Blast Management & Consulting

Quality Service on Time

Report: Blast Impact Assessment Proposed Elandsfontein Colliery Project		
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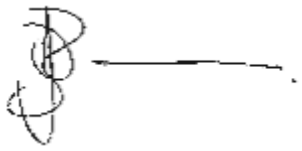
Document Authorised:	JD Zeeman	

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ii. Legal Requirements

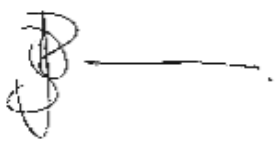
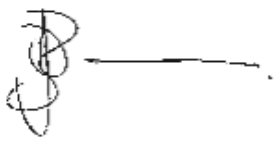
In terms of the NEMA 2014 EIA Regulations contained in GN R982 of 04 December 2014 (as amended by GN R 326 of 07 April 2017) all specialist studies must comply with Appendix 6 of the NEMA EIA Regulations, 2014 (as amended). Table 1 shows the requirements as indicated above.

Table 1: Legal Requirements for All Specialist Studies Conducted

Legal Requirement		Relevant Section in Specialist study
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of-	
	(i) the specialist who prepared the report; and	i
	(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 31 Appendix B
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Section 30
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 4
(d)	the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 8
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process;	Section 6
(f)	the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	Section 12
(g)	an identification of any areas to be avoided, including buffers;	Section 12

Legal Requirement		Relevant Section in Specialist study
(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 12
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 10
(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 19
(k)	any mitigation measures for inclusion in the EMPr;	Section 19.5
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 25
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 24
(n)	a reasoned opinion (Environmental Impact Statement)-	Section 27
	as to whether the proposed activity or portions thereof should be authorised; and	Section 27
	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 27
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 13
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Section 13
(q)	any other information requested by the competent authority.	None

iii. Document Control:

Name & Company	Responsibility	Action	Date	Signature
C Zeeman Blast Management & Consulting	Document Preparation	Report Prepared	02/07/2020	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalise	24/08/2020	
JD Zeeman Blast Management & Consulting	Consultant	Updated alternative operations layout recommendation	29/11/2020	

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List of Acronyms used in this Report

a and b	Site Constant
APP	Air Pressure Pulse
B	Burden (m)
BH	Blast Hole
BM&C	Blast Management & Consulting
D	Distance (m)
E	Explosive Mass (kg)
EIA	Environmental Impact Assessment
Freq.	Frequency
GRP	Gas Release Pulse
I&AP	Interested and Affected Parties
k	Factor value
L	Maximum Throw (m)
Lat/Lon hddd°mm'ss.s"	Latitude/Longitude Hours/degrees/minutes/seconds
M	Charge Height
m (SH)	Stemming height
M/S	Magnitude/Severity
Mc	Charge mass per metre column
N	North
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
NOx's	Noxious Fumes
P	Probability
POI	Points of Interest
PPV	Peak Particle Velocity
RPP	Rock Pressure Pulse
S	Scale
S	South
SE	South East
SH	Stemming height (m)
SW	South West
T	Blasted Tonnage
USBM	United States Bureau of Mine
WGS 84	Coordinates (South African)
WM	With Mitigation Measures
WOM	Without Mitigation Measures

List of Units used in this Report

%	percentage
dB	decibel
dBL	linear decibel
gr/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
m^2	metre squared
MJ	Mega Joules
MJ/m^3	Mega Joules per cubic meter
MJ/t	Mega Joules per tonne
mm/s	millimetres per second
ms	milliseconds
Pa	Pascal
ppm	parts per million
psi	pounds per square inch

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2 Executive Summary

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

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed is typical roads (tar and gravel), low cost houses, corrugated iron structures, brick and mortar houses, boreholes and heritage sites.

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

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

On charges considered it is expected that air blast will be greater than 134 dB at a distance of 110 m and closer to pit boundary. The structures inside the Pit areas is expected to be relocated and will then not be of concern as it is currently inside the pit area. Infrastructure at the pit areas such as roads, heritage sites, power lines/pylons and Hydrocencus boreholes are present but air blast does not have any influence on these installations.

Fly rock remains and concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 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 thereof can never be eliminated.

There are boreholes that are in proximity of the blasting areas and could be problematic.

Specific actions will be required for the pit areas such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Road, Railway Line, Power Lines/Pylons, Houses, Boreholes, Heritage Sites and buildings/structures falls within the 500 m range from the various pit areas.

The pit areas are located such that specific concerns were identified and addressed in the report. The greatest concern is area south of Clever. Opencast operations will be significantly restricted, and it may lead to areas not minable. This is mainly due to the location of this area closer than 100 m to the Clever township and the restrictions with regards to ground vibration, air blast and fly rock.

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

3 Introduction

The proposed project is located on a portion of the remaining extent of portion 8; remaining extent of portion 1; a portion of the remaining extent of portion 6; portion 44; portion 14 and the remaining extent of portion 7 of the Farm Elandsfontein 309 JS, located in Emalahleni Local Municipality, Nkangala District Municipality, Mpumalanga Province. The site is approximately 4 km south of Kwa-Guqa and 16 km west of Emalahleni. The centre point of the site is 25°53'05.01"S and 29°05'36.57"E.

The Elandsfontein Colliery comprises of 2 distinct mining rights (MR314 and MR63). The applicant plans to consolidate the two mining right areas into a single mining right with associated consolidated EMPR. In addition, the applicant wishes to expand their existing mining operations to include additional mineral resource areas (i.e.: new open cast & underground areas within the consolidated mining right boundary).

The proposed project includes inter alia the following application processes with associated activities:

- New Integrated Environmental Authorisation and Waste Management Licence (Scoping and Environmental Impact Report (S&EIR));
- New Integrated Water Use Licence (IWUL);
- Section 102 consolidation of mining rights as well as consolidation of EMPR's into one holistic EMPR.

Elandsfontein Colliery is currently undertaking opencast mining of the No. 1 and No. 2 coal seam in Pit 1. Underground and Opencast mining is currently being done.

Roll over strip mining method is utilised to extract the coal from the No. 1 and No. 2 Coal Seam and rehabilitation is undertaken concurrently as the coal is extracted. A dozer, truck and shovel are used to remove the topsoil and subsoil material to expose the No 2 Coal Seam. Hard overburden material is blasted to expose the No 2 Coal Seam which is mined and placed on the ROM stockpile for dry processing.

The initial waste mining material will be placed on dumps to create space for the next cut material to be rolled into. This will form a continuous roll over method where the waste material will be placed in the previous mined out cut. The placement of material on the low wall side as part of the rehabilitation strategy will be in the same sequence as the material mined from bottom to top, i.e. hards at the bottom, then subsoil on top of the hards and then topsoil on top of the subsoil.
Drilling and blasting operations will for a critical part of mining the hards and the No 2 seam. Both material horizons will be drilled at specific patterns and blasted with the use of emulsion and pyrotechnics (shock tube).

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

4 Objectives

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

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

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

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

5 Scope of blast impact study

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

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

6 Study area

The proposed project is located on a portion of the remaining extent of portion 8; remaining extent of portion 1; a portion of the remaining extent of portion 6; portion 44; portion 14 and the remaining extent of portion 7 of the Farm Elandsfontein 309 JS, located in Emalahleni Local Municipality, Nkangala District Municipality, Mpumalanga Province. The site is approximately 4 km south of Kwa-Guqa and 16 km west of Emalahleni. The centre point of the site is 25°53'05.01"S and 29°05'36.57"E.

Figure 1 shows the Mine Layout Map of the proposed Project area. Figure 2 shows the proposed Mining Area Map.

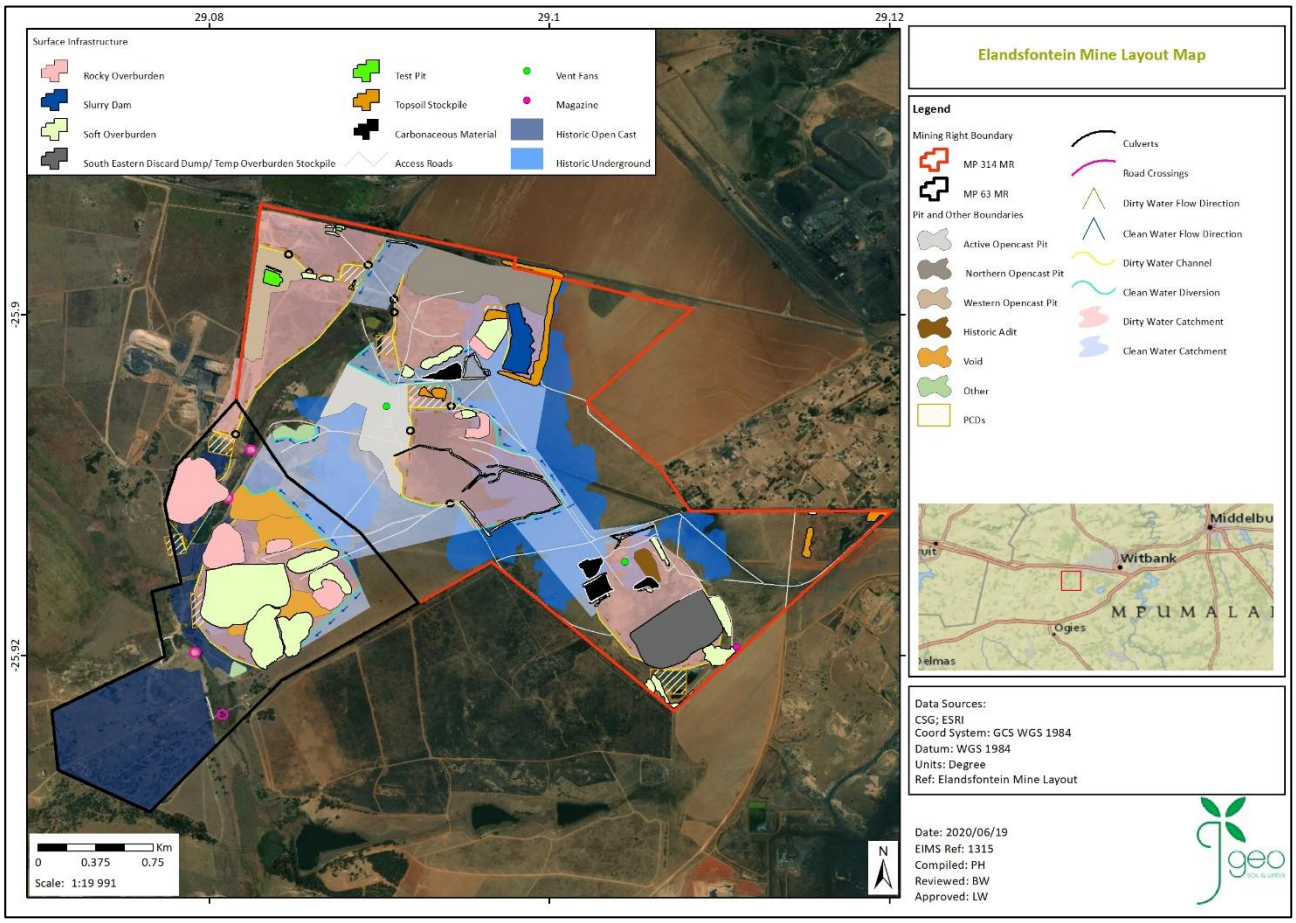

Figure 1: Elandsfontein Mine Layout Map

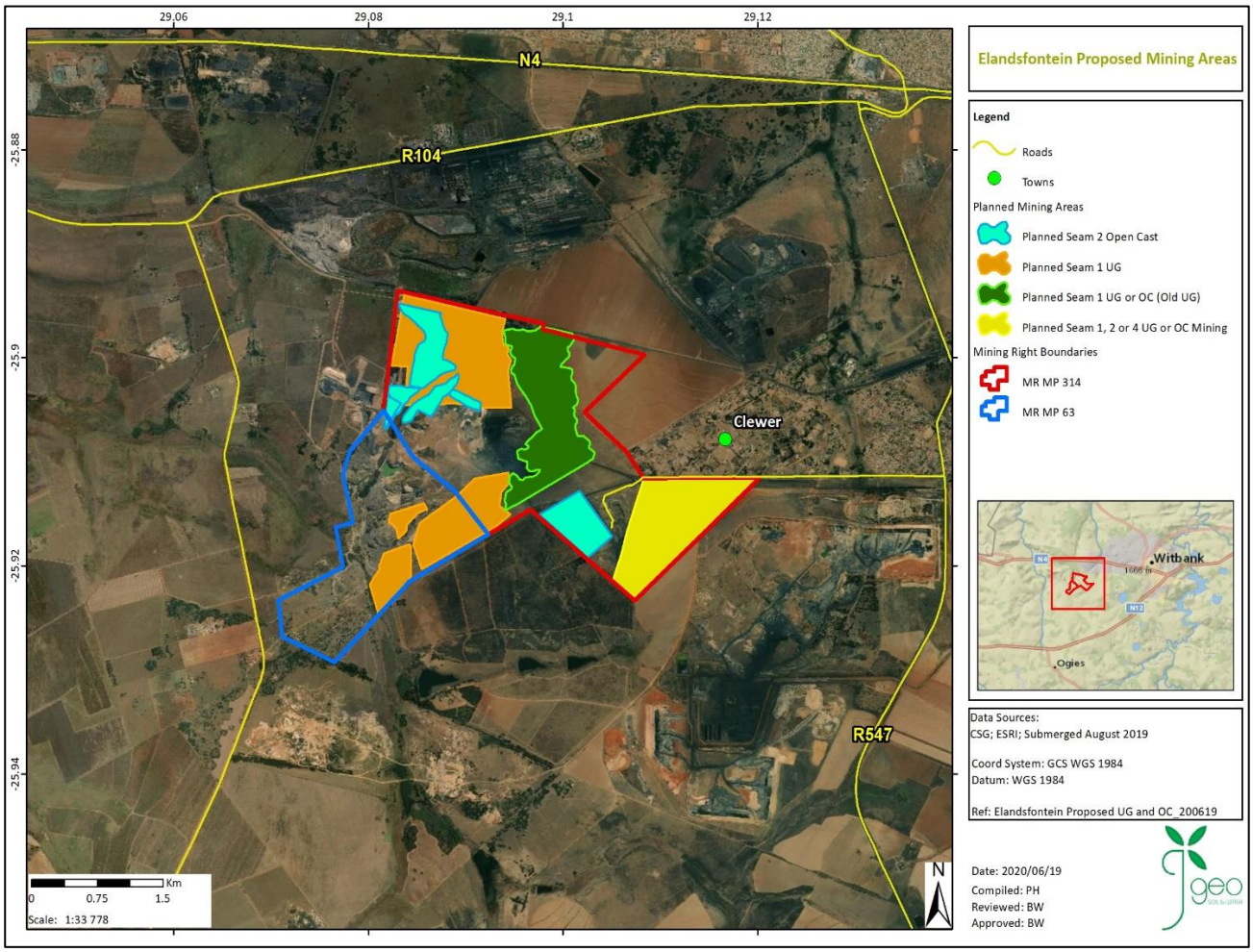

Figure 2: Proposed Mining Areas Map

7 Methodology

The detailed plan of study consists of the following sections:

- Site visit: Intention to understand location of the site and its surroundings;
- Identifying surface structures / installations that are found within reason from project site. A list of Point of Interests (POI's) is created that will be used for evaluation;
- Base line influence: Information from other parts of the mine was considered in evaluation of the whole mining area.
- Site evaluation: This consists of evaluation of the mining operations and the possible influences from blasting operations. The methodology is modelling the expected impact based on the expected drilling and blasting information provided for the project. Various accepted mathematical equations are applied to determine the attenuation of ground vibration, air blast and fly rock. These values are then calculated over the distance investigated from site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors then gives an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels then gives an indication of the possible mitigation measures to be

applied. The possible environmental or social impacts are then addressed in the detailed EIA phase investigation;

- Reporting: All data is prepared in a single report and provided for review.

8 Site Investigation

The site was visited on 30 June 2020. This site visit was done to get understanding of the location and the structures and installations surrounding the proposed new pit areas.

9 Season applicable to the investigation

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

10 Assumptions and Limitations

The following assumptions have been made:

- The project area consists of new planned areas. There are drilling and blasting operations currently active on parts of the mine. The total planned mining area is considered in this assessment.
- 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 limited data was available from this operation for a confirmation of the predicted values from the existing operations.
- Blast Management & Consulting was not involved in the blast design. The information on blast design applied was provided by the client.
- The type of blasting conducted on the existing operations varies significantly with designs provided that shows different designs and results. A best estimate was applied for this project regarding blasting design and expected outcomes.
- The work done is based on the author's knowledge and information provided by the project applicant.
- The evaluation done considers all areas of the Elandsfontein Mine as one source area. Indicated on plans are areas identified as opencast and underground as well as areas that may be opencast or underground. In light of this is the whole mining area grouped as one source.

11 Legal Requirements

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

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

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

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

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

MINE HEALTH AND SAFETY REGULATIONS

Precautionary measures before initiating explosive charges

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

General precautions

4.16 The employer must take reasonable measures to ensure that:

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

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

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

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

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

(a) a risk assessment has identified a lesser safe distance and any restrictions and conditions to be complied with;
(b) a copy of the risk assessment, restrictions and conditions contemplated, in paragraph (a) have been provided for approval to the Principal Inspector of Mines;
(c) shot holes written permission has been granted by the Principal Inspector of Mines; and
(d) any restrictions and conditions determined by the Principal Inspector of Mines are complied with.

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

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

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

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

12 Sensitivity of Project

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

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

Figure 3 shows the sensitivity mapping with the identified points of interest (POI) in the surrounding areas for the proposed Project area. The specific influences will be determined through the work done for this project in this report.

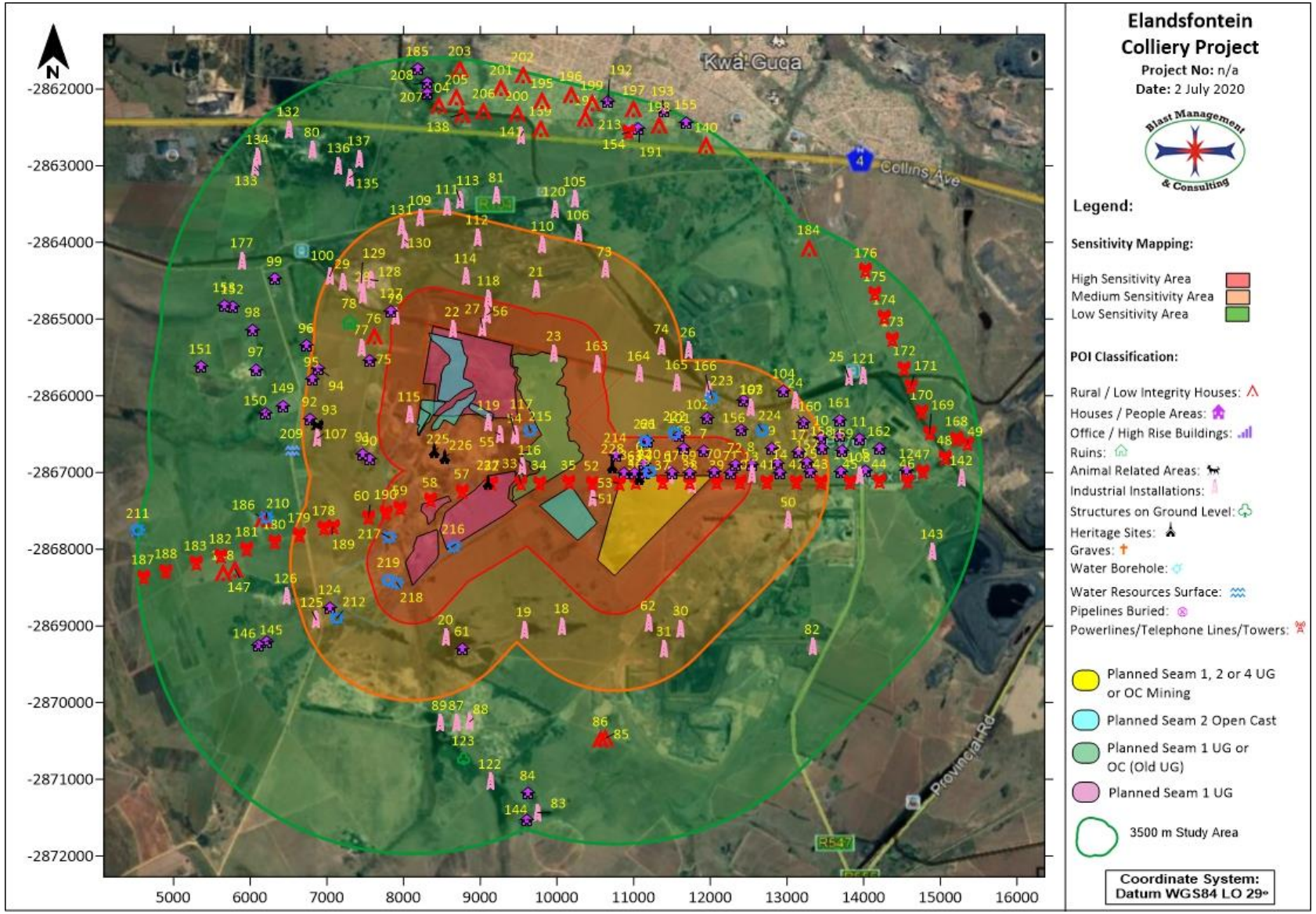

Figure 3: Identified sensitive areas

13 Consultation process

No specific consultation with external parties was utilised. The only consultation done was during the site visit to the mine with mine personnel. The work done is based on the author's knowledge and information provided by the client.

14 Influence from blasting operations

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

14.1 Ground vibration limitations on structures

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

Currently, the USBM criteria for safe blasting are applied as the industry standard where private structures are of concern. Ground vibration amplitude and frequency is recorded and analysed. The data is then evaluated accordingly. The USBM graph is used for plotting of data and evaluating the data. Figure 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,

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

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

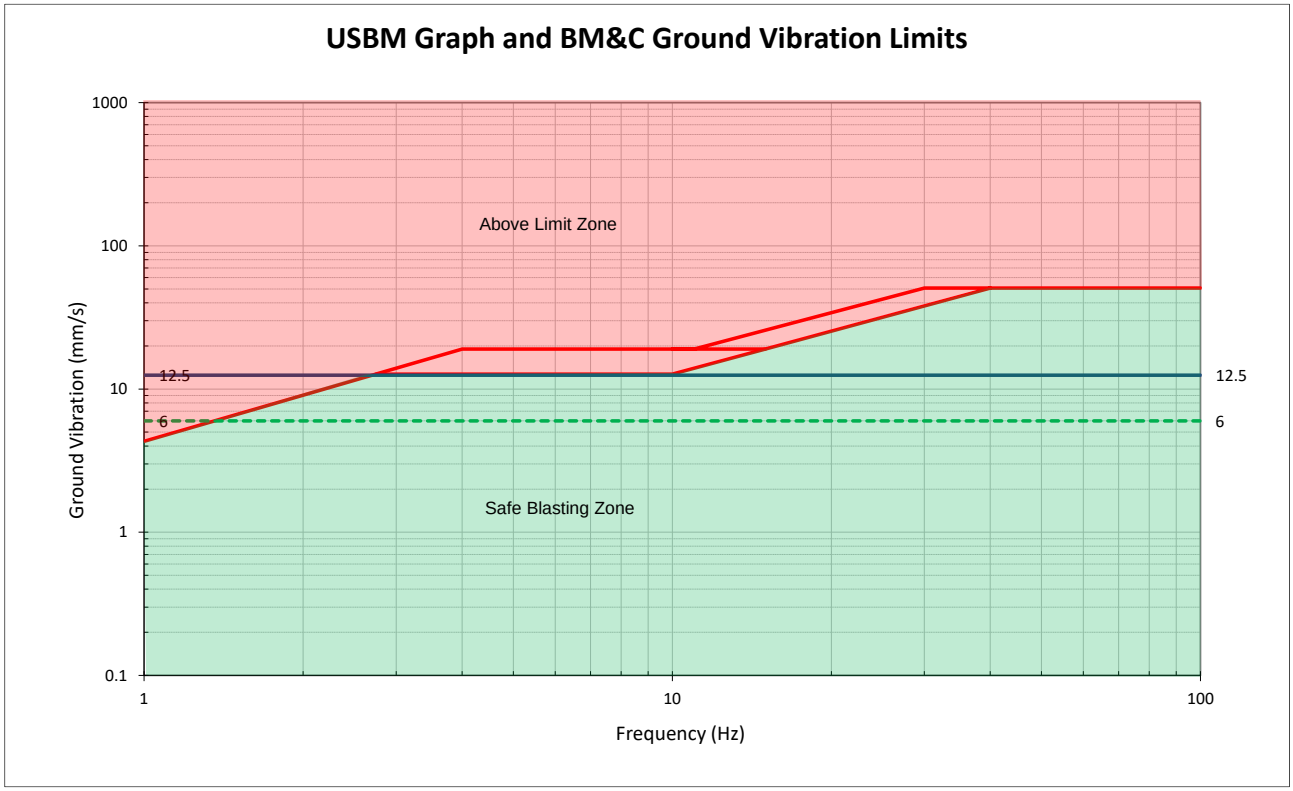

Figure 4: USBM Analysis Graph

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

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

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

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

Considering the above limitations, BM&C work is based on the following:

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

14.2 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).

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

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

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 the evaluation.

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

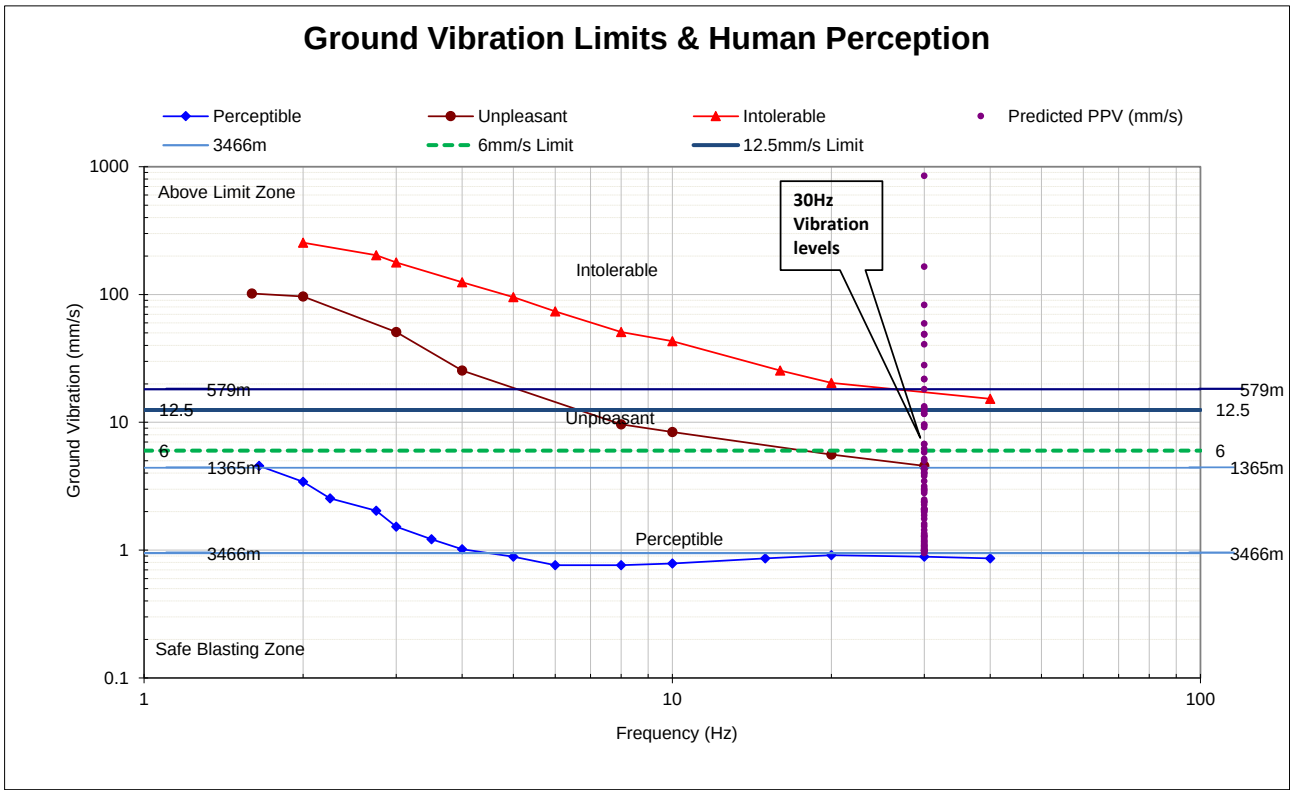


Figure 5: Human perception of ground vibration

14.3 Air blast limitations on structures

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

- Direct rock displacement at the blast; the air pressure pulse (APP);

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

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

Table 2: Damage Causing Levels for Air Blast

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

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

Table 3: Air Blast Limits

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

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

14.4 Air blast limitations and human perceptions

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

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

14.5 Fly rock

Blasting practices require some movement of rock to facilitate the excavation process. The extent of movement is dependent on the scale and type of operation. For example, blasting activities at large coal mines are designed to cast the blasted material over a greater distance than in quarries or hard rock operations. The movement should be in the direction of the free face, and therefore the orientation of the blast is important. Material or elements travelling outside of this expected range would be considered to be fly rock. Figure 6 shows schematic of fly rock definitions.

Fly rock can be categorised as follows:

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

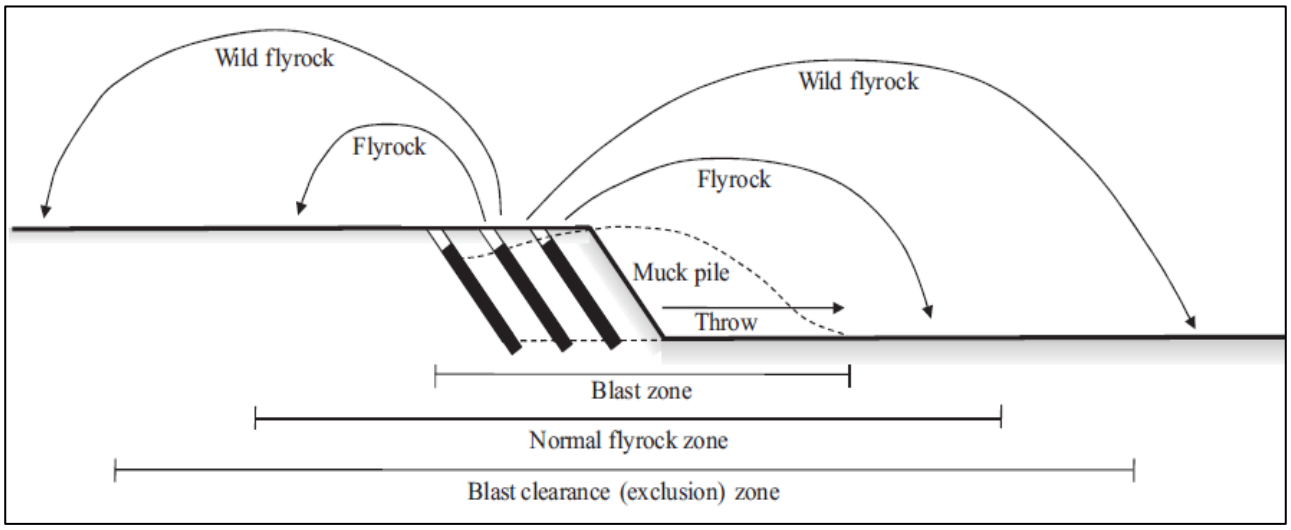


Figure 6: Schematic of fly rock terminology

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.

14.6 Noxious Fumes

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

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

14.7 Vibration impact on provincial and national roads

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

The only time damage can be induced is when blasting is done next to the road and there is movement of ground. Fly rock will have greater influence on the road as damage from falling debris may impact on the road surface if no control on fly rock is considered.

14.8 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.

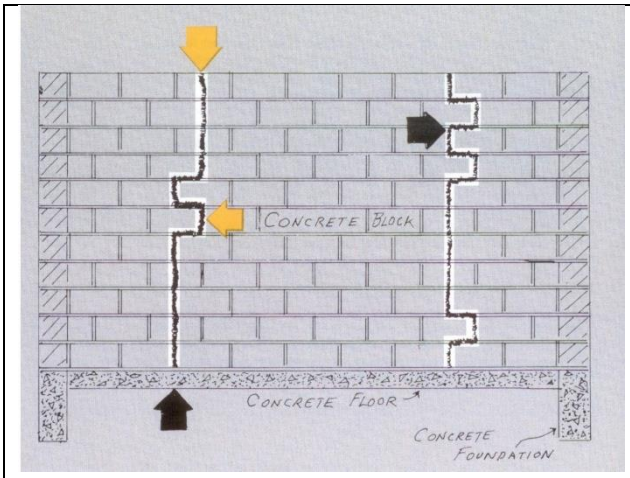
14.9 Cracking of houses and consequent devaluation

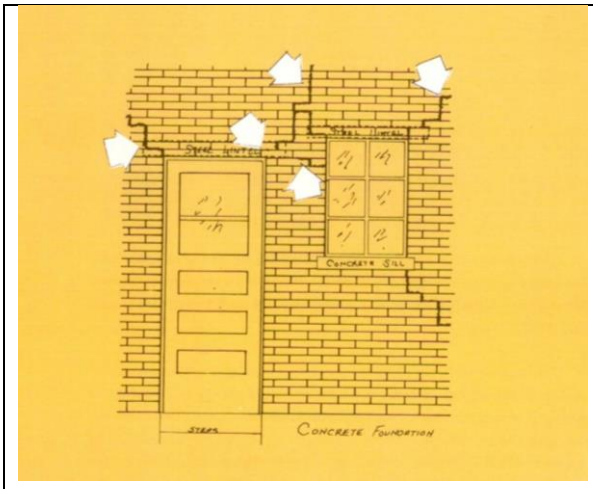
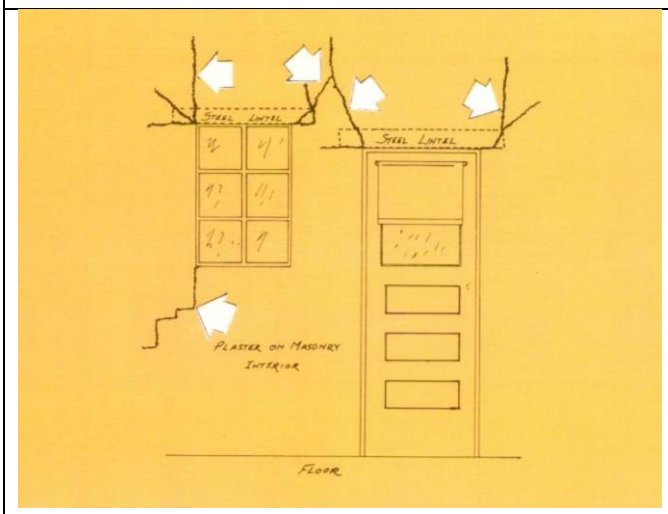
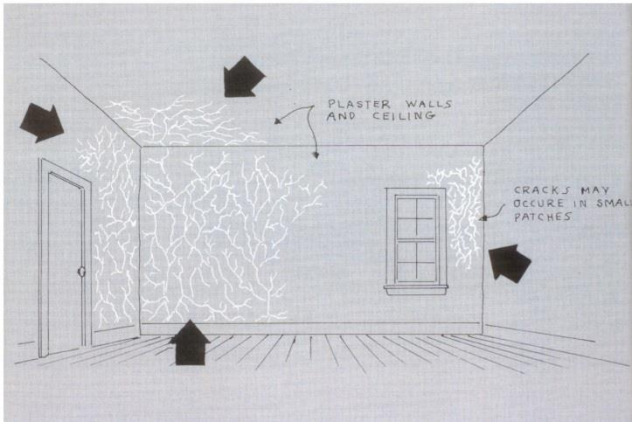
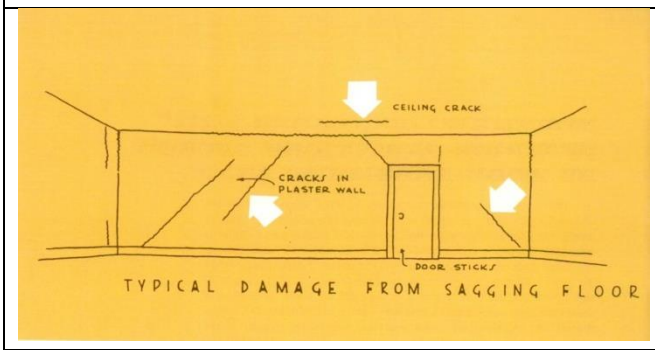
Houses in general have cracks. It is reported that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc. are more reason for cracks that have developed. Visual results of actual damage due to blasting operations are limited. There are cases where it did occur, and a result is shown in Figure 7 below. A typical X crack formation is observed.

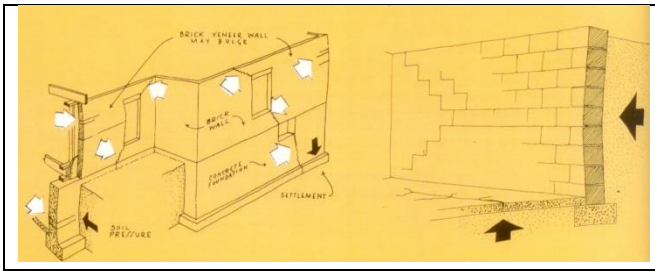
Figure 7: Example of blast induced damage.

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

Table 4: Examples of typical non-blasting cracks

	Cracks Resulting from Shrinkage of Concrete Blocks

	Typical Lintel Cracks
	Typical Lintel Cracks
	"Crazing" Cracks on Plaster
	Plaster Cracks Caused by Sagging Floors

	Cracks Resulting from Foundational Failure

Observing cracks in the form indicated in Figure 7 on a structure will certainly influence the value as structural damage has occurred. The presence of general vertical cracks or horizontal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Proper building standards are not always applied, and the general existence of cracks may be due to materials used. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to estimate. A property valuator will be required for this and I do believe that property value will include the total property and not just the house alone. Mining operations may not have influence to change the status quo of any property.

14.10 Water well Influence from Blasting Activities

Domestic, agricultural and monitoring boreholes are present around the proposed site. The author has not had much experience on the effect of blasting on water wells, but specific research was done and results from this research work are presented.

Case 1 looked at 36 case histories. Vibration levels up 50 mm/s were measured. The well yield and aquifer storage improved as the mining neared the wells, because of the opening of the fractures from loss of lateral confinement, not blasting. This is similar to how stress-relief fractures form. At one site, the process was reversed after the mine was backfilled. It was more likely the fractures were recompressed. It was stated that blasting may cause some temporary (transient) turbidity similar to those events that cause turbidity without blasting.

Such as:

1. Natural sloughing off inside of the well bore due to inherent rock instability. This can be accelerated by frequent over pumping. This is common to wells completed through considerable thickness of poorly consolidated and/or highly fractured clay stones and shales.
2. Significant rainfall events. The apertures of the shallow fractures that are intersected by a domestic well are commonly highly transmissive, thus will transmit substantial amounts of shallow flowing and rapidly recharging water. This water will commonly be turbid and can enter the well in high volumes. The lack of grouting of the near surface casing commonly allows this to happen. Also, if the top of the well is not grouted properly surface water can enter along the side of the casing and flow down the annulus.

The Berger Study observed ground-water impacts from manmade stress-release caused the rock mass removal during mining, but nothing from the blasting. The water quality and water levels were unaffected by the blasting. The "opening up" of the fractures lowered the ground-water levels by increasing the storage or porosity.

A study tested wells 50 m from a blast. Wells exhibited no quality or quantity impacts. Blast pressure surges ranged from 3 cm to 10 cm. Blasting caused no noticeable water table fluctuations and the hydraulic conductivity was unchanged. The pumping of the pit and encroachment of the high wall toward the wells dewatered the water table aquifer.

It may then be concluded from the studies researched as follows: Depending on the well construction, litho logic units encountered, and proximity to the blasting, it is believed that large shots could act as a catalyst for some well sloughing or collapse. However, the well would have to be inherently weak to begin with. The small to moderate shots will not show to impact wells. The minor water fluctuations attributed to blasting may cause a short-term turbidity problem, but do not pose any long-term problems. This fluctuation would not cause well collapse, as fluctuations from recharge and pumping occurs frequently. Long term changes to the well yield are more likely due to the opening of fractures from loss of lateral confinement. Short term dewatering of wells is caused by the opening of the fractures creating additional storage. A longer-term dewatering is caused by encroachment of the high wall and pumping of the pit water. The pit acts like a large pumping well. It is not believed that long term water quality problems will be caused by blasting alone. The possible exception is the introduction of residual nitrates, from the blasting materials, into the ground water system. This is only possible through wells that are hydro logically connected to a blasting site. Most of the long-term impacts on water quality are due to the mining (the breakup of the rocks). The influence will also be dependent if wells are beneath the excavation. Stress relief effects occur at shorter distances in this instance.

The results observed and levels recorded during research done showed that levels up to 50 mm/s or even higher in certain cases did not have any noticeable effect. It seems that safe conditions will be in the order of the 50 mm/s. In addition to this there are certain aspects that will need to be addressed prior to blasting operations.

15 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.

15.1 Baseline influence

Elandsfontein Opencast sections is operational for some areas of the mine. There are no results currently available that could have been used for baseline evaluation. All areas are evaluated according to standard rules as if it is a new operation.

15.2 Structure profile

As part of the baseline, all possible structures in a possible influence areas 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 and underground areas, which will require consideration during modelling of blasting operations, e.g. houses, general structures, power lines, pipelines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the open pit and underground areas. The list includes structures and POI within the 3500 m boundary – see Table 6 below. A list of structure locations was required to determine the allowable ground vibration limits and air blast limits. Figure 8 shows an aerial view of the planned open pit and underground areas and surroundings with POIs. The type of POIs identified is grouped into different classes. These classes are indicated as “Classification” in Table 5. The classification used is a BM&C classification and does not relate to any standard or national or international code or practice. Table 5 shows the descriptions for the classifications used.

Table 5: POI Classification used

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

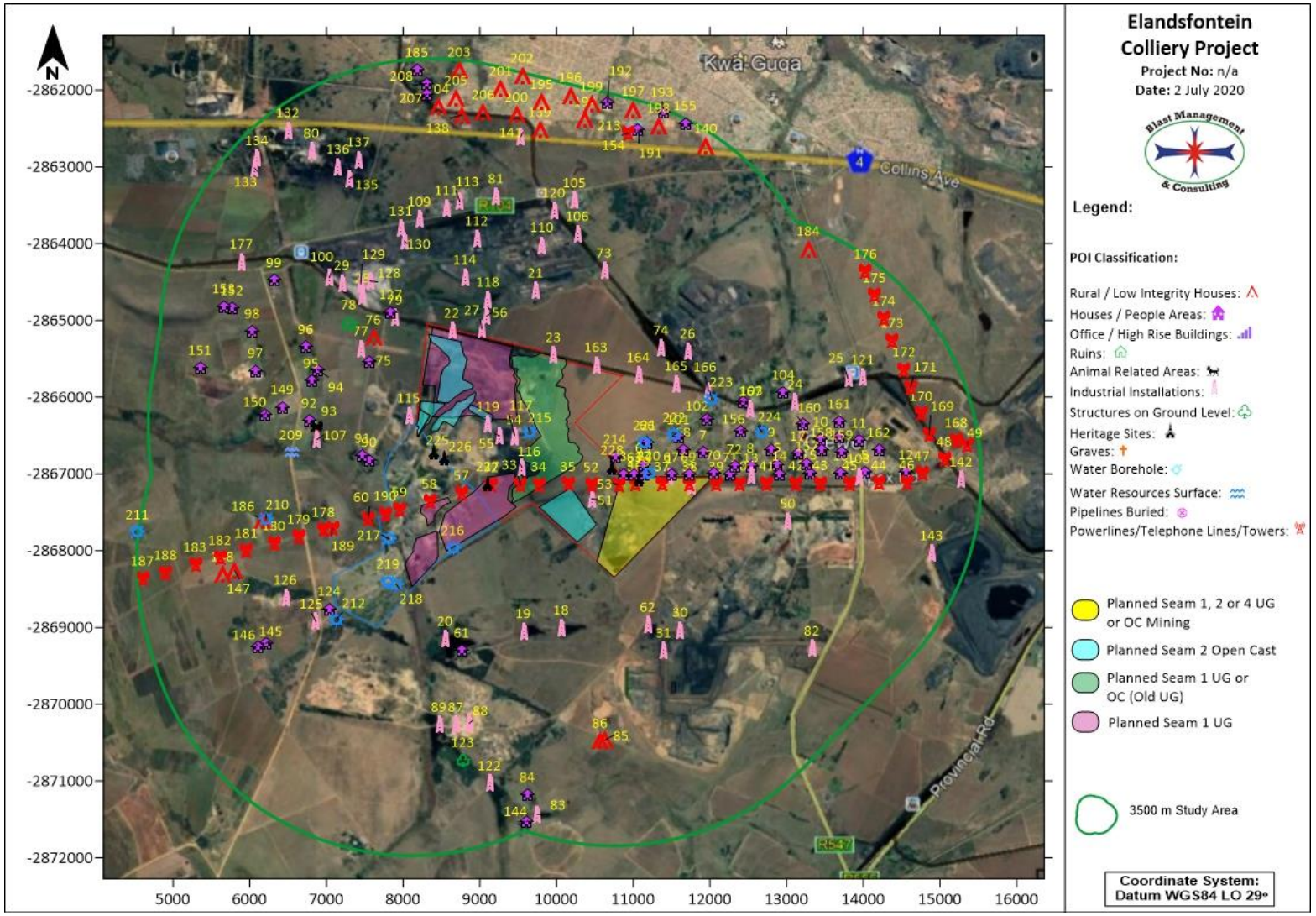


Figure 8: Aerial view and surface plan of the proposed mining areas with points of interest identified

Table 6: List of points of interest identified (WGS84 – LO 29°)

Tag	Description	Classification	Y	X
1	Road	6	-11469.13	2867032.36
2	Dam (Inside OC Pit Area)	6	-11760.49	2867157.80
3	Buildings/Structures	2	-10875.61	2867000.12
4	School	2	-13694.62	2866514.64
5	Church	2	-14023.50	2866977.38
6	Sport Terrain	2	-12880.27	2866887.69
7	Houses	2	-11914.00	2866722.31
8	Houses	2	-12534.72	2866893.28
9	Houses	2	-12808.24	2866682.76
10	Houses	2	-13447.39	2866552.67
11	Houses	2	-13944.67	2866566.32
12	Houses	2	-14559.13	2866982.17
13	Road	6	-12536.21	2867021.92
14	Houses	2	-12911.68	2866998.92
15	Houses	2	-13300.68	2866986.35
16	Houses	2	-13708.24	2866995.26
17	Church	2	-13149.61	2866736.96
18	Dam/Dam Wall	6	-10062.72	2869004.05
19	Dam/Dam Wall	6	-9569.56	2869050.08
20	Dam/Dam Wall	6	-8552.03	2869149.80
21	Industrial Structure	6	-9730.00	2864611.45
22	Railway Line	6	-8639.80	2865132.10
23	Railway Line	6	-9964.95	2865449.12
24	Railway Line	6	-13113.41	2866061.55
25	Railway Substation	6	-13802.16	2865760.30
26	Industrial Structures	6	-11711.17	2865400.14
27	Sewer Works	6	-9024.05	2865106.65
28	Mining Activity	6	-7471.72	2864678.32
29	Mine Buildings	6	-7207.26	2864512.96
30	Mine Activity	6	-11616.09	2869032.87
31	Mine Building/Structures	6	-11399.98	2869300.58
32	Power lines/Pylons (Inside Pit Area)	13	-9152.09	2867143.01
33	Power lines/Pylons (Inside Pit Area)	13	-9532.53	2867144.78
34	Power line/Pylons (Inside Pit Area)	13	-9773.33	2867136.80
35	Power lines/Pylons	13	-10154.86	2867134.56
36	Power lines/Pylons (Inside Pit Area)	13	-11021.92	2867134.62
37	Power lines/Pylons (Inside Pit Area)	13	-11376.45	2867134.92
38	Power lines/Pylons (Inside Pit Area)	13	-11738.24	2867134.98
39	Power lines/Pylons	13	-12087.70	2867131.47
40	Power lines/Pylons	13	-12388.56	2867126.00
41	Power lines/Pylons	13	-12746.52	2867127.55
42	Power lines/Pylons	13	-13129.13	2867122.19

Tag	Description	Classification	Y	X
43	Power lines/Pylons	13	-13442.91	2867120.92
44	Power lines/Pylons	13	-14207.74	2867118.91
45	Power lines/Pylons	13	-13828.23	2867121.53
46	Power lines/Pylons	13	-14573.53	2867116.03
47	Power lines/Pylons	13	-14768.27	2866992.31
48	Power lines/Pylons	13	-15056.64	2866810.53
49	Power lines/Pylons	13	-15359.69	2866620.21
50	Mine Activity	6	-13018.68	2867616.02
51	Mine Buildings/Structures	6	-10457.59	2867321.40
52	Power lines/Pylons	13	-10456.25	2867142.12
53	Power lines/Pylons	13	-10807.38	2867139.12
54	Mine Activity	6	-9452.55	2866518.80
55	Mine Buildings/Structures	6	-9257.65	2866506.73
56	Industrial Structures	6	-9092.01	2864942.84
57	Power lines/Pylons	13	-8763.83	2867250.04
58	Power lines/Pylons	13	-8346.36	2867360.08
59	Power lines/Pylons	13	-7960.39	2867464.52
60	Power lines/Pylons	13	-7541.90	2867580.72
61	Game Lodge Buildings	2	-8767.12	2869300.01
62	Tailings Dam Active	6	-11193.34	2868962.82
63	Houses	2	-11020.01	2867012.21
64	Houses	2	-11154.42	2867005.54
65	Houses	2	-11132.97	2866890.50
66	Houses	2	-11186.05	2866596.82
67	Houses	2	-11498.32	2867011.00
68	Houses	2	-11654.74	2866686.08
69	Houses	2	-11724.28	2867008.97
70	Houses	2	-12046.99	2866986.32
71	Houses	2	-12265.26	2867012.88
72	Houses	2	-12324.71	2866905.34
73	Railway line	6	-10624.65	2864350.70
74	Railway line	6	-11366.53	2865359.23
75	Farmstead	2	-7557.26	2865537.80
76	Informal Housing	1	-7615.25	2865220.58
77	Cement Dam	6	-7452.38	2865370.72
78	Ruins	4	-7294.08	2865027.87
79	Railway line	6	-7896.88	2864960.78
80	Mine Buildings	6	-6810.45	2862791.25
81	Power Station	6	-9214.73	2863383.70
82	Power Substation	6	-13331.99	2869272.76
83	Dam/Dam Wall	6	-9751.67	2871435.49
84	Farmstead	2	-9624.93	2871181.18
85	Informal Housing	1	-10630.36	2870465.91
86	Informal Housing	1	-10571.09	2870478.77

Tag	Description	Classification	Y	X
87	Mine Building/Structures	6	-8690.61	2870266.15
88	Mine Activity	6	-8862.05	2870248.92
89	Dam/Dam Wall	6	-8468.76	2870266.97
90	Farm Building	2	-7562.80	2866817.20
91	Farm Building	2	-7473.61	2866762.99
92	Farmstead	2	-6780.80	2866305.04
93	Cattle Yard	5	-6866.90	2866382.17
94	Farm Buildings	2	-6885.12	2865639.89
95	Farm House	2	-6806.98	2865785.93
96	Farmstead	2	-6736.77	2865347.50
97	Buildings/Structures	2	-6078.93	2865655.48
98	Farm Buildings	2	-6036.09	2865142.55
99	Farm Building/Structures	2	-6319.29	2864475.95
100	Railway line	6	-7036.75	2864443.10
101	Houses	2	-11594.38	2866522.36
102	Houses	2	-11959.36	2866283.28
103	Houses	2	-12432.36	2866062.79
104	Building Structures	2	-12959.93	2865939.77
105	Industrial Buildings	6	-10238.67	2863438.57
106	Dam/Dam Wall	6	-10276.85	2863874.93
107	Dam/Dam Wall	6	-6876.56	2866553.10
108	Road (R547)	6	-13943.23	2867033.85
109	Road (R104)	6	-8217.73	2863681.64
110	Industrial Structures	6	-9811.28	2864020.06
111	Industrial Structures	6	-8568.46	2863538.41
112	Industrial Structures	6	-8959.97	2863933.39
113	Industrial Structures	6	-8738.96	2863452.26
114	Tailings Dam Old	6	-8807.00	2864440.13
115	Mine Activity	6	-8074.47	2866242.39
116	Coal Yard	6	-9551.62	2866907.23
117	Mine Building	6	-9454.89	2866500.15
118	Dam/Dam Wall	6	-9110.06	2864727.98
119	Mine Activity	6	-9109.77	2866351.15
120	Road Bridge	6	-9966.97	2863567.80
121	Bridge	6	-13995.26	2865741.00
122	Dam/Dam Wall	6	-9129.96	2871029.72
123	Marsh	7	-8782.45	2870727.51
124	Farm House	2	-7041.40	2868757.32
125	Industrial Area	6	-6863.66	2868922.53
126	Industrial Area	6	-6467.14	2868610.03
127	Building/Structure	2	-7841.06	2864894.09
128	Mine Building	6	-7567.06	2864486.20
129	Mine Buildings/Structure	6	-7445.63	2864523.74
130	Industrial Buildings	6	-8015.57	2863970.28

Tag	Description	Classification	Y	X
131	Industrial Building/Structure	6	-7976.08	2863803.73
132	Industrial Building/Structure	6	-6501.51	2862527.09
133	Coal Yard	6	-6064.61	2863017.84
134	Industrial Building/Structure	6	-6096.23	2862888.79
135	Industrial Building/Structure	6	-7296.96	2863154.11
136	Mine Building/Structure	6	-7153.20	2862999.33
137	Mine Building/Structure	6	-7420.68	2862908.81
138	Kwa-Guqa Houses	1	-8761.39	2862326.46
139	Kwa-Guqa Houses	1	-9785.01	2862516.89
140	Kwa-Guqu Houses	1	-11949.41	2862730.84
141	N4 Road	6	-9529.39	2862611.91
142	Anglo Mining Operations	6	-15272.87	2867072.93
143	Tailings Dam	6	-14890.51	2868034.10
144	Farmstead	2	-9609.67	2871528.40
145	Farm Buildings	2	-6207.41	2869205.80
146	Farmstead	2	-6103.09	2869244.30
147	Informal Houses	1	-5800.68	2868251.08
148	Informal Houses	1	-5645.81	2868309.45
149	Farmstead	2	-6427.53	2866132.35
150	Farmstead	2	-6194.38	2866223.76
151	Farmstead	2	-5354.98	2865617.58
152	Farmstead	2	-5771.70	2864839.64
153	Farmstead	2	-5665.86	2864815.23
154	Reservoir	11	-10994.18	2862531.51
155	Church	2	-11679.74	2862434.71
156	Houses	2	-12402.55	2866433.18
157	Houses	2	-13265.77	2866868.67
158	Houses	2	-13454.41	2866686.69
159	Houses	2	-13719.16	2866718.49
160	Houses	2	-13217.68	2866355.96
161	Houses	2	-13686.14	2866318.31
162	Houses	2	-14205.20	2866692.44
163	Railway Line	6	-10517.81	2865580.48
164	Railway Line	6	-11070.91	2865708.91
165	Railway Line	6	-11562.89	2865825.26
166	Railway Line	6	-11980.71	2865920.14
167	Railway Line	6	-12532.65	2866153.90
168	Power lines/Pylons	13	-15214.09	2866562.03
169	Power lines/Pylons	13	-14859.34	2866490.12
170	Power lines/Pylons	13	-14755.65	2866218.09
171	Power lines/Pylons	13	-14617.95	2865869.04
172	Power lines/Pylons	13	-14534.32	2865641.81
173	Power lines/Pylons	13	-14376.92	2865264.24
174	Power lines/Pylons	13	-14270.97	2864976.74

Tag	Description	Classification	Y	X
175	Power lines/Pylons	13	-14148.12	2864675.14
176	Power lines/Pylons	13	-14029.74	2864367.14
177	Sub Station	6	-5895.04	2864237.60
178	Power lines/Pylons	13	-6965.08	2867728.56
179	Power lines/Pylons	13	-6644.03	2867819.19
180	Power lines/Pylons	13	-6319.27	2867907.50
181	Power lines/Pylons	13	-5960.44	2868003.80
182	Power lines/Pylons	13	-5613.98	2868094.23
183	Power lines/Pylons	13	-5290.79	2868185.72
184	Informal Housing	1	-13283.38	2864067.16
185	Farm Buildings/Structures	2	-8182.59	2861737.38
186	Informal Housing	1	-6173.30	2867609.36
187	Power lines/Pylons	13	-4604.28	2868364.62
188	Power lines/Pylons	13	-4907.14	2868287.79
189	Power lines/Pylons	13	-7078.11	2867703.36
190	Power lines/Pylons	13	-7770.35	2867518.32
191	Church	2	-11065.71	2862518.32
192	School	2	-10665.10	2862165.16
193	School	2	-11400.63	2862287.63
194	Kwa-Guqa Houses	1	-10376.38	2862382.29
195	Kwa-Guqa Houses	1	-9809.51	2862155.17
196	Kwa-Guqa Houses	1	-10185.10	2862065.14
197	Kwa-Guqa Houses	1	-11002.11	2862247.76
198	Kwa-Guqa Houses	1	-11333.90	2862464.17
199	Kwa-Guqa Houses	1	-10458.26	2862182.29
200	Kwa-Guqa Houses	1	-9480.67	2862322.35
201	Kwa-Guqa Houses	1	-9277.61	2861981.64
202	Kwa-Guqa Houses	1	-9557.07	2861812.64
203	Kwa-Guqa Houses	1	-8734.76	2861733.09
204	Kwa-Guqa Houses	1	-8456.85	2862216.12
205	Kwa-Guqa Houses	1	-8695.64	2862103.51
206	Kwa-Guqa Houses	1	-9047.82	2862287.41
207	Buildings/Structures	2	-8310.97	2862049.89
208	Buildings/Structures	2	-8309.75	2861914.87
209	River (Site ASW01- Not in use)	11	-6544.74	2866722.44
210	Hydrocencus Borehole - Domestic (AHBH01)	10	-6214.68	2867588.63
211	Hydrocencus Borehole - Domestic& Livestock (AHBH02)	10	-4537.47	2867760.77
212	Hydrocencus Borehole - Domestic (AHBH03)	10	-7128.69	2868898.60
213	Communication Tower	13	-10942.19	2862562.24
214	Buildings/Structures	2	-10764.82	2866775.95
215	Monitoring Borehole (ECBH 03)	10	-9651.98	2866457.36
216	Monitoring Borehole (ELNBH 03)	10	-8653.02	2867967.80
217	River (Site ASW 02 - Not in use)	10	-7815.54	2867845.41
218	Monitoring Borehole (BH 173)	10	-7909.36	2868434.85

Tag	Description	Classification	Y	X
219	Monitoring Borehole (BH 172)	10	-7809.20	2868404.88
220	Hydrocencus Borehole (AHBH04 - Not in use)	10	-11206.58	2866993.70
221	Hydrocencus Borehole (AHBH05 - Domestic& Livestock)	10	-11151.81	2866598.14
222	Hydrocencus Borehole (AHBH06 - Domestic& Irrigation)	10	-11538.66	2866493.23
223	Hydrocencus Borehole (AHBH07 - Not in use)	10	-12021.03	2866030.57
224	Hydrocencus Borehole (AHBH08 - Not in use)	10	-12678.94	2866456.61
225	Heritage Site (11478/BGG-001 - Historic burial ground)	8	-8402.96	2866718.18
226	Heritage Site (11478/BGG-002 - Historic burial ground)	8	-8542.88	2866788.73
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	8	-9104.64	2867132.88
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	8	-10729.63	2866916.08
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	8	-11076.27	2867068.48

During the site visit the structures were observed and the initial POI list ground-truthed and finalised as represented in this section. Structures ranged from well-built structures to informal building styles. Table 7 shows photos of structures found in the area.

Table 7: Structure Profile

Structure Photo	Description
	Highveld Operations

	Highveld Operations
	R104 Road
	Highveld Operations

	Sub Station
	Power Lines/Pylons
	Old Railway Bridge

	Old Railway Bridge
	Highveld Offices
	Industrial Park

	Reservoir
	Reservoirs
	Communication Tower

	Church
	Highveld Plant
	Dam

	Old House
	Tent
	Railway Line

	Industrial Buildings
	Railway Line
	Informal Settlement

	Informal Settlement
	Hot Houses
	Communication Tower

	Structures
	Livestock
	Structures

	Railway Line
	Wind Mill
	Structures

	Old Structures
	Highveld Steel Plant
	Borehole

	Pumphouse
	Mobile Structure
	Hydraulic Station

	Elandsfontein Colliery Entrance
	Graveyard
	Graves

	Ruins
	Supermarket

16 Blasting Operations

In order to evaluate the possible influence from blasting operations with regards to ground vibration, air blast and fly rock a planned blast design is required to determine possible influences. In the mining process blasting will definitely be required for the overburden material. Indications are that coal may be mechanically dug and ripped with drilling and blasting as a last option.
This report concentrates on the drilling and blasting of the overburden. Coal requires significantly less explosives per unit than the overburden. The overburden blasts are then considered as a worst-case scenario and is used as indicator of possible influence.

Using blast information data provided, JKSimblast blast design software was used to design and simulate the blast. This designed blast was applied for the evaluation done in this report. The simulation of the blast provided the best prediction possible. Table 8 shows summary technical information of the blast designed in JKSimblast. Figure 9 below shows the blast layout with blast holes, simulation and maximum charge mass per delay. Figure 10 shows simulation timing contours

with number of blast holes per delay from the typical timing applied. Figure 11 shows the simulation with timing contours and charge mass per delay.

Table 8: Blast design technical information

Blast Name:	Elandsfontein	
Av. Burden	5	m
Av. Spacing	5	m
All Hole Lengths	2 400.000	m
Volume	60 000.000	m³
Rock SG	2.6	
Tonnage	156 000.000	tonnes
Marked Holes	160	
Charge Mass	44 261.703	kg
Charge Energy	130 129.408	MJ
POWDER FACTOR	0.738	kg/m³
POWDER FACTOR	0.284	kg/t
ENERGY FACTOR	2.169	MJ/m³
ENERGY FACTOR	0.834	MJ/t

HOLES											
Diameter (mm)	Number of Holes	Total Length (m)	Min. Length (m)	Max. Length (m)	Av. Length (m)	Total Cost (R)					
165	160	2320	14.5	14.5	14.5	0					
CHARGE DECKS											
Material Name	SG	Total Number	Total Cost (R)	Total Length (m)	Min. Length (m)	Max. Length (m)	Mean Length (m)	Total Mass (kg)	Min. Mass (kg)	Max. Mass (kg)	Mean Mass (kg)
Maxam RIOFLEX MX 7000	1.15	160	0	1800	11.25	11.25	11.25	44261.7	277	277	277
STEMMING DECKS											
Material Name	SG	Total Number	Total Cost (R)	Total Length (m)	Min. Length (m)	Max. Length (m)	Mean Length (m)	Total Mass (kg)	Min. Mass (kg)	Max. Mass (kg)	Mean Mass (kg)
Stemming	2	160	0	520	3.25	3.25	3.25	22237.76	138.986	138.986	138.986
DOWN-HOLE DELAYS											
Delay Name	Nominal Delay (ms)	Actual Delay (ms)	Number Of Delays	Total Cost (R)							
MS 500 ms	500	500	160	0							
DOWN-HOLE CONNECTIONS											
Connection Name	Burn Speed (m/s)	Number Of Connections	Supplied Length (m)	Actual Length (m)	Total Cost (R)						
Nonel	2000	160	2320	2320	0						
DOWN-HOLE PRIMERS											
Primer Name	Number of Primers	Total Cost (R)									
Viper 400	160	640									
INTER-ROW DELAYS											
Delay Name	Nominal Delay (ms)	Actual Delay (ms)	Number Of Delays	Total Cost (R)							

SNonel42	42	42	16	0							
INTER-ROW CONNECTIONS											
Connection Name	Burn Speed (m/s)	Number Of Connections	Supplied Length (m)	Actual Length (m)	Total Cost (R)						
Nonel	2000	16	90.06899	90.06899	0						
INTER-HOLE DELAYS											
Delay Name	Nominal Delay (ms)	Actual Delay (ms)	Number Of Delays	Total Cost (R)							
SNonel17	17	17	144	0							
INTER-HOLE CONNECTIONS											
Connection Name	Burn Speed (m/s)	Number Of Connections	Supplied Length (m)	Actual Length (m)	Total Cost (R)						
Nonel	2000	144	720	720	0						

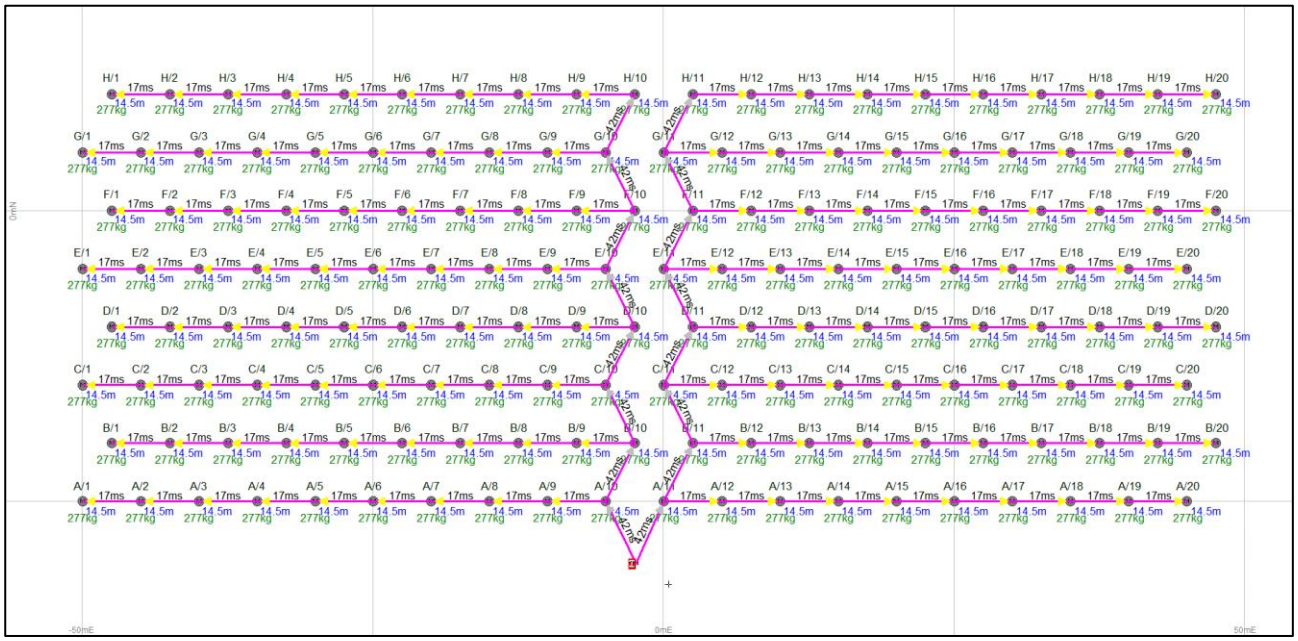


Figure 9: Blast holes layout with length and charge mass

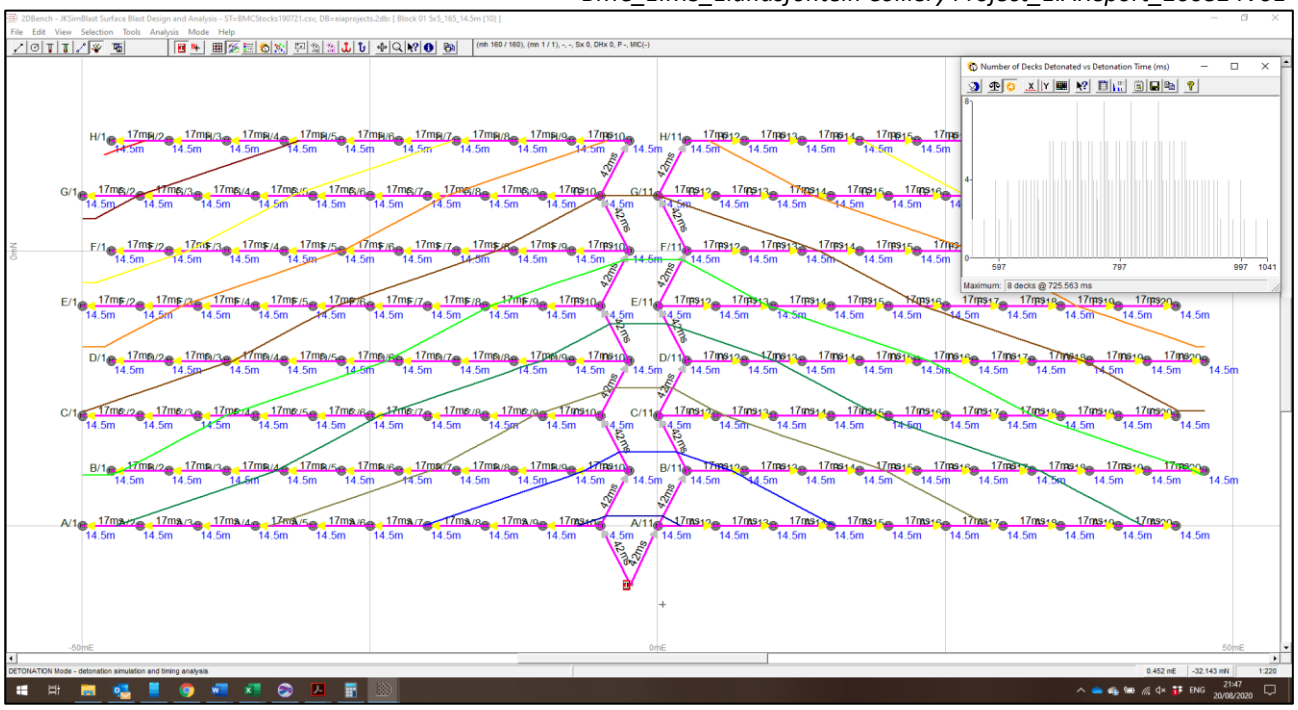


Figure 10: Simulation and number of holes/decks per delay graph

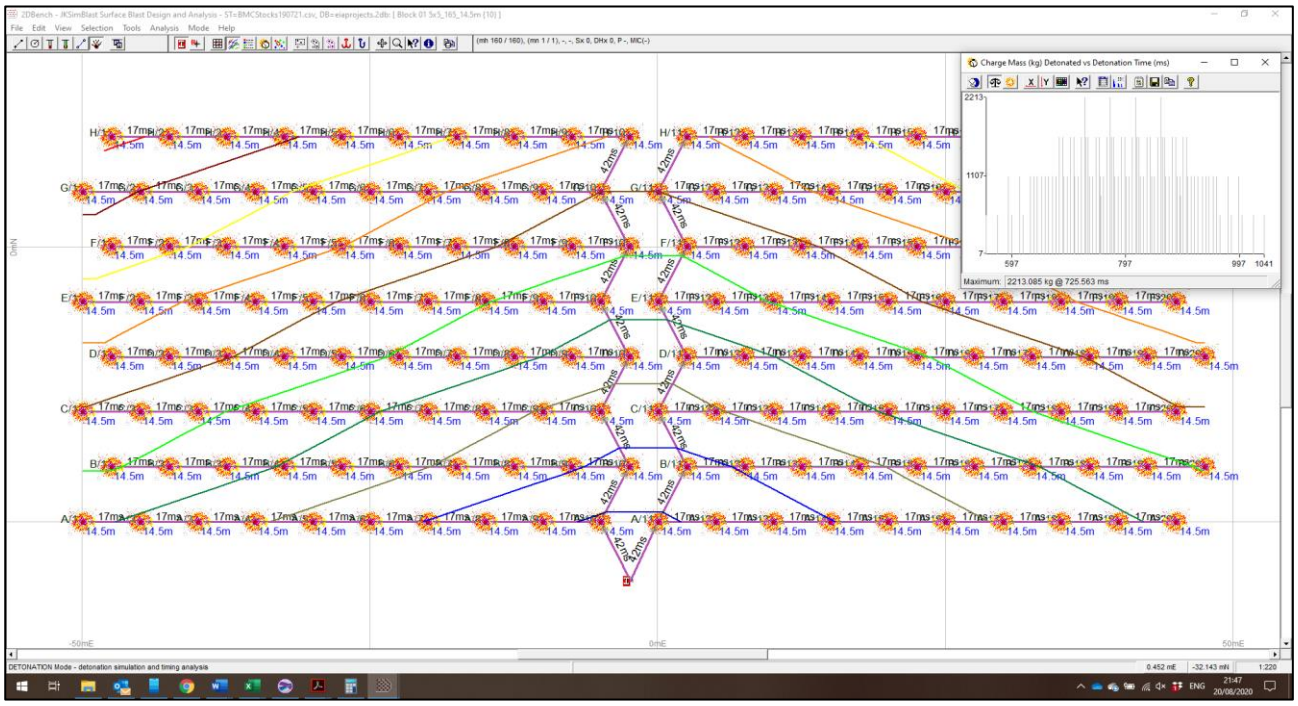


Figure 11: Simulation and charge mass per delay graph

The simulation work done provided information that is applied for predicting ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 165 mm diameter single blast hole and the maximum charge was extracted from the blast simulation in JKSimblast. The maximum charge relates to the total number of blast holes that detonates simultaneously based on the blast layout

and initiation timing of the blast. Thus, the maximum mass of explosives detonating at once. The minimum charge relates to 277 kg and the maximum charge relates to 2213 kg. These values were applied in all predictions for ground vibration and air blast.

16.1 Ground Vibration

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

Equation 1:

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

Where:

PPV = Predicted ground vibration (mm/s)

a = Site constant

b = Site constant

D = Distance (m)

E = Explosive Mass (kg)

Applicable and accepted factors a&b for new operations is as follows:

Factors:

a = 1143

b = -1.65

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

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

Based on the designs presented on expected drilling and charging design, the following Table 9 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. The charge masses are 277 kg and 2213 kg for the Pit areas.

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

No.	Distance (m)	Expected PPV (mm/s) for 277 kg Charge	Expected PPV (mm/s) for 2213 kg Charge
1	50.0	186.1	1033.6
2	100.0	95.3	529.4
3	150.0	30.4	168.7
4	200.0	18.9	104.9
5	250.0	13.1	72.6
6	300.0	9.7	53.8
7	400.0	6.0	33.4
8	500.0	4.2	23.1
9	600.0	3.1	17.1
10	700.0	2.4	13.3
11	800.0	1.9	10.7
12	900.0	1.6	8.8
13	1000.0	1.3	7.4
14	1250.0	0.9	5.1
15	1500.0	0.7	3.8
16	1750.0	0.5	2.9
17	2000.0	0.4	2.3
18	2500.0	0.3	1.6
19	3000.0	0.2	1.2
20	3500.0	0.2	0.9

16.2 Air blast

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

In most cases mainly an indication of typical levels can be obtained. The indication of levels or the prediction of air blast in this report is used to predefine possible indicators of concern.

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

Equation 2:

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

Where:

P = Air blast level (mB)

D = Distance from source (m)

E = Maximum charge mass per delay (kg)

A = Constant - (5.37)

B = Constant – (-0.79)

The constants for A and B were then selected according to the information as provided in Figure 12 below. Various types of mining operations are expected to yield different results. The information provided in Figure 12 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 (highwall)" was applied in the prediction or air blast.

Air Overpressure Prediction Equations

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

Table 26.7 - Air overpressure prediction equations.

Figure 12: Proposed prediction equations

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

Equation 3:

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

Where:

p_s = Air blast level (dB)

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

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

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

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

Table 10: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) for 277 kg Charge	Air blast (dB) for 2213 kg Charge
1	50.0	134.5	139.3
2	100.0	131.8	136.5
3	150.0	127.0	131.8
4	200.0	125.1	129.8
5	250.0	123.5	128.3
6	300.0	122.3	127.0
7	400.0	120.3	125.1
8	500.0	118.8	123.5
9	600.0	117.5	122.3
10	700.0	116.5	121.2
11	800.0	115.6	120.3
12	900.0	114.8	119.5
13	1000.0	114.0	118.8
14	1250.0	112.5	117.2
15	1500.0	111.3	116.0
16	1750.0	110.2	114.9
17	2000.0	109.3	114.0
18	2500.0	107.7	112.5
19	3000.0	106.6	111.3
20	3500.0	105.5	110.2

17 Planning Phase Impacts

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

18 Construction Phase: Impact Assessment and Mitigation Measures

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

19 Operational Phase: Impact Assessment and Mitigation Measures

The area surrounding the proposed mining area was reviewed for structures, traffic, roads, human interface, animals' interface etc. Various installations and structures were observed. These are listed in Table 6. This section concentrates on the outcome of modelling the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces. In evaluation, the charge mass scenarios selected as indicated in section 15.2 is considered with regards to ground vibration and air blast.

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

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

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

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

19.1 Review of expected ground vibration

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

- "Tag" No. is the number corresponding to the POI figures;
- "Description" indicates the type of the structure;
- "Distance" is the distance between the structure and edge of the pit area;
- "Specific Limit" is the maximum limit for ground vibration at the specific structure or installation;
- "Predicted PPV (mm/s)" is the calculated ground vibration at the structure;

- The "Structure Response @ 10Hz and Human Tolerance @ 30Hz" indicates the possible concern and if there is any concern for structural damage or potential negative human perception, respectively. Indicators used are "perceptible"," unpleasant", "intolerable" which stems from the human perception information given and indicators such as "high" or "low" is given for the possibility of damage to a structure. Levels below 0.76 mm/s could be considered to have negligible possibility of influence.

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

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

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

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

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

19.1.1 Ground vibration minimum charge mass per delay – 277 kg

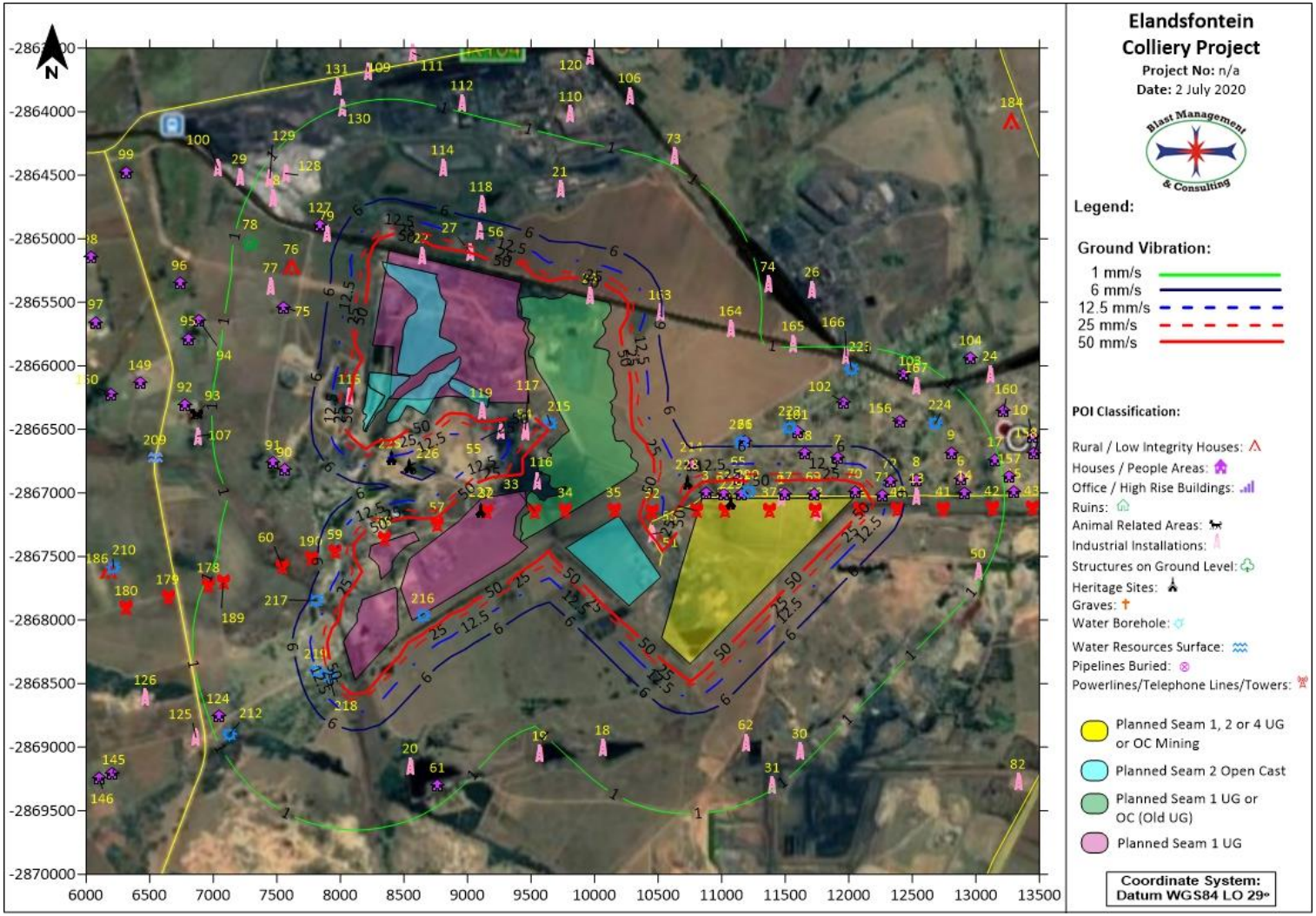


Figure 13: Ground vibration influence from minimum charge per delay

Table 11: Ground vibration evaluation for minimum charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Road	150	15	277	1330.4	Problematic	N/A
2	Dam (Inside OC Pit Area)	50	-	277	-	-	-
3	Buildings/Structures	12.5	43	277	237.8	Problematic	Intolerable
4	School	25	1740	277	0.5	Acceptable	Too Low
5	Church	12.5	1988	277	0.4	Acceptable	Too Low
6	Sport Terrain	50	858	277	1.7	Acceptable	Perceptible
7	Houses	12.5	318	277	8.8	Acceptable	Unpleasant
8	Houses	12.5	520	277	3.9	Acceptable	Perceptible
9	Houses	12.5	851	277	1.7	Acceptable	Perceptible
10	Houses	12.5	1493	277	0.7	Acceptable	Too Low
11	Houses	12.5	1967	277	0.4	Acceptable	Too Low
12	Houses	12.5	2524	277	0.3	Acceptable	Too Low
13	Road	150	500	277	4.2	Acceptable	N/A
14	Houses	12.5	876	277	1.7	Acceptable	Perceptible
15	Houses	12.5	1266	277	0.9	Acceptable	Perceptible
16	Houses	12.5	1673	277	0.6	Acceptable	Too Low
17	Church	12.5	1154	277	1.0	Acceptable	Perceptible
18	Dam/Dam Wall	50	952	277	1.4	Acceptable	N/A
19	Dam/Dam Wall	50	1320	277	0.8	Acceptable	N/A
20	Dam/Dam Wall	50	809	277	1.9	Acceptable	N/A
21	Industrial Structure	50	799	277	1.9	Acceptable	N/A
22	Railway Line	150	26	277	545.7	Problematic	N/A
23	Railway Line	150	22	277	746.8	Problematic	N/A
24	Railway Line	150	1456	277	0.7	Acceptable	N/A
25	Railway Substation	25	2182	277	0.4	Acceptable	N/A
26	Industrial Structures	50	1590	277	0.6	Acceptable	N/A
27	Sewer Works	50	137	277	35.2	Acceptable	N/A
28	Mining Activity	200	1003	277	1.3	Acceptable	N/A
29	Mine Buildings	25	1313	277	0.8	Acceptable	N/A
30	Mine Activity	200	1098	277	1.1	Acceptable	N/A
31	Mine Building/Structures	25	1161	277	1.0	Acceptable	N/A
32	Power lines/Pylons (Inside Pit Area)	75	-	277	-	-	-
33	Power lines/Pylons (Inside Pit Area)	75	-	277	-	-	-
34	Power line/Pylons (Inside Pit Area)	75	-	277	-	-	-
35	Power lines/Pylons	75	50	277	185.6	Problematic	N/A
36	Power lines/Pylons (Inside Pit Area)	75	-	277	-	-	-
37	Power lines/Pylons (Inside Pit Area)	75	-	277	-	-	--
38	Power lines/Pylons (Inside Pit Area)	75	--	277	-	-	-
39	Power lines/Pylons	75	100	277	58.9	Acceptable	N/A
40	Power lines/Pylons	75	362	277	7.1	Acceptable	N/A
41	Power lines/Pylons	75	715	277	2.3	Acceptable	N/A
42	Power lines/Pylons	75	1096	277	1.1	Acceptable	N/A
43	Power lines/Pylons	75	1409	277	0.8	Acceptable	N/A
44	Power lines/Pylons	75	2173	277	0.4	Acceptable	N/A
45	Power lines/Pylons	75	1794	277	0.5	Acceptable	N/A
46	Power lines/Pylons	75	2538	277	0.3	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
47	Power lines/Pylons	75	2732	277	0.3	Acceptable	N/A
48	Power lines/Pylons	75	3029	277	0.2	Acceptable	N/A
49	Power lines/Pylons	75	3350	277	0.2	Acceptable	N/A
50	Mine Activity	200	1138	277	1.1	Acceptable	N/A
51	Mine Buildings/Structures	25	140	277	34.2	Problematic	N/A
52	Power lines/Pylons	75	235	277	14.5	Acceptable	N/A
53	Power lines/Pylons	75	21	277	780.8	Problematic	N/A
54	Mine Activity	200	227	277	15.3	Acceptable	N/A
55	Mine Buildings/Structures	25	218	277	16.3	Acceptable	N/A
56	Industrial Structures	50	312	277	9.1	Acceptable	N/A
57	Power lines/Pylons	75	81	277	84.1	Problematic	N/A
58	Power lines/Pylons	75	27	277	516.6	Problematic	N/A
59	Power lines/Pylons	75	270	277	11.5	Acceptable	N/A
60	Power lines/Pylons	75	684	277	2.5	Acceptable	N/A
61	Game Lodge Buildings	12.5	1056	277	1.2	Acceptable	Perceptible
62	Tailings Dam Active	25	765	277	2.1	Acceptable	N/A
63	Houses	12.5	35	277	328.9	Problematic	Intolerable
64	Houses	12.5	37	277	304.0	Problematic	Intolerable
65	Houses	12.5	152	277	29.7	Problematic	Intolerable
66	Houses	12.5	445	277	5.0	Acceptable	Perceptible
67	Houses	12.5	34	277	345.2	Problematic	Intolerable
68	Houses	12.5	355	277	7.3	Acceptable	Unpleasant
69	Houses	12.5	31	277	399.3	Problematic	Intolerable
70	Houses	12.5	56	277	152.8	Problematic	Intolerable
71	Houses	12.5	231	277	14.9	Problematic	Unpleasant
72	Houses	12.5	319	277	8.7	Acceptable	Unpleasant
73	Railway line	150	1264	277	0.9	Acceptable	N/A
74	Railway line	150	1253	277	0.9	Acceptable	N/A
75	Farmstead	12.5	739	277	2.2	Acceptable	Perceptible
76	Informal Housing	6	719	277	2.3	Acceptable	Perceptible
77	Cement Dam	50	870	277	1.7	Acceptable	N/A
78	Ruins	6	1055	277	1.2	Acceptable	N/A
79	Railway line	150	500	277	4.2	Acceptable	N/A
80	Mine Buildings	25	2788	277	0.2	Acceptable	N/A
81	Power Station	50	1855	277	0.5	Acceptable	N/A
82	Power Substation	50	2489	277	0.3	Acceptable	N/A
83	Dam/Dam Wall	50	3253	277	0.2	Acceptable	N/A
84	Farmstead	12.5	3056	277	0.2	Acceptable	Too Low
85	Informal Housing	6	2132	277	0.4	Acceptable	Too Low
86	Informal Housing	6	2148	277	0.4	Acceptable	Too Low
87	Mine Building/Structures	25	1890	277	0.5	Acceptable	N/A
88	Mine Activity	200	1933	277	0.4	Acceptable	N/A
89	Dam/Dam Wall	50	1837	277	0.5	Acceptable	N/A
90	Farm Building	12.5	699	277	2.4	Acceptable	Perceptible
91	Farm Building	12.5	758	277	2.1	Acceptable	Perceptible
92	Farmstead	12.5	1397	277	0.8	Acceptable	Perceptible
93	Cattle Yard	50	1310	277	0.9	Acceptable	N/A
94	Farm Buildings	12.5	1384	277	0.8	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
95	Farm House	12.5	1449	277	0.7	Acceptable	Too Low
96	Farmstead	12.5	1579	277	0.6	Acceptable	Too Low
97	Buildings/Structures	12.5	2184	277	0.4	Acceptable	Too Low
98	Farm Buildings	12.5	2299	277	0.3	Acceptable	Too Low
99	Farm Building/Structures	12.5	2142	277	0.4	Acceptable	Too Low
100	Railway line	150	1497	277	0.7	Acceptable	N/A
101	Houses	12.5	518	277	3.9	Acceptable	Perceptible
102	Houses	12.5	756	277	2.1	Acceptable	Perceptible
103	Houses	12.5	1056	277	1.2	Acceptable	Perceptible
104	Building Structures	12.5	1438	277	0.7	Acceptable	Too Low
105	Industrial Buildings	50	2036	277	0.4	Acceptable	N/A
106	Dam/Dam Wall	50	1620	277	0.6	Acceptable	N/A
107	Dam/Dam Wall	50	1306	277	0.9	Acceptable	N/A
108	Road (R547)	150	1907	277	0.5	Acceptable	N/A
109	Road (R104)	150	1419	277	0.7	Acceptable	N/A
110	Industrial Structures	50	1382	277	0.8	Acceptable	N/A
111	Industrial Structures	50	1563	277	0.6	Acceptable	N/A
112	Industrial Structures	50	1261	277	0.9	Acceptable	N/A
113	Industrial Structures	50	1676	277	0.6	Acceptable	N/A
114	Tailings Dam Old	50	732	277	2.2	Acceptable	N/A
115	Mine Activity	200	127	277	40.2	Acceptable	N/A
116	Coal Yard	150	74	277	96.4	Acceptable	N/A
117	Mine Building	25	209	277	17.6	Acceptable	N/A
118	Dam/Dam Wall	50	525	277	3.8	Acceptable	N/A
119	Mine Activity	200	49	277	191.2	Acceptable	N/A
120	Road Bridge	50	1860	277	0.5	Acceptable	N/A
121	Bridge	50	2351	277	0.3	Acceptable	N/A
122	Dam/Dam Wall	50	2757	277	0.2	Acceptable	N/A
123	Marsh	200	2358	277	0.3	Acceptable	N/A
124	Farm House	12.5	1112	277	1.1	Acceptable	Perceptible
125	Industrial Area	50	1333	277	0.8	Acceptable	N/A
126	Industrial Area	50	1618	277	0.6	Acceptable	N/A
127	Building/Structure	12.5	579	277	3.3	Acceptable	Perceptible
128	Mine Building	25	1018	277	1.3	Acceptable	N/A
129	Mine Buildings/Structure	25	1098	277	1.1	Acceptable	N/A
130	Industrial Buildings	50	1180	277	1.0	Acceptable	N/A
131	Industrial Building/Structure	50	1351	277	0.8	Acceptable	N/A
132	Industrial Building/Structure	50	3182	277	0.2	Acceptable	N/A
133	Coal Yard	150	3112	277	0.2	Acceptable	N/A
134	Industrial Building/Structure	50	3177	277	0.2	Acceptable	N/A
135	Industrial Building/Structure	50	2222	277	0.4	Acceptable	N/A
136	Mine Building/Structure	25	2428	277	0.3	Acceptable	N/A
137	Mine Building/Structure	25	2386	277	0.3	Acceptable	N/A
138	Kwa-Guqa Houses	6	2790	277	0.2	Acceptable	Too Low
139	Kwa-Guqa Houses	6	2833	277	0.2	Acceptable	Too Low
140	Kwa-Guqu Houses	6	3333	277	0.2	Acceptable	Too Low
141	N4 Road	150	2680	277	0.3	Acceptable	N/A
142	Anglo Mining Operations	200	3237	277	0.2	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
143	Tailings Dam	25	3022	277	0.2	Acceptable	N/A
144	Farmstead	12.5	3387	277	0.2	Acceptable	Too Low
145	Farm Buildings	12.5	2048	277	0.4	Acceptable	Too Low
146	Farmstead	12.5	2159	277	0.4	Acceptable	Too Low
147	Informal Houses	6	2226	277	0.4	Acceptable	Too Low
148	Informal Houses	6	2383	277	0.3	Acceptable	Too Low
149	Farmstead	12.5	1764	277	0.5	Acceptable	Too Low
150	Farmstead	12.5	1987	277	0.4	Acceptable	Too Low
151	Farmstead	12.5	2907	277	0.2	Acceptable	Too Low
152	Farmstead	12.5	2588	277	0.3	Acceptable	Too Low
153	Farmstead	12.5	2697	277	0.3	Acceptable	Too Low
154	Reservoir	50	3100	277	0.2	Acceptable	N/A
155	Church	12.5	3450	277	0.2	Acceptable	Too Low
156	Houses	12.5	710	277	2.3	Acceptable	Perceptible
157	Houses	12.5	1242	277	0.9	Acceptable	Perceptible
158	Houses	12.5	1462	277	0.7	Acceptable	Too Low
159	Houses	12.5	1714	277	0.5	Acceptable	Too Low
160	Houses	12.5	1366	277	0.8	Acceptable	Perceptible
161	Houses	12.5	1801	277	0.5	Acceptable	Too Low
162	Houses	12.5	2197	277	0.4	Acceptable	Too Low
163	Railway Line	150	390	277	6.3	Acceptable	N/A
164	Railway Line	150	954	277	1.4	Acceptable	N/A
165	Railway Line	150	1216	277	1.0	Acceptable	N/A
166	Railway Line	150	1120	277	1.1	Acceptable	N/A
167	Railway Line	150	1017	277	1.3	Acceptable	N/A
168	Power lines/Pylons	75	3214	277	0.2	Acceptable	N/A
169	Power lines/Pylons	75	2876	277	0.2	Acceptable	N/A
170	Power lines/Pylons	75	2841	277	0.2	Acceptable	N/A
171	Power lines/Pylons	75	2836	277	0.2	Acceptable	N/A
172	Power lines/Pylons	75	2864	277	0.2	Acceptable	N/A
173	Power lines/Pylons	75	2939	277	0.2	Acceptable	N/A
174	Power lines/Pylons	75	3043	277	0.2	Acceptable	N/A
175	Power lines/Pylons	75	3172	277	0.2	Acceptable	N/A
176	Power lines/Pylons	75	3336	277	0.2	Acceptable	N/A
177	Sub Station	25	2624	277	0.3	Acceptable	N/A
178	Power lines/Pylons	75	1150	277	1.1	Acceptable	N/A
179	Power lines/Pylons	75	1427	277	0.7	Acceptable	N/A
180	Power lines/Pylons	75	1727	277	0.5	Acceptable	N/A
181	Power lines/Pylons	75	2072	277	0.4	Acceptable	N/A
182	Power lines/Pylons	75	2413	277	0.3	Acceptable	N/A
183	Power lines/Pylons	75	2735	277	0.3	Acceptable	N/A
184	Informal Housing	6	3225	277	0.2	Acceptable	Too Low
185	Farm Buildings/Structures	12.5	3360	277	0.2	Acceptable	Too Low
186	Informal Housing	6	1937	277	0.4	Acceptable	Too Low
187	Power lines/Pylons	75	3426	277	0.2	Acceptable	N/A
188	Power lines/Pylons	75	3120	277	0.2	Acceptable	N/A
189	Power lines/Pylons	75	1058	277	1.2	Acceptable	N/A
190	Power lines/Pylons	75	462	277	4.7	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
191	Church	12.5	3134	277	0.2	Acceptable	Too Low
192	School	25	3374	277	0.2	Acceptable	Too Low
193	School	25	3466	277	0.2	Acceptable	Too Low
194	Kwa-Guqa Houses	6	3100	277	0.2	Acceptable	Too Low
195	Kwa-Guqa Houses	6	3190	277	0.2	Acceptable	Too Low
196	Kwa-Guqa Houses	6	3366	277	0.2	Acceptable	Too Low
197	Kwa-Guqa Houses	6	3375	277	0.2	Acceptable	Too Low
198	Kwa-Guqa Houses	6	3278	277	0.2	Acceptable	Too Low
199	Kwa-Guqa Houses	6	3311	277	0.2	Acceptable	Too Low
200	Kwa-Guqa Houses	6	2949	277	0.2	Acceptable	Too Low
201	Kwa-Guqa Houses	6	3232	277	0.2	Acceptable	Too Low
202	Kwa-Guqa Houses	6	3463	277	0.2	Acceptable	Too Low
203	Kwa-Guqa Houses	6	3376	277	0.2	Acceptable	Too Low
204	Kwa-Guqa Houses	6	2876	277	0.2	Acceptable	Too Low
205	Kwa-Guqa Houses	6	3003	277	0.2	Acceptable	Too Low
206	Kwa-Guqa Houses	6	2881	277	0.2	Acceptable	Too Low
207	Buildings/Structures	12.5	3042	277	0.2	Acceptable	Too Low
208	Buildings/Structures	12.5	3177	277	0.2	Acceptable	Too Low
209	River (Site ASW01- Not in use)	200	1653	277	0.6	Acceptable	N/A
210	Hydrocencus Borehole - Domestic (AHBH01)	50	1903	277	0.5	Acceptable	N/A
211	Hydrocencus Borehole - Domestic& Livestock (AHBH02)	50	3513	277	0.2	Acceptable	N/A
212	Hydrocencus Borehole - Domestic (AHBH03)	50	1080	277	1.2	Acceptable	N/A
213	Communication Tower	25	3056	277	0.2	Acceptable	N/A
214	Buildings/Structures	12.5	283	277	10.7	Acceptable	Unpleasant
215	Monitoring Borehole (ECBH 03)	50	105	277	55.0	Problematic	N/A
216	Monitoring Borehole (ELNBH 03)	50	24	277	630.8	Problematic	N/A
217	River (Site ASW 02 - Not in use)	50	339	277	7.9	Acceptable	N/A
218	Monitoring Borehole (BH 173)	50	188	277	21.0	Acceptable	N/A
219	Monitoring Borehole (BH 172)	50	274	277	11.2	Acceptable	N/A
220	Hydrocencus Borehole (AHBH04 - Not in use)	50	48	277	196.2	Problematic	N/A
221	Hydrocencus Borehole (AHBH05 - Domestic& Livestock)	50	444	277	5.1	Acceptable	N/A
222	Hydrocencus Borehole (AHBH06 - Domestic& Irrigation)	50	548	277	3.6	Acceptable	N/A
223	Hydrocencus Borehole (AHBH07 - Not in use)	50	1009	277	1.3	Acceptable	N/A
224	Hydrocencus Borehole (AHBH08 - Not in use)	50	869	277	1.7	Acceptable	N/A
225	Heritage Site (11478/BGG-001 - Historic burial ground)	50	274	277	11.2	Acceptable	Unpleasant
226	Heritage Site (11478/BGG-002 - Historic burial ground)	50	370	277	6.8	Acceptable	Unpleasant
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	50	-	277	-	-	-
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	50	174	277	23.7	Acceptable	Intolerable
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	50	-	277	-	-	-

19.1.2 Ground vibration maximum charge mass per delay - 2213 kg

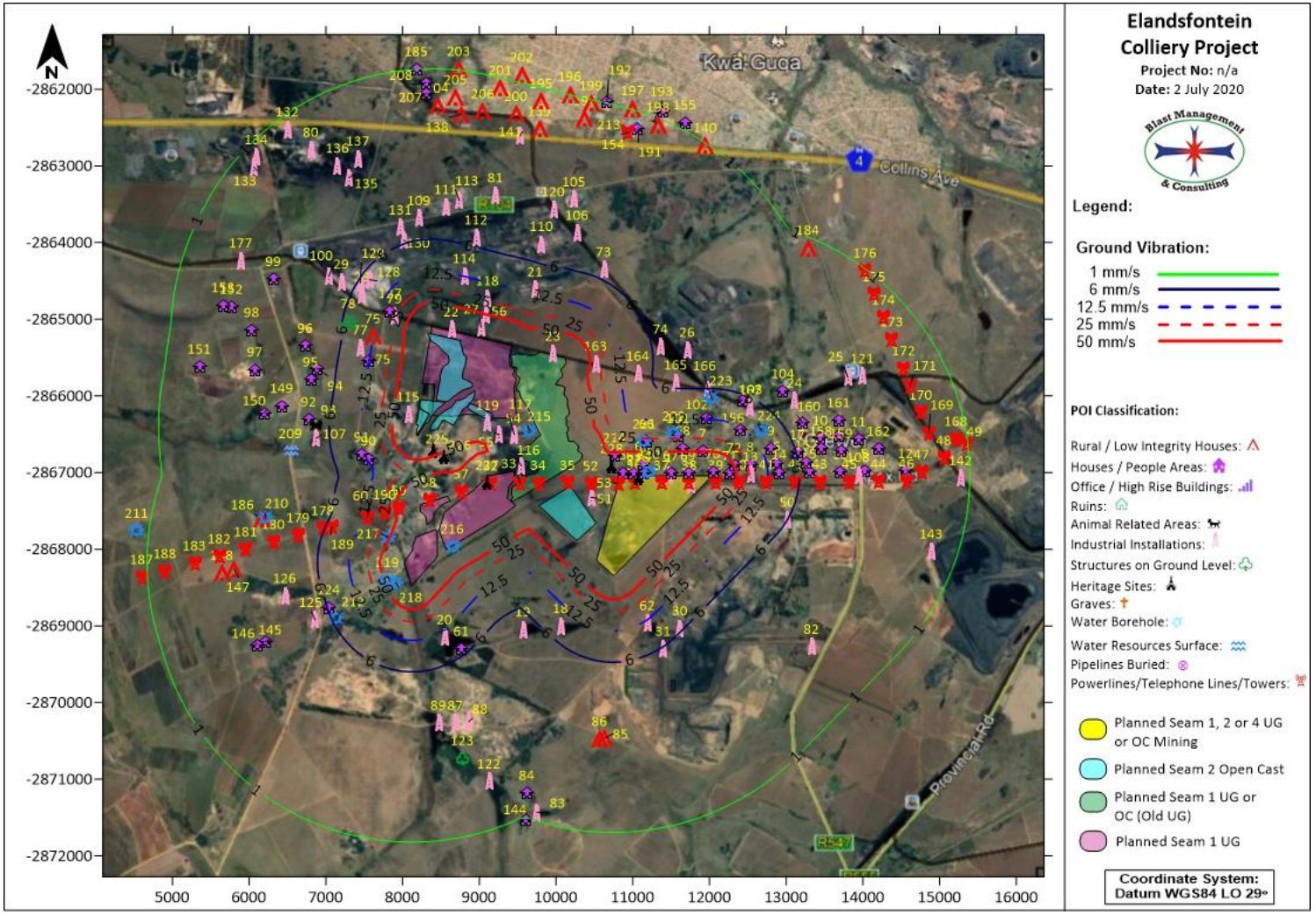


Figure 14: Ground vibration influence from maximum charge per delay

Table 12: Ground vibration evaluation for maximum charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Road	150	15	2213	7388.4	Problematic	N/A
2	Dam (Inside OC Pit Area)	50	-	2213	-	-	-
3	Buildings/Structures	12.5	43	2213	1320.4	Problematic	Intolerable
4	School	25	1740	2213	3.0	Acceptable	Perceptible
5	Church	12.5	1988	2213	2.4	Acceptable	Perceptible
6	Sport Terrain	50	858	2213	9.5	Acceptable	Unpleasant
7	Houses	12.5	318	2213	48.9	Problematic	Intolerable
8	Houses	12.5	520	2213	21.7	Problematic	Intolerable
9	Houses	12.5	851	2213	9.6	Acceptable	Unpleasant
10	Houses	12.5	1493	2213	3.8	Acceptable	Perceptible
11	Houses	12.5	1967	2213	2.4	Acceptable	Perceptible
12	Houses	12.5	2524	2213	1.6	Acceptable	Perceptible
13	Road	150	500	2213	23.1	Acceptable	N/A
14	Houses	12.5	876	2213	9.2	Acceptable	Unpleasant
15	Houses	12.5	1266	2213	5.0	Acceptable	Perceptible
16	Houses	12.5	1673	2213	3.2	Acceptable	Perceptible
17	Church	12.5	1154	2213	5.8	Acceptable	Unpleasant
18	Dam/Dam Wall	50	952	2213	8.0	Acceptable	N/A
19	Dam/Dam Wall	50	1320	2213	4.7	Acceptable	N/A
20	Dam/Dam Wall	50	809	2213	10.4	Acceptable	N/A
21	Industrial Structure	50	799	2213	10.7	Acceptable	N/A
22	Railway Line	150	26	2213	3030.4	Problematic	N/A
23	Railway Line	150	22	2213	4147.2	Problematic	N/A
24	Railway Line	150	1456	2213	4.0	Acceptable	N/A
25	Railway Substation	25	2182	2213	2.0	Acceptable	N/A
26	Industrial Structures	50	1590	2213	3.4	Acceptable	N/A
27	Sewer Works	50	137	2213	195.4	Problematic	N/A
28	Mining Activity	200	1003	2213	7.3	Acceptable	N/A
29	Mine Buildings	25	1313	2213	4.7	Acceptable	N/A
30	Mine Activity	200	1098	2213	6.3	Acceptable	N/A
31	Mine Building/Structures	25	1161	2213	5.8	Acceptable	N/A
32	Power lines/Pylons (Inside Pit Area)	75	-	2213	-	-	-
33	Power lines/Pylons (Inside Pit Area)	75	-	2213	-	-	-
34	Power line/Pylons (Inside Pit Area)	75	-	2213	-	-	-
35	Power lines/Pylons	75	50	2213	1030.5	Problematic	N/A
36	Power lines/Pylons (Inside Pit Area)	75	-	2213	-	-	-
37	Power lines/Pylons (Inside Pit Area)	75	-	2213	-	-	-
38	Power lines/Pylons (Inside Pit Area)	75	--	2213	-	-	-
39	Power lines/Pylons	75	100	2213	327.1	Problematic	N/A
40	Power lines/Pylons	75	362	2213	39.4	Acceptable	N/A
41	Power lines/Pylons	75	715	2213	12.8	Acceptable	N/A
42	Power lines/Pylons	75	1096	2213	6.3	Acceptable	N/A
43	Power lines/Pylons	75	1409	2213	4.2	Acceptable	N/A
44	Power lines/Pylons	75	2173	2213	2.0	Acceptable	N/A
45	Power lines/Pylons	75	1794	2213	2.8	Acceptable	N/A
46	Power lines/Pylons	75	2538	2213	1.6	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
47	Power lines/Pylons	75	2732	2213	1.4	Acceptable	N/A
48	Power lines/Pylons	75	3029	2213	1.2	Acceptable	N/A
49	Power lines/Pylons	75	3350	2213	1.0	Acceptable	N/A
50	Mine Activity	200	1138	2213	6.0	Acceptable	N/A
51	Mine Buildings/Structures	25	140	2213	189.8	Problematic	N/A
52	Power lines/Pylons	75	235	2213	80.7	Problematic	N/A
53	Power lines/Pylons	75	21	2213	4336.3	Problematic	N/A
54	Mine Activity	200	227	2213	85.0	Acceptable	N/A
55	Mine Buildings/Structures	25	218	2213	90.8	Problematic	N/A
56	Industrial Structures	50	312	2213	50.5	Problematic	N/A
57	Power lines/Pylons	75	81	2213	467.1	Problematic	N/A
58	Power lines/Pylons	75	27	2213	2868.7	Problematic	N/A
59	Power lines/Pylons	75	270	2213	64.1	Acceptable	N/A
60	Power lines/Pylons	75	684	2213	13.8	Acceptable	N/A
61	Game Lodge Buildings	12.5	1056	2213	6.7	Acceptable	Unpleasant
62	Tailings Dam Active	25	765	2213	11.5	Acceptable	N/A
63	Houses	12.5	35	2213	1826.5	Problematic	Intolerable
64	Houses	12.5	37	2213	1688.0	Problematic	Intolerable
65	Houses	12.5	152	2213	165.0	Problematic	Intolerable
66	Houses	12.5	445	2213	28.0	Problematic	Intolerable
67	Houses	12.5	34	2213	1917.0	Problematic	Intolerable
68	Houses	12.5	355	2213	40.8	Problematic	Intolerable
69	Houses	12.5	31	2213	2217.4	Problematic	Intolerable
70	Houses	12.5	56	2213	848.7	Problematic	Intolerable
71	Houses	12.5	231	2213	82.9	Problematic	Intolerable
72	Houses	12.5	319	2213	48.6	Problematic	Intolerable
73	Railway line	150	1264	2213	5.0	Acceptable	N/A
74	Railway line	150	1253	2213	5.1	Acceptable	N/A
75	Farmstead	12.5	739	2213	12.2	Acceptable	Unpleasant
76	Informal Housing	6	719	2213	12.7	Problematic	Unpleasant
77	Cement Dam	50	870	2213	9.3	Acceptable	N/A
78	Ruins	6	1055	2213	6.7	Problematic	N/A
79	Railway line	150	500	2213	23.1	Acceptable	N/A
80	Mine Buildings	25	2788	2213	1.4	Acceptable	N/A
81	Power Station	50	1855	2213	2.7	Acceptable	N/A
82	Power Substation	50	2489	2213	1.6	Acceptable	N/A
83	Dam/Dam Wall	50	3253	2213	1.1	Acceptable	N/A
84	Farmstead	12.5	3056	2213	1.2	Acceptable	Perceptible
85	Informal Housing	6	2132	2213	2.1	Acceptable	Perceptible
86	Informal Housing	6	2148	2213	2.1	Acceptable	Perceptible
87	Mine Building/Structures	25	1890	2213	2.6	Acceptable	N/A
88	Mine Activity	200	1933	2213	2.5	Acceptable	N/A
89	Dam/Dam Wall	50	1837	2213	2.7	Acceptable	N/A
90	Farm Building	12.5	699	2213	13.3	Problematic	Unpleasant
91	Farm Building	12.5	758	2213	11.6	Acceptable	Unpleasant
92	Farmstead	12.5	1397	2213	4.2	Acceptable	Perceptible
93	Cattle Yard	50	1310	2213	4.7	Acceptable	N/A
94	Farm Buildings	12.5	1384	2213	4.3	Acceptable	Perceptible
95	Farm House	12.5	1449	2213	4.0	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
96	Farmstead	12.5	1579	2213	3.5	Acceptable	Perceptible
97	Buildings/Structures	12.5	2184	2213	2.0	Acceptable	Perceptible
98	Farm Buildings	12.5	2299	2213	1.9	Acceptable	Perceptible
99	Farm Building/Structures	12.5	2142	2213	2.1	Acceptable	Perceptible
100	Railway line	150	1497	2213	3.8	Acceptable	N/A
101	Houses	12.5	518	2213	21.8	Problematic	Intolerable
102	Houses	12.5	756	2213	11.7	Acceptable	Unpleasant
103	Houses	12.5	1056	2213	6.7	Acceptable	Unpleasant
104	Building Structures	12.5	1438	2213	4.0	Acceptable	Perceptible
105	Industrial Buildings	50	2036	2213	2.3	Acceptable	N/A
106	Dam/Dam Wall	50	1620	2213	3.3	Acceptable	N/A
107	Dam/Dam Wall	50	1306	2213	4.7	Acceptable	N/A
108	Road (R547)	150	1907	2213	2.5	Acceptable	N/A
109	Road (R104)	150	1419	2213	4.1	Acceptable	N/A
110	Industrial Structures	50	1382	2213	4.3	Acceptable	N/A
111	Industrial Structures	50	1563	2213	3.5	Acceptable	N/A
112	Industrial Structures	50	1261	2213	5.0	Acceptable	N/A
113	Industrial Structures	50	1676	2213	3.1	Acceptable	N/A
114	Tailings Dam Old	50	732	2213	12.3	Acceptable	N/A
115	Mine Activity	200	127	2213	223.4	Problematic	N/A
116	Coal Yard	150	74	2213	535.4	Problematic	N/A
117	Mine Building	25	209	2213	97.7	Problematic	N/A
118	Dam/Dam Wall	50	525	2213	21.4	Acceptable	N/A
119	Mine Activity	200	49	2213	1062.1	Problematic	N/A
120	Road Bridge	50	1860	2213	2.6	Acceptable	N/A
121	Bridge	50	2351	2213	1.8	Acceptable	N/A
122	Dam/Dam Wall	50	2757	2213	1.4	Acceptable	N/A
123	Marsh	200	2358	2213	1.8	Acceptable	N/A
124	Farm House	12.5	1112	2213	6.2	Acceptable	Unpleasant
125	Industrial Area	50	1333	2213	4.6	Acceptable	N/A
126	Industrial Area	50	1618	2213	3.3	Acceptable	N/A
127	Building/Structure	12.5	579	2213	18.1	Problematic	Unpleasant
128	Mine Building	25	1018	2213	7.2	Acceptable	N/A
129	Mine Buildings/Structure	25	1098	2213	6.3	Acceptable	N/A
130	Industrial Buildings	50	1180	2213	5.6	Acceptable	N/A
131	Industrial Building/Structure	50	1351	2213	4.5	Acceptable	N/A
132	Industrial Building/Structure	50	3182	2213	1.1	Acceptable	N/A
133	Coal Yard	150	3112	2213	1.1	Acceptable	N/A
134	Industrial Building/Structure	50	3177	2213	1.1	Acceptable	N/A
135	Industrial Building/Structure	50	2222	2213	2.0	Acceptable	N/A
136	Mine Building/Structure	25	2428	2213	1.7	Acceptable	N/A
137	Mine Building/Structure	25	2386	2213	1.8	Acceptable	N/A
138	Kwa-Guqa Houses	6	2790	2213	1.4	Acceptable	Perceptible
139	Kwa-Guqa Houses	6	2833	2213	1.3	Acceptable	Perceptible
140	Kwa-Guqu Houses	6	3333	2213	1.0	Acceptable	Perceptible
141	N4 Road	150	2680	2213	1.4	Acceptable	N/A
142	Anglo Mining Operations	200	3237	2213	1.1	Acceptable	N/A
143	Tailings Dam	25	3022	2213	1.2	Acceptable	N/A
144	Farmstead	12.5	3387	2213	1.0	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
145	Farm Buildings	12.5	2048	2213	2.3	Acceptable	Perceptible
146	Farmstead	12.5	2159	2213	2.1	Acceptable	Perceptible
147	Informal Houses	6	2226	2213	2.0	Acceptable	Perceptible
148	Informal Houses	6	2383	2213	1.8	Acceptable	Perceptible
149	Farmstead	12.5	1764	2213	2.9	Acceptable	Perceptible
150	Farmstead	12.5	1987	2213	2.4	Acceptable	Perceptible
151	Farmstead	12.5	2907	2213	1.3	Acceptable	Perceptible
152	Farmstead	12.5	2588	2213	1.5	Acceptable	Perceptible
153	Farmstead	12.5	2697	2213	1.4	Acceptable	Perceptible
154	Reservoir	50	3100	2213	1.1	Acceptable	N/A
155	Church	12.5	3450	2213	1.0	Acceptable	Perceptible
156	Houses	12.5	710	2213	13.0	Problematic	Unpleasant
157	Houses	12.5	1242	2213	5.2	Acceptable	Perceptible
158	Houses	12.5	1462	2213	3.9	Acceptable	Perceptible
159	Houses	12.5	1714	2213	3.0	Acceptable	Perceptible
160	Houses	12.5	1366	2213	4.4	Acceptable	Perceptible
161	Houses	12.5	1801	2213	2.8	Acceptable	Perceptible
162	Houses	12.5	2197	2213	2.0	Acceptable	Perceptible
163	Railway Line	150	390	2213	34.9	Acceptable	N/A
164	Railway Line	150	954	2213	8.0	Acceptable	N/A
165	Railway Line	150	1216	2213	5.3	Acceptable	N/A
166	Railway Line	150	1120	2213	6.1	Acceptable	N/A
167	Railway Line	150	1017	2213	7.2	Acceptable	N/A
168	Power lines/Pylons	75	3214	2213	1.1	Acceptable	N/A
169	Power lines/Pylons	75	2876	2213	1.3	Acceptable	N/A
170	Power lines/Pylons	75	2841	2213	1.3	Acceptable	N/A
171	Power lines/Pylons	75	2836	2213	1.3	Acceptable	N/A
172	Power lines/Pylons	75	2864	2213	1.3	Acceptable	N/A
173	Power lines/Pylons	75	2939	2213	1.2	Acceptable	N/A
174	Power lines/Pylons	75	3043	2213	1.2	Acceptable	N/A
175	Power lines/Pylons	75	3172	2213	1.1	Acceptable	N/A
176	Power lines/Pylons	75	3336	2213	1.0	Acceptable	N/A
177	Sub Station	25	2624	2213	1.5	Acceptable	N/A
178	Power lines/Pylons	75	1150	2213	5.9	Acceptable	N/A
179	Power lines/Pylons	75	1427	2213	4.1	Acceptable	N/A
180	Power lines/Pylons	75	1727	2213	3.0	Acceptable	N/A
181	Power lines/Pylons	75	2072	2213	2.2	Acceptable	N/A
182	Power lines/Pylons	75	2413	2213	1.7	Acceptable	N/A
183	Power lines/Pylons	75	2735	2213	1.4	Acceptable	N/A
184	Informal Housing	6	3225	2213	1.1	Acceptable	Perceptible
185	Farm Buildings/Structures	12.5	3360	2213	1.0	Acceptable	Perceptible
186	Informal Housing	6	1937	2213	2.5	Acceptable	Perceptible
187	Power lines/Pylons	75	3426	2213	1.0	Acceptable	N/A
188	Power lines/Pylons	75	3120	2213	1.1	Acceptable	N/A
189	Power lines/Pylons	75	1058	2213	6.7	Acceptable	N/A
190	Power lines/Pylons	75	462	2213	26.4	Acceptable	N/A
191	Church	12.5	3134	2213	1.1	Acceptable	Perceptible
192	School	25	3374	2213	1.0	Acceptable	Perceptible
193	School	25	3466	2213	0.9	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
194	Kwa-Guqa Houses	6	3100	2213	1.1	Acceptable	Perceptible
195	Kwa-Guqa Houses	6	3190	2213	1.1	Acceptable	Perceptible
196	Kwa-Guqa Houses	6	3366	2213	1.0	Acceptable	Perceptible
197	Kwa-Guqa Houses	6	3375	2213	1.0	Acceptable	Perceptible
198	Kwa-Guqa Houses	6	3278	2213	1.0	Acceptable	Perceptible
199	Kwa-Guqa Houses	6	3311	2213	1.0	Acceptable	Perceptible
200	Kwa-Guqa Houses	6	2949	2213	1.2	Acceptable	Perceptible
201	Kwa-Guqa Houses	6	3232	2213	1.1	Acceptable	Perceptible
202	Kwa-Guqa Houses	6	3463	2213	0.9	Acceptable	Perceptible
203	Kwa-Guqa Houses	6	3376	2213	1.0	Acceptable	Perceptible
204	Kwa-Guqa Houses	6	2876	2213	1.3	Acceptable	Perceptible
205	Kwa-Guqa Houses	6	3003	2213	1.2	Acceptable	Perceptible
206	Kwa-Guqa Houses	6	2881	2213	1.3	Acceptable	Perceptible
207	Buildings/Structures	12.5	3042	2213	1.2	Acceptable	Perceptible
208	Buildings/Structures	12.5	3177	2213	1.1	Acceptable	Perceptible
209	River (Site ASW01- Not in use)	200	1653	2213	3.2	Acceptable	N/A
210	Hydrocencus Borehole - Domestic (AHBH01)	50	1903	2213	2.5	Acceptable	N/A
211	Hydrocencus Borehole - Domestic& Livestock (AHBH02)	50	3513	2213	0.9	Acceptable	N/A
212	Hydrocencus Borehole - Domestic (AHBH03)	50	1080	2213	6.5	Acceptable	N/A
213	Communication Tower	25	3056	2213	1.2	Acceptable	N/A
214	Buildings/Structures	12.5	283	2213	59.3	Problematic	Intolerable
215	Monitoring Borehole (ECBH 03)	50	105	2213	305.2	Problematic	N/A
216	Monitoring Borehole (ELNBH 03)	50	24	2213	3503.1	Problematic	N/A
217	River (Site ASW 02 - Not in use)	50	339	2213	44.0	Acceptable	N/A
218	Monitoring Borehole (BH 173)	50	188	2213	116.5	Problematic	N/A
219	Monitoring Borehole (BH 172)	50	274	2213	62.3	Problematic	N/A
220	Hydrocencus Borehole (AHBH04 - Not in use)	50	48	2213	1089.6	Problematic	N/A
221	Hydrocencus Borehole (AHBH05 - Domestic& Livestock)	50	444	2213	28.2	Acceptable	N/A
222	Hydrocencus Borehole (AHBH06 - Domestic& Irrigation)	50	548	2213	19.9	Acceptable	N/A
223	Hydrocencus Borehole (AHBH07 - Not in use)	50	1009	2213	7.3	Acceptable	N/A
224	Hydrocencus Borehole (AHBH08 - Not in use)	50	869	2213	9.3	Acceptable	N/A
225	Heritage Site (11478/BGG-001 - Historic burial ground)	50	274	2213	62.3	Problematic	Intolerable
226	Heritage Site (11478/BGG-002 - Historic burial ground)	50	370	2213	38.0	Acceptable	Intolerable
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	50	-	2213	-	-	-
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	50	174	2213	131.5	Problematic	Intolerable
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	50	-	2213	-	-	-

19.1.3 Summary of ground vibration levels

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

The distances between structures and the pit areas is a contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated that levels of ground vibration will change as well. In view of the minimum and maximum charge specific attention will need to be given to specific areas. The minimum charge used indicated twenty-one POI's of concern and the maximum charge indicated fifty-three POI's of concern (included are the Dam, Power Lines/Pylons and Heritage Sites inside the pit areas) in relation to possible structural damage. On a human perception scale thirty-nine POI's were identified where vibration levels may be perceptible and higher for the minimum charge and ninety-three POI's for the maximum charge. Perceptible levels of vibration that may be experienced up to 3466 m, unpleasant up to 1365 m and intolerable up to 579 m. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 1055 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have lesser influence on these points.

The evaluation mainly considered a distance up to 3500 m from the pit areas. The closest structures observed are the Road, Power Lines/Pylons, Railway Line, Heritage Sites, Houses, Sewer Works, Boreholes, Industrial Structures and Buildings/Structures. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human perception. The ground vibration levels predicted for these POI's ranged between 6.7 mm/s and very high for structures surrounding the open pit areas.

The nearest public houses are located 31 m from the pit boundary. Ground vibration level predicted at this building where people may be present is 2217.4 mm/s for the maximum charge. In view of this specific mitigations will be required.

Structure conditions ranged from industrial construction to poor condition structures. Water boreholes identified are at close proximity to the Pit areas. There are a significant number of water boreholes within the mining rights area and it is uncertain what the long-term plan will be for these boreholes. A mitigation plan will be required to determine if these boreholes will be retained or replaced.

Five Heritage Sites which include Historic Burial Grounds and Municipal Cemetery were identified by the Heritage Specialist (2 sites fall within the pit area). Specific recommendations will be required from the Heritage Specialist regarding these sites as it could be problematic in terms of potential damage.

Mitigation of ground vibration was considered and discussed in Section 18.4. A detail inspection of the area and accurate identification of structures will also need to be done to ensure the levels of ground vibration allowable and limit to be applied.

19.1.4 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 15 below). The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. Based on the maximum charge and ground vibration predicted over distance it can be seen from Figure 15 that up to a distance of 3466 m people may experience levels of ground vibration as perceptible. At 1365 m and closer the perception of ground vibration could be unpleasant. Closer than 579 m the levels will be intolerable and generally greater than limits applied for structures in the areas.

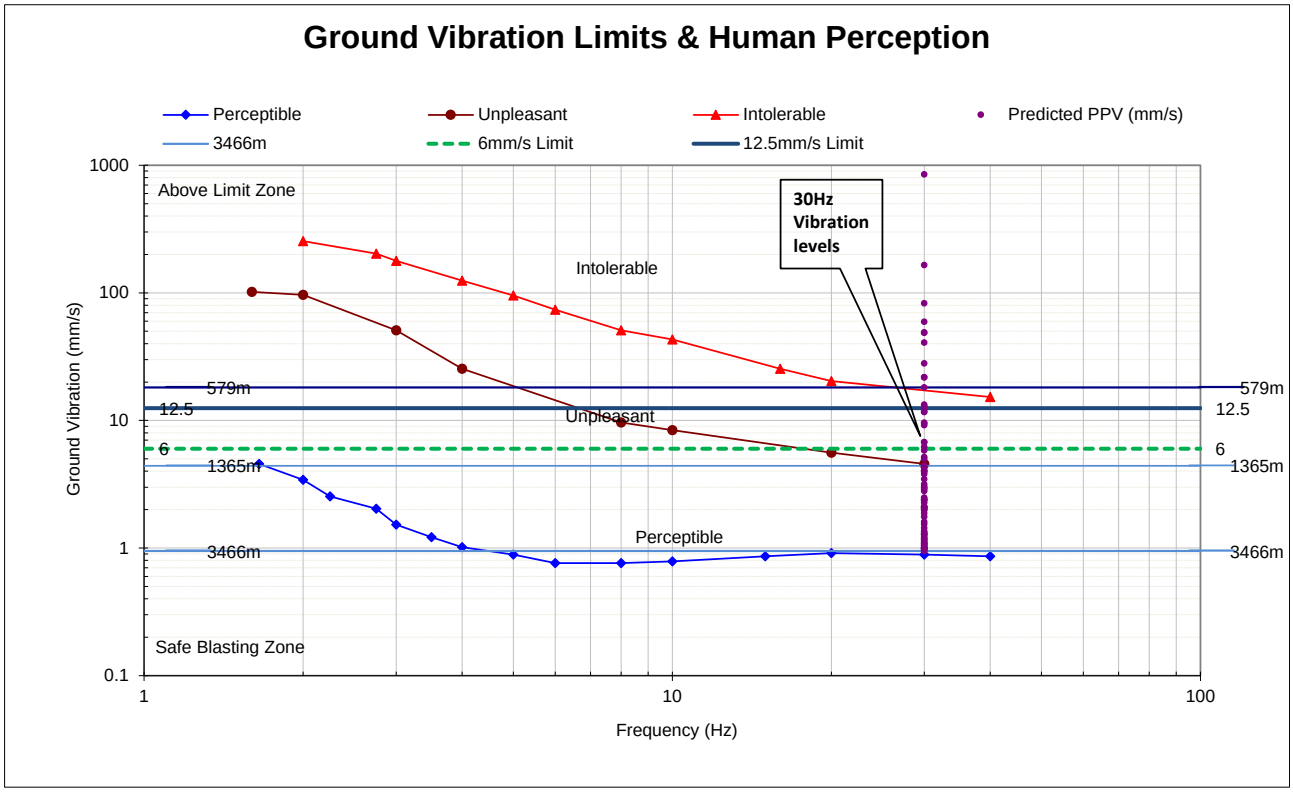


Figure 15: The effect of ground vibration with human perception and vibration limits

19.1.5 Vibration impact on roads

The N4 National road is at an approximate distance of 2680 m from the nearest pit area and will require no specific consideration regarding effects from blasting operations. There are provincial roads in the vicinity of the project area to be considered. The R104 road is located to the northern side of the Pit areas at 1419 m and the R547 road is located on the eastern side at 1907 m. Expected ground vibration levels at these roads are within the recommended limits. No specific actions are required for these roads. The road on the southern side of the Clewer town is in very close proximity to one pit at 15 m. Blasting will need to be managed for ground vibration levels. The location of houses close to this road will however be predictive on the allowed charge mass per delay and contribute to low levels at the road.

19.1.6 Potential that vibration will upset adjacent communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. The nearest houses (POI 69) are approximately 31 m from the planned operation. These buildings are located such that levels of ground vibration predicted may be problematic and could be damaging.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 3466 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 1397 m. Within these distance ranges there are a number of houses. The anticipated ground vibration levels are certain to have possibility of upsetting the house holds within these ranges. Intolerable levels are expected up to a distance of 579 m.

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

19.1.7 Cracking of houses and consequent devaluation

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

The presence of general vertical cracks, horizontal and diagonal cracks that are found in all structures does not need to indicate devaluation due to blasting operations but rather devaluation due to construction, building material, age, standards of building applied. Thus, damage in the form of cracks will be present. Exact costing of devaluation for normal cracks observed is difficult to

estimate. Mining operations may not have influence to change the status quo of any property if correct precautions are considered.

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

19.1.8 Water borehole influence

Location of boreholes for water was evaluated for possible influence from blasting. Hydrocencus and Monitoring boreholes were identified within the influence area at all Pit areas. There are boreholes that are in proximity of the blasting areas and could be problematic. Table 13 shows all the identified boreholes. Figure 16 shows the location of the boreholes in the area.

Table 13: Identified water boreholes

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m) to Pit	Predicted PPV (mm/s)
210	Hydrocencus Borehole - Domestic (AHBH01)	-6214.68	2867588.63	50	1903	2.5
211	Hydrocencus Borehole - Domestic& Livestock (AHBH02)	-4537.47	2867760.77	50	3513	0.9
212	Hydrocencus Borehole - Domestic (AHBH03)	-7128.69	2868898.60	50	1080	6.5
215	Monitoring Borehole (ECBH 03)	-9651.98	2866457.36	50	105	305.2
216	Monitoring Borehole (ELNBH 03)	-8653.02	2867967.80	50	24	3503.1
217	River (Site ASW 02 - Not in use)	-7815.54	2867845.41	50	339	44.0
218	Monitoring Borehole (BH 173)	-7909.36	2868434.85	50	188	116.5
219	Monitoring Borehole (BH 172)	-7809.20	2868404.88	50	274	62.3
220	Hydrocencus Borehole (AHBH04 - Not in use)	-11206.58	2866993.70	50	48	1089.6
221	Hydrocencus Borehole (AHBH05 - Domestic& Livestock)	-11151.81	2866598.14	50	444	28.2
222	Hydrocencus Borehole (AHBH06 - Domestic& Irrigation)	-11538.66	2866493.23	50	548	19.9
223	Hydrocencus Borehole (AHBH07 - Not in use)	-12021.03	2866030.57	50	1009	7.3
224	Hydrocencus Borehole (AHBH08 - Not in use)	-12678.94	2866456.61	50	869	9.3

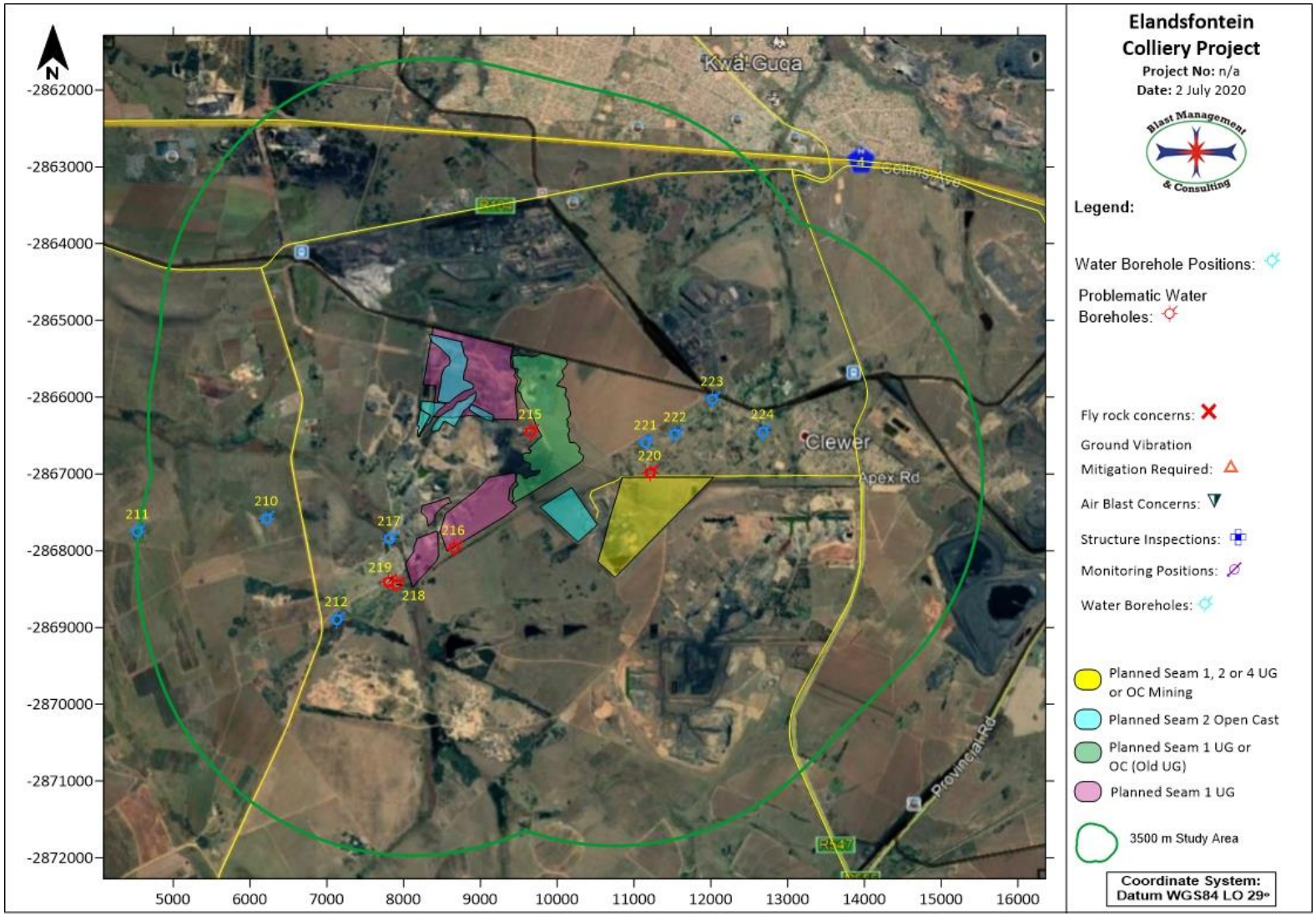


Figure 16: Location of the Boreholes for all Pit areas

19.2 Review of expected air blast

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

- "Tag" No. is number corresponding to the location indicated on POI figures;
- "Description" indicates the type of the structure;
- "Distance" is the distance between the structure and edge of the pit area;
- "Air Blast (dB)" is the calculated air blast level at the structure;
- "Possible concern" indicates if there is any concern for structural damage or human perception. Indicators used are:
    - "Problematic" where there is real concern for possible damage – at levels greater than 134 dB;
    - "Complaint" where people will be complaining due to the experienced effect on structures at levels of 120 dB and higher (not necessarily damaging);
    - "Acceptable" if levels are less than 120 dB;
    - "Low" where there is very limited possibility that the levels will give rise to any influence on people or structures. Levels below 115 dB could be considered to have low or negligible possibility of influence.

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

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

19.2.1 Air blast minimum charge mass per delay – 277 kg

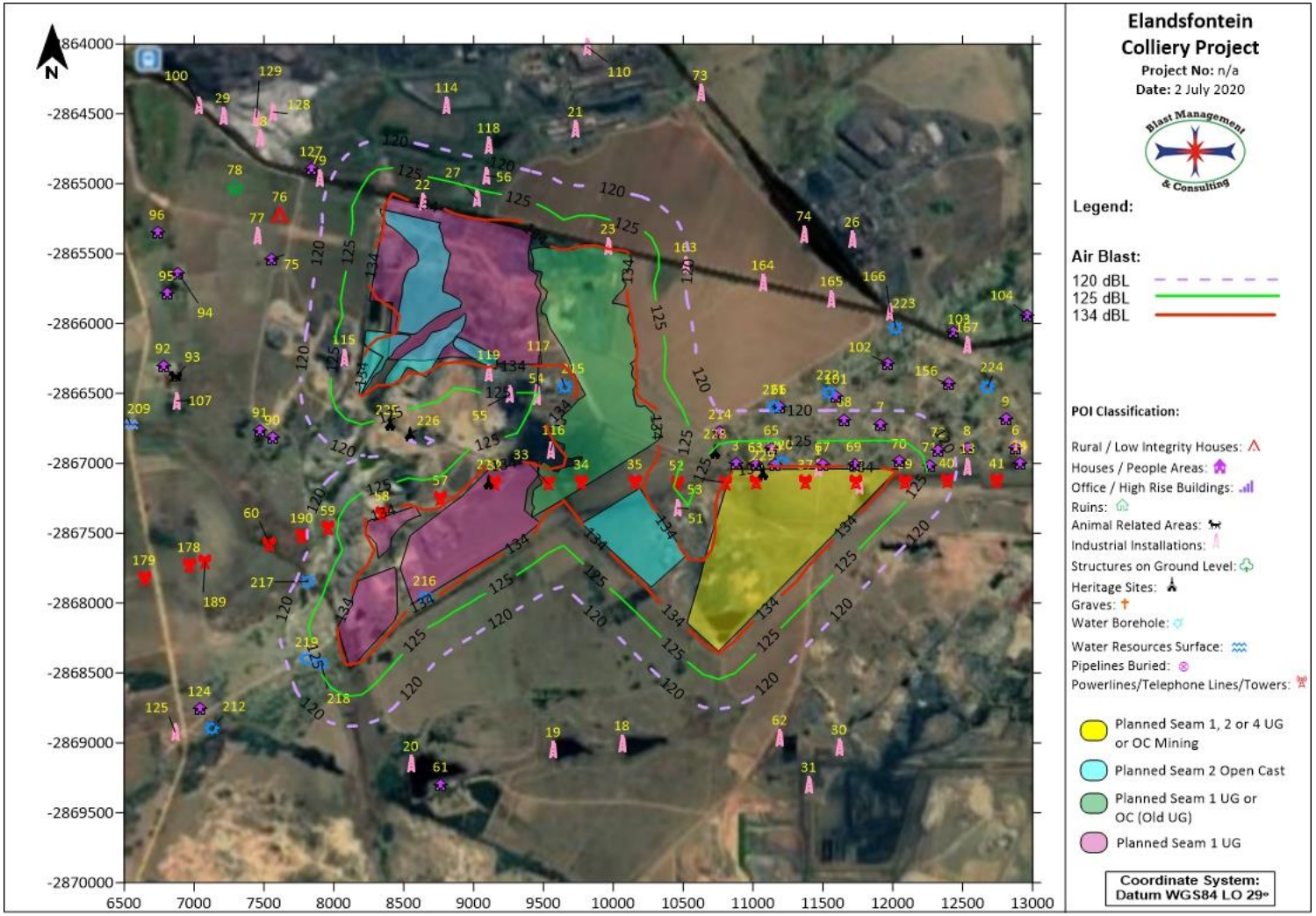


Figure 17: Air blast influence from minimum charge

Table 14: Air blast evaluation for minimum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Road	15	142.7	N/A
2	Dam (Inside OC Pit Area)	-	-	-
3	Buildings/Structures	43	135.6	Problematic
4	School	1740	110.3	Acceptable
5	Church	1988	109.3	Acceptable
6	Sport Terrain	858	115.1	Acceptable
7	Houses	318	121.9	Complaint
8	Houses	520	118.5	Acceptable
9	Houses	851	115.1	Acceptable
10	Houses	1493	111.3	Acceptable
11	Houses	1967	109.5	Acceptable
12	Houses	2524	107.7	Acceptable
13	Road	500	118.8	N/A
14	Houses	876	114.9	Acceptable
15	Houses	1266	112.4	Acceptable
16	Houses	1673	110.6	Acceptable
17	Church	1154	113.0	Acceptable
18	Dam/Dam Wall	952	114.4	N/A
19	Dam/Dam Wall	1320	112.1	N/A
20	Dam/Dam Wall	809	115.5	N/A
21	Industrial Structure	799	115.6	N/A
22	Railway Line	26	139.0	N/A
23	Railway Line	22	140.3	N/A
24	Railway Line	1456	111.4	N/A
25	Railway Substation	2182	108.7	N/A
26	Industrial Structures	1590	110.8	N/A
27	Sewer Works	137	127.6	N/A
28	Mining Activity	1003	114.0	N/A
29	Mine Buildings	1313	112.2	N/A
30	Mine Activity	1098	113.4	N/A
31	Mine Building/Structures	1161	113.0	N/A
32	Power lines/Pylons (Inside Pit Area)	-	-	-
33	Power lines/Pylons (Inside Pit Area)	-	-	-
34	Power line/Pylons (Inside Pit Area)	-	-	-
35	Power lines/Pylons	50	134.5	N/A
36	Power lines/Pylons (Inside Pit Area)	-	-	-
37	Power lines/Pylons (Inside Pit Area)	-	-	-
38	Power lines/Pylons (Inside Pit Area)	-	-	-
39	Power lines/Pylons	100	129.8	N/A
40	Power lines/Pylons	362	121.0	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
41	Power lines/Pylons	715	116.3	N/A
42	Power lines/Pylons	1096	113.4	N/A
43	Power lines/Pylons	1409	111.7	N/A
44	Power lines/Pylons	2173	108.7	N/A
45	Power lines/Pylons	1794	110.1	N/A
46	Power lines/Pylons	2538	107.7	N/A
47	Power lines/Pylons	2732	107.2	N/A
48	Power lines/Pylons	3029	106.4	N/A
49	Power lines/Pylons	3350	105.8	N/A
50	Mine Activity	1138	113.1	N/A
51	Mine Buildings/Structures	140	127.5	N/A
52	Power lines/Pylons	235	124.0	N/A
53	Power lines/Pylons	21	140.5	N/A
54	Mine Activity	227	124.2	N/A
55	Mine Buildings/Structures	218	124.5	N/A
56	Industrial Structures	312	122.0	N/A
57	Power lines/Pylons	81	131.3	N/A
58	Power lines/Pylons	27	138.8	N/A
59	Power lines/Pylons	270	123.0	N/A
60	Power lines/Pylons	684	116.6	N/A
61	Game Lodge Buildings	1056	113.7	Acceptable
62	Tailings Dam Active	765	115.9	N/A
63	Houses	35	136.9	Problematic
64	Houses	37	136.6	Problematic
65	Houses	152	126.9	Complaint
66	Houses	445	119.6	Acceptable
67	Houses	34	137.1	Problematic
68	Houses	355	121.1	Complaint
69	Houses	31	137.7	Problematic
70	Houses	56	133.7	Problematic
71	Houses	231	124.1	Complaint
72	Houses	319	121.9	Complaint
73	Railway line	1264	112.4	N/A
74	Railway line	1253	112.5	N/A
75	Farmstead	739	116.1	Acceptable
76	Informal Housing	719	116.3	Acceptable
77	Cement Dam	870	115.0	N/A
78	Ruins	1055	113.7	N/A
79	Railway line	500	118.8	N/A
80	Mine Buildings	2788	107.0	N/A
81	Power Station	1855	109.8	N/A
82	Power Substation	2489	107.9	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
83	Dam/Dam Wall	3253	106.0	N/A
84	Farmstead	3056	106.4	Acceptable
85	Informal Housing	2132	108.9	Acceptable
86	Informal Housing	2148	108.9	Acceptable
87	Mine Building/Structures	1890	109.6	N/A
88	Mine Activity	1933	109.5	N/A
89	Dam/Dam Wall	1837	109.9	N/A
90	Farm Building	699	116.5	Acceptable
91	Farm Building	758	115.9	Acceptable
92	Farmstead	1397	111.8	Acceptable
93	Cattle Yard	1310	112.2	N/A
94	Farm Buildings	1384	111.8	Acceptable
95	Farm House	1449	111.5	Acceptable
96	Farmstead	1579	111.0	Acceptable
97	Buildings/Structures	2184	108.7	Acceptable
98	Farm Buildings	2299	108.4	Acceptable
99	Farm Building/Structures	2142	108.9	Acceptable
100	Railway line	1497	111.3	N/A
101	Houses	518	118.5	Acceptable
102	Houses	756	115.9	Acceptable
103	Houses	1056	113.7	Acceptable
104	Building Structures	1438	111.5	Acceptable
105	Industrial Buildings	2036	109.2	N/A
106	Dam/Dam Wall	1620	110.7	N/A
107	Dam/Dam Wall	1306	112.2	N/A
108	Road (R547)	1907	109.6	N/A
109	Road (R104)	1419	111.7	N/A
110	Industrial Structures	1382	111.9	N/A
111	Industrial Structures	1563	111.0	N/A
112	Industrial Structures	1261	112.4	N/A
113	Industrial Structures	1676	110.5	N/A
114	Tailings Dam Old	732	116.1	N/A
115	Mine Activity	127	128.2	N/A
116	Coal Yard	74	131.8	N/A
117	Mine Building	209	124.8	N/A
118	Dam/Dam Wall	525	118.4	N/A
119	Mine Activity	49	134.7	N/A
120	Road Bridge	1860	109.8	N/A
121	Bridge	2351	108.2	N/A
122	Dam/Dam Wall	2757	107.2	N/A
123	Marsh	2358	108.2	N/A
124	Farm House	1112	113.3	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
125	Industrial Area	1333	112.1	N/A
126	Industrial Area	1618	110.7	N/A
127	Building/Structure	579	117.8	Acceptable
128	Mine Building	1018	113.9	N/A
129	Mine Buildings/Structure	1098	113.4	N/A
130	Industrial Buildings	1180	112.9	N/A
131	Industrial Building/Structure	1351	112.0	N/A
132	Industrial Building/Structure	3182	106.2	N/A
133	Coal Yard	3112	106.4	N/A
134	Industrial Building/Structure	3177	106.2	N/A
135	Industrial Building/Structure	2222	108.6	N/A
136	Mine Building/Structure	2428	107.9	N/A
137	Mine Building/Structure	2386	108.1	N/A
138	Kwa-Guqa Houses	2790	107.0	Acceptable
139	Kwa-Guqa Houses	2833	107.0	Acceptable
140	Kwa-Guqu Houses	3333	105.8	Acceptable
141	N4 Road	2680	107.4	N/A
142	Anglo Mining Operations	3237	106.0	N/A
143	Tailings Dam	3022	106.6	N/A
144	Farmstead	3387	105.8	Acceptable
145	Farm Buildings	2048	109.2	Acceptable
146	Farmstead	2159	108.7	Acceptable
147	Informal Houses	2226	108.6	Acceptable
148	Informal Houses	2383	108.1	Acceptable
149	Farmstead	1764	110.2	Acceptable
150	Farmstead	1987	109.3	Acceptable
151	Farmstead	2907	106.8	Acceptable
152	Farmstead	2588	107.6	Acceptable
153	Farmstead	2697	107.4	Acceptable
154	Reservoir	3100	106.4	N/A
155	Church	3450	105.5	Acceptable
156	Houses	710	116.3	Acceptable
157	Houses	1242	112.5	Acceptable
158	Houses	1462	111.4	Acceptable
159	Houses	1714	110.3	Acceptable
160	Houses	1366	111.9	Acceptable
161	Houses	1801	110.1	Acceptable
162	Houses	2197	108.7	Acceptable
163	Railway Line	390	120.5	N/A
164	Railway Line	954	114.4	N/A
165	Railway Line	1216	112.7	N/A
166	Railway Line	1120	113.3	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
167	Railway Line	1017	113.9	N/A
168	Power lines/Pylons	3214	106.2	N/A
169	Power lines/Pylons	2876	106.8	N/A
170	Power lines/Pylons	2841	107.0	N/A
171	Power lines/Pylons	2836	107.0	N/A
172	Power lines/Pylons	2864	106.8	N/A
173	Power lines/Pylons	2939	106.6	N/A
174	Power lines/Pylons	3043	106.4	N/A
175	Power lines/Pylons	3172	106.2	N/A
176	Power lines/Pylons	3336	105.8	N/A
177	Sub Station	2624	107.6	N/A
178	Power lines/Pylons	1150	113.1	N/A
179	Power lines/Pylons	1427	111.7	N/A
180	Power lines/Pylons	1727	110.3	N/A
181	Power lines/Pylons	2072	109.0	N/A
182	Power lines/Pylons	2413	108.1	N/A
183	Power lines/Pylons	2735	107.2	N/A
184	Informal Housing	3225	106.0	Acceptable
185	Farm Buildings/Structures	3360	105.8	Acceptable
186	Informal Housing	1937	109.5	Acceptable
187	Power lines/Pylons	3426	105.8	N/A
188	Power lines/Pylons	3120	106.2	N/A
189	Power lines/Pylons	1058	113.7	N/A
190	Power lines/Pylons	462	119.3	N/A
191	Church	3134	106.2	Acceptable
192	School	3374	105.8	Acceptable
193	School	3466	105.5	Acceptable
194	Kwa-Guqa Houses	3100	106.4	Acceptable
195	Kwa-Guqa Houses	3190	106.2	Acceptable
196	Kwa-Guqa Houses	3366	105.8	Acceptable
197	Kwa-Guqa Houses	3375	105.8	Acceptable
198	Kwa-Guqa Houses	3278	106.0	Acceptable
199	Kwa-Guqa Houses	3311	106.0	Acceptable
200	Kwa-Guqa Houses	2949	106.6	Acceptable
201	Kwa-Guqa Houses	3232	106.0	Acceptable
202	Kwa-Guqa Houses	3463	105.5	Acceptable
203	Kwa-Guqa Houses	3376	105.8	Acceptable
204	Kwa-Guqa Houses	2876	106.8	Acceptable
205	Kwa-Guqa Houses	3003	106.6	Acceptable
206	Kwa-Guqa Houses	2881	106.8	Acceptable
207	Buildings/Structures	3042	106.4	Acceptable
208	Buildings/Structures	3177	106.2	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
209	River (Site ASW01- Not in use)	1653	110.6	N/A
210	Hydrocencus Borehole - Domestic (AHBH01)	1903	109.6	N/A
211	Hydrocencus Borehole - Domestic& Livestock (AHBH02)	3513	105.5	N/A
212	Hydrocencus Borehole - Domestic (AHBH03)	1080	113.5	N/A
213	Communication Tower	3056	106.4	N/A
214	Buildings/Structures	283	122.7	Complaint
215	Monitoring Borehole (ECBH 03)	105	129.5	N/A
216	Monitoring Borehole (ELNBH 03)	24	139.6	N/A
217	River (Site ASW 02 - Not in use)	339	121.5	N/A
218	Monitoring Borehole (BH 173)	188	125.5	N/A
219	Monitoring Borehole (BH 172)	274	122.9	N/A
220	Hydrocencus Borehole (AHBH04 - Not in use)	48	134.8	N/A
221	Hydrocencus Borehole (AHBH05 - Domestic& Livestock)	444	119.6	N/A
222	Hydrocencus Borehole (AHBH06 - Domestic& Irrigation)	548	118.2	N/A
223	Hydrocencus Borehole (AHBH07 - Not in use)	1009	114.0	N/A
224	Hydrocencus Borehole (AHBH08 - Not in use)	869	115.0	N/A
225	Heritage Site (11478/BGG-001 - Historic burial ground)	274	122.9	Complaint
226	Heritage Site (11478/BGG-002 - Historic burial ground)	370	120.8	Complaint
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	-	-	-
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	174	126.0	Complaint
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	-	-	-

19.2.2 Air blast maximum charge mass per delay - 2213 kg

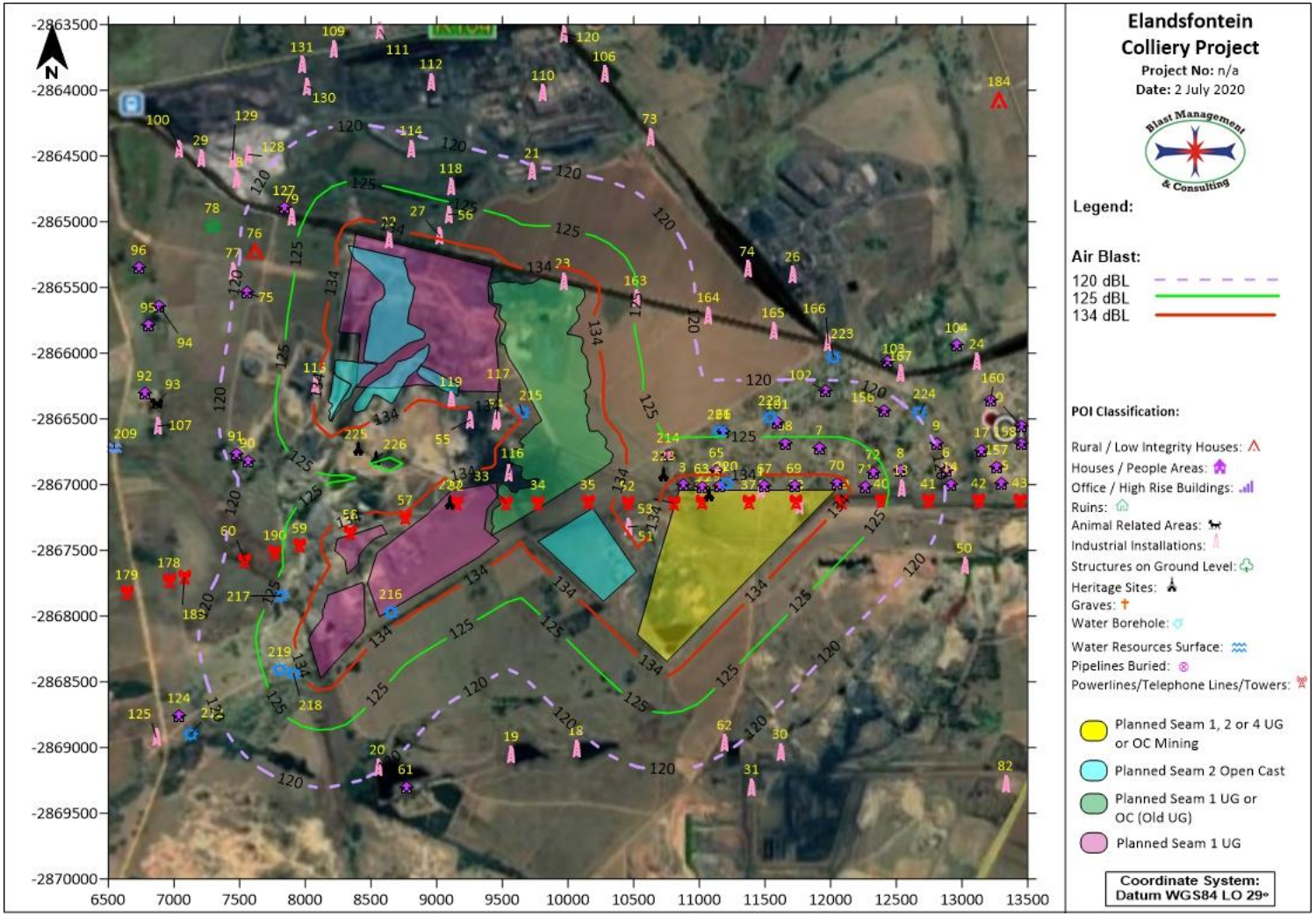


Figure 18: Air blast influence from maximum charge

Table 15: Air blast influence from maximum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Road	15	147.5	N/A
2	Dam (Inside OC Pit Area)	-	-	-
3	Buildings/Structures	43	140.3	Problematic
4	School	1740	115.0	Acceptable
5	Church	1988	114.1	Acceptable
6	Sport Terrain	858	119.8	Acceptable
7	Houses	318	126.6	Complaint
8	Houses	520	123.2	Complaint
9	Houses	851	119.9	Acceptable
10	Houses	1493	116.0	Acceptable
11	Houses	1967	114.2	Acceptable
12	Houses	2524	112.4	Acceptable
13	Road	500	123.5	N/A
14	Houses	876	119.7	Acceptable
15	Houses	1266	117.2	Acceptable
16	Houses	1673	115.2	Acceptable
17	Church	1154	117.8	Acceptable
18	Dam/Dam Wall	952	119.1	N/A
19	Dam/Dam Wall	1320	116.9	N/A
20	Dam/Dam Wall	809	120.2	N/A
21	Industrial Structure	799	120.3	N/A
22	Railway Line	26	143.8	N/A
23	Railway Line	22	145.1	N/A
24	Railway Line	1456	116.2	N/A
25	Railway Substation	2182	113.5	N/A
26	Industrial Structures	1590	115.6	N/A
27	Sewer Works	137	132.4	N/A
28	Mining Activity	1003	118.7	N/A
29	Mine Buildings	1313	116.9	N/A
30	Mine Activity	1098	118.1	N/A
31	Mine Building/Structures	1161	117.7	N/A
32	Power lines/Pylons (Inside Pit Area)	-	-	-
33	Power lines/Pylons (Inside Pit Area)	-	-	-
34	Power line/Pylons (Inside Pit Area)	-	-	-
35	Power lines/Pylons	50	139.3	N/A
36	Power lines/Pylons (Inside Pit Area)	-	-	-
37	Power lines/Pylons (Inside Pit Area)	-	-	-
38	Power lines/Pylons (Inside Pit Area)	-	-	-
39	Power lines/Pylons	100	134.5	N/A
40	Power lines/Pylons	362	125.7	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
41	Power lines/Pylons	715	121.0	N/A
42	Power lines/Pylons	1096	118.1	N/A
43	Power lines/Pylons	1409	116.4	N/A
44	Power lines/Pylons	2173	113.5	N/A
45	Power lines/Pylons	1794	114.8	N/A
46	Power lines/Pylons	2538	112.4	N/A
47	Power lines/Pylons	2732	111.9	N/A
48	Power lines/Pylons	3029	111.2	N/A
49	Power lines/Pylons	3350	110.5	N/A
50	Mine Activity	1138	117.9	N/A
51	Mine Buildings/Structures	140	132.3	N/A
52	Power lines/Pylons	235	128.7	N/A
53	Power lines/Pylons	21	145.3	N/A
54	Mine Activity	227	128.9	N/A
55	Mine Buildings/Structures	218	129.2	N/A
56	Industrial Structures	312	126.8	N/A
57	Power lines/Pylons	81	136.0	N/A
58	Power lines/Pylons	27	143.5	N/A
59	Power lines/Pylons	270	127.8	N/A
60	Power lines/Pylons	684	121.4	N/A
61	Game Lodge Buildings	1056	118.4	Acceptable
62	Tailings Dam Active	765	120.6	N/A
63	Houses	35	141.7	Problematic
64	Houses	37	141.3	Problematic
65	Houses	152	131.7	Complaint
66	Houses	445	124.3	Complaint
67	Houses	34	141.9	Problematic
68	Houses	355	125.9	Complaint
69	Houses	31	142.5	Problematic
70	Houses	56	138.5	Problematic
71	Houses	231	128.8	Complaint
72	Houses	319	126.6	Complaint
73	Railway line	1264	117.2	N/A
74	Railway line	1253	117.2	N/A
75	Farmstead	739	120.9	Complaint
76	Informal Housing	719	121.0	Complaint
77	Cement Dam	870	119.7	N/A
78	Ruins	1055	118.4	N/A
79	Railway line	500	123.5	N/A
80	Mine Buildings	2788	111.8	N/A
81	Power Station	1855	114.5	N/A
82	Power Substation	2489	112.5	N/A
83	Dam/Dam Wall	3253	110.7	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
84	Farmstead	3056	111.2	Acceptable
85	Informal Housing	2132	113.6	Acceptable
86	Informal Housing	2148	113.6	Acceptable
87	Mine Building/Structures	1890	114.4	N/A
88	Mine Activity	1933	114.3	N/A
89	Dam/Dam Wall	1837	114.6	N/A
90	Farm Building	699	121.2	Complaint
91	Farm Building	758	120.7	Complaint
92	Farmstead	1397	116.5	Acceptable
93	Cattle Yard	1310	116.9	N/A
94	Farm Buildings	1384	116.5	Acceptable
95	Farm House	1449	116.2	Acceptable
96	Farmstead	1579	115.7	Acceptable
97	Buildings/Structures	2184	113.4	Acceptable
98	Farm Buildings	2299	113.1	Acceptable
99	Farm Building/Structures	2142	113.6	Acceptable
100	Railway line	1497	116.0	N/A
101	Houses	518	123.3	Complaint
102	Houses	756	120.7	Complaint
103	Houses	1056	118.4	Acceptable
104	Building Structures	1438	116.3	Acceptable
105	Industrial Buildings	2036	113.9	N/A
106	Dam/Dam Wall	1620	115.4	N/A
107	Dam/Dam Wall	1306	117.0	N/A
108	Road (R547)	1907	114.4	N/A
109	Road (R104)	1419	116.4	N/A
110	Industrial Structures	1382	116.5	N/A
111	Industrial Structures	1563	115.7	N/A
112	Industrial Structures	1261	117.2	N/A
113	Industrial Structures	1676	115.2	N/A
114	Tailings Dam Old	732	120.9	N/A
115	Mine Activity	127	132.9	N/A
116	Coal Yard	74	136.6	N/A
117	Mine Building	209	129.5	N/A
118	Dam/Dam Wall	525	123.2	N/A
119	Mine Activity	49	139.4	N/A
120	Road Bridge	1860	114.5	N/A
121	Bridge	2351	112.9	N/A
122	Dam/Dam Wall	2757	111.9	N/A
123	Marsh	2358	112.9	N/A
124	Farm House	1112	118.1	Acceptable
125	Industrial Area	1333	116.8	N/A
126	Industrial Area	1618	115.5	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
127	Building/Structure	579	122.5	Complaint
128	Mine Building	1018	118.6	N/A
129	Mine Buildings/Structure	1098	118.1	N/A
130	Industrial Buildings	1180	117.6	N/A
131	Industrial Building/Structure	1351	116.7	N/A
132	Industrial Building/Structure	3182	110.8	N/A
133	Coal Yard	3112	111.1	N/A
134	Industrial Building/Structure	3177	110.8	N/A
135	Industrial Building/Structure	2222	113.3	N/A
136	Mine Building/Structure	2428	112.7	N/A
137	Mine Building/Structure	2386	112.8	N/A
138	Kwa-Guqa Houses	2790	111.8	Acceptable
139	Kwa-Guqa Houses	2833	111.7	Acceptable
140	Kwa-Guqu Houses	3333	110.6	Acceptable
141	N4 Road	2680	112.0	N/A
142	Anglo Mining Operations	3237	110.7	N/A
143	Tailings Dam	3022	111.2	N/A
144	Farmstead	3387	110.5	Acceptable
145	Farm Buildings	2048	113.8	Acceptable
146	Farmstead	2159	113.5	Acceptable
147	Informal Houses	2226	113.3	Acceptable
148	Informal Houses	2383	112.8	Acceptable
149	Farmstead	1764	114.9	Acceptable
150	Farmstead	1987	114.1	Acceptable
151	Farmstead	2907	111.4	Acceptable
152	Farmstead	2588	112.3	Acceptable
153	Farmstead	2697	112.0	Acceptable
154	Reservoir	3100	111.1	N/A
155	Church	3450	110.3	Acceptable
156	Houses	710	121.1	Complaint
157	Houses	1242	117.3	Acceptable
158	Houses	1462	116.1	Acceptable
159	Houses	1714	115.1	Acceptable
160	Houses	1366	116.7	Acceptable
161	Houses	1801	114.8	Acceptable
162	Houses	2197	113.4	Acceptable
163	Railway Line	390	125.2	N/A
164	Railway Line	954	119.1	N/A
165	Railway Line	1216	117.5	N/A
166	Railway Line	1120	118.0	N/A
167	Railway Line	1017	118.6	N/A
168	Power lines/Pylons	3214	110.8	N/A
169	Power lines/Pylons	2876	111.5	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
170	Power lines/Pylons	2841	111.7	N/A
171	Power lines/Pylons	2836	111.7	N/A
172	Power lines/Pylons	2864	111.5	N/A
173	Power lines/Pylons	2939	111.4	N/A
174	Power lines/Pylons	3043	111.2	N/A
175	Power lines/Pylons	3172	110.8	N/A
176	Power lines/Pylons	3336	110.6	N/A
177	Sub Station	2624	112.2	N/A
178	Power lines/Pylons	1150	117.8	N/A
179	Power lines/Pylons	1427	116.3	N/A
180	Power lines/Pylons	1727	115.1	N/A
181	Power lines/Pylons	2072	113.8	N/A
182	Power lines/Pylons	2413	112.7	N/A
183	Power lines/Pylons	2735	111.9	N/A
184	Informal Housing	3225	110.8	Acceptable
185	Farm Buildings/Structures	3360	110.5	Acceptable
186	Informal Housing	1937	114.3	Acceptable
187	Power lines/Pylons	3426	110.3	N/A
188	Power lines/Pylons	3120	111.0	N/A
189	Power lines/Pylons	1058	118.4	N/A
190	Power lines/Pylons	462	124.1	N/A
191	Church	3134	111.0	Acceptable
192	School	3374	110.5	Acceptable
193	School	3466	110.3	Acceptable
194	Kwa-Guqa Houses	3100	111.1	Acceptable
195	Kwa-Guqa Houses	3190	110.8	Acceptable
196	Kwa-Guqa Houses	3366	110.5	Acceptable
197	Kwa-Guqa Houses	3375	110.5	Acceptable
198	Kwa-Guqa Houses	3278	110.7	Acceptable
199	Kwa-Guqa Houses	3311	110.6	Acceptable
200	Kwa-Guqa Houses	2949	111.4	Acceptable
201	Kwa-Guqa Houses	3232	110.7	Acceptable
202	Kwa-Guqa Houses	3463	110.3	Acceptable
203	Kwa-Guqa Houses	3376	110.5	Acceptable
204	Kwa-Guqa Houses	2876	111.5	Acceptable
205	Kwa-Guqa Houses	3003	111.3	Acceptable
206	Kwa-Guqa Houses	2881	111.5	Acceptable
207	Buildings/Structures	3042	111.2	Acceptable
208	Buildings/Structures	3177	110.8	Acceptable
209	River (Site ASW01- Not in use)	1653	115.4	N/A
210	Hydrocencus Borehole - Domestic (AHBH01)	1903	114.4	N/A
211	Hydrocencus Borehole - Domestic& Livestock (AHBH02)	3513	110.2	N/A
212	Hydrocencus Borehole - Domestic (AHBH03)	1080	118.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
213	Communication Tower	3056	111.2	N/A
214	Buildings/Structures	283	127.4	Complaint
215	Monitoring Borehole (ECBH 03)	105	134.2	N/A
216	Monitoring Borehole (ELNBH 03)	24	144.4	N/A
217	River (Site ASW 02 - Not in use)	339	126.2	N/A
218	Monitoring Borehole (BH 173)	188	130.2	N/A
219	Monitoring Borehole (BH 172)	274	127.6	N/A
220	Hydrocencus Borehole (AHBH04 - Not in use)	48	139.5	N/A
221	Hydrocencus Borehole (AHBH05 - Domestic& Livestock)	444	124.3	N/A
222	Hydrocencus Borehole (AHBH06 - Domestic& Irrigation)	548	122.9	N/A
223	Hydrocencus Borehole (AHBH07 - Not in use)	1009	118.7	N/A
224	Hydrocencus Borehole (AHBH08 - Not in use)	869	119.7	N/A
225	Heritage Site (11478/BGG-001 - Historic burial ground)	274	127.6	Complaint
226	Heritage Site (11478/BGG-002 - Historic burial ground)	370	125.6	Complaint
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	-	-	-
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	174	130.7	Complaint
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	-	-	-

19.2.3 Summary of findings for air blast

Review of the air blast levels indicate some concerns. Air blast predicted for the maximum charge ranges between 110.3 and 143.6 dB for all the POI's considered. This includes the nearest points such as the Clewer Houses. These levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints. The closest structures at 31 m (POI 69) showed concerns of possible structural damages at minimum and maximum charge. Minimum charge predictions identified that nine POI's at pit areas could experience levels of air blast that could lead to complaints. Maximum charge predictions indicate that nineteen POI's at pit areas could experience air blast that could lead to complaints. Apart from 2 Heritage Sites inside the pit areas, six POI's were identified where damage may be induced.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 110 m and closer to pit boundary. Infrastructure at the pit areas such as roads, heritage sites, power lines/pylons and Hydrocencus boreholes are present but air blast does not have any influence on these installations.

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

19.3 Fly-rock unsafe zone

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

Calculations are also used to help and assist determining safe distances. A safe distance from blasting is calculated following rules and guidelines from the International Society of Explosives Engineers (ISEE) Blasters Handbook. Using this calculation, the minimum safe distances can be determined that should be cleared of people, animals and equipment. Figure 19 shows the results from the ISEE calculations for fly rock range based on a 165 mm diameter blast hole and 3.25 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 thereof can never be eliminated. Figure 20 shows the area around the Pit areas that incorporates the 447 m unsafe zone.
The unsafe zone indicate specific concerns regards blasting operations to be in various areas of the planned project. The mining area south of Clever and south of the northern railway. The unsafe zone covers a greater deal of the township and any means of evacuation of this large numder of houses could be problematic. A clear defined plan of action will be required when blasting operations are conductedin this pit area.

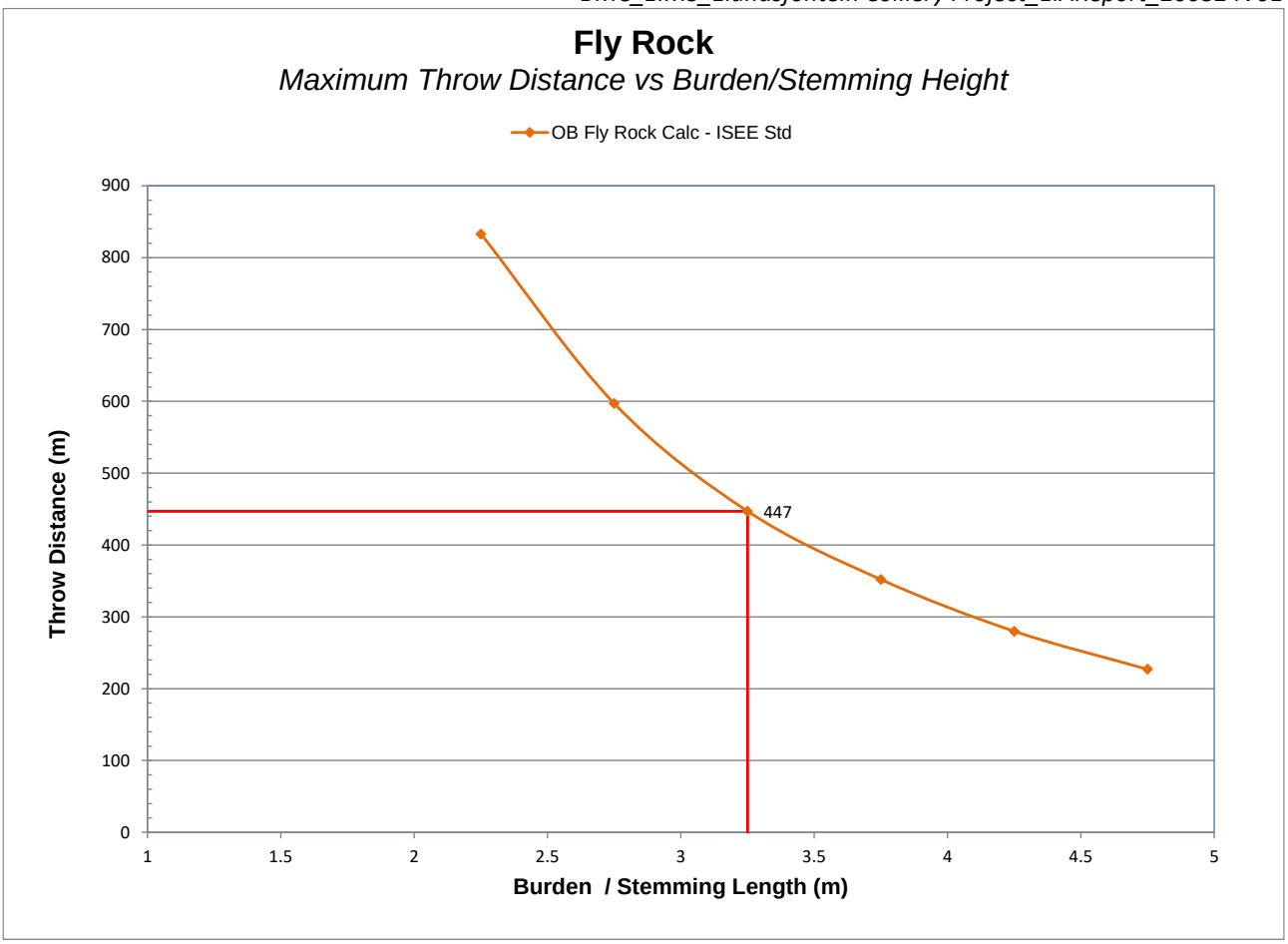


Figure 19: Fly rock prediction calculation

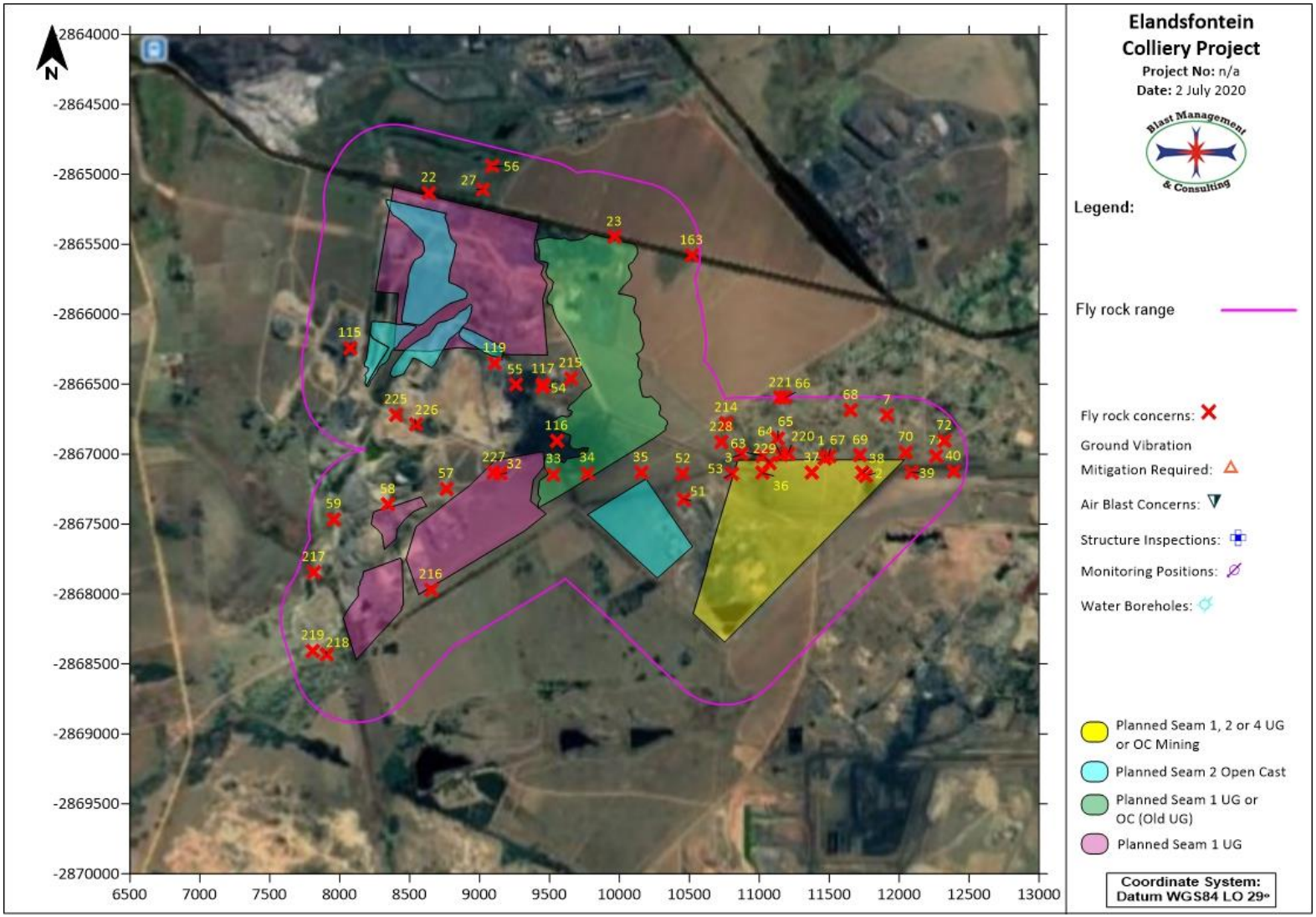


Figure 20: Predicted Fly Rock Exclusion Zone for all the Pit areas

Review of the calculated unsafe zone showed fifty-three POI's for the Pit areas (including nine POI's inside the pit area at this stage), are within the unsafe zone. This includes mainly the dam, Power Lines/Pylons and Heritage Sites that is located inside the pit area. Table 16 below shows the POI's of concern and coordinates.

Table 16: Fly rock concern POI's

Tag	Description	Y	X
1	Road	-11469.13	2867032.36
2	Dam (Inside OC Pit Area)	-11760.49	2867157.80
3	Buildings/Structures	-10875.61	2867000.12
7	Houses	-11914.00	2866722.31
22	Railway Line	-8639.80	2865132.10
23	Railway Line	-9964.95	2865449.12
27	Sewer Works	-9024.05	2865106.65
32	Power lines/Pylons (Inside Pit Area)	-9152.09	2867143.01
33	Power lines/Pylons (Inside Pit Area)	-9532.53	2867144.78
34	Power line/Pylons (Inside Pit Area)	-9773.33	2867136.80
35	Power lines/Pylons	-10154.86	2867134.56
36	Power lines/Pylons (Inside Pit Area)	-11021.92	2867134.62
37	Power lines/Pylons (Inside Pit Area)	-11376.45	2867134.92
38	Power lines/Pylons (Inside Pit Area)	-11738.24	2867134.98
39	Power lines/Pylons	-12087.70	2867131.47
40	Power lines/Pylons	-12388.56	2867126.00
51	Mine Buildings/Structures	-10457.59	2867321.40
52	Power lines/Pylons	-10456.25	2867142.12
53	Power lines/Pylons	-10807.38	2867139.12
54	Mine Activity	-9452.55	2866518.80
55	Mine Buildings/Structures	-9257.65	2866506.73
56	Industrial Structures	-9092.01	2864942.84
57	Power lines/Pylons	-8763.83	2867250.04
58	Power lines/Pylons	-8346.36	2867360.08
59	Power lines/Pylons	-7960.39	2867464.52
63	Houses	-11020.01	2867012.21
64	Houses	-11154.42	2867005.54
65	Houses	-11132.97	2866890.50
66	Houses	-11186.05	2866596.82
67	Houses	-11498.32	2867011.00
68	Houses	-11654.74	2866686.08
69	Houses	-11724.28	2867008.97
70	Houses	-12046.99	2866986.32
71	Houses	-12265.26	2867012.88
72	Houses	-12324.71	2866905.34

Tag	Description	Y	X
115	Mine Activity	-8074.47	2866242.39
116	Coal Yard	-9551.62	2866907.23
117	Mine Building	-9454.89	2866500.15
119	Mine Activity	-9109.77	2866351.15
163	Railway Line	-10517.81	2865580.48
214	Buildings/Structures	-10764.82	2866775.95
215	Monitoring Borehole (ECBH 03)	-9651.98	2866457.36
216	Monitoring Borehole (ELNBH 03)	-8653.02	2867967.80
217	River (Site ASW 02 - Not in use)	-7815.54	2867845.41
218	Monitoring Borehole (BH 173)	-7909.36	2868434.85
219	Monitoring Borehole (BH 172)	-7809.20	2868404.88
220	Hydrocencus Borehole (AHBH04 - Not in use)	-11206.58	2866993.70
221	Hydrocencus Borehole (AHBH05 - Domestic& Livestock)	-11151.81	2866598.14
225	Heritage Site (11478/BGG-001 - Historic burial ground)	-8402.96	2866718.18
226	Heritage Site (11478/BGG-002 - Historic burial ground)	-8542.88	2866788.73
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	-9104.64	2867132.88
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	-10729.63	2866916.08
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	-11076.27	2867068.48

19.4 Noxious fumes

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

19.5 Mitigations

In review of the evaluations made in this report it is certain that specific mitigation will be required with regards to ground vibration. Ground vibration is the primary possible cause of structural damage and requires more detailed planning in preventing damage and maintaining levels within accepted norms. Air blast and fly rock can be controlled using proper charging methodology irrespective of the blast hole diameter and patterns used. Ground vibration requires more detailed planning and forms the focus for mitigation measures.

Specific impacts are expected at the following POI's identified. Table 17 shows list of POI's that will need to be considered and Table 18 the POI's that needs specific attention due to location of the infrastructure. Figure 21 shows the location of these POI's in relation to the pit areas.

Table 17: Structures identified as problematic in and around the project area

Tag	Description	Classification	Y	X
1	Road	6	-11469.13	2867032.36
2	Dam (Inside OC Pit Area)	6	-11760.49	2867157.80
3	Buildings/Structures	2	-10875.61	2867000.12
7	Houses	2	-11914.00	2866722.31
8	Houses	2	-12534.72	2866893.28
22	Railway Line	6	-8639.80	2865132.10
23	Railway Line	6	-9964.95	2865449.12
27	Sewer Works	6	-9024.05	2865106.65
32	Power lines/Pylons (Inside Pit Area)	13	-9152.09	2867143.01
33	Power lines/Pylons (Inside Pit Area)	13	-9532.53	2867144.78
34	Power line/Pylons (Inside Pit Area)	13	-9773.33	2867136.80
35	Power lines/Pylons	13	-10154.86	2867134.56
36	Power lines/Pylons (Inside Pit Area)	13	-11021.92	2867134.62
37	Power lines/Pylons (Inside Pit Area)	13	-11376.45	2867134.92
38	Power lines/Pylons (Inside Pit Area)	13	-11738.24	2867134.98
39	Power lines/Pylons	13	-12087.70	2867131.47
51	Mine Buildings/Structures	6	-10457.59	2867321.40
52	Power lines/Pylons	13	-10456.25	2867142.12
53	Power lines/Pylons	13	-10807.38	2867139.12
55	Mine Buildings/Structures	6	-9257.65	2866506.73
56	Industrial Structures	6	-9092.01	2864942.84
57	Power lines/Pylons	13	-8763.83	2867250.04
58	Power lines/Pylons	13	-8346.36	2867360.08
63	Houses	2	-11020.01	2867012.21
64	Houses	2	-11154.42	2867005.54
65	Houses	2	-11132.97	2866890.50
66	Houses	2	-11186.05	2866596.82
67	Houses	2	-11498.32	2867011.00
68	Houses	2	-11654.74	2866686.08
69	Houses	2	-11724.28	2867008.97
70	Houses	2	-12046.99	2866986.32
71	Houses	2	-12265.26	2867012.88
72	Houses	2	-12324.71	2866905.34
76	Informal Housing	1	-7615.25	2865220.58
78	Ruins	4	-7294.08	2865027.87
90	Farm Building	2	-7562.80	2866817.20
101	Houses	2	-11594.38	2866522.36
115	Mine Activity	6	-8074.47	2866242.39
116	Coal Yard	6	-9551.62	2866907.23
117	Mine Building	6	-9454.89	2866500.15
119	Mine Activity	6	-9109.77	2866351.15
127	Building/Structure	2	-7841.06	2864894.09
156	Houses	2	-12402.55	2866433.18
214	Buildings/Structures	2	-10764.82	2866775.95
215	Monitoring Borehole (ECBH 03)	10	-9651.98	2866457.36
216	Monitoring Borehole (ELNBH 03)	10	-8653.02	2867967.80
218	Monitoring Borehole (BH 173)	10	-7909.36	2868434.85

Tag	Description	Classification	Y	X
219	Monitoring Borehole (BH 172)	10	-7809.20	2868404.88
220	Hydrocencus Borehole (AHBH04 - Not in use)	10	-11206.58	2866993.70
225	Heritage Site (11478/BGG-001 - Historic burial ground)	8	-8402.96	2866718.18
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	8	-9104.64	2867132.88
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	8	-10729.63	2866916.08
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	8	-11076.27	2867068.48

Table 18: Structures identified that needs specific attention due to location inside the planned pit area

Tag	Description	Classification	Y	X
2	Dam (Inside OC Pit Area)	6	-11760.49	2867157.80
32	Power lines/Pylons (Inside Pit Area)	13	-9152.09	2867143.01
33	Power lines/Pylons (Inside Pit Area)	13	-9532.53	2867144.78
34	Power line/Pylons (Inside Pit Area)	13	-9773.33	2867136.80
36	Power lines/Pylons (Inside Pit Area)	13	-11021.92	2867134.62
37	Power lines/Pylons (Inside Pit Area)	13	-11376.45	2867134.92
38	Power lines/Pylons (Inside Pit Area)	13	-11738.24	2867134.98
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	8	-9104.64	2867132.88
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	8	-11076.27	2867068.48

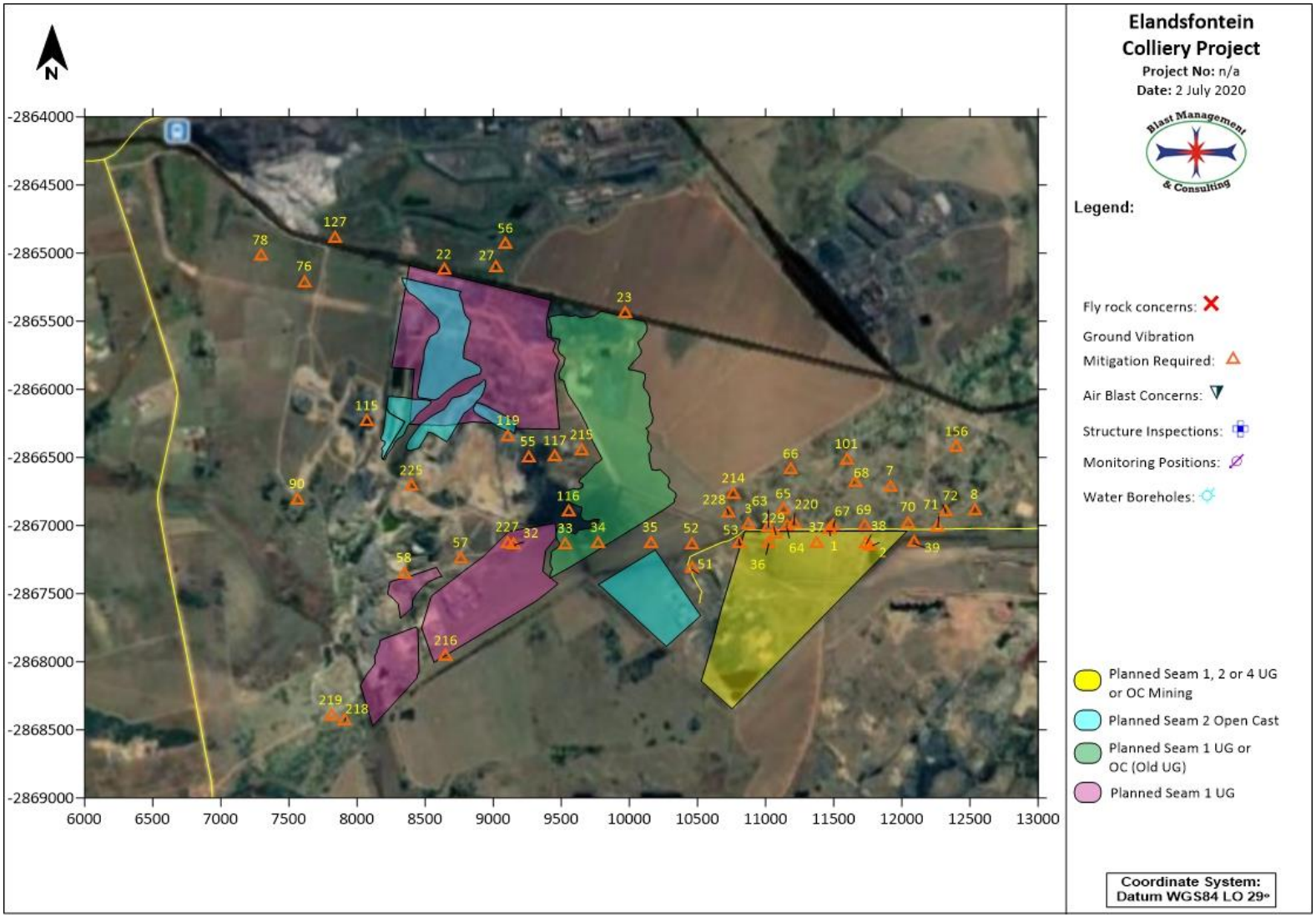


Figure 21: Structures identified where ground vibration mitigation will be required.

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

- Do blast design that considers the actual blasting, and the ground vibration levels to be adhered too.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.
- Relocate the POI / acquire the POI of concern – mined owned.

The identified POI's of concern is found in close proximity of the actual operations. Some of the POI's identified includes mine infrastructure. In order to give indication of the possibilities of mitigation to consider two basic indicators are presented. Firstly, the maximum charge per delay that can be allowed for the shortest distance between blast and POI. Secondly the minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay. These table gives indication for planning of blasts when blast at shortest distance to the POI's.

Table 19 do show mitigation in the form of maximum charge mass that will be allowed to maintain safe levels of ground vibration. Table 20 shows minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay.

Table 19: Mitigation measures: Maximum charge per delay for distance to POI

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
1	Road	-11469.13	2867032.36	150	15	20	150	Acceptable
3	Buildings/Structures	-10875.61	2867000.12	12.5	43	8	12.5	Acceptable
7	Houses	-11914.00	2866722.31	12.5	318	423	12.5	Acceptable
8	Houses	-12534.72	2866893.28	12.5	520	1135	12.5	Acceptable
22	Railway Line	-8639.80	2865132.10	150	26	58	150	Acceptable
23	Railway Line	-9964.95	2865449.12	150	22	40	150	Acceptable
27	Sewer Works	-9024.05	2865106.65	50	137	424	50	Acceptable
35	Power lines/Pylons	-10154.86	2867134.56	75	50	92	75	Acceptable
39	Power lines/Pylons	-12087.70	2867131.47	75	100	371	75	Acceptable
51	Mine Buildings/Structures	-10457.59	2867321.40	25	140	190	25	Acceptable
52	Power lines/Pylons	-10456.25	2867142.12	75	235	2026	75	Acceptable
53	Power lines/Pylons	-10807.38	2867139.12	75	21	16	75	Acceptable
55	Mine Buildings/Structures	-9257.65	2866506.73	25	218	464	25	Acceptable
56	Industrial Structures	-9092.01	2864942.84	50	312	2188	50	Acceptable
57	Power lines/Pylons	-8763.83	2867250.04	75	81	241	75	Acceptable
58	Power lines/Pylons	-8346.36	2867360.08	75	27	27	75	Acceptable
63	Houses	-11020.01	2867012.21	12.5	35	5	12.5	Acceptable
64	Houses	-11154.42	2867005.54	12.5	37	6	12.5	Acceptable
65	Houses	-11132.97	2866890.50	12.5	152	97	12.5	Acceptable
66	Houses	-11186.05	2866596.82	12.5	445	832	12.5	Acceptable
67	Houses	-11498.32	2867011.00	12.5	34	5	12.5	Acceptable

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
68	Houses	-11654.74	2866686.08	12.5	355	528	12.5	Acceptable
69	Houses	-11724.28	2867008.97	12.5	31	4	12.5	Acceptable
70	Houses	-12046.99	2866986.32	12.5	56	13	12.5	Acceptable
71	Houses	-12265.26	2867012.88	12.5	231	224	12.5	Acceptable
72	Houses	-12324.71	2866905.34	12.5	319	427	12.5	Acceptable
76	Informal Housing	-7615.25	2865220.58	6	719	892	6	Acceptable
78	Ruins	-7294.08	2865027.87	6	1055	1919	6	Acceptable
90	Farm Building	-7562.80	2866817.20	12.5	699	2052	12.5	Acceptable
101	Houses	-11594.38	2866522.36	12.5	518	1128	12.5	Acceptable
115	Mine Activity	-8074.47	2866242.39	200	127	1935	200	Acceptable
116	Coal Yard	-9551.62	2866907.23	150	74	473	150	Acceptable
117	Mine Building	-9454.89	2866500.15	25	209	424	25	Acceptable
119	Mine Activity	-9109.77	2866351.15	200	49	292	200	Acceptable
127	Building/Structure	-7841.06	2864894.09	12.5	579	1409	12.5	Acceptable
156	Houses	-12402.55	2866433.18	12.5	710	2116	12.5	Acceptable
214	Buildings/Structures	-10764.82	2866775.95	12.5	283	335	12.5	Acceptable
215	Monitoring Borehole (ECBH 03)	-9651.98	2866457.36	50	105	247	50	Acceptable
216	Monitoring Borehole (ELNBH 03)	-8653.02	2867967.80	50	24	13	50	Acceptable
218	Monitoring Borehole (BH 173)	-7909.36	2868434.85	50	188	794	50	Acceptable
219	Monitoring Borehole (BH 172)	-7809.20	2868404.88	50	274	1694	50	Acceptable
220	Hydrocencus Borehole (AHBH04 - Not in use)	-11206.58	2866993.70	50	48	53	50	Acceptable
225	Heritage Site (11478/BGG-001 - Historic burial ground)	-8402.96	2866718.18	50	274	1695	50	Acceptable
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	-10729.63	2866916.08	50	174	685	50	Acceptable

Table 20: Mitigation measures: Minimum distance for minimum and maximum charge to POI

Tag	Description	Y	X	Specific Limit (mm/s)	Minimum Distance (m)	Total Mass/Delay (kg)
Minimum distance required between blast and POI for Minimum Charge per delay						
76	Informal Housing	-7615.2503	2865220.6	6	401	277
3	Buildings/Structures	-10875.606	2867000.1	12.5	257	277
63	Houses	-11020.014	2867012.2	12.5	257	277
51	Mine Buildings/Structures	-10457.591	2867321.4	25	169	277
56	Industrial Structures	-9092.0108	2864942.8	50	111	277
215	Monitoring Borehole (ECBH 03)	-9651.9803	2866457.4	50	111	277
35	Power lines/Pylons	-10154.858	2867134.6	75	87	277
1	Road	-11469.128	2867032.4	150	57	277

Tag	Description	Y	X	Specific Limit (mm/s)	Minimum Distance (m)	Total Mass/Delay (kg)
23	Railway Line	-9964.9467	2865449.1	150	57	277
Minimum distance required between blast and POI for Maximum Charge per delay						
Tag	Description	Y	X	Specific Limit (mm/s)	Minimum Distance (m)	Total Mass/Delay (kg)
76	Informal Housing	-7615.25	2865220.6	6	1133	2213
3	Buildings/Structures	-10875.61	2867000.1	12.5	726	2213
63	Houses	-11020.01	2867012.2	12.5	726	2213
51	Mine Buildings/Structures	-10457.59	2867321.4	25	477	2213
56	Industrial Structures	-9092.01	2864942.8	50	313	2213
215	Monitoring Borehole (ECBH 03)	-9651.98	2866457.4	50	313	2213
35	Power lines/Pylons	-10154.86	2867134.6	75	245	2213
1	Road	-11469.13	2867032.4	150	161	2213
23	Railway Line	-9964.95	2865449.1	150	161	2213

Review of the tables above clearly indicates that there is concern for blasting operations specifically due to the location of Clever town. The planned mining of Seam 1, 2 or 4 in area directly south of Clever is most concern. The area is close to the town area and will require review of typical blasting operations. A further concern is that the mining area indicated is up to the town area. As it will be indicated later is that there is a restriction of 100 m that cannot be mined unless permission is obtained. Considering POI's 63 and 64 for example the allowed charge mass to satisfy the limits is significantly less than what is required for proper mining operations. Alternative view on mining this area will be required. Underground mining may rather be considered than opencast drilling and blasting. The final 100 m will be very difficult to mine in conventional fashion. It will be indicated that air blast and fly rock concerns will exist for mining of the specific area. Figure 22 shows area of concern with 100 m and 500 m restrictions indicated.

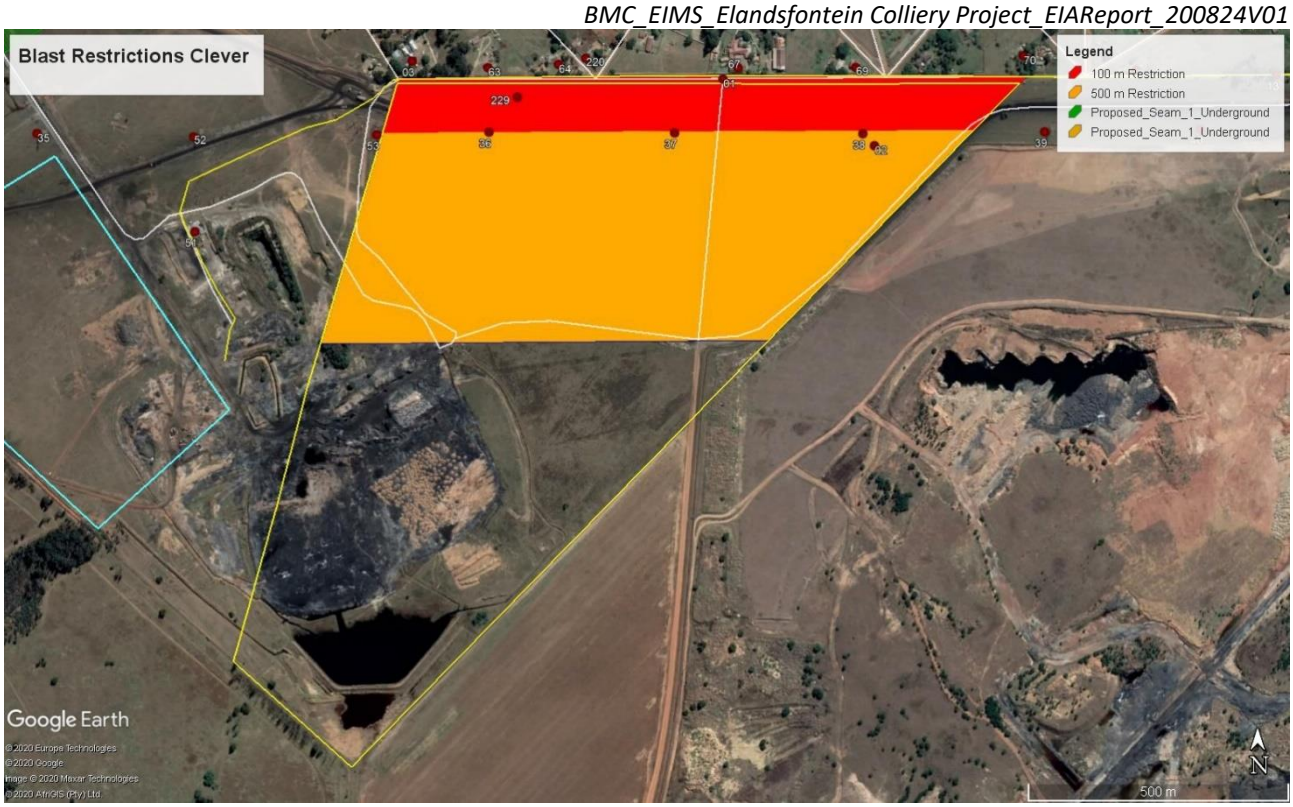


Figure 22: 100 m and 500 m Restrictions identified

19.6 Impact Evaluation Assessment

The impact significance rating methodology, as provided by EIMS (attached as Appendix C), is guided by the requirements of the NEMA EIA Regulations 2014 (as amended). The broad approach to the significance rating methodology is to determine the environmental risk (ER) by considering the consequence (C) of each impact (comprising Nature, Extent, Duration, Magnitude, and Reversibility) and relate this to the probability/ likelihood (P) of the impact occurring. This determines the environmental risk. In addition, other factors, including cumulative impacts and potential for irreplaceable loss of resources, are used to determine a prioritisation factor (PF) which is applied to the ER to determine the overall significance (S). The impact assessment will be applied to all identified alternatives. Where possible, mitigation measures will be recommended for impacts identified.

Table 21: Impact assessment evaluation

IMPACT DESCRIPTION				Pre-Mitigation							Post Mitigation								Priority Factor Criteria			
Identifier	Impact	Alternative	Phase	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Pre-mitigation ER	Nature	Extent	Duration	Magnitude	Reversibility	Probability	Post-mitigation ER	Confidence	Cumulative Impact	Irreplaceable loss	Priority Factor	Final score
17.1	**Blasting Ground vibration**	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.1	Buildings/Structures	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.1	Houses	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	**Blasting Air blast**	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Informal Housing	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Buildings/Structures	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Houses	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Mine Buildings/Structures	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Industrial Structures	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Monitoring Borehole (ECBH 03)	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Power lines/Pylons	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Road	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.2	Railway Line	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	**Blasting Fly rock**	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Road	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Buildings/Structures	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Houses	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Railway Line	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Sewer Works	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Power lines/Pylons	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Industrial Structures	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Hydrocencus Borehole	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28
17.3	Heritage Site	Alternative 1	Operation	-1	3	3	5	3	5	-17.5	-1	3	3	3	2	3	-8.25	High	2	1	1.13	-9.28

19.7 Specialist Management Plan

Table below shows management plan actions required as part of the mitigation measures.

Table 22: Mitigation measures for management plan

No.	Mitigation Measures	Phase	Timeframe	Responsible Party for Implementation	Monitoring Party (Frequency)	Target	Performance Indicators (Monitoring Tool)
1. Management of Ground Vibration							
A	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, using electronic initiation instead of shock tube systems to obtain single hole firing. Consider underground mining instead of opencast operations.	Operation	Continuous for all blasting operations	Mine Manager	External Consultant Blasting Contractor	Ensure compliance with relevant legislation	Blast Reports Monitoring reports Results within compliance
2. Management of Air blast							
A	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, use of specific stemming materials to manage air blast, increased stemming lengths to reduce air blast effect. Used of specific stemming to manage fly rock - crushed aggregate of specific size. Re-design with increased stemming lengths.	Operation	Continuous for all blasting operations	Mine Manager	External Consultant Blasting Contractor	Ensure compliance with relevant legislation	Blast Reports Monitoring reports Results within compliance
3. Management of Fly rock							
A	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, use of specific stemming materials to manage air blast, increased stemming lengths to reduce air blast effect. Used of specific stemming to manage fly rock - crushed aggregate of specific size. Re-design with increased stemming lengths.	Operation	Continuous for all blasting operations	Mine Manager	External Consultant Blasting Contractor	Ensure compliance with relevant legislation	Blast Reports Monitoring reports Results within compliance

20 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.

21 Decommissioning Phase Impacts

During the decommissioning phase no mining, drilling and blasting operations are expected. No detail impact evaluation was done.

22 Rehabilitation and Closure Phase Impacts

During the rehabilitation phase no mining, drilling and blasting operations are expected. No detail impact evaluation was done.

23 Alternatives (Comparison and Recommendation)

No specific alternative mining methods are discussed or specifically considered other than opencast operation or underground operations.

24 Monitoring

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

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

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

Eleven monitoring positions were identified as possible locations that will need to be considered. Not all points will be required at once but active monitoring and observation of where blasting is done will dictate the requirements for the areas around the pit. Some of these points may be applicable to more than one location to be monitored – specifically regarding the railway line and

Eskom pylons – roving station may be applied. Monitoring positions are indicated in Figure 23 and Table 23 lists the positions with coordinates. These points will need to be re-defined after the first blasts done and the monitoring programme defined.

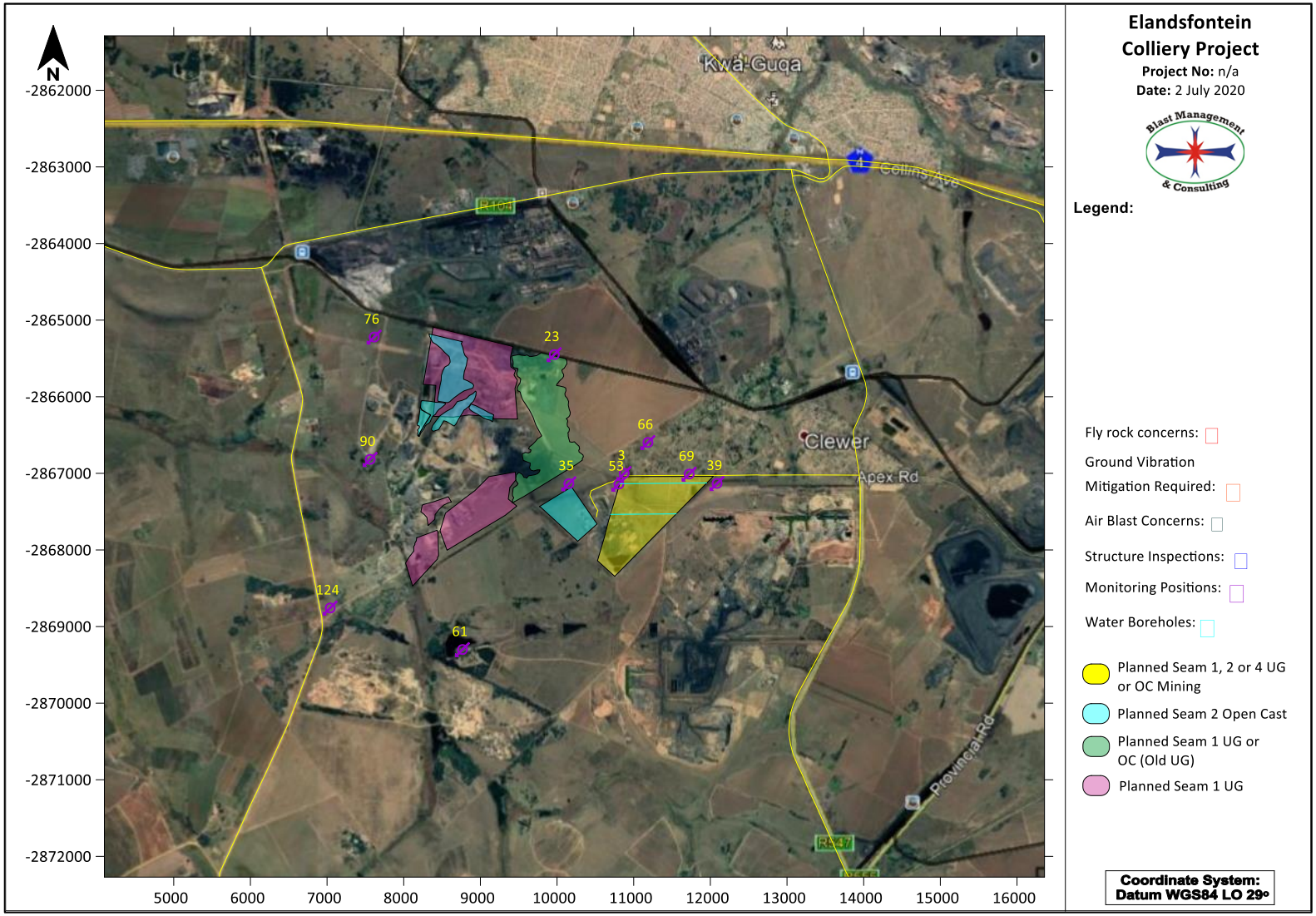


Figure 23: Suggested monitoring positions

Table 23: List of possible monitoring positions

Tag	Description	Y	X
3	Buildings/Structures	-10875.61	2867000.12
23	Railway Line	-9964.95	2865449.12
35	Power lines/Pylons	-10154.86	2867134.56
39	Power lines/Pylons	-12087.70	2867131.47
53	Power lines/Pylons	-10807.38	2867139.12
61	Game Lodge Buildings	-8767.12	2869300.01
66	Houses	-11186.05	2866596.82
69	Houses	-11724.28	2867008.97
76	Informal Housing	-7615.25	2865220.58
90	Farm Building	-7562.80	2866817.20
124	Farm House	-7041.40	2868757.32

25 Recommendations

The following recommendations are proposed.

25.1 Review of future mining options

As indicated in the report and described it is recommended that certain areas rather be done underground than opencast. The restrictions are significant and underground operations will be more suitable. This is particular with the new mining areas on the southern side of Clever. Based on the above outcomes and these recommendations the following Figure 24 shows alternative opencast and underground areas that will contribute to significantly reduce possible impacts. The impacts specifically towards Clever will be reduced and thus properly mitigated. The following Figure 24 shows the proposed allocation of underground and opencast operations. The reduction of the opencast to the indicated area will increase distance between Clever and the opencast area to approximately 600 m instead of the current 100 m. This will have a positive outcome with regards to the effects of ground vibration, air blast, fly rock, less infrastructure within 500 m and 100 m from the opencast operations. An obvious significant positive outcome expected.

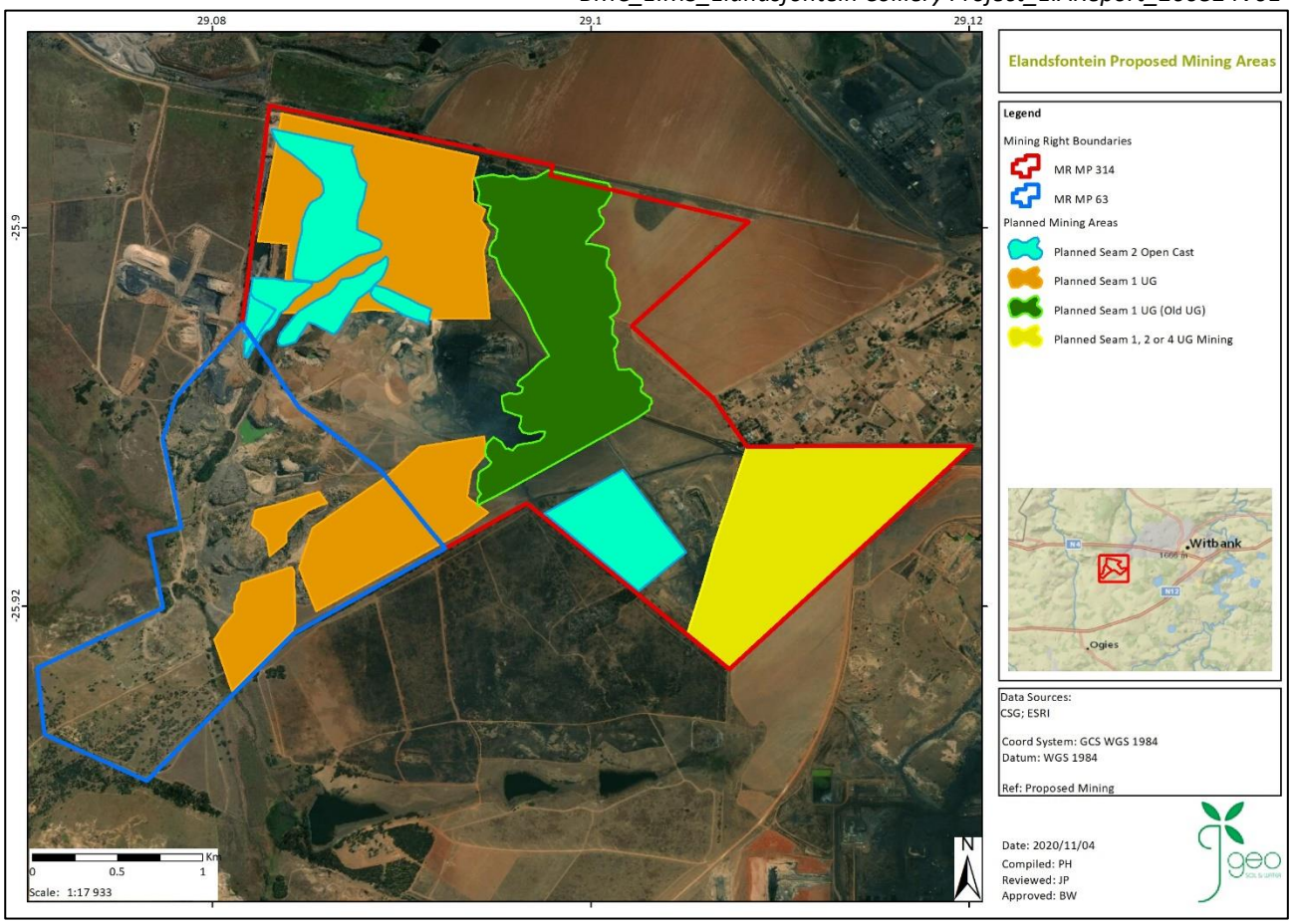


Figure 24: Proposed new definition of opencast and underground areas

25.2 Regulatory requirements – MHSA Reg. 4.16(2)

Regulatory requirements indicate specific requirements for all non-mining structures and installations within 500 m from the mining operation. Various POI's are observed within the pit that needs consideration as well within 500 m from the mining area. The mine will have to apply for the necessary authorisations as prescribed in the various acts, and specifically Mine Health and Safety Act Reg 4.16 as well as recommendations regarding infrastructure within the pit areas. Table 24 shows list of these installations. Figure 25 below shows the 500 m boundary around the opencast pit area. The location of non-mining installations is clearly observed.

Table 24: List of possible installations within the regulatory 500 m

Tag	Description	Y	X
1	Road	-11469.13	2867032.36
2	Dam (Inside OC Pit Area)	-11760.49	2867157.80
3	Buildings/Structures	-10875.61	2867000.12
7	Houses	-11914.00	2866722.31

Tag	Description	Y	X
13	Road	-12536.21	2867021.92
22	Railway Line	-8639.80	2865132.10
23	Railway Line	-9964.95	2865449.12
27	Sewer Works	-9024.05	2865106.65
32	Power lines/Pylons (Inside Pit Area)	-9152.09	2867143.01
33	Power lines/Pylons (Inside Pit Area)	-9532.53	2867144.78
34	Power line/Pylons (Inside Pit Area)	-9773.33	2867136.80
35	Power lines/Pylons	-10154.86	2867134.56
36	Power lines/Pylons (Inside Pit Area)	-11021.92	2867134.62
37	Power lines/Pylons (Inside Pit Area)	-11376.45	2867134.92
38	Power lines/Pylons (Inside Pit Area)	-11738.24	2867134.98
39	Power lines/Pylons	-12087.70	2867131.47
40	Power lines/Pylons	-12388.56	2867126.00
51	Mine Buildings/Structures	-10457.59	2867321.40
52	Power lines/Pylons	-10456.25	2867142.12
53	Power lines/Pylons	-10807.38	2867139.12
54	Mine Activity	-9452.55	2866518.80
55	Mine Buildings/Structures	-9257.65	2866506.73
56	Industrial Structures	-9092.01	2864942.84
57	Power lines/Pylons	-8763.83	2867250.04
58	Power lines/Pylons	-8346.36	2867360.08
59	Power lines/Pylons	-7960.39	2867464.52
63	Houses	-11020.01	2867012.21
64	Houses	-11154.42	2867005.54
65	Houses	-11132.97	2866890.50
66	Houses	-11186.05	2866596.82
67	Houses	-11498.32	2867011.00
68	Houses	-11654.74	2866686.08
69	Houses	-11724.28	2867008.97
70	Houses	-12046.99	2866986.32
71	Houses	-12265.26	2867012.88
72	Houses	-12324.71	2866905.34
79	Railway line	-7896.88	2864960.78
115	Mine Activity	-8074.47	2866242.39
116	Coal Yard	-9551.62	2866907.23
117	Mine Building	-9454.89	2866500.15
119	Mine Activity	-9109.77	2866351.15
163	Railway Line	-10517.81	2865580.48
190	Power lines/Pylons	-7770.35	2867518.32
214	Buildings/Structures	-10764.82	2866775.95
215	Monitoring Borehole (ECBH 03)	-9651.98	2866457.36
216	Monitoring Borehole (ELNBH 03)	-8653.02	2867967.80
217	River (Site ASW 02 - Not in use)	-7815.54	2867845.41
218	Monitoring Borehole (BH 173)	-7909.36	2868434.85
219	Monitoring Borehole (BH 172)	-7809.20	2868404.88
220	Hydrocencus Borehole (AHBH04 - Not in use)	-11206.58	2866993.70
221	Hydrocencus Borehole (AHBH05 - Domestic& Livestock)	-11151.81	2866598.14
225	Heritage Site (11478/BGG-001 - Historic burial ground)	-8402.96	2866718.18
226	Heritage Site (11478/BGG-002 - Historic burial ground)	-8542.88	2866788.73

Tag	Description	Y	X
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	-9104.64	2867132.88
228	Heritage Site (11478/BGG-004 - Municipal Cemetery)	-10729.63	2866916.08
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	-11076.27	2867068.48

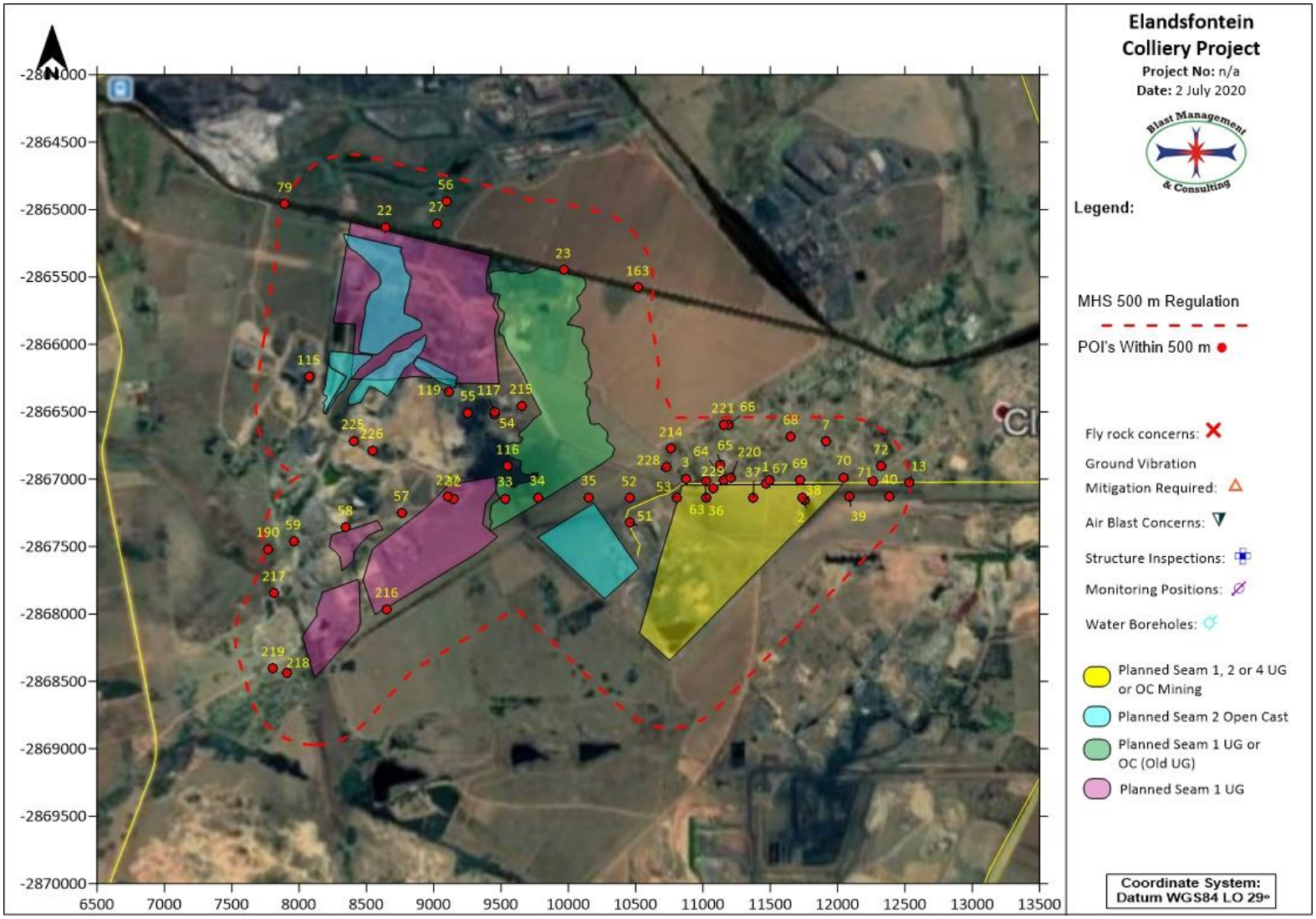


Figure 25: Regulatory 500 m range for the opencast area

25.1 Regulatory requirements – MHSA Reg. 17.6(a)

On review of the pit area's location, it is such that Mine Health and Safety act regulation 17.6(a) will be applicable and will need to be considered. The location of both planned seam 1, 2 open cast and underground Pit boundary is closer than 100 m from private installations and the necessary legal requirements will need to be addressed. Figure 26 shows all Pits with 100 m boundary that will need to be considered with indication of infrastructure within the 100 m. Please note that an icon may represent more than one structure / installation. Table 25 shows list of POI's identified.

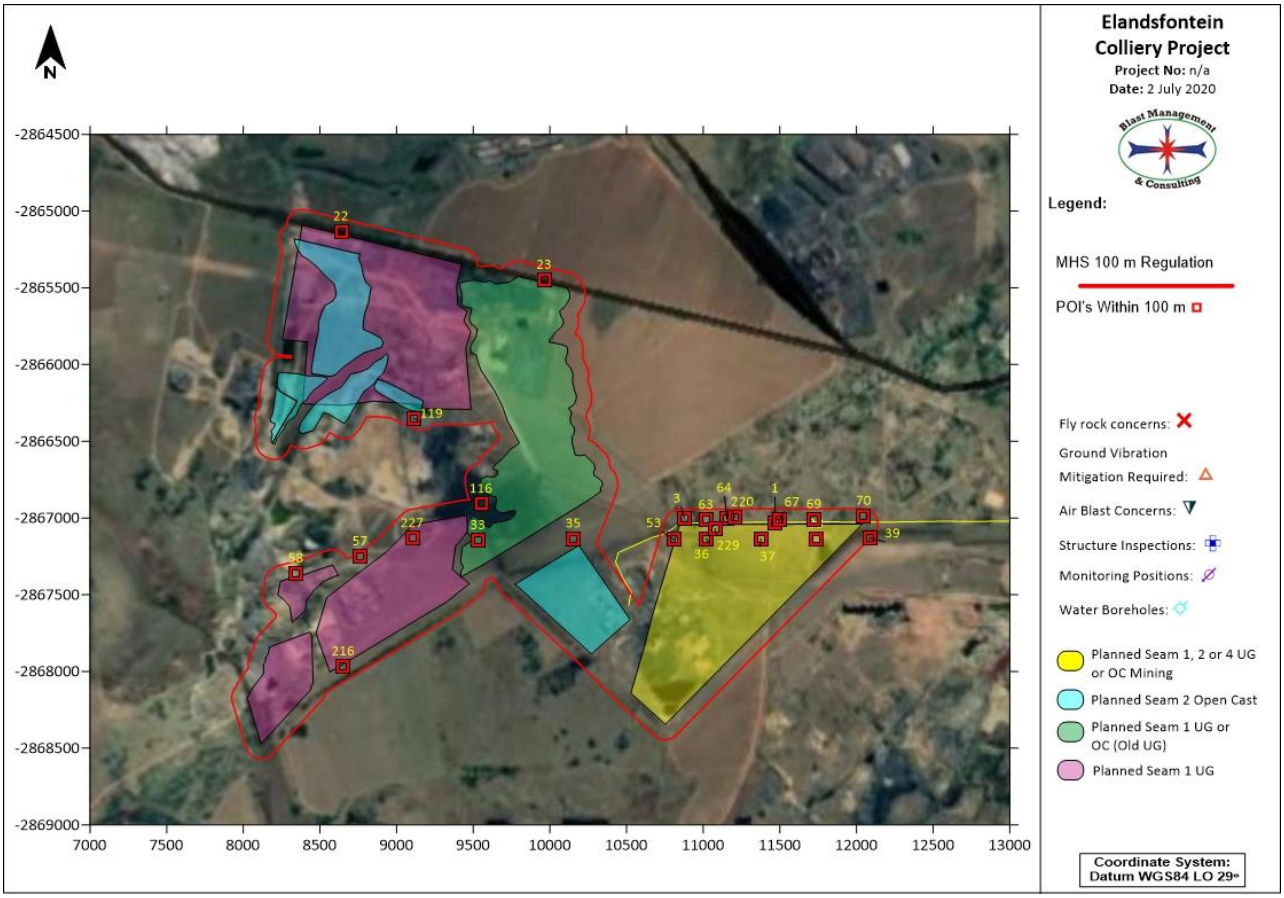


Figure 26: Regulatory 100 m range for all pit areas

Table 25: List of possible installations within the regulatory 100 m

Tag	Description	Y	X
1	Road	-11469.13	2867032.36
3	Buildings/Structures	-10875.61	2867000.12
22	Railway Line	-8639.80	2865132.10
23	Railway Line	-9964.95	2865449.12
33	Power lines/Pylons (Inside Pit Area)	-9532.53	2867144.78
35	Power lines/Pylons	-10154.86	2867134.56
36	Power lines/Pylons (Inside Pit Area)	-11021.92	2867134.62
37	Power lines/Pylons (Inside Pit Area)	-11376.45	2867134.92

38	Power lines/Pylons (Inside Pit Area)	-11738.24	2867134.98
39	Power lines/Pylons	-12087.70	2867131.47
53	Power lines/Pylons	-10807.38	2867139.12
57	Power lines/Pylons	-8763.83	2867250.04
58	Power lines/Pylons	-8346.36	2867360.08
63	Houses	-11020.01	2867012.21
64	Houses	-11154.42	2867005.54
67	Houses	-11498.32	2867011.00
69	Houses	-11724.28	2867008.97
70	Houses	-12046.99	2866986.32
116	Coal Yard	-9551.62	2866907.23
119	Mine Activity	-9109.77	2866351.15
216	Monitoring Borehole (ELNBH 03)	-8653.02	2867967.80
220	Hydrocencus Borehole (AHBH04 - Not in use)	-11206.58	2866993.70
227	Heritage Site (11478/BGG-003 - Historic burial ground) - Inside Pit Area	-9104.64	2867132.88
229	Heritage Site (11478/BGG-005 - Burial ground) - Inside Pit Area	-11076.27	2867068.48

25.2 Blast Designs

Blast designs should be reviewed and done prior to blasting operations planned. This is specifically areas that are close to areas such as Clever. The final mining decision with the different restrictions will have influence on allowable charging and design will need to consider this. Distance between blast and POI's must be confirmed and the specific drill pattern and blasthole depth must be considered. Attention can also be given to the possible use of electronic initiation rather than conventional timing systems. This will allow for single blast hole firing instead of multiple blast holes. Single blast hole firing will provide single hole firing – thus less charge mass per delay and less influence.

25.3 Test Blasting

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

25.4 Stemming length

The current proposed stemming lengths used provides for some control on fly rock. Consideration can be given to increase this length for better control. Specific designs where distances between blast and point of concern are known should be considered. Recommended stemming length should range between 20 and 30 times the blast hole diameter. In cases for better fly control this should range between 30 and 34 times the blast holes diameter. Increased stemming lengths will also contribute to more acceptable air blast levels.

25.5 Safe blasting distance and evacuation

Calculated minimum safe distance is 447 m. The final blast designs that may be used will determine the final decision on safe distance to evacuate people and animals. This distance may be greater pending the final code of practice of the mine and responsible blaster's decision on safe distance. The blaster has a legal obligation concerning the safe distance and he needs to determine this distance.

25.6 Road and railway management

The N4 National road is at an approximate distance of 2680 m from the nearest pit area and will require no specific consideration regarding effects from blasting operations. There are provincial roads in the vicinity of the project area to be considered. The R104 road is located to the northern side of the Pit areas at 1419 m and the R547 road is located on the eastern side at 1907 m. Expected ground vibration levels at these roads are within the recommended limits. No specific actions are required for these roads.
The road on the southern side of the Clewer town is in very close proximity to one pit at 15 m. This road is specifically of concern when blasting is done. This road is used continuously and will require careful planning to maintain safe blasting radius. It will be required that clearance distances be set, and road travel managed during blasting operations especially when blasting operations are within 500 m from this road.

The Railway line on the northern side of the project area is at closest distance of 22 m and could be problematic. Rail schedules and authority to last should be put in place. This should form part of the blast management plan. Again, specifically when blasting is done within 500 m from the railway.

25.7 Photographic Inspections

The option of photographic survey of all structures up to 1500 m from the pit areas is recommended. The mine will be operating for a significant number of years. This will give advantage on any negotiations with regards to complaints from neighbours on structural issues due to blasting. This process can however only succeed if done in conjunction with a proper monitoring program. It is expected that ground vibration levels will be significantly less than proposed limits at 1500 m, but this process will ensure record of the pre-blasting status of the nearest structures to the pit areas. At 1500 m the expected level of ground vibration will be perceptible. Figure 27 shows extent of the

range of 1500 m around the pit areas with POI's identified. It must be noted that a point may represent a group of structures found in the vicinity of the point identified.

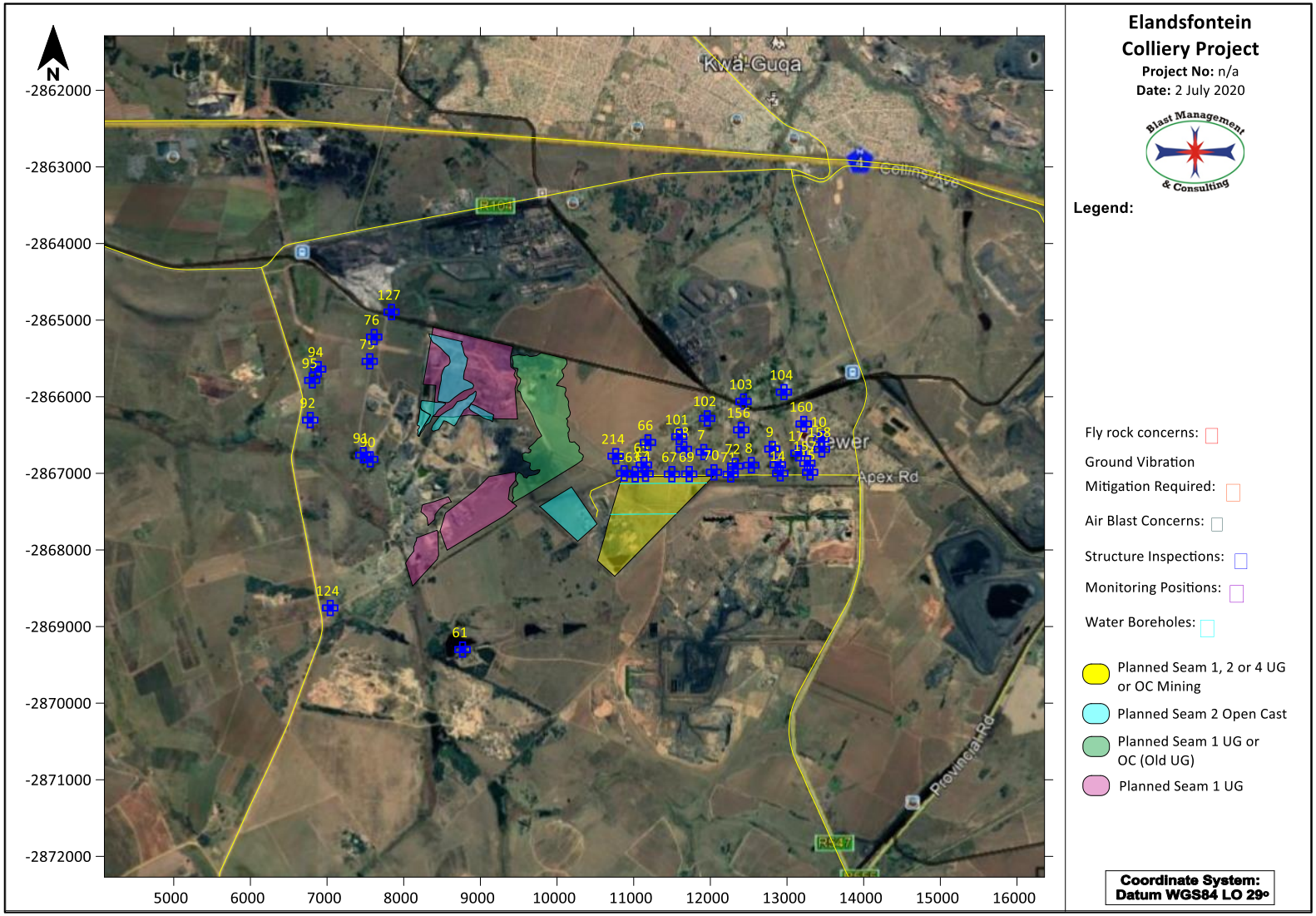


Figure 27: 1500 m area around opencast pit identified for structure inspections.

Table 26: Combined list of structures identified for inspections

Tag	Description	Y	X
3	Buildings/Structures	-10875.61	2867000.12
6	Sport Terrain	-12880.27	2866887.69
7	Houses	-11914.00	2866722.31
8	Houses	-12534.72	2866893.28
9	Houses	-12808.24	2866682.76
10	Houses	-13447.39	2866552.67
14	Houses	-12911.68	2866998.92
15	Houses	-13300.68	2866986.35
17	Church	-13149.61	2866736.96
61	Game Lodge Buildings	-8767.12	2869300.01
63	Houses	-11020.01	2867012.21
64	Houses	-11154.42	2867005.54
65	Houses	-11132.97	2866890.50
66	Houses	-11186.05	2866596.82
67	Houses	-11498.32	2867011.00
68	Houses	-11654.74	2866686.08
69	Houses	-11724.28	2867008.97
70	Houses	-12046.99	2866986.32
71	Houses	-12265.26	2867012.88
72	Houses	-12324.71	2866905.34
75	Farmstead	-7557.26	2865537.80
76	Informal Housing	-7615.25	2865220.58
90	Farm Building	-7562.80	2866817.20
91	Farm Building	-7473.61	2866762.99
92	Farmstead	-6780.80	2866305.04
94	Farm Buildings	-6885.12	2865639.89
95	Farm House	-6806.98	2865785.93
101	Houses	-11594.38	2866522.36
102	Houses	-11959.36	2866283.28
103	Houses	-12432.36	2866062.79
104	Building Structures	-12959.93	2865939.77
124	Farm House	-7041.40	2868757.32
127	Building/Structure	-7841.06	2864894.09
156	Houses	-12402.55	2866433.18
157	Houses	-13265.77	2866868.67
158	Houses	-13454.41	2866686.69
160	Houses	-13217.68	2866355.96
214	Buildings/Structures	-10764.82	2866775.95

25.8 Recommended ground vibration and air blast levels

The ground vibration and air blast levels limits recommended for blasting operations in this area are provided in Table 27.

Table 27: Recommended ground vibration air blast limits

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

25.9 Blasting times

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

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

25.10 Third party monitoring

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

25.11 Video monitoring of each blast

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

26 Knowledge Gaps

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

27 Project Result

In view of the data evaluated it is the opinion of the author that the project can be executed successfully with consideration of the recommendations. There are areas that would be better mined underground than opencast due to the significant restrictions it will have on opencast blasting operations. Areas will not be feasible to mine if opencast operation will be selected. Proper management and control on the aspects of ground vibration, air blast and fly rock is possible and can be done. Specific problem areas were identified, and recommendations made. It is possible that the full resource may be mined with careful consideration of the recommendations.

28 Conclusion

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

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed is typical roads (tar and gravel), low cost houses, corrugated iron structures, brick and mortar houses, boreholes and heritage sites.

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

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

On charges considered it is expected that air blast will be greater than 134 dB at a distance of 110 m and closer to pit boundary. The structures inside the Pit areas is expected to be relocated and will then not be of concern as it is currently inside the pit area. Infrastructure at the pit areas such as roads, heritage sites, power lines/pylons and Hydrocencus boreholes are present but air blast does not have any influence on these installations.

Fly rock remains and concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 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 thereof can never be eliminated.

There are boreholes that are in proximity of the blasting areas and could be problematic.

Specific actions will be required for the pit areas such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Road, Railway Line, Power Lines/Pylons, Houses, Boreholes, Heritage Sites and buildings/structures falls within the 500 m range from the various pit areas.

The pit areas are located such that specific concerns were identified and addressed in the report. The greatest concern is area south of Clever. Opencast operations will be significantly restricted, and it may lead to areas not minable. This is mainly due to the location of this area closer than 100 m to the Clever township and the restrictions with regards to ground vibration, air blast and fly rock.

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

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30 Appendix A: Specialist Declaration

SPECIALIST DECLARATION

The specialist appointed in terms of the Regulations_

I, JD Zeeman, declare that –

General declaration:

I act as the independent specialist in this application;

I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;

declare that there are no circumstances that may compromise my objectivity in performing such work;

I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;

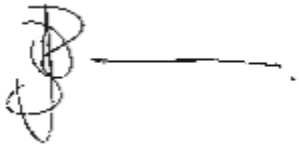
I will comply with the Act, Regulations and all other applicable legislation;

I have no, and will not engage in, conflicting interests in the undertaking of the activity;

I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;

all the particulars furnished by me in this form are true and correct; and

I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the specialist: 

Name of company (if applicable): Blast Management and Consulting (PTY) Ltd

Date: 21/08/2020

31 Appendix B: Specialist CV

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.

32 Appendix C: Impact Assessment Methodology