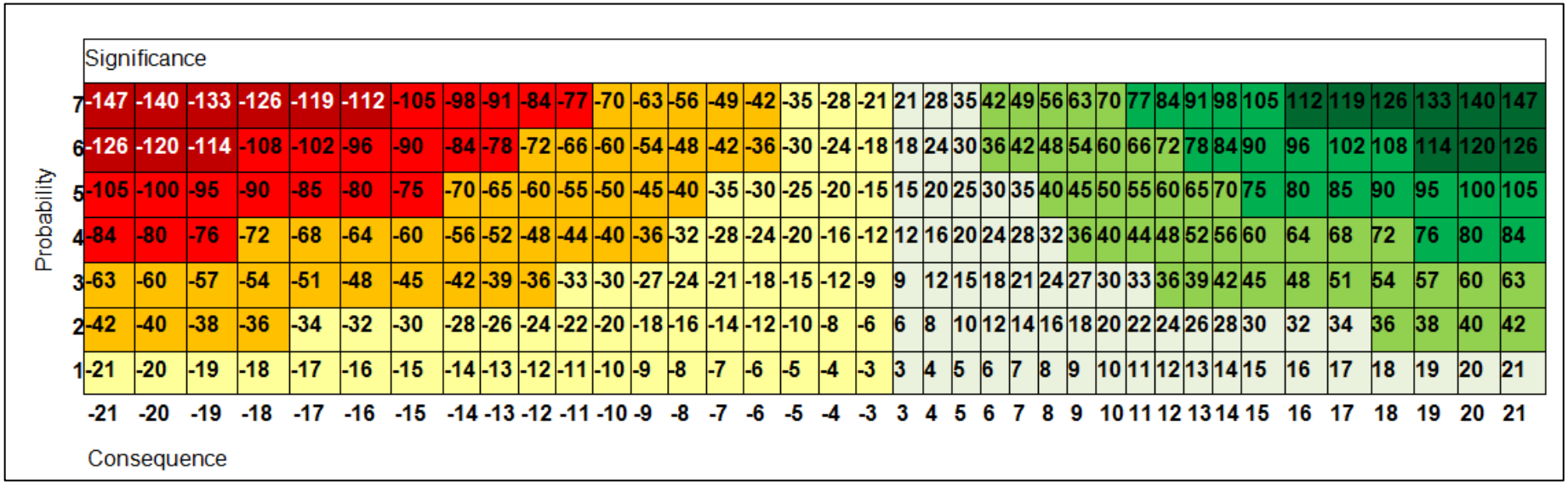


Table 17: Significance Rating Description

Score	Description	Rating
109 to 147	A very beneficial impact that may be sufficient by itself to justify implementation of the project. The impact may result in permanent positive change	Major (positive) (+)
73 to 108	A beneficial impact which may help to justify the implementation of the project. These impacts would be considered by society as constituting a major and usually a long-term positive change to the (natural and / or social) environment	Moderate (positive) (+)
36 to 72	A positive impact. These impacts will usually result in positive medium to long-term effect on the natural and / or social environment	Minor (positive) (+)
3 to 35	A small positive impact. The impact will result in medium to short term effects on the natural and / or social environment	Negligible (positive) (+)
-3 to -35	An acceptable negative impact for which mitigation is desirable. The impact by itself is insufficient even in combination with other low impacts to prevent the development being approved. These impacts will result in negative medium to short term effects on the natural and / or social environment	Negligible (negative) (-)
-36 to -72	A minor negative impact requires mitigation. The impact is insufficient by itself to prevent the implementation of the project but which in conjunction with other impacts may prevent its implementation. These impacts will usually result in negative medium to long-term effect on the natural and / or social environment	Minor (negative) (-)
-73 to -108	A moderate negative impact may prevent the implementation of the project. These impacts would be considered as constituting a major and usually a long- term change to the (natural and / or social) environment and result in severe changes.	Moderate (negative) (-)
-109 to -147	A major negative impact may be sufficient by itself to prevent implementation of the project. The impact may result in permanent change. Very often these impacts are immitigable and usually result in very severe effects. The impacts are likely to be irreversible and/or irreplaceable.	Major (negative) (-)

15.14.1 Assessment

Table 18: Risk Assessment Outcome before mitigation

No.	Impact	Intensity	Extend	Duration	Consequence	Probability	Nature	Significance Before Mitigation	
		Score	Score	Score	Score	Score	Score	Score	Magnitude
Construction Phase									
	None	0	0	0	0	0	1	0	Minor (positive) (+)
Operational Phase									
1	Ground vibration Impact on houses	4	3	5	12	7	-1	-84	Moderate (negative) (-)
3	Ground vibration Impact on roads	1	3	5	9	1	-1	-9	Negligible (negative) (-)
4	Air blast Impact on houses	4	3	5	12	5	-1	-60	Minor (negative) (-)
6	Air blast Impact on roads	1	3	5	9	1	-1	-9	Negligible (negative) (-)
7	Fly Rock Impact on houses	4	3	5	12	7	-1	-84	Moderate (negative) (-)
9	Fly Rock Impact on roads	4	3	5	12	7	-1	-84	Moderate (negative) (-)
10	Impact of Fumes - Houses	3	3	5	11	4	-1	-44	Minor (negative) (-)
12	Impact of Fumes - Roads	1	3	5	9	1	-1	-9	Negligible (negative) (-)
Closure and Post-Closure Phase									
	None	0	0	0	0	0	1	0	Minor (positive) (+)

Table 19: Risk Assessment Outcome after mitigation

No.	Impact	Mitigation Measures	Intensity	Extend	Duration	Consequence	Probability	Nature	Significance after Mitigation	
			Score	Score	Score	Score	Score	Score	Score	Magnitude
Operational Phase										
	None		0	0	0	0	0	1	0	Minor (positive) (+)
Operational Phase										
1	Ground vibration Impact on houses	Reduce Charge Mass/Delay, Reconsider blast initiation system - electronics, Relocate POI's of concern at least 650m, proper blast design.	2	3	3	8	4	-1	-32	Negligible (negative) (-)
3	Ground vibration Impact on roads		1	3	3	7	1	-1	-7	Negligible (negative) (-)
4	Air blast Impact on houses	Reduce Charge Mass/Delay, Increase stemming length, controls put in place for management of stemming lengths and quality stemming material, Relocate POI's of concern at least 650m, Proper blast design.	2	3	3	8	4	-1	-32	Negligible (negative) (-)
6	Air blast Impact on roads		1	3	3	7	1	-1	-7	Negligible (negative) (-)
7	Fly Rock Impact on houses	Increase stemming length, Use quality stemming material, controls put in place for	2	3	3	8	4	-1	-32	Negligible (negative) (-)

		management of stemming lengths, Relocate POI's of concern at least 650m, Proper blast designs.								
9	Fly Rock Impact on roads	Increase stemming length, controls put in place for management of stemming lengths, Relocate POI's of concern at least 650m, Proper blast designs.	2	3	3	8	2	-1	-16	Negligible (negative) (-)
10	Impact of Fumes - Houses	Use correct product, Control product quality, prevent sleep time for charged blast holes, same day charge and blast, Proper blast designs.	3	3	3	9	3	-1	-27	Negligible (negative) (-)
12	Impact of Fumes - Roads		1	3	3	7	1	-1	-7	Negligible (negative) (-)
Closure and Post-Closure Phase										
	None		0	0	0	0	0	1	0	Minor (positive) (+)

15.15 Mitigation Measures

In review of the evaluations made in this report it is certain that specific mitigation will be required. The mitigations measures proposed are general mitigation measures. Any further detail mitigations will require active involvement on the project at operational level. The current mitigation measures presented is considered sufficient at this stage of the project.
Mitigation measures will be required for the following:

- Ground vibration
- Air blast
- Fly rock

There are specific ground vibration concerns on installations close to the open pit area. There are concerns for the Power lines, Informal Housing, Buildings/structures and road. This section mainly concentrates on the mitigation for ground vibration. The mitigation measures required for ground vibration will require review of blast designs, fragmentation required, costing and subsequent loading and hauling. Most of these need to be decided by the client.

Though no specific mitigation detail for air blast and fly rock is provided it will required adjustments after considering the ground vibration levels. Mitigation for air blast and fly rock control is very similar and is based on the following. Air blast and fly rock can be controlled using proper charging methodology irrespective of the blast hole diameter and patterns used. The most effective way to mitigate air blast is the design of the stemming length and stemming material. This will require changed blast design to ensure energy levels remain as expected but with increased stemming lengths and the use of proper stemming material. The use of a crushed product with size of 10 % of the blasthole diameter is the recommended material.

Specific ground vibration impacts are expected at the following POI's identified.
Table 20 shows list of POI's that will need to be considered as defined above. Figure 18 shows the location of these POI's in relation to the open pit area.

Table 20: Structures at the Open Pit Area identified as problematic

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz
53	Power lines/Pylons	43698.90	2903298.33	75	254	82.3	Problematic
54	Power lines/Pylons (Inside Pit Area)	43437.06	2903265.56	75			Problematic
55	Power lines/Pylons (Inside Pit Area)	43003.64	2903214.25	75			Problematic

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Structure Response @ 10Hz
56	Power lines/Pylons (Inside Pit Area)	42753.61	2903183.62	75			Problematic
57	Power lines/Pylons (Inside Pit Area)	42474.60	2903154.64	75			Problematic
58	Power lines/Pylons	42227.80	2903125.73	75	56	999.6	Problematic
59	Power lines/Pylons	42092.19	2903109.90	75	108	338.1	Problematic
60	Power lines/Pylons	41940.94	2903092.78	75	166	166.8	Problematic
61	Power lines/Pylons	41742.04	2903069.03	75	242	89.1	Problematic
103	Power lines/Pylons	41143.97	2906170.45	75	220	104.1	Problematic
104	Power lines/Pylons	40879.80	2906027.45	75	107	343.1	Problematic
105	Power lines/Pylons	40550.07	2905844.75	75	152	191.9	Problematic
106	Power lines/Pylons	40220.96	2905666.69	75	201	121.4	Problematic
107	Power lines/Pylons	39901.67	2905490.07	75	245	87.4	Problematic
123	Informal Housing	43944.54	2904312.31	6	500	27.0	Problematic
124	Buildings/Structures	43597.33	2904482.12	25	153	190.9	Problematic
125	Farm Buildings/Structures	43546.21	2904565.05	25	101	375.8	Problematic
126	Buildings/Structures	43706.09	2904794.75	25	294	64.7	Problematic
127	Buildings/Structures	43554.91	2904915.64	25	233	94.7	Problematic
128	Buildings/Structures	43431.87	2905099.30	25	234	94.4	Problematic
129	Buildings/Structures	43296.21	2905293.96	25	230	97.1	Problematic
130	Reservoir????	43273.42	2905224.33	50	172	156.3	Problematic
145	Road	41488.10	2905993.23	50	22	4765.4	Problematic
204	Informal Housing	38630.69	2904982.01	6	617	19.0	Problematic
229	Mine Infrastructure-Buildings	43845.18	2904174.24	25	400	38.9	Problematic
230	Mine Infrastructure-Plant Office	43929.25	2904327.83	25	484	28.4	Problematic
231	Mine Infrastructure-Plant Infrastructure	43929.68	2904419.06	25	485	28.4	Problematic

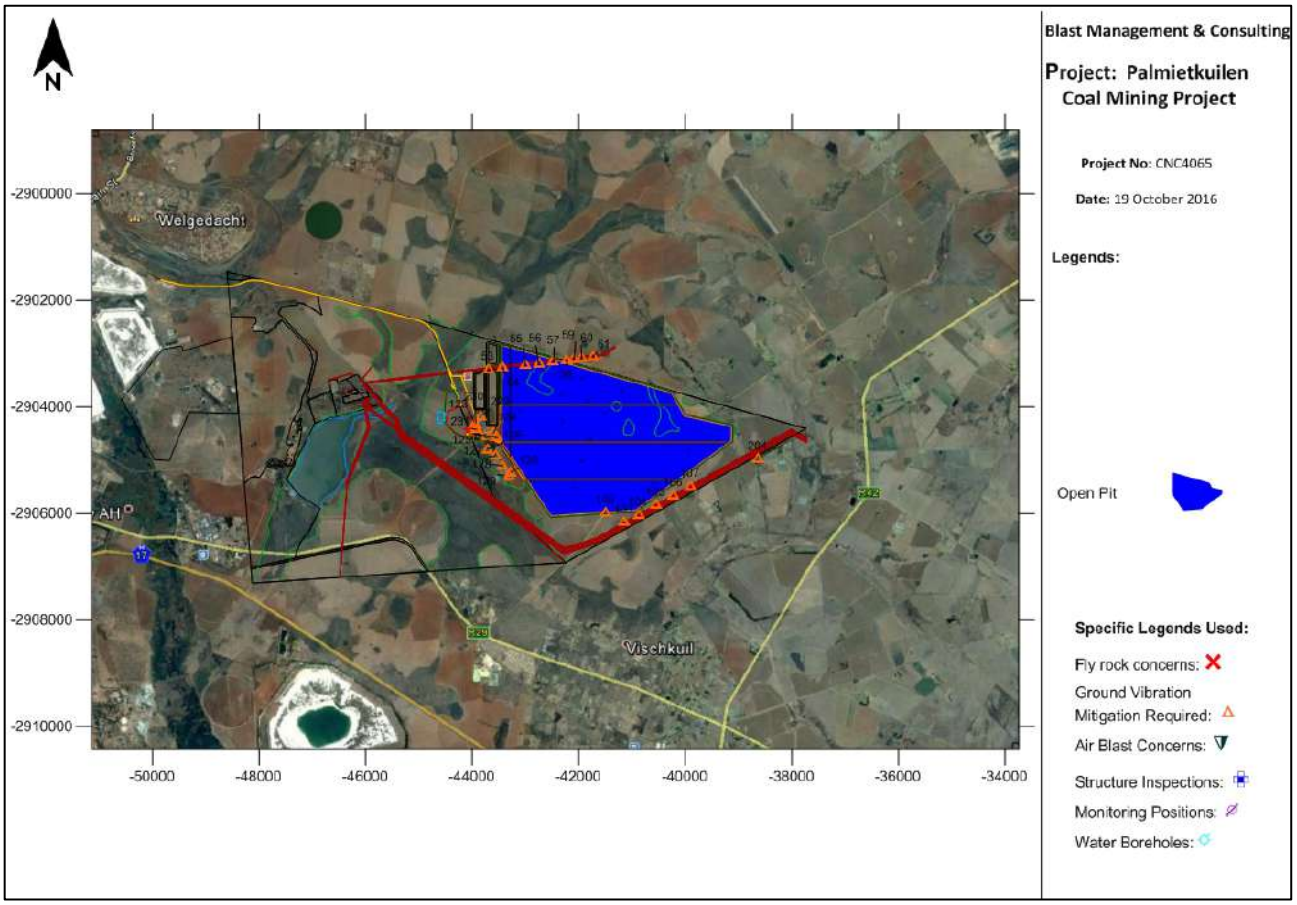


Figure 18: Structures identified where ground vibration mitigation will be required at Open Pit Area

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.
- Change the initiating system to facilitate less blast holes detonating simultaneously making using of electronic initiation that allow for single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blasthole.

Considering the basic mitigation reduction of ground vibration is achieved by reducing the charge mass per delay and distance between source and receptor. These mitigations are guidelines that can be used when doing a final detail blast design. Table 21 shows mitigation in the form of maximum charge mass allowed and minimum distance require for the maximum charge used in the evaluation. Firstly the maximum charge mass per delay that will satisfy the required limits for the actual distance between blast area and point of concern is shown. Secondly the minimum distance required to satisfy limits for the maximum charge used in evaluation. These factors are highlighted yellow.

Table 21: Mitigation measures for ground vibration

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
Maximum Charge allowed								
53	Power lines/Pylons	43698.90	2903298.33	75	254	2375	75.0	Acceptable
54	Power lines/Pylons (Inside Pit Area)	43437.06	2903265.56	75				
55	Power lines/Pylons (Inside Pit Area)	43003.64	2903214.25	75				
56	Power lines/Pylons (Inside Pit Area)	42753.61	2903183.62	75				
57	Power lines/Pylons (Inside Pit Area)	42474.60	2903154.64	75				
58	Power lines/Pylons	42227.80	2903125.73	75	56	115	75.0	Acceptable
59	Power lines/Pylons	42092.19	2903109.90	75	108	429	75.0	Acceptable
60	Power lines/Pylons	41940.94	2903092.78	75	166	1010	75.0	Acceptable
61	Power lines/Pylons	41742.04	2903069.03	75	242	2158	75.0	Acceptable
103	Power lines/Pylons	41143.97	2906170.45	75	220	1787	75.0	Acceptable
104	Power lines/Pylons	40879.80	2906027.45	75	107	421	75.0	Acceptable
105	Power lines/Pylons	40550.07	2905844.75	75	152	852	75.0	Acceptable
106	Power lines/Pylons	40220.96	2905666.69	75	201	1484	75.0	Acceptable
107	Power lines/Pylons	39901.67	2905490.07	75	245	2210	75.0	Acceptable
123	Informal Housing	43944.54	2904312.31	6	500	430	6.0	Acceptable
124	Buildings/Structures	43597.33	2904482.12	25	153	226	25.0	Acceptable
125	Farm Buildings/Structures	43546.21	2904565.05	25	101	100	25.0	Acceptable
126	Buildings/Structures	43706.09	2904794.75	25	294	840	25.0	Acceptable
127	Buildings/Structures	43554.91	2904915.64	25	233	529	25.0	Acceptable
128	Buildings/Structures	43431.87	2905099.30	25	234	532	25.0	Acceptable
129	Buildings/Structures	43296.21	2905293.96	25	230	514	25.0	Acceptable
130	Silo	43273.42	2905224.33	50	172	668	50.0	Acceptable
145	Road	41488.10	2905993.23	50	22	11	50.0	Acceptable
204	Informal Housing	38630.69	2904982.01	6	617	657	6.0	Acceptable
229	Mine Infrastructure-Buildings	43845.18	2904174.24	25	400	1557	25.0	Acceptable
230	Mine Infrastructure-Plant Office	43929.25	2904327.83	25	484	2281	25.0	Acceptable
231	Mine Infrastructure-Plant Infrastructure	43929.68	2904419.06	25	485	2284	25.0	Acceptable
Minimum distance Required								
Tag	**Description**	**Y**	**X**	**Specific Limit (mm/s)**	**Distance (m)**	**Total Mass/Delay (kg)**	**Predicted PPV (mm/s)**	**Structure Response @ 10Hz**
53	Power lines/Pylons	43698.90	2903298.33	75	269	2660	75.0	Acceptable

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
54	Power lines/Pylons (Inside Pit Area)	43437.06	2903265.56	75	269	2660	75.0	Acceptable
55	Power lines/Pylons (Inside Pit Area)	43003.64	2903214.25	75	269	2660	75.0	Acceptable
56	Power lines/Pylons (Inside Pit Area)	42753.61	2903183.62	75	269	2660	75.0	Acceptable
57	Power lines/Pylons (Inside Pit Area)	42474.60	2903154.64	75	269	2660	75.0	Acceptable
58	Power lines/Pylons	42227.80	2903125.73	75	269	2660	75.0	Acceptable
59	Power lines/Pylons	42092.19	2903109.90	75	269	2660	75.0	Acceptable
60	Power lines/Pylons	41940.94	2903092.78	75	269	2660	75.0	Acceptable
61	Power lines/Pylons	41742.04	2903069.03	75	269	2660	75.0	Acceptable
103	Power lines/Pylons	41143.97	2906170.45	75	269	2660	75.0	Acceptable
104	Power lines/Pylons	40879.80	2906027.45	75	269	2660	75.0	Acceptable
105	Power lines/Pylons	40550.07	2905844.75	75	269	2660	75.0	Acceptable
106	Power lines/Pylons	40220.96	2905666.69	75	269	2660	75.0	Acceptable
107	Power lines/Pylons	39901.67	2905490.07	75	269	2660	75.0	Acceptable
123	Informal Housing	43944.54	2904312.31	6	1242	2660	6.0	Acceptable
124	Buildings/Structures	43597.33	2904482.12	25	523	2660	25.0	Acceptable
125	Farm Buildings/Structures	43546.21	2904565.05	25	523	2660	25.0	Acceptable
126	Buildings/Structures	43706.09	2904794.75	25	523	2660	25.0	Acceptable
127	Buildings/Structures	43554.91	2904915.64	25	523	2660	25.0	Acceptable
128	Buildings/Structures	43431.87	2905099.30	25	523	2660	25.0	Acceptable
129	Buildings/Structures	43296.21	2905293.96	25	523	2660	25.0	Acceptable
130	Silo	43273.42	2905224.33	50	344	2660	50.0	Acceptable
145	Road	41488.10	2905993.23	50	344	2660	50.0	Acceptable
204	Informal Housing	38630.69	2904982.01	6	1242	2660	6.0	Acceptable
229	Mine Infrastructure-Buildings	43845.18	2904174.24	25	523	2660	25.0	Acceptable
230	Mine Infrastructure-Plant Office	43929.25	2904327.83	25	523	2660	25.0	Acceptable
231	Mine Infrastructure-Plant Infrastructure	43929.68	2904419.06	25	523	2660	25.0	Acceptable

16 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.

17 Alternatives (Comparison and Recommendation)

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

18 Recommendations

18.1 Regulatory requirements

Regulatory requirements indicate specific requirements for all non-mining structures and installations within 500 m from the mining operation. The mine will have to apply for the necessary authorisations as prescribed in the various acts. Table 22 shows list of these installations. Figure 19 below shows the 500 m boundary around the Open Pit area. The location of non-mining installations is clearly observed.

Table 22: List of possible installations within the regulatory 500 m

Tag	Description	Y	X
52	Power lines/Pylons	43940.78	2903325.62
53	Power lines/Pylons	43698.90	2903298.33
54	Power lines/Pylons (Inside Pit Area)	43437.06	2903265.56
55	Power lines/Pylons (Inside Pit Area)	43003.64	2903214.25
56	Power lines/Pylons (Inside Pit Area)	42753.61	2903183.62
57	Power lines/Pylons (Inside Pit Area)	42474.60	2903154.64
58	Power lines/Pylons	42227.80	2903125.73
59	Power lines/Pylons	42092.19	2903109.90
60	Power lines/Pylons	41940.94	2903092.78
61	Power lines/Pylons	41742.04	2903069.03
62	Power lines/Pylons	41528.88	2903032.26
97	Power lines/Pylons	42857.62	2906242.95
98	Power lines/Pylons	42560.78	2906460.69
101	Power lines/Pylons	41684.30	2906472.59
102	Power lines/Pylons	41419.00	2906328.56
103	Power lines/Pylons	41143.97	2906170.45
104	Power lines/Pylons	40879.80	2906027.45
105	Power lines/Pylons	40550.07	2905844.75
106	Power lines/Pylons	40220.96	2905666.69
107	Power lines/Pylons	39901.67	2905490.07

108	Power lines/Pylons	39536.34	2905281.61
109	Power lines/Pylons	39247.42	2905124.84
110	Power lines/Pylons	38940.72	2904955.14
123	Informal Housing	43944.54	2904312.31
124	Buildings/Structures	43597.33	2904482.12
125	Farm Buildings/Structures	43546.21	2904565.05
126	Buildings/Structures	43706.09	2904794.75
127	Buildings/Structures	43554.91	2904915.64
128	Buildings/Structures	43431.87	2905099.30
129	Buildings/Structures	43296.21	2905293.96
130	Silo	43273.42	2905224.33
145	Road	41488.10	2905993.23

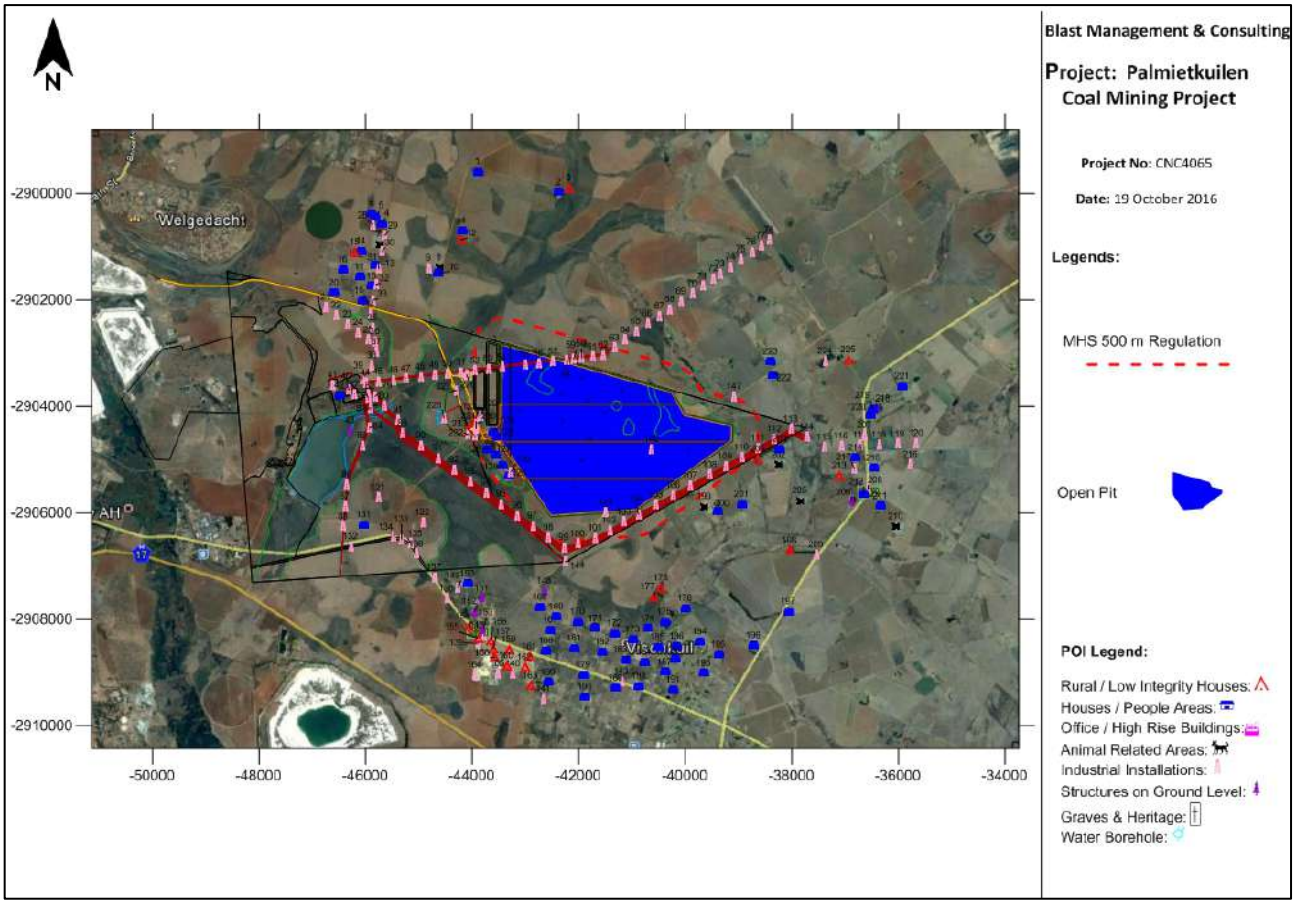


Figure 19: Regulatory 500 m range for Open Pit Area

18.2 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 blasthole firing instead of multiple blast holes resulting in less charge mass per delay. Consideration must also be given structures surrounding the blast intended. This may require changed drilling diameters, blasting patterns, charging configurations (single charge, decking etc.)

or initiation system. A detail design cannot be done at this stage by the author as much more information is required than currently available.

18.3 Safe Blasting Distance and Evacuation

The calculated minimum safe distance is 447 m. This is the estimated area that must be cleared at least around a blast before firing. General evacuation used in the mining industry is at least 500 m from any blast. 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.

18.4 Road Closure

There are gravel roads that link the different farming areas. These routes are specifically of concern when blasting is done. There may be people and animals on these routes and will require careful planning to main safe blasting radius. The road on the southern side is running through the planned opencast area and depending on the re-routing considerations it may be required that road closures will be needed when blasting close to this road.

18.5 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.

18.6 Stemming length

The current proposed stemming lengths at least must be maintained to ensure control on fly rock. Specific designs where distances between point of concern and blast is known should be considered with this. It may be required to increase stemming lengths for additional control.

18.7 Power lines

There are power lines that are close and inside the open pit area. The current design does not take this into account. A specific design will be required to address the powerlines inside the pit area. It is uncertain if there is plan to relocate the powerline. Blasting within 500 m from any of the

powerlines in and outside of the pit area will also require specific permissions from Eskom and application as indicated in Section 9.

18.8 Photographic Inspections

The option of photographic survey of all structures up to 2000 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. This process can however only succeed if done in conjunction with a proper monitoring program. A 2000 m equates to 2.7 mm/s of expected ground vibration for the charge used. This level of ground vibration is already perceptible and people in structures could experience ground vibration negatively. Figure 20 shows the structures within the 2000 m area for the pit areas to be considered. Table 23 shows list of structures identified for inspection. The list indicates a point used. This point may refer to a multiple number of structures in the area of the specific point.

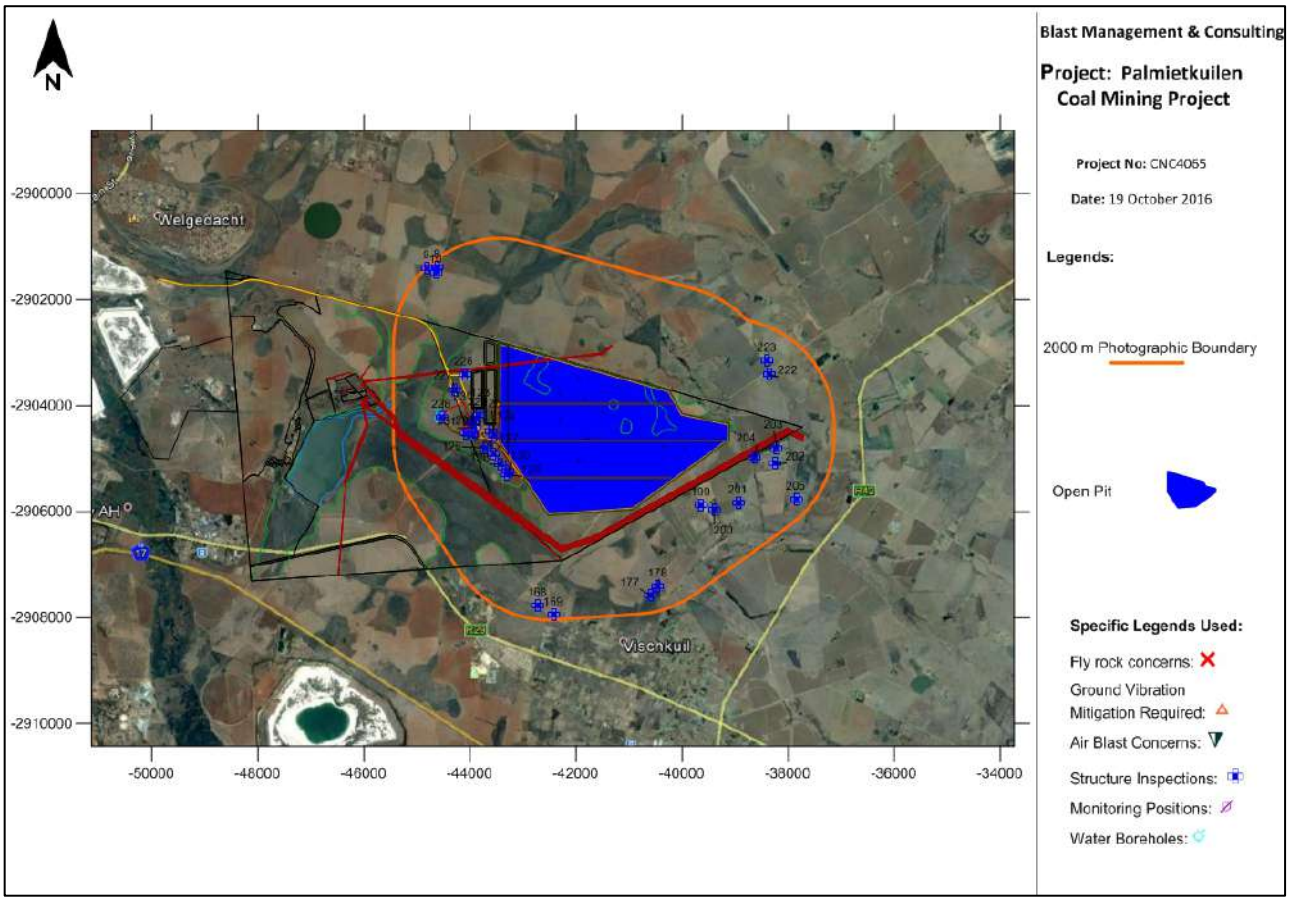


Figure 20: Structures within 2000 m area around pit area identified for structure inspections.

Table 23: List of structures identified for inspections

Tag	Description	Y	X
8	Chicken Farm	44618.41	2901386.80
9	Grain Silo's	44812.00	2901400.66
10	Farm Buildings/Structures	44635.97	2901486.09
123	Informal Housing	43944.54	2904312.31
124	Buildings/Structures	43597.33	2904482.12
125	Farm Buildings/Structures	43546.21	2904565.05
126	Buildings/Structures	43706.09	2904794.75
127	Buildings/Structures	43554.91	2904915.64
128	Buildings/Structures	43431.87	2905099.30
129	Buildings/Structures	43296.21	2905293.96
130	Silo	43273.42	2905224.33
168	Buildings/Structures	42720.62	2907774.53
169	Farm Buildings/Structures	42417.97	2907949.44
177	Informal Housing	40599.51	2907582.16
178	Informal Housing	40452.65	2907406.09
199	Chicken Farm	39638.89	2905880.78
200	Farm Buildings/Structures	39397.91	2905967.63
201	Farm Buildings/Structures	38938.19	2905836.78
202	Chicken Farm	38239.73	2905093.23
203	Farm Buildings/Structures	38216.70	2904806.23
204	Informal Housing	38630.69	2904982.01
205	Chicken Farm	37846.35	2905769.14
222	Farm Buildings/Structures	38355.24	2903415.21
223	Farm Buildings/Structures	38393.82	2903153.24

18.9 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 24.

Table 24: 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

Houses of lesser proper construction	12.5	of concern but 120 dB preferred
Rural building – Mud houses	6	

18.10 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 an atmospheric inversion or too late in the afternoon in winter. Do not blast in fog or 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 be adhered to and blasting notice boards setup at various routes around the project area that will inform the community of blasting dates and times.

18.11 Monitoring

A monitoring programme for recording blasting operations is recommended. This process will be mainly for the development of the different decline shafts. 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 improved relationships with the neighbours. Ten crucial monitoring positions were identified for the Open Pit Area. Positions indicated in the case of the power line pylons will require a measurement at the nearest pylon. This position will change as blasting progresses. Monitoring positions are indicated in Figure 21 and Table 25 lists the positions with coordinates. These points

will need to be re-defined with the initial first blast and consider the final blast design that will be applicable.

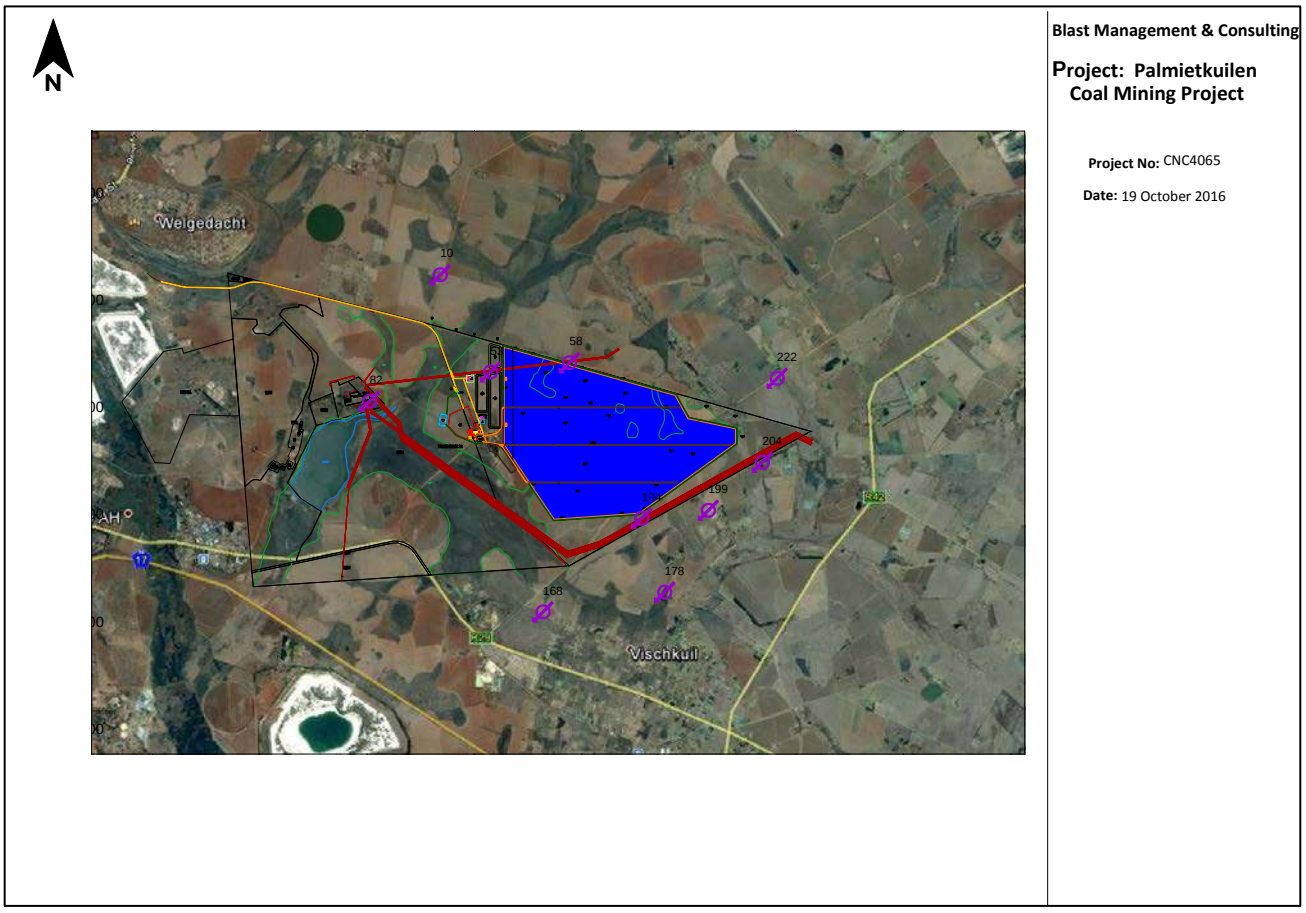


Figure 21: Monitoring Positions suggested for Open Pit Area.

Table 25: List of possible monitoring positions

Tag	Description	Y	X
10	Farm Buildings/Structures	44635.97	2901486.09
53	Power lines/Pylons	43698.90	2903298.33
58	Power lines/Pylons	42227.80	2903125.73
82	Power lines/Pylons	45953.73	2903845.36
104	Power lines/Pylons	40879.80	2906027.45
168	Buildings/Structures	42720.62	2907774.53
178	Informal Housing	40452.65	2907406.09
199	Chicken Farm	39638.89	2905880.78
204	Informal Housing	38630.69	2904982.01
222	Farm Buildings/Structures	38355.24	2903415.21

18.12 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.

18.13 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.

18.14 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 617 m from the pit area. A relocation program should be considered for all households within this distance. This is a process that will require careful planning and execution.

19 Knowledge Gaps

The data provided by the project applicant 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.

20 Conclusion

Blast Management & Consulting (BM&C) was contracted as part of the Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations on the proposed Palmietkuilen Coal Mining Project located in the Gauteng Province of South Africa. Ground vibration, air blast, fly rock and fumes are some of the aspects resulting from blasting operations. The report concentrates on the possible influences of ground vibration, air blast and fly rock. It intends to provide information, calculations, predictions, possible influences and mitigation of blasting operations for the project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as a 3500 m radius from where blasting will take place. The range of structures observed and

considered in this evaluation ranged between industrial structures, farm buildings, power lines and railway lines.

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

There are people and houses at close distances to the project area. The nearest house or building is found at a distance of 101 m from the open pit area. Industrial installations i.e. Power lines and the road are very close to the open pit and can also be found inside the open pit area. Ground vibration mitigation will be required for these structures. Specific attention will be required for adjustments in the blasting operations to ensure expected levels of ground vibration and air blast are within the required limits. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage. There is a possibility that ground vibration may be intolerable at the closest residential houses and Informal housing and unpleasant at the closest chicken farm. Considerations will have to be given to alternative placement or installation of the power lines and road specifically. The ground vibration levels predicted for all installations evaluated surrounding the open pit area ranged between 1.1 mm/s and 4765.4 mm/s. Ground vibration levels at the nearest buildings where people may be present is 375.8 mm/s. These structures considered in the evaluation showed concern for possible damages.

Air blast predicted for the maximum charge ranges between 110.8 and 134.9 dB for all the POI's considered. No specific damages are expected from the levels calculated. Damages are only expected to occur at levels greater than 134dB. On prediction it is expected that air blast will be greater than 134 dB at a distance of 101 m and closer to the open pit boundary. The nearest buildings are 101 m from the open pit boundary and could be problematic. Air blast that could lead to complaints is however expected to reach distances of 716 m from the pit area. The levels at other private houses or settlements are expected to be within limits and not damaging. Levels at the nearest houses may cause effects such as rattling of roofs or doors and could result in complaints from the owners. Infrastructure such as Power lines and the Road are closer 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 447 m. Normal practice observed in mines is a 500 m exclusion zone. The minimum distance recommended is 447 m. This distance may be greater but not less.

The following recommendations are made and should be considered:

- There are structures and installations within 500 m from the open pit area and specific regulatory authorisations for blasting within 500 m of these installations will be required.

- At time of developing the open pit the blast designs must be reviewed for improvements on the general design used in this report.
- A minimum safe clearance distance of 447 m must be applied.
- Farming activities and travelling on farm roads must be considered when areas are cleared prior to blasting operations.
- Ground vibration limits as recommended and presented should be adhered to.
- The use of a third party to monitor the blasting operations for ground vibration and air blast is recommended.

There is no reason to believe that this operation cannot continue if the recommendations made are adhered to.

Recommendations were made that should be considered, specifically for review of blast designs, monitoring of ground vibration and air blast, safe blasting zones, safe ground vibration and air blast limits, blast designs, blasting times and relocations of infrastructure to be considered.

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

21 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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