APPENDIX 17

BLAST IMPACT ASSESSMENT

Blast Management & Consulting

Quality Service on Time

Report: Blast Impact Assessment Proposed Tawana Hotazel Mine (THM) Project		
Report Date:	8 November 2021	
BM&C Ref No:	Prime Resources_Hotazel Project_EIAReport_211108	
Clienf Ref No:	N/A	
DMR Ref No:	NC30/5/1/1/2/12148 PR	
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ii. Independence Declaration

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

iii. Legal Requirements

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

Table 1: Legal Requirements for All Specialist Studies Conducted

Legal Requirement		**Relevant Section in Specialist study**
(1)	A specialist report prepared in terms of these Regulations must contain-	
(a)	details of-	
	(i) the specialist who prepared the report; and	i
	(ii) the expertise of that specialist to compile a specialist report including a curriculum vitae;	Section 26
(b)	a declaration that the specialist is independent in a form as may be specified by the competent authority;	Section ii
(c)	an indication of the scope of, and the purpose for which, the report was prepared;	Section 4

Legal Requirement		**Relevant Section in Specialist study**
(d)	the date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 8
(e)	a description of the methodology adopted in preparing the report or carrying out the specialised process;	Section 6
(f)	the specific identified sensitivity of the site related to the activity and its associated structures and infrastructure;	Section 11
(g)	an identification of any areas to be avoided, including buffers;	Section 11
(h)	a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Section 11
(i)	a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 9
(j)	a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment;	Section 17
(k)	any mitigation measures for inclusion in the EMPr;	Section 18.3
(l)	any conditions/aspects for inclusion in the environmental authorisation;	Section 22
(m)	any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 21
(n)	a reasoned opinion (Environmental Impact Statement)-	Section 24
	as to whether the proposed activity or portions thereof should be authorised; and	Section 24
	if the opinion is that the proposed activity or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr, and where applicable, the closure plan;	Section 24
(o)	a description of any consultation process that was undertaken during the course of preparing the specialist report;	Section 12
(p)	a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	Section 12
(q)	any other information requested by the competent authority.	None

iv. Document Control:

Name & Company	Responsibility	Action	Date	Signature
C Zeeman Blast Management & Consulting	Document Preparation	Report Prepared	08/11/2021	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalised	08/11/2021	

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List of Acronyms used in this Report

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

List of Units used in this Report

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

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

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1 Executive Summary

Blast Management & Consulting (BMC) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed opencast mining operations. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations.

The report evaluates the effects of ground vibration, air blast and fly rock and intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

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

The location of structures around the Pit area is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Structures, Railway Line and Communication Tower. Ground vibration at structures and installations is well below any specific concern for inducing damage.

Air blast predicted also showed more concerns for opencast blasting. 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 pit is located such that “free blasting” – meaning no controls on blast preparation – will not be possible.

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 290 m and closer to pit boundary. Infrastructure at the pit areas such as roads, power lines/pylons are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 291 m. The absolute minimum unsafe zone is then the 291 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Structures, Railway Line and Communication Tower falls within the 500 m range from the pit area.

The pit area is located such that specific concerns were identified and addressed in the report.

This concludes this investigation for the proposed Tawana Hotazel Mine (THM) Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

2 Introduction

The Department of Mineral Resources and Energy (DMRE) has accepted an application for a Mining Right (MR) made by Tawana Hotazel Mining (Pty) Ltd (THM) in terms of Section 22 of the Mineral and Petroleum Resources Development Act, 2002 (MPRDA). The types of minerals applied for are all (Code UN); Iron and Iron bearing minerals including hematite, goethite, specularite and limonite (Code (Fe) Type (B)) and Manganese and manganese bearing minerals (Code (Mn) Type (B)).

The THM covers portions of two farms within the Joe Morolong Local Municipality (JMLM) in the Northern Cape Province; Hotazel 280 and York 279 and is located approximately 1 km south-east of the town of Hotazel. The THM largely incorporates the historical Hotazel Manganese Mine (HMM), and the MR area includes the residual opencast void and surface dumps of low-grade material. The mothballed processing plant and rail loadout facility fall outside the MR area. HMM stopped production in 1989. The area was historically mined by both opencast and underground means and yielded high grade manganese ore. All current plans for the project specifically exclude underground mining.

The overall area applied for is approximately 154 Ha (inclusive of the MR application area and access road). Surface infrastructure will include the opencast pit (incorporating the historical HMM void and further expansion of the opencast footprint), in-pit waste dumps (residue material), surface residue handling / storage, vehicle yard, workshop, access and haul roads, offices, stores, processing plant for the crushing and screening of mined ore, product stockpile area, run of mine pad, refuel bay and water management infrastructure. The centre point of the site is 27°12'40.46"S and 22°58'23.06"E.

Mining

- Opencast mining methods will be used to a maximum depth of 95 m.
- The ore zone of the various seams is found at depths from 25 to 91 m below the surface and the manganese seam thicknesses varies from 3 to 27 m.
- The proposed mining process is as follows: drilling → blasting → load and haul → dry crushing and screening plant → product stockpiling → road truck loading.
- The annual Run of Mine (RoM) ore production is estimated at 0.5 Mt.
- The mining of the opencast pit will require as many as two active work areas in certain schedule overlap years.

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

3 Objectives

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

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

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

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

4 Scope of blast impact study

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

- Background information of the proposed site.
- Blasting Operation Requirements.
- Site specific evaluation of blasting operations according to the following:
    - Evaluation of expected ground vibration levels from blasting operations at specific distances and on structures in surrounding areas;
    - Evaluation of expected ground vibration influence on neighbouring communities;

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

5 Study area

The THM covers portions of two farms within the Joe Morolong Local Municipality in the Northern Cape Province; Hotazel 280 and York 279 and is located approximately 1 km south-east of the town of Hotazel. The centre point of the site is 27°12'40.46"S and 22°58'23.06"E. Figure 1 shows the Mining Right Area with proposed mine layout for the Tawana Hotazel Mine Project.

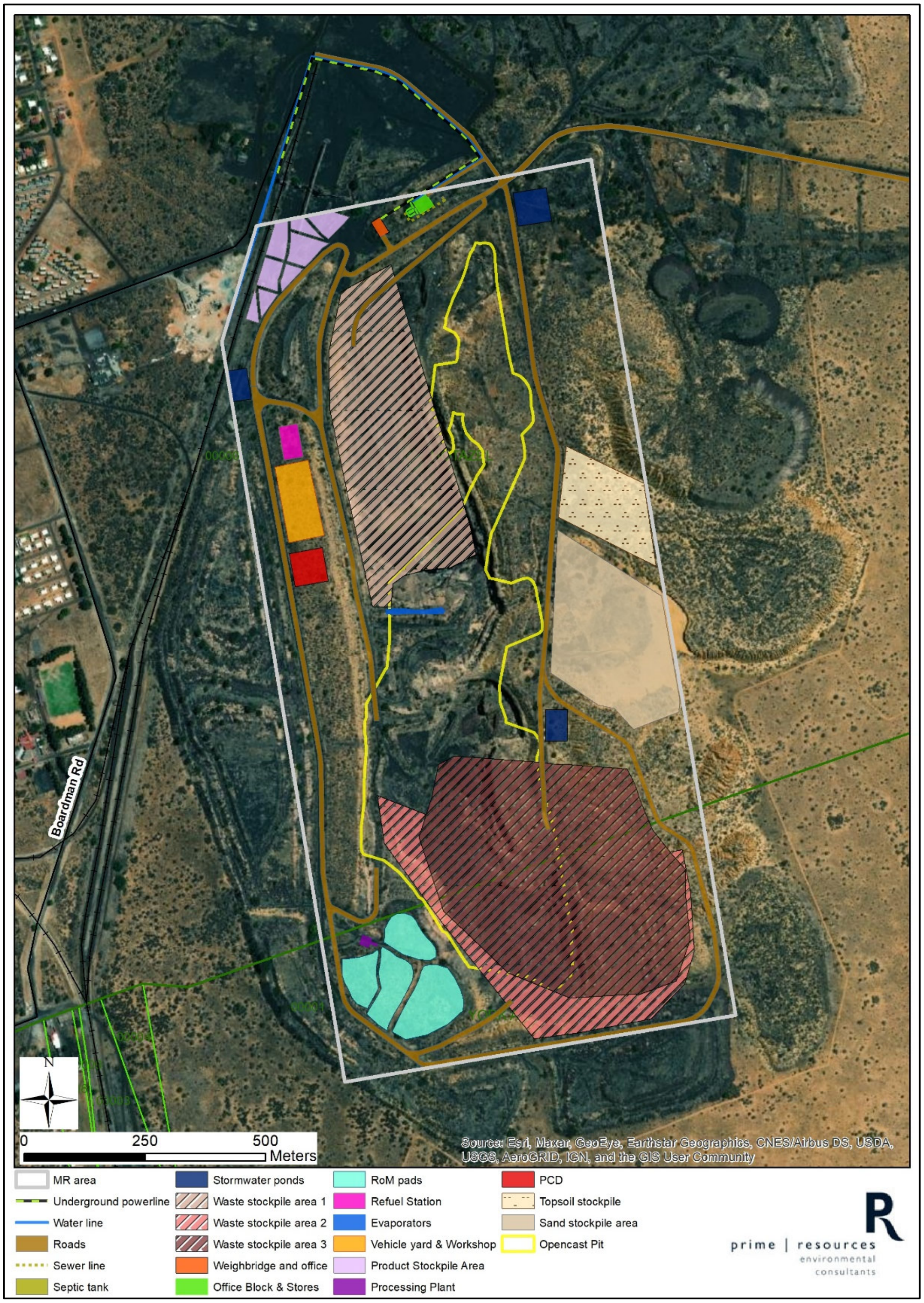

Figure 1: Mining Right Area with proposed mine layout

6 Methodology

The detailed plan of study consists of the following sections:

- Site visit: Intention to understand location of the site and its surroundings.
- Identifying surface structures / installations that are found within reason from project site. A list of Point of Interests (POI's) is created that will be used for evaluation.

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

7 Site Investigation

The site was visited on 24 September 2020. This site visit was done to get understanding of the location and the structures and installations surrounding the proposed new pit areas.

8 Season applicable to the investigation

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

9 Assumptions and Limitations

The following assumptions have been made:

- The project area is not currently an active full-scale mining operation. Drilling and blasting operations were done previously.
- The anticipated levels of influence estimated in this report are calculated using standard accepted methodology according to international and local regulations.
- The assumption is made that the predictions are a good estimate with significant safety factors to ensure that expected levels are based on worst case scenarios. These will have to be confirmed with actual measurements once the operation is active.
- The limitation is that no data was available from this operation for a confirmation of the predicted values.
- There was no drilling and blasting information available at time of this report. Blast designs was provided from external consultant Blast Vision (PTY) Ltd – AJ Rorke. The designs from

Blast Vision were applied in the evaluation of the project. The recommendations in the report were also considered and applied in this evaluation.

- These designs may change when the project is started.
- The work done is based on the author's knowledge and information provided by the project applicant.

10 Legal Requirements

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

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

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

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

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

MINE HEALTH AND SAFETY REGULATIONS

Precautionary measures before initiating explosive charges

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

General precautions

4.16 The employer must take reasonable measures to ensure that:

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

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

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

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

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

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

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

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

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

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

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

MINERAL AND PETROLEUM RESOURCES DEVELOPMENT REGULATIONS

67. Blasting, vibration and shock management and control

(1) A holder of a right or permit in terms of the Act must comply with the provisions of the Mine Health and Safety Act, 1996, (Act No. 29 of 1996), as well as other applicable law regarding blasting, vibration and shock management and control.

(2) An assessment of impacts relating to blasting, vibration and shock management and control, where applicable, must form part of the environmental impact assessment report and environmental management programme or the environmental management plan, as the case may be.

The current pit layout indicates that the planned pit area may be close to private installations. The Mine Health and Safety Act has specific requirements regarding blasting within 500 m and mining within 100 m from private installations. This will be addressed in the recommendations.

11 Sensitivity of Project

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

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

- An area greater than 1500 m is considered low sensitivity area. In this area, it is relatively certain that influences will be low with low possibility of damages and limited possibility to upset people.

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

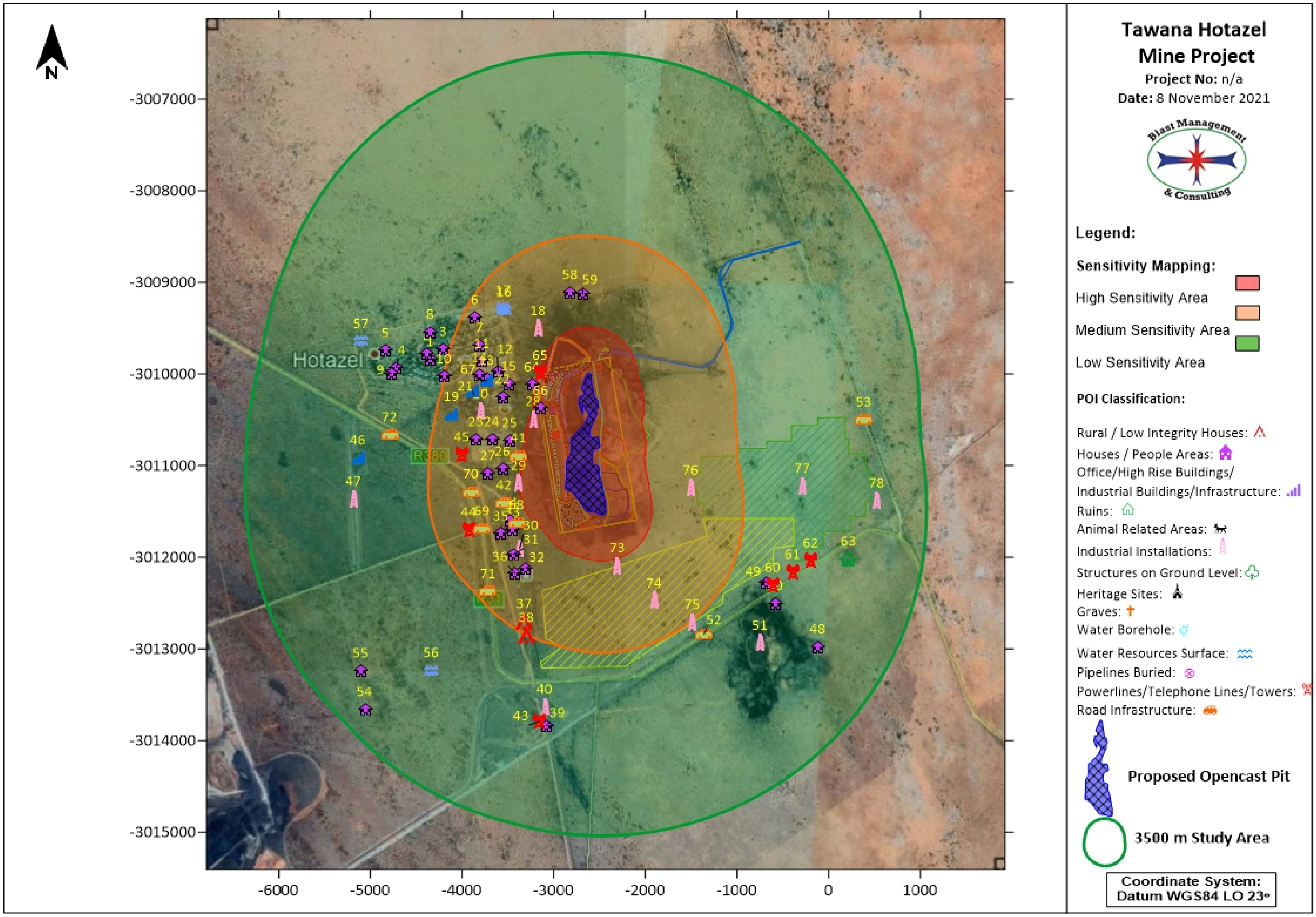

Figure 2: Identified sensitive areas for the Open Pit area

12 Consultation process

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

13 Influence from blasting operations

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

13.1 Ground vibration limitations on structures

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

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

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

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

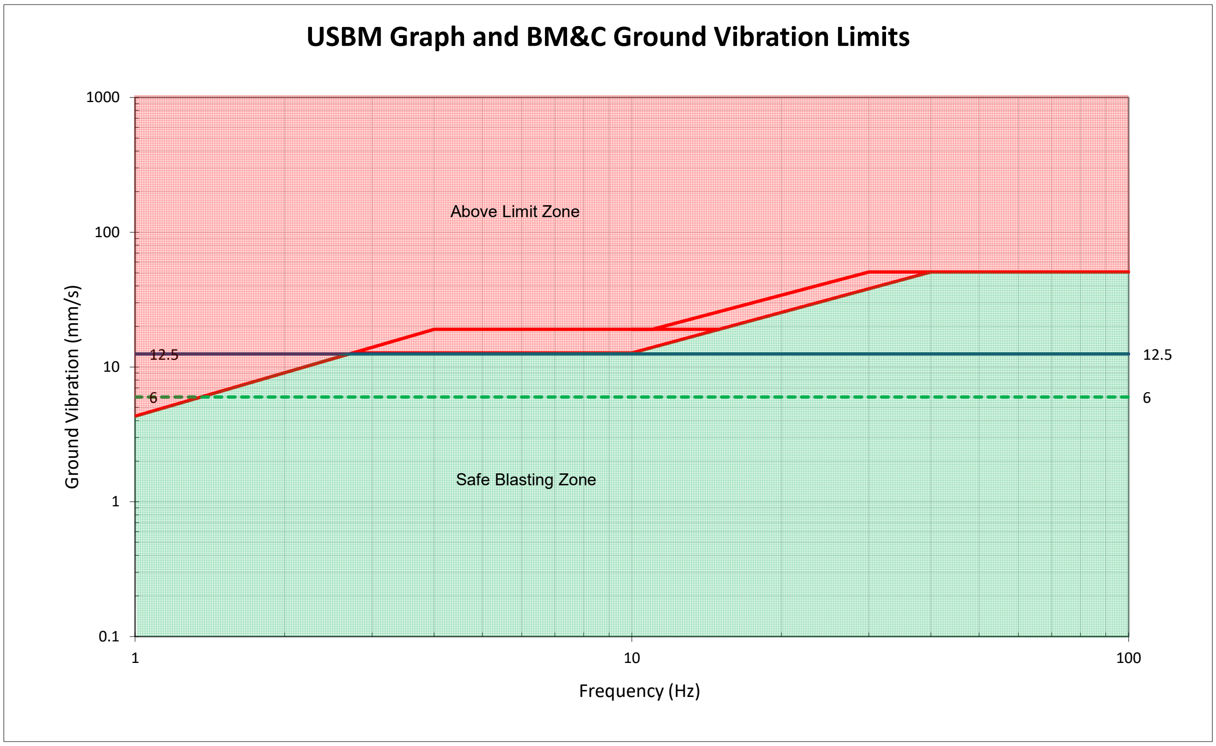

Figure 3: USBM Analysis Graph

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

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

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

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

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

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

13.2 Ground vibration limitations and human perceptions

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

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

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

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

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

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

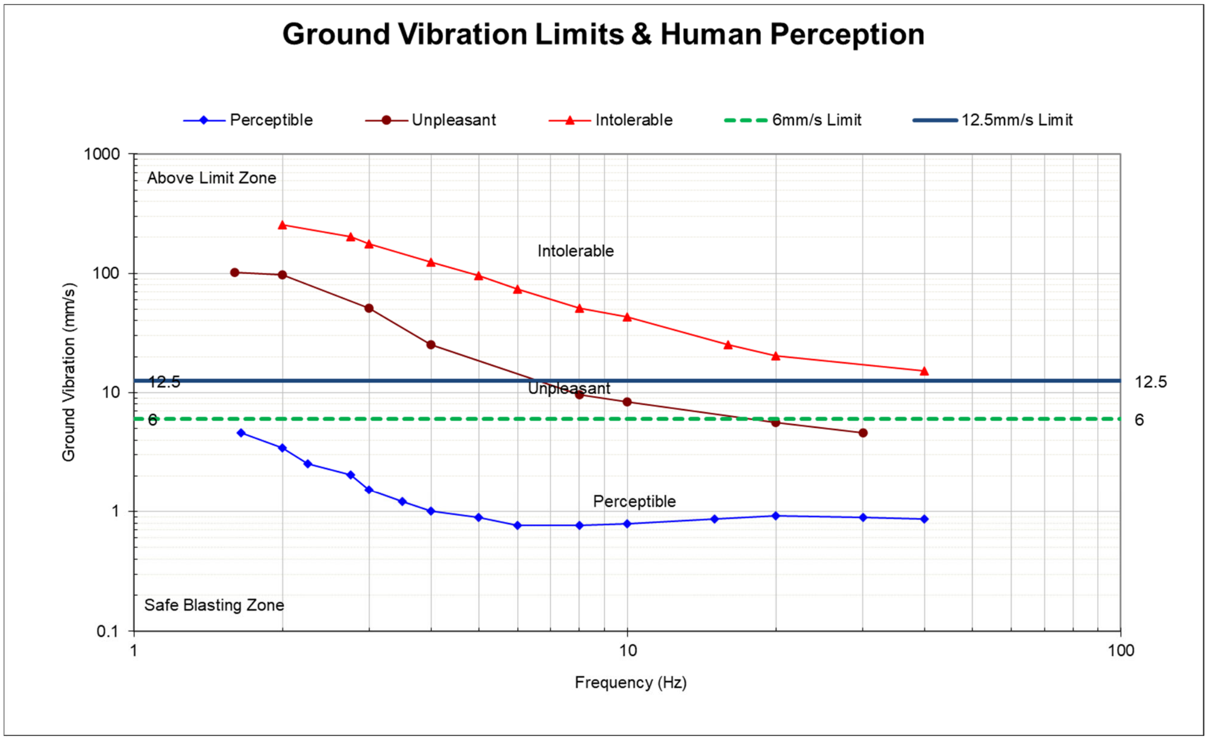


Figure 4: USBM Analysis with Human Perception

13.3 Air blast limitations on structures

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

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

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

Table 2: Damage Causing Levels for Air Blast

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

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

Table 3: Air Blast Limits

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

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

13.4 Air blast limitations and human perceptions

Considering human perceptions and the misunderstanding about ground vibration and air blast, BMC generally recommends that blasting be done in such a way that air blast levels are kept below 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.

13.5 Fly rock

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

Fly rock can be categorised as follows:

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

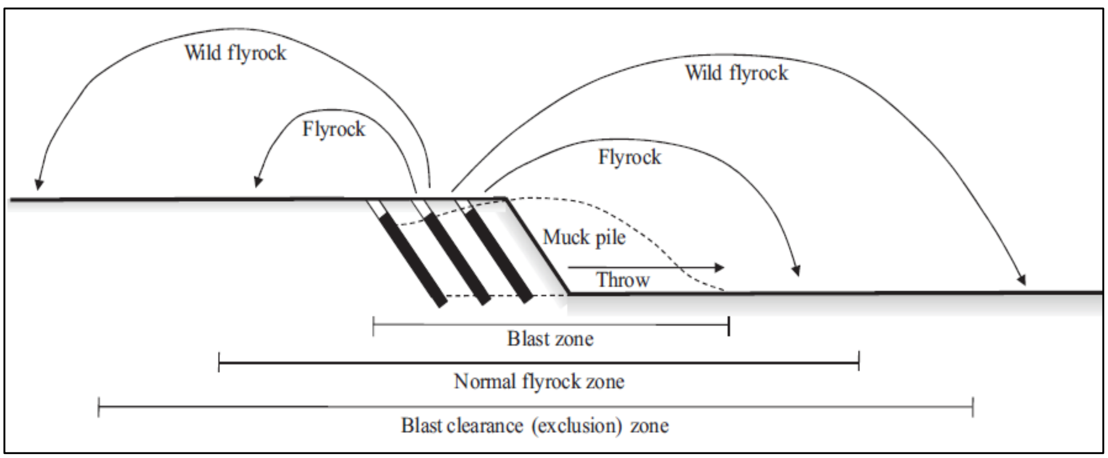


Figure 5: Schematic of fly rock terminology

Fly rock from blasting can result under the following conditions:

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

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

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

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

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

13.6 Noxious Fumes

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

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

13.7 Vibration impact on provincial and national roads

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

13.8 Vibration will upset adjacent communities

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

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

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

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

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

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

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

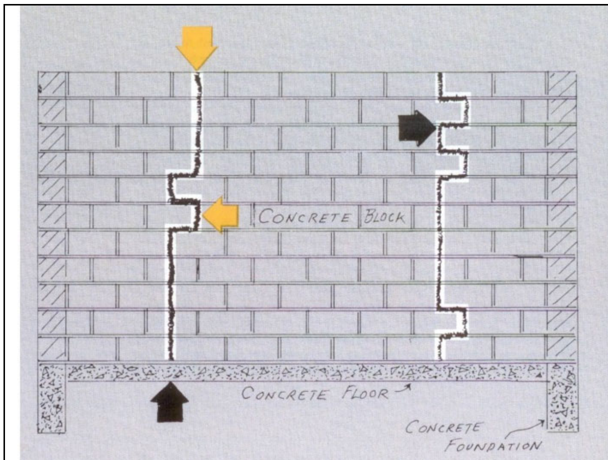
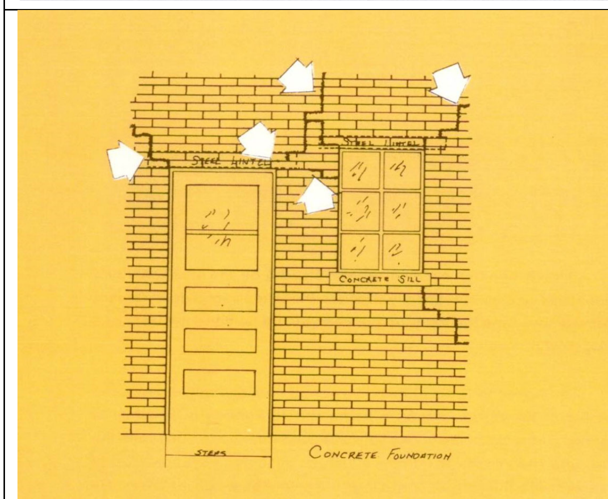
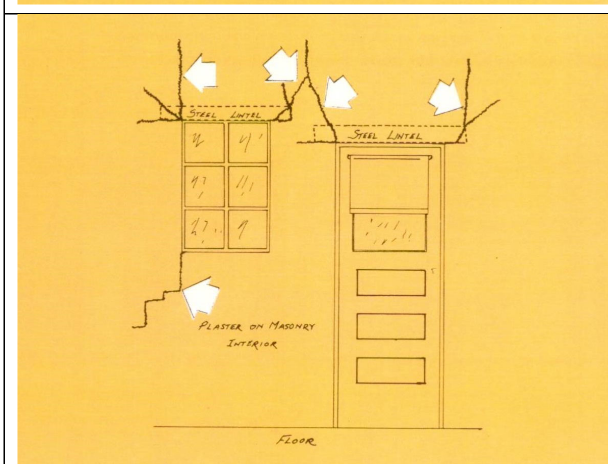
13.9 Cracking of houses and consequent devaluation

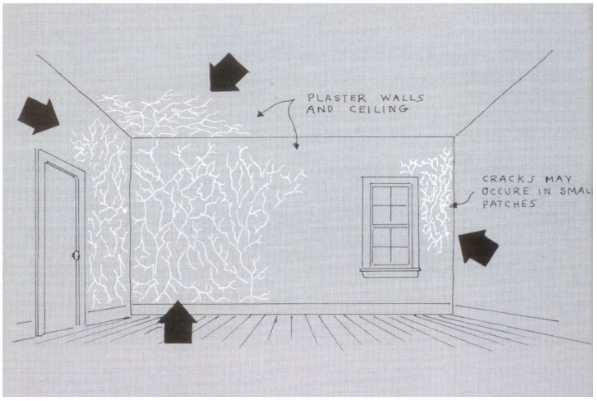
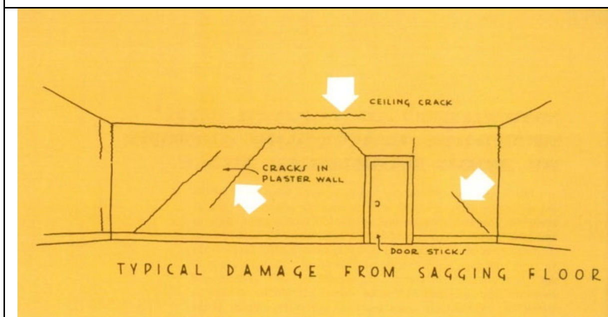
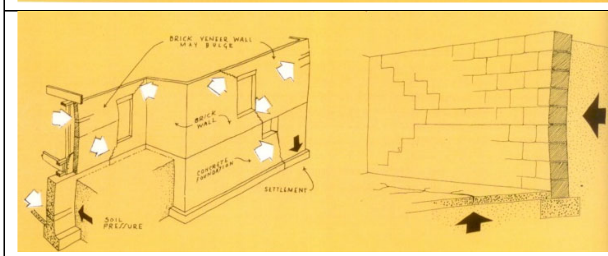
Houses in general have cracks. It is reported that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc.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

Figure 6: Example of blast induced damage.

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

Table 4: Examples of typical non-blasting cracks

<table>
<tr><td>
</td><td>Cracks Resulting from Shrinkage of Concrete Blocks</td></tr>
<tr><td>
</td><td>Typical Lintel Cracks</td></tr>
<tr><td>
</td><td>Typical Lintel Cracks</td></tr>
</table>

<table>
<tr><td>
</td><td>“Crazing” Cracks on Plaster</td></tr>
<tr><td>
</td><td>Plaster Cracks Caused by Sagging Floors</td></tr>
<tr><td>
</td><td>Cracks Resulting from Foundational Failure</td></tr>
</table>

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

14 Baseline Results

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

14.1 Baseline influence

The project is not currently operational and thus no actual monitored baseline data is available to be used for substantiating expected impacts from blasting operations.

14.2 Structure profile

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

Table 5: POI Classification used

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

Table 6: List of points of interest identified (WGS – LO 23°)

Tag	Description	Classification	Y	X
1	Pool	2	4344.47	3009842.17
2	School	2	4380.90	3009772.13
3	Sports field	2	4201.97	3009729.04
4	Golf Course	2	4716.76	3009930.33
5	Houses	2	4830.75	3009743.22

Tag	Description	Classification	Y	X
6	Houses	2	3857.20	3009383.68
7	Houses	2	3804.09	3009684.48
8	Structures	2	4342.62	3009540.44
9	Houses	2	4771.81	3009996.50
10	Houses	2	4193.64	3010026.93
11	Houses	2	3782.10	3009859.77
12	Houses	2	3604.33	3009968.82
13	Shops	2	3729.63	3010043.68
14	Shops	2	3806.10	3010009.66
15	Houses	2	3487.00	3010106.22
16	Reservoirs	11	3538.83	3009300.20
17	Reservoir	11	3546.79	3009277.61
18	Sewage Plant	6	3165.73	3009500.08
19	Substation	3	4112.05	3010438.06
20	South 32 Operations	6	3793.40	3010406.43
21	South32 Offices	3	3884.66	3010188.66
22	Structures	2	3552.69	3010248.81
23	Houses	2	3846.40	3010713.54
24	Houses	2	3673.16	3010711.01
25	Houses	2	3477.56	3010726.14
26	Structures	2	3554.73	3011034.77
27	Structures	2	3713.58	3011081.10
28	Railway	6	3220.77	3010491.29
29	Railway Yard	6	3379.34	3011187.90
30	Railway	6	3372.08	3011904.57
31	Houses	2	3441.68	3011971.33
32	Railway Structure	2	3303.36	3012116.03
33	Structures	2	3447.82	3011701.85
34	Structures	2	3469.59	3011594.46
35	Structures	2	3574.36	3011741.52
36	Houses	2	3421.70	3012173.44
37	Low-cost Houses	1	3319.63	3012697.51
38	Low-cost Houses	1	3293.98	3012847.79
39	Structures	2	3079.82	3013839.68
40	Railway	6	3095.65	3013631.14
41	Road	14	3382.01	3010889.14
42	Road Intersection	14	3537.01	3011402.88
43	Powerline	13	3153.38	3013786.09
44	Powerline	13	3921.24	3011700.19
45	Powerline	13	4000.24	3010879.64
46	Airfield Structure	3	5131.60	3010914.58
47	Airfield	6	5179.74	3011361.76
48	Structures	2	115.17	3012975.27
49	Houses	2	680.34	3012272.04
50	Houses	2	581.71	3012502.93
51	Mining Operation	6	747.19	3012934.55

Tag	Description	Classification	Y	X
52	R31 Road	14	1359.27	3012836.87
53	Road	14	-385.90	3010497.79
54	Lodge	2	5057.78	3013654.63
55	Structure	2	5103.39	3013235.08
56	Waterhole	11	4333.15	3013233.82
57	Reservoir	11	5098.48	3009642.18
58	Structures - Shooting Range	2	2816.56	3009107.21
59	Shooting Range	2	2684.89	3009125.52
60	Powerline	13	605.57	3012303.07
61	Powerline	13	390.41	3012161.07
62	Powerline	13	192.97	3012034.43
63	Ruins	4	-220.66	3012014.69
64	Structures	2	3233.16	3010115.46
65	Communication Tower	13	3144.41	3009987.06
66	Structure	2	3141.44	3010372.93
67	Fuel	3	3728.67	3010077.23
68	Gravel Road	14	3402.55	3011618.89
69	R31 Road	14	3778.39	3011686.22
70	R31 Road	14	3900.22	3011282.89
71	R31 Road	14	3714.60	3012370.49
72	R380 Intersection	14	4787.20	3010661.82
73	Hotazel Solar Facility	6	2302.56	3012091.18
74	Hotazel Solar Facility	6	1899.80	3012472.77
75	Hotazel Solar Facility	6	1483.58	3012708.21
76	Hotazel 2 Solar Facility	6	1502.10	3011240.65
77	Hotazel 2 Solar Facility	6	286.71	3011219.93
78	Hotazel 2 Solar Facility	6	-528.22	3011381.14

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.

15 Blasting Operations

In order to evaluate the possible influence from blasting operations with regards to ground vibration, air blast and fly rock a planned blast design is required to determine possible influences. A report done by Blast Vision; AJ Rorke provided proposed blast designs for the client. The report from Blast Vision shows various designs for different diameters of blastholes and at different bench heights. Recommendation was made that some of the deigns may not be feasible and only single hole or charge per deck firing to be applied.

Table 7 and Table 8 shows summary technical information of the blast designs recommended by Blast Vision. The specific design information applied in this report is highlighted.

Table 7: Design for 10 m bench blasting with 171 mm holes

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
BLAST DESIGN					
Rock Blastability (A-value)	5	8	2	4	7
Hole Diameter (mm)	171	171	171	171	171
Bench height (m)	10	10	10	10	10
Stemming length (m)	4.4	4.1	4.4	4.1	4.1
SDOB (Appendix 2)	1.5	1.4	1.5	1.4	1.4
Sub-drill (m)	1.3	1.2	1.7	1.3	1.3
Hole depth (m)	11.3	11.2	11.7	11.3	11.3
Burden (m)	4.3	3.9	5.6	4.4	4.3
Spacing (m)	4.9	4.5	6.5	5.1	4.9
ENERGY					
Explosives Type	Emulsion	Emulsion	Emulsion	Emulsion	Emulsion
Explosives Density (g/cm3)	1.16	1.16	1.16	1.16	1.16
Charge length (m)	6.8	7.1	7.3	7.3	7.2
Charge mass/linear metre (kg/m)	26.6	26.6	26.6	26.6	26.6
Total charge mass per hole (kg)	182.5	189.1	193.4	193.2	191.9
Powder Factor (kg/m3)	0.87	1.06	0.53	0.85	0.91
Explosive RWS (%)	80	80	80	80	80
Explosive absolute energy (kJ/kg)	3.05	3.05	3.05	3.05	3.05
Energy/m3 (kJ/m3)	2.65	3.24	1.61	2.59	2.78
PRODUCTIVITY (Rock blasted per hole to total drill metres per hole)					
Rock m3/drilling metre	18.63	15.91	31.32	20.06	18.63

Table 8: Design for 15 m bench blasting with 171 mm holes

	Calcrete	BIF	UMO Oxidised	LMO	Dyke
BLAST DESIGN					
Rock Blastability (A-value)	5	8	2	4	7
Hole Diameter (mm)	171	171	171	171	171
Bench height (m)	15	15	15	15	15
Stemming length (m)	4.5	4.1	4.5	4.1	4.1
SDOB (Appendix 2)	1.5	1.4	1.5	1.4	1.4
Sub-drill (m)	1.4	1.3	1.8	1.4	1.4

Hole depth (m)	16.4	16.3	16.8	16.4	16.4
Burden (m)	4.6	4.3	6.0	4.8	4.6
Spacing (m)	5.3	4.9	6.9	5.5	5.3
ENERGY					
Explosives Type	Emulsion	Emulsion	Emulsion	Emulsion	Emulsion
Explosives Density (g/cm3)	1.18	1.18	1.18	1.18	1.18
Charge length (m)	11.9	12.2	12.3	12.3	12.3
Charge mass/linear metre (kg/m)	27.1	27.1	27.1	27.1	27.1
Total charge mass per hole (kg)	323.1	329.9	334.2	334.1	332.7
Powder Factor (kg/m3)	0.88	1.05	0.54	0.84	0.90
Explosive RWS (%)	80	80	80	80	80
Explosive absolute energy (kJ/kg)	3.05	3.05	3.05	3.05	3.05
Energy/m3 (kJ/m3)	2.68	3.19	1.65	2.58	2.76
PRODUCTIVITY (Rock blasted per hole to total drill metres per hole)					
Rock m3/drilling metre	22.44	19.36	36.79	24.06	22.44

Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the maximum observed on the 10 m bench designs and the maximum taken from the maximum charge of the 15 m bench designs. Due to recommended single hole firing it is the charge mass given that is applied. The minimum and maximum is then guided by the difference in bench heights applied in the designs. The minimum charge relates to 193.4 kg and the maximum charge relates to 334.2 kg. These values were applied in all predictions for ground vibration and air blast.

15.1 Ground Vibration

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

Equation 1:

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

Where:

PPV = Predicted ground vibration (mm/s)

a = Site constant

b = Site constant

D = Distance (m)

E = Explosive Mass (kg)

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

Factors:

a = 1143

b = -1.65

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

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

Based on the designs presented on expected drilling and charging design, the following Table 9 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. The charge masses are 193.4 kg and 334.2 kg for the Pit area.

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

No.	Distance (m)	Expected PPV (mm/s) for 193.4 kg Charge	Expected PPV (mm/s) for 334.2 kg Charge
1	50.0	138.4	217.3
2	100.0	70.9	111.3
3	150.0	22.6	35.5
4	200.0	14.0	22.1
5	250.0	9.7	15.3
6	300.0	7.2	11.3
7	400.0	4.5	7.0
8	500.0	3.1	4.9
9	600.0	2.3	3.6
10	700.0	1.8	2.8
11	800.0	1.4	2.2
12	900.0	1.2	1.8
13	1000.0	1.0	1.6
14	1250.0	0.7	1.1
15	1500.0	0.5	0.8
16	1750.0	0.4	0.6
17	2000.0	0.3	0.5
18	2500.0	0.2	0.3
19	3000.0	0.2	0.3
20	3500.0	0.1	0.2

15.2 Air blast

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

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

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

Equation 2:

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

Where:

P = Air blast level (mB)

D = Distance from source (m)

E = Maximum charge mass per delay (kg)

A = Constant - (14.3)

B = Constant – (-0.71)

The constants for A and B were then selected according to the information as provided in Figure 7 below. Various types of mining operations are expected to yield different results. The information provided in Figure 7 is based on detailed research that was conducted for each of the different types of mining environments. In this report, the data for “Metal Mine” was applied in the prediction or air blast.

Air Overpressure Prediction Equations

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

Table 26.7 - Air overpressure prediction equations.

Figure 7: 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 193.4kg Charge	Air blast (dB) for 334.2kg Charge
1	50.0	143.7	144.9
2	100.0	141.2	142.4
3	150.0	137.0	138.1
4	200.0	135.2	136.3
5	250.0	133.8	134.9
6	300.0	132.7	133.8
7	400.0	130.9	132.0
8	500.0	129.5	130.7
9	600.0	128.4	129.5
10	700.0	127.5	128.6
11	800.0	126.6	127.8
12	900.0	125.9	127.1
13	1000.0	125.3	126.4
14	1250.0	123.9	125.0
15	1500.0	122.8	123.9
16	1750.0	121.8	122.9
17	2000.0	121.0	122.1
18	2500.0	119.6	120.7
19	3000.0	118.5	119.6
20	3500.0	117.6	118.7

16 Construction Phase: Impact Assessment and Mitigation Measures

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

17 Operational Phase: Impact Assessment and Mitigation Measures

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

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

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

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

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

17.1 Review of expected ground vibration

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

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

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

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

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

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

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

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

17.1.1 Ground vibration minimum charge mass per delay – 193.4kg

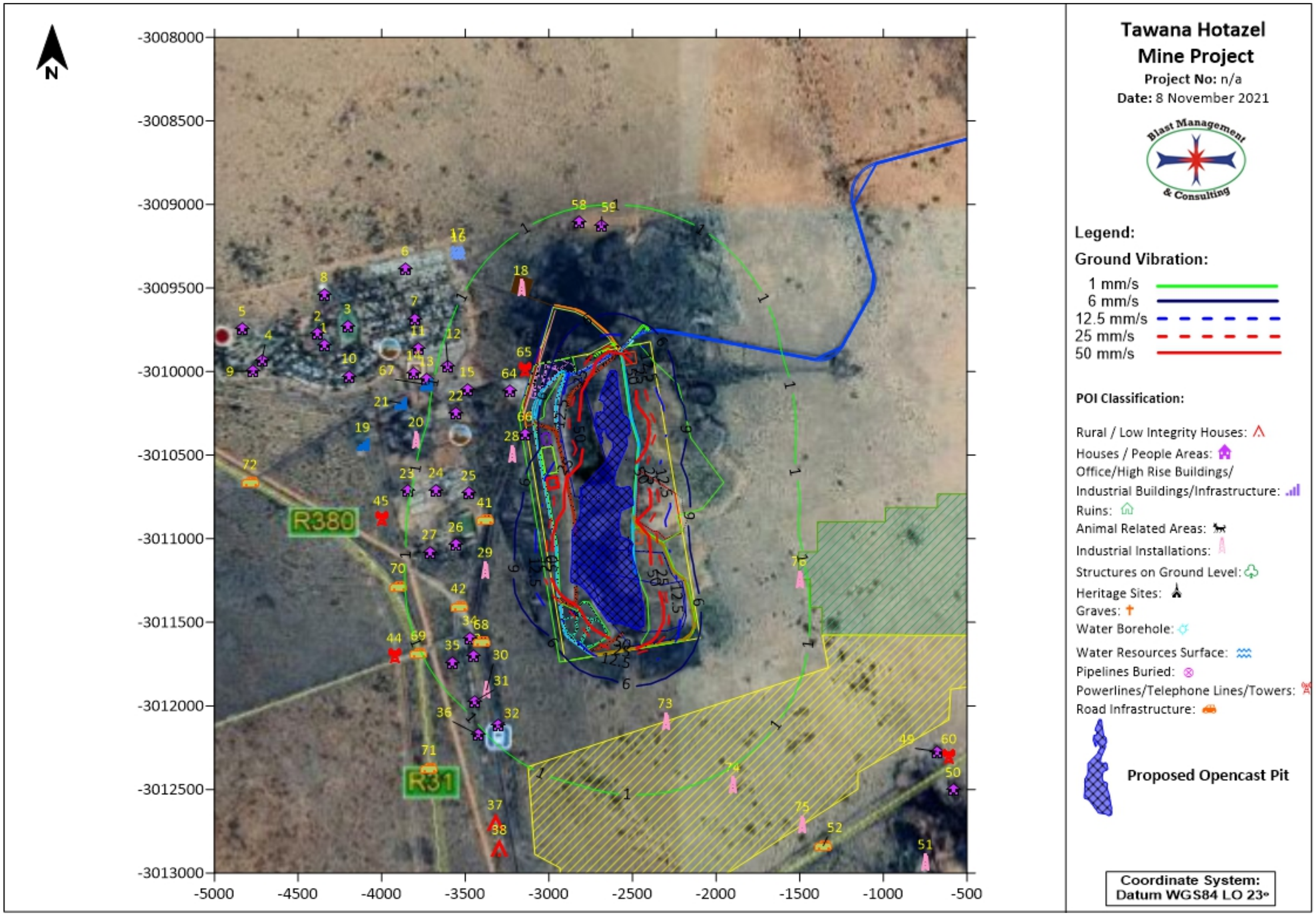


Figure 8: Ground vibration influence from minimum charge per delay

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	Pool	25	1678	193.4	0.4	Acceptable	Too Low
2	School	25	1729	193.4	0.4	Acceptable	Too Low
3	Sports field	50	1566	193.4	0.5	Acceptable	Too Low
4	Golf Course	25	2025	193.4	0.3	Acceptable	Too Low
5	Houses	12.5	2174	193.4	0.3	Acceptable	Too Low
6	Houses	12.5	1369	193.4	0.6	Acceptable	Too Low
7	Houses	12.5	1202	193.4	0.7	Acceptable	Too Low
8	Structures	12.5	1757	193.4	0.4	Acceptable	Too Low
9	Houses	12.5	2070	193.4	0.3	Acceptable	Too Low
10	Houses	12.5	1494	193.4	0.5	Acceptable	Too Low
11	Houses	12.5	1126	193.4	0.8	Acceptable	Perceptible
12	Houses	12.5	929	193.4	1.1	Acceptable	Perceptible
13	Shops	12.5	1034	193.4	0.9	Acceptable	Perceptible
14	Shops	12.5	1116	193.4	0.8	Acceptable	Perceptible
15	Houses	12.5	784	193.4	1.5	Acceptable	Perceptible
16	Reservoirs	50	1142	193.4	0.8	Acceptable	N/A
17	Reservoir	50	1162	193.4	0.8	Acceptable	N/A
18	Sewage Plant	50	728	193.4	1.7	Acceptable	Perceptible
19	Substation	25	1327	193.4	0.6	Acceptable	Too Low
20	South 32 Operations	200	1026	193.4	0.9	Acceptable	Perceptible
21	South32 Offices	25	1166	193.4	0.8	Acceptable	Perceptible
22	Structures	12.5	830	193.4	1.3	Acceptable	Perceptible
23	Houses	12.5	1015	193.4	1.0	Acceptable	Perceptible
24	Houses	12.5	849	193.4	1.3	Acceptable	Perceptible
25	Houses	12.5	658	193.4	2.0	Acceptable	Perceptible
26	Structures	12.5	693	193.4	1.8	Acceptable	Perceptible
27	Structures	12.5	851	193.4	1.3	Acceptable	Perceptible
28	Railway	150	459	193.4	3.6	Acceptable	Perceptible
29	Railway Yard	150	510	193.4	3.0	Acceptable	Perceptible
30	Railway	150	820	193.4	1.4	Acceptable	Perceptible
31	Houses	12.5	916	193.4	1.1	Acceptable	Perceptible
32	Railway Structure	12.5	905	193.4	1.2	Acceptable	Perceptible
33	Structures	12.5	731	193.4	1.7	Acceptable	Perceptible
34	Structures	12.5	691	193.4	1.8	Acceptable	Perceptible
35	Structures	12.5	857	193.4	1.3	Acceptable	Perceptible
36	Houses	12.5	1031	193.4	0.9	Acceptable	Perceptible
37	Low-cost Houses	6	1379	193.4	0.6	Acceptable	Too Low
38	Low-cost Houses	6	1501	193.4	0.5	Acceptable	Too Low
39	Structures	12.5	2378	193.4	0.2	Acceptable	Too Low
40	Railway	150	2181	193.4	0.3	Acceptable	Too Low
41	Road	150	526	193.4	2.8	Acceptable	N/A
42	Road Intersection	150	685	193.4	1.8	Acceptable	N/A
43	Powerline	75	2346	193.4	0.2	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
44	Powerline	75	1144	193.4	0.8	Acceptable	N/A
45	Powerline	75	1143	193.4	0.8	Acceptable	N/A
46	Airfield Structure	50	2270	193.4	0.3	Acceptable	Too Low
47	Airfield	150	2313	193.4	0.2	Acceptable	Too Low
48	Structures	12.5	2739	193.4	0.2	Acceptable	Too Low
49	Houses	12.5	1910	193.4	0.3	Acceptable	Too Low
50	Houses	12.5	2099	193.4	0.3	Acceptable	Too Low
51	Mining Operation	200	2201	193.4	0.3	Acceptable	Too Low
52	R31 Road	150	1698	193.4	0.4	Acceptable	N/A
53	Road	150	2895	193.4	0.2	Acceptable	N/A
54	Lodge	12.5	3238	193.4	0.1	Acceptable	Too Low
55	Structure	12.5	2985	193.4	0.2	Acceptable	Too Low
56	Waterhole	150	2423	193.4	0.2	Acceptable	N/A
57	Reservoir	50	2458	193.4	0.2	Acceptable	N/A
58	Structures - Shooting Range	12.5	906	193.4	1.2	Acceptable	Perceptible
59	Shooting Range	25	870	193.4	1.2	Acceptable	Perceptible
60	Powerline	75	1991	193.4	0.3	Acceptable	N/A
61	Powerline	75	2143	193.4	0.3	Acceptable	N/A
62	Powerline	75	2301	193.4	0.2	Acceptable	N/A
63	Ruins	6	2702	193.4	0.2	Acceptable	N/A
64	Structures	12.5	534	193.4	2.8	Acceptable	Perceptible
65	Communication Tower	25	479	193.4	3.3	Acceptable	N/A
66	Structure	12.5	417	193.4	4.2	Acceptable	Perceptible
67	Fuel	12.5	1027	193.4	0.9	Acceptable	Perceptible
68	Gravel Road	200	646	193.4	2.0	Acceptable	N/A
69	R31 Road	150	1008	193.4	1.0	Acceptable	N/A
70	R31 Road	150	1031	193.4	0.9	Acceptable	N/A
71	R31 Road	150	1382	193.4	0.6	Acceptable	N/A
72	R380 Intersection	150	1950	193.4	0.3	Acceptable	N/A
73	Hotazel Solar Facility	25	578	193.4	2.4	Acceptable	N/A
74	Hotazel Solar Facility	25	1089	193.4	0.9	Acceptable	N/A
75	Hotazel Solar Facility	25	1520	193.4	0.5	Acceptable	N/A
76	Hotazel 2 Solar Facility	25	946	193.4	1.1	Acceptable	N/A
77	Hotazel 2 Solar Facility	25	2155	193.4	0.3	Acceptable	N/A
78	Hotazel 2 Solar Facility	25	2961	193.4	0.2	Acceptable	N/A

17.1.2 Ground vibration maximum charge mass per delay – 334.2kg

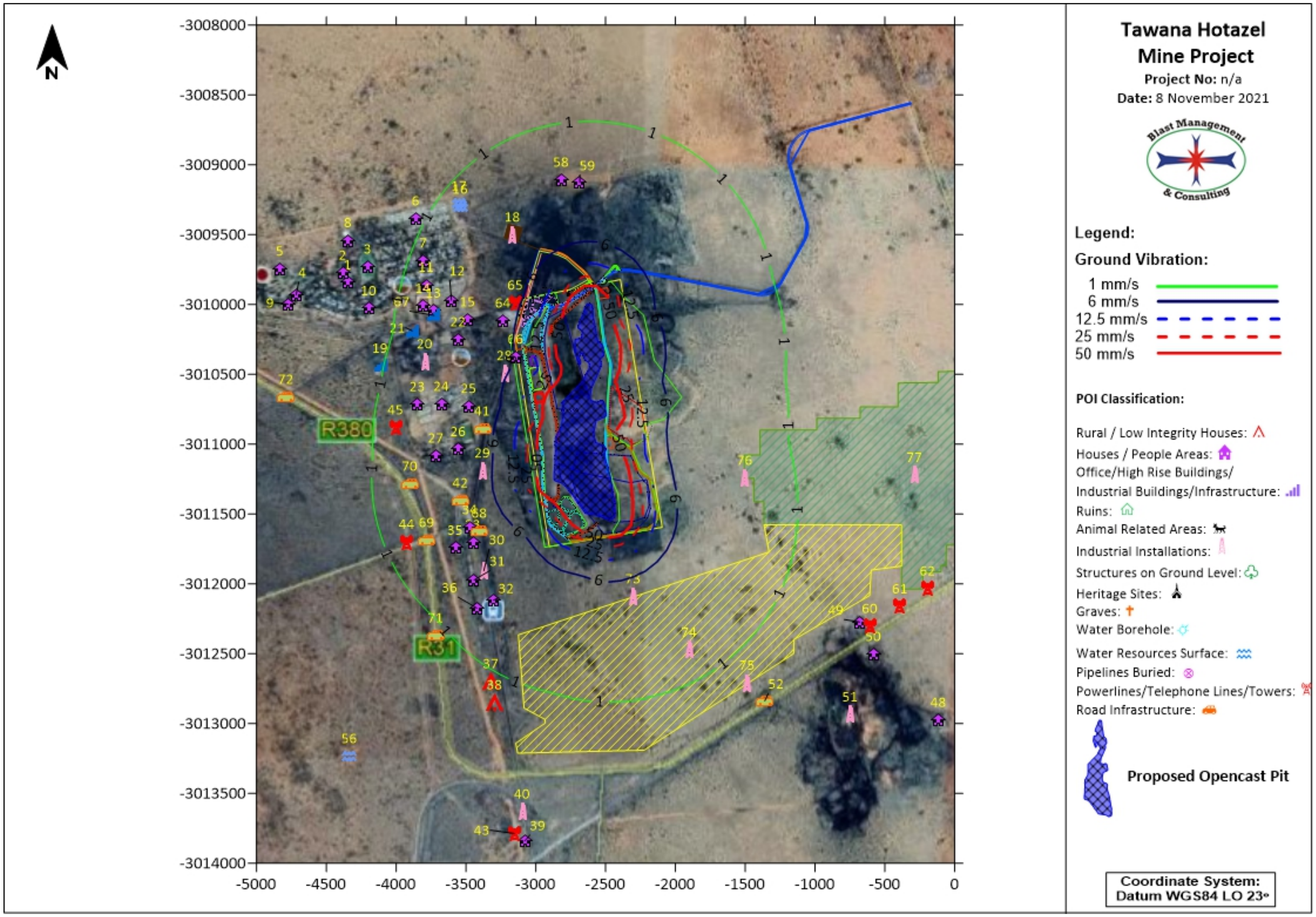


Figure 9: Ground vibration influence from maximum charge per delay

Table 12: Ground vibration evaluation for maximum charge - Pit NW

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Pool	25	1678	334.2	0.7	Acceptable	Too Low
2	School	25	1729	334.2	0.6	Acceptable	Too Low
3	Sports field	50	1566	334.2	0.7	Acceptable	Too Low
4	Golf Course	25	2025	334.2	0.5	Acceptable	Too Low
5	Houses	12.5	2174	334.2	0.4	Acceptable	Too Low
6	Houses	12.5	1369	334.2	0.9	Acceptable	Perceptible
7	Houses	12.5	1202	334.2	1.1	Acceptable	Perceptible
8	Structures	12.5	1757	334.2	0.6	Acceptable	Too Low
9	Houses	12.5	2070	334.2	0.5	Acceptable	Too Low
10	Houses	12.5	1494	334.2	0.8	Acceptable	Perceptible
11	Houses	12.5	1126	334.2	1.3	Acceptable	Perceptible
12	Houses	12.5	929	334.2	1.8	Acceptable	Perceptible
13	Shops	12.5	1034	334.2	1.5	Acceptable	Perceptible
14	Shops	12.5	1116	334.2	1.3	Acceptable	Perceptible
15	Houses	12.5	784	334.2	2.3	Acceptable	Perceptible
16	Reservoirs	50	1142	334.2	1.2	Acceptable	N/A
17	Reservoir	50	1162	334.2	1.2	Acceptable	N/A
18	Sewage Plant	50	728	334.2	2.6	Acceptable	Perceptible
19	Substation	25	1327	334.2	1.0	Acceptable	Perceptible
20	South 32 Operations	200	1026	334.2	1.5	Acceptable	Perceptible
21	South32 Offices	25	1166	334.2	1.2	Acceptable	Perceptible
22	Structures	12.5	830	334.2	2.1	Acceptable	Perceptible
23	Houses	12.5	1015	334.2	1.5	Acceptable	Perceptible
24	Houses	12.5	849	334.2	2.0	Acceptable	Perceptible
25	Houses	12.5	658	334.2	3.1	Acceptable	Perceptible
26	Structures	12.5	693	334.2	2.8	Acceptable	Perceptible
27	Structures	12.5	851	334.2	2.0	Acceptable	Perceptible
28	Railway	150	459	334.2	5.6	Acceptable	Perceptible
29	Railway Yard	150	510	334.2	4.7	Acceptable	Perceptible
30	Railway	150	820	334.2	2.2	Acceptable	Perceptible
31	Houses	12.5	916	334.2	1.8	Acceptable	Perceptible
32	Railway Structure	12.5	905	334.2	1.8	Acceptable	Perceptible
33	Structures	12.5	731	334.2	2.6	Acceptable	Perceptible
34	Structures	12.5	691	334.2	2.9	Acceptable	Perceptible
35	Structures	12.5	857	334.2	2.0	Acceptable	Perceptible
36	Houses	12.5	1031	334.2	1.5	Acceptable	Perceptible
37	Low-cost Houses	6	1379	334.2	0.9	Acceptable	Perceptible
38	Low-cost Houses	6	1501	334.2	0.8	Acceptable	Perceptible
39	Structures	12.5	2378	334.2	0.4	Acceptable	Too Low
40	Railway	150	2181	334.2	0.4	Acceptable	Too Low
41	Road	150	526	334.2	4.5	Acceptable	N/A
42	Road Intersection	150	685	334.2	2.9	Acceptable	N/A
43	Powerline	75	2346	334.2	0.4	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
44	Powerline	75	1144	334.2	1.2	Acceptable	N/A
45	Powerline	75	1143	334.2	1.2	Acceptable	N/A
46	Airfield Structure	50	2270	334.2	0.4	Acceptable	Too Low
47	Airfield	150	2313	334.2	0.4	Acceptable	Too Low
48	Structures	12.5	2739	334.2	0.3	Acceptable	Too Low
49	Houses	12.5	1910	334.2	0.5	Acceptable	Too Low
50	Houses	12.5	2099	334.2	0.5	Acceptable	Too Low
51	Mining Operation	200	2201	334.2	0.4	Acceptable	Too Low
52	R31 Road	150	1698	334.2	0.6	Acceptable	N/A
53	Road	150	2895	334.2	0.3	Acceptable	N/A
54	Lodge	12.5	3238	334.2	0.2	Acceptable	Too Low
55	Structure	12.5	2985	334.2	0.3	Acceptable	Too Low
56	Waterhole	150	2423	334.2	0.4	Acceptable	N/A
57	Reservoir	50	2458	334.2	0.4	Acceptable	N/A
58	Structures - Shooting Range	12.5	906	334.2	1.8	Acceptable	Perceptible
59	Shooting Range	25	870	334.2	1.9	Acceptable	Perceptible
60	Powerline	75	1991	334.2	0.5	Acceptable	N/A
61	Powerline	75	2143	334.2	0.4	Acceptable	N/A
62	Powerline	75	2301	334.2	0.4	Acceptable	N/A
63	Ruins	6	2702	334.2	0.3	Acceptable	N/A
64	Structures	12.5	534	334.2	4.4	Acceptable	Perceptible
65	Communication Tower	25	479	334.2	5.2	Acceptable	N/A
66	Structure	12.5	417	334.2	6.6	Acceptable	Unpleasant
67	Fuel	12.5	1027	334.2	1.5	Acceptable	Perceptible
68	Gravel Road	200	646	334.2	3.2	Acceptable	N/A
69	R31 Road	150	1008	334.2	1.5	Acceptable	N/A
70	R31 Road	150	1031	334.2	1.5	Acceptable	N/A
71	R31 Road	150	1382	334.2	0.9	Acceptable	N/A
72	R380 Intersection	150	1950	334.2	0.5	Acceptable	N/A
73	Hotazel Solar Facility	25	578	334.2	3.8	Acceptable	N/A
74	Hotazel Solar Facility	25	1089	334.2	1.3	Acceptable	N/A
75	Hotazel Solar Facility	25	1520	334.2	0.8	Acceptable	N/A
76	Hotazel 2 Solar Facility	25	946	334.2	1.7	Acceptable	N/A
77	Hotazel 2 Solar Facility	25	2155	334.2	0.4	Acceptable	N/A
78	Hotazel 2 Solar Facility	25	2961	334.2	0.3	Acceptable	N/A

17.2 Summary of ground vibration levels

The opencast operations were evaluated for expected levels of ground vibration from future blasting operations. Review of the site and the surrounding installations / houses / buildings showed that structures vary in distances from the pit area. The influences will also vary with distance from the pit area. The model used for evaluation does indicate significant levels. It will be imperative to ensure that 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 area are a contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated 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 and maximum charge used indicated no POI's of concern in relation to possible structural damage.

On a human perception scale thirty-three POI's were identified where vibration levels may be perceptible and one POI may be unpleasant for the maximum charge. Perceptible levels of vibration that may be experienced up to 1565 m and unpleasant up to 417 m.

The evaluation mainly considered a distance up to 3500 m from the pit area. The closest structures observed are the Structures, Railway Line and Communication Tower. The planned maximum charge evaluated showed that it could be unpleasant, but no potential structural damage is foreseen. The ground vibration levels predicted for these POI's ranged between 0.2 mm/s and 6.6 mm/s for structures surrounding the open pit area.

The nearest public houses are located 658 m from the pit boundary. Ground vibration level predicted at this building where people may be present is 3.1 mm/s for the maximum charge. In view of this no specific mitigations will be required.

Considering the planned solar facilities expected levels of ground vibration is significantly lower than the proposed conservative limits on the infrastructure. The nearest point of the solar facilities is 587 m away with expected ground vibration level of 3.8 mm/s for the maximum charge.

Structure conditions ranged from industrial construction to poor condition structures.

17.3 Ground Vibration and human perception

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to an average of 30Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 10 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 10 that up to a distance of 1565 m people may experience levels of ground vibration as perceptible. At 417 m and closer the perception of ground vibration could be unpleasant for people in the areas.

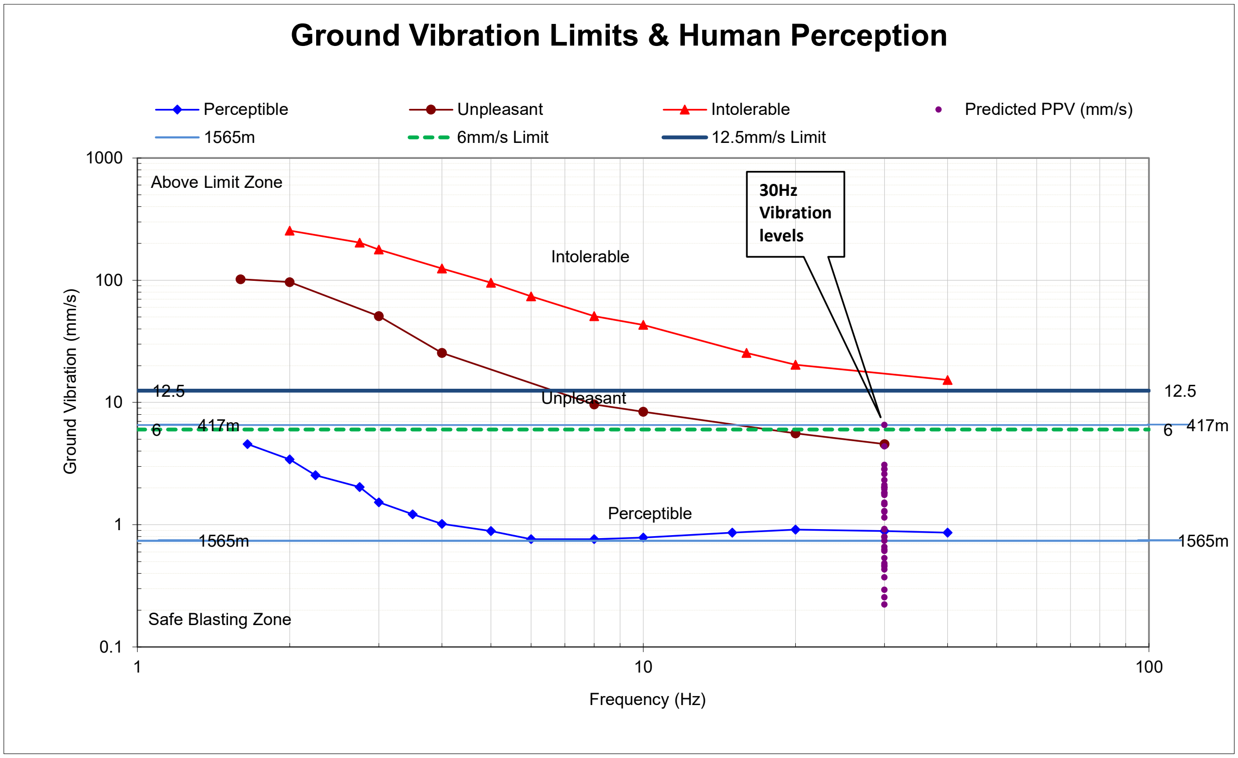


Figure 10: The effect of ground vibration with human perception and vibration limits

17.4 Vibration impact on roads

The R31 Provincial road is at an approximate distance of 1008 m from the Pit area and will require no specific consideration regarding effects from blasting operations. The R380 road is at closest distance of 1950 m. There are other Roads and Gravel roads in the vicinity of the Project area but are all expected to be within the recommended limits. There may however be people and animals on these routes and will require careful planning to maintain safe blasting radius. It will be required that clearance distances are set, and road travel managed during blasting operations.

17.5 Potential that vibration will upset adjacent communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. The nearest houses (POI 25) are approximately 658 m from the planned operation. These buildings are located such that levels of ground vibration predicted may be perceptible but not damaging.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 1565 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 1166 m. Within these distance ranges there are only a limited number of houses. The anticipated ground vibration levels are certain to have possibility of upsetting the house holds within these ranges.

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

17.6 Cracking of houses and consequent devaluation

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

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

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

17.7 Review of expected air blast

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

- "Tag" No. is number corresponding to the location indicated on POI figures;
- "Description" indicates the type of the structure;
- "Distance" is the distance between the structure and edge of the pit area;

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

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

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

17.7.1 Air blast minimum charge mass per delay – 193.4 kg

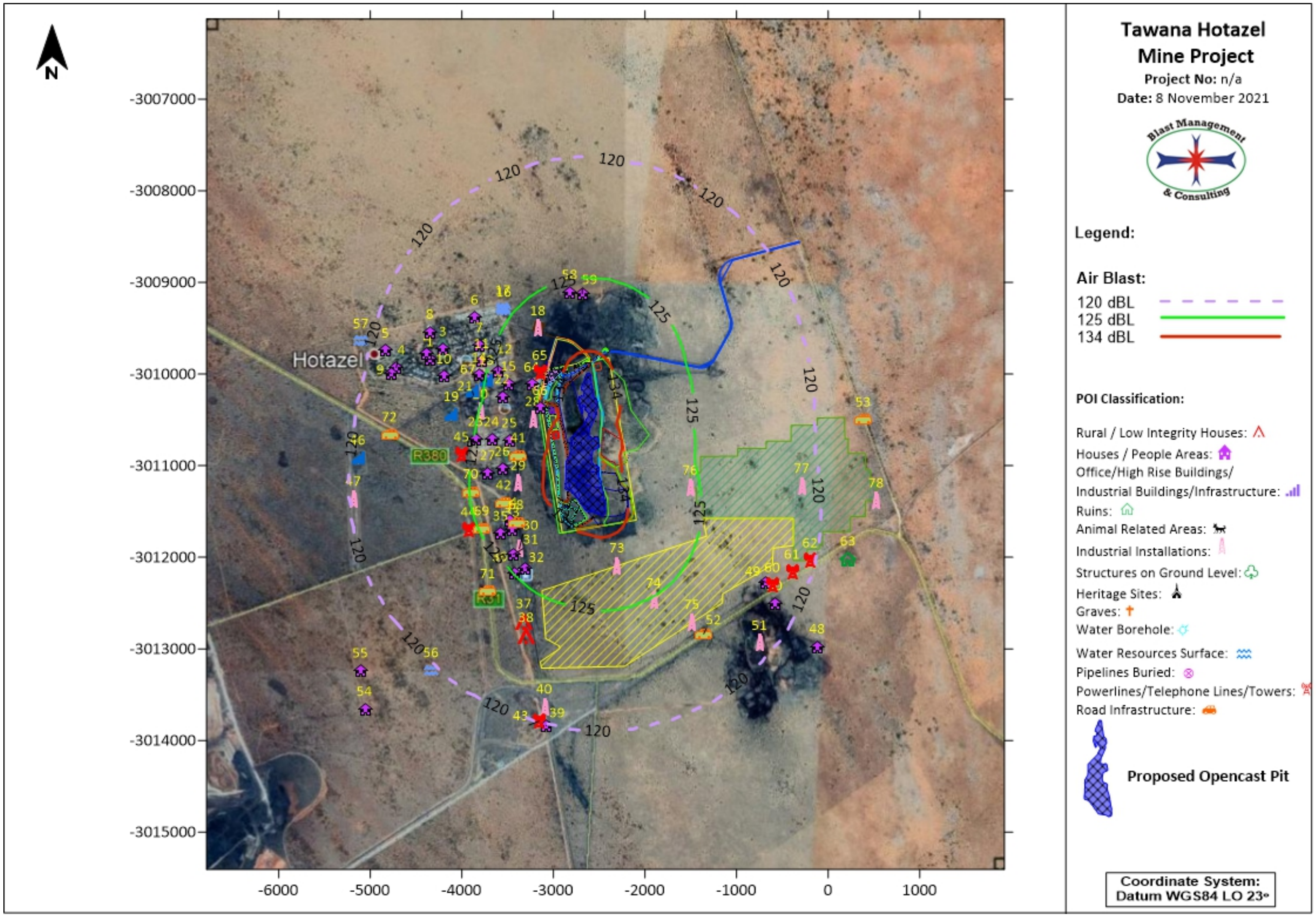


Figure 11: Air blast influence from minimum charge

Table 13: Air blast evaluation for minimum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Pool	1678	122.1	N/A
2	School	1729	121.9	Complaint
3	Sports field	1566	122.5	Complaint
4	Golf Course	2025	120.9	Complaint
5	Houses	2174	120.5	Complaint
6	Houses	1369	123.3	Complaint
7	Houses	1202	124.1	Complaint
8	Structures	1757	121.8	Complaint
9	Houses	2070	120.8	Complaint
10	Houses	1494	122.8	Complaint
11	Houses	1126	124.5	Complaint
12	Houses	929	125.7	Complaint
13	Shops	1034	125.1	Complaint
14	Shops	1116	124.6	Complaint
15	Houses	784	126.8	Complaint
16	Reservoirs	1142	124.5	N/A
17	Reservoir	1162	124.4	N/A
18	Sewage Plant	728	127.2	Complaint
19	Substation	1327	123.5	Complaint
20	South 32 Operations	1026	125.1	N/A
21	South32 Offices	1166	124.3	Complaint
22	Structures	830	126.4	Complaint
23	Houses	1015	125.2	Complaint
24	Houses	849	126.3	Complaint
25	Houses	658	127.8	Complaint
26	Structures	693	127.5	Complaint
27	Structures	851	126.3	Complaint
28	Railway	459	130.1	N/A
29	Railway Yard	510	129.4	N/A
30	Railway	820	126.5	N/A
31	Houses	916	125.8	Complaint
32	Railway Structure	905	125.9	Complaint
33	Structures	731	127.2	Complaint
34	Structures	691	127.6	Complaint
35	Structures	857	126.2	Complaint
36	Houses	1031	125.1	Complaint
37	Low-cost Houses	1379	123.3	Complaint
38	Low-cost Houses	1501	122.8	Complaint
39	Structures	2378	120.0	Acceptable
40	Railway	2181	120.5	N/A
41	Road	526	129.2	N/A
42	Road Intersection	685	127.6	N/A
43	Powerline	2346	120.0	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Powerline	1144	124.4	N/A
45	Powerline	1143	124.5	N/A
46	Airfield Structure	2270	120.2	Complaint
47	Airfield	2313	120.1	N/A
48	Structures	2739	119.1	Acceptable
49	Houses	1910	121.3	Complaint
50	Houses	2099	120.7	Complaint
51	Mining Operation	2201	120.4	N/A
52	R31 Road	1698	122.0	N/A
53	Road	2895	118.7	N/A
54	Lodge	3238	118.1	Acceptable
55	Structure	2985	118.5	Acceptable
56	Waterhole	2423	119.8	N/A
57	Reservoir	2458	119.7	N/A
58	Structures - Shooting Range	906	125.9	Complaint
59	Shooting Range	870	126.1	N/A
60	Powerline	1991	121.0	N/A
61	Powerline	2143	120.6	N/A
62	Powerline	2301	120.1	N/A
63	Ruins	2702	119.1	Acceptable
64	Structures	534	129.1	Complaint
65	Communication Tower	479	129.8	Complaint
66	Structure	417	130.7	Complaint
67	Fuel	1027	125.1	Complaint
68	Gravel Road	646	128.0	N/A
69	R31 Road	1008	125.2	N/A
70	R31 Road	1031	125.1	N/A
71	R31 Road	1382	123.3	N/A
72	R380 Intersection	1950	121.2	N/A
73	Hotazel Solar Facility	578	128.6	N/A
74	Hotazel Solar Facility	1089	124.7	N/A
75	Hotazel Solar Facility	1520	122.7	N/A
76	Hotazel 2 Solar Facility	946	125.6	N/A
77	Hotazel 2 Solar Facility	2155	120.5	N/A
78	Hotazel 2 Solar Facility	2961	118.6	N/A

17.7.2 Air blast maximum charge mass per delay – 334.2 kg

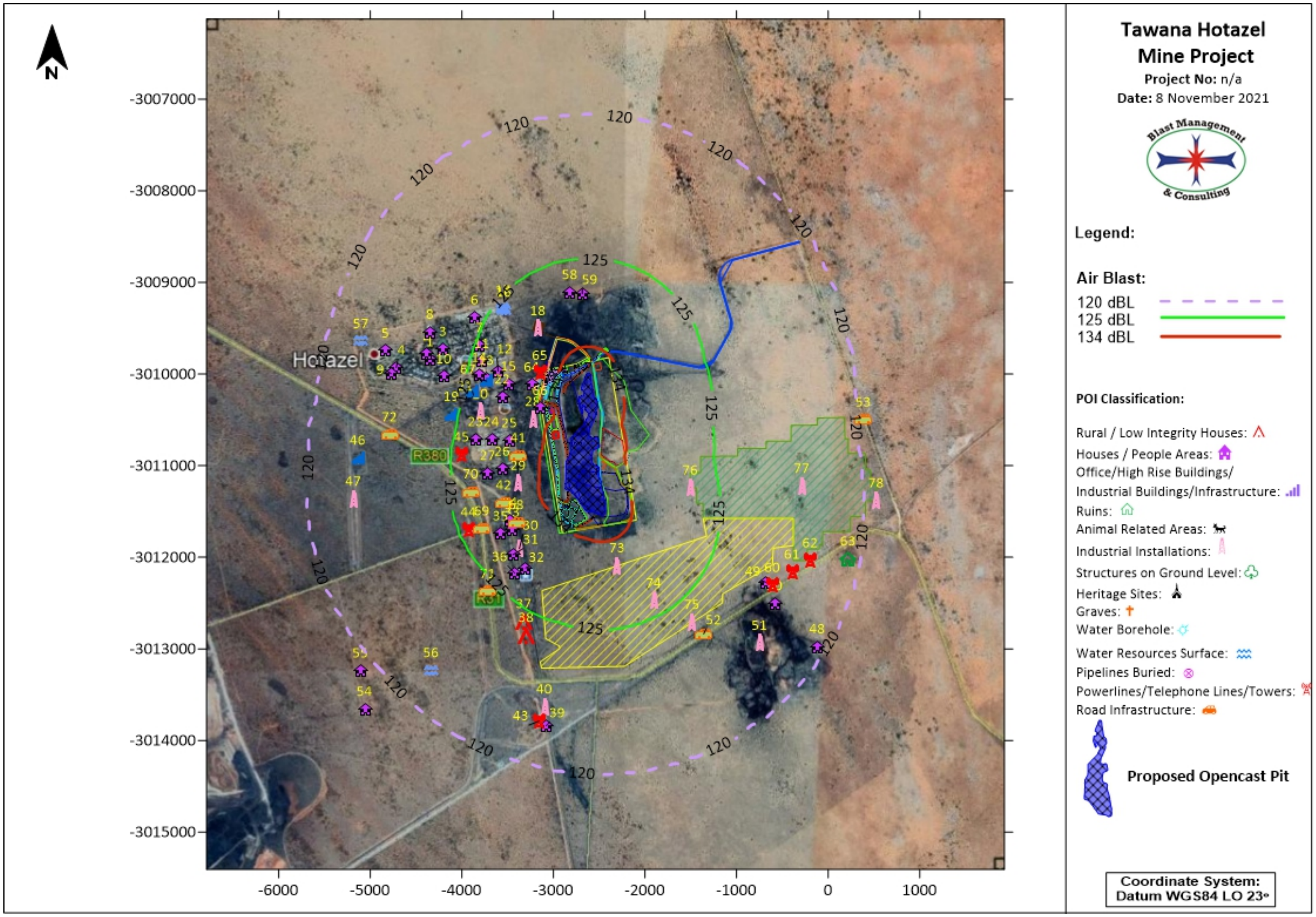


Figure 12: Air blast influence from maximum charge

Table 14: Air blast influence from maximum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Pool	1678	123.2	N/A
2	School	1729	123.0	Complaint
3	Sports field	1566	123.6	Complaint
4	Golf Course	2025	122.1	Complaint
5	Houses	2174	121.6	Complaint
6	Houses	1369	124.5	Complaint
7	Houses	1202	125.3	Complaint
8	Structures	1757	122.9	Complaint
9	Houses	2070	121.9	Complaint
10	Houses	1494	123.9	Complaint
11	Houses	1126	125.7	Complaint
12	Houses	929	126.9	Complaint
13	Shops	1034	126.2	Complaint
14	Shops	1116	125.7	Complaint
15	Houses	784	127.9	Complaint
16	Reservoirs	1142	125.6	N/A
17	Reservoir	1162	125.5	N/A
18	Sewage Plant	728	128.3	Complaint
19	Substation	1327	124.7	Complaint
20	South 32 Operations	1026	126.2	N/A
21	South32 Offices	1166	125.5	Complaint
22	Structures	830	127.5	Complaint
23	Houses	1015	126.3	Complaint
24	Houses	849	127.4	Complaint
25	Houses	658	129.0	Complaint
26	Structures	693	128.7	Complaint
27	Structures	851	127.4	Complaint
28	Railway	459	131.2	N/A
29	Railway Yard	510	130.5	N/A
30	Railway	820	127.6	N/A
31	Houses	916	126.9	Complaint
32	Railway Structure	905	127.0	Complaint
33	Structures	731	128.3	Complaint
34	Structures	691	128.7	Complaint
35	Structures	857	127.3	Complaint
36	Houses	1031	126.2	Complaint
37	Low-cost Houses	1379	124.4	Complaint
38	Low-cost Houses	1501	123.9	Complaint
39	Structures	2378	121.0	Complaint
40	Railway	2181	121.6	N/A
41	Road	526	130.3	N/A
42	Road Intersection	685	128.7	N/A
43	Powerline	2346	121.1	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Powerline	1144	125.6	N/A
45	Powerline	1143	125.6	N/A
46	Airfield Structure	2270	121.4	Complaint
47	Airfield	2313	121.2	N/A
48	Structures	2739	120.2	Complaint
49	Houses	1910	122.4	Complaint
50	Houses	2099	121.8	Complaint
51	Mining Operation	2201	121.5	N/A
52	R31 Road	1698	123.1	N/A
53	Road	2895	119.9	N/A
54	Lodge	3238	119.2	Acceptable
55	Structure	2985	119.6	Acceptable
56	Waterhole	2423	120.9	N/A
57	Reservoir	2458	120.9	N/A
58	Structures - Shooting Range	906	127.0	Complaint
59	Shooting Range	870	127.2	N/A
60	Powerline	1991	122.2	N/A
61	Powerline	2143	121.7	N/A
62	Powerline	2301	121.3	N/A
63	Ruins	2702	120.3	Complaint
64	Structures	534	130.3	Complaint
65	Communication Tower	479	130.9	Complaint
66	Structure	417	131.8	Complaint
67	Fuel	1027	126.2	Complaint
68	Gravel Road	646	129.1	N/A
69	R31 Road	1008	126.4	N/A
70	R31 Road	1031	126.2	N/A
71	R31 Road	1382	124.4	N/A
72	R380 Intersection	1950	122.3	N/A
73	Hotazel Solar Facility	578	129.8	N/A
74	Hotazel Solar Facility	1089	125.9	N/A
75	Hotazel Solar Facility	1520	123.8	N/A
76	Hotazel 2 Solar Facility	946	126.7	N/A
77	Hotazel 2 Solar Facility	2155	121.7	N/A
78	Hotazel 2 Solar Facility	2961	119.7	N/A

17.8 Summary of findings for air blast

Review of the air blast levels indicate some concerns. Air blast predicted for the maximum charge ranges between 119.2 and 131.8 dB for all the POI's considered. There are no levels of air blast expected greater than the normally accepted of 134 dB at any housing structures. This includes the nearest points such as structures and Communication Tower. The levels predicted may contribute to effects such as rattling of roofs or door or windows with no points that are expected to be damaging but others could lead to complaints. Minimum charge predictions identified that thirty-nine POI's could experience levels of air blast that could lead to complaints. Maximum charge predictions identified that forty-two POI's could experience levels of air blast that could lead to complaints.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 290 m and closer to pit boundary. Infrastructure at the pit area such as roads, power lines/pylons, Reservoirs and Railway are present, but air blast does not have any influence on these installations.

In view of the planned solar facilities it is not expected that air blast should have any significant influence on the panels itself. It is accepted that some buildings will be present. Standard limits of 134 dB were applied. Levels expected are within the range of safe blasting for the solar facilities.

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

17.9 Fly-rock unsafe zone

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

Calculations are also used to help and assist determining safe distances. A safe distance from blasting is calculated following rules and guidelines from the International Society of Explosives Engineers (ISEE) Blasters Handbook. Using this calculation, the minimum safe distances can be determined that should be cleared of people, animals and equipment. Figure 13 shows the results from the ISEE calculations for fly rock range based on a 171 mm diameter blast hole and 4.4 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 291 m.

The absolute minimum unsafe zone is then the 291 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 14 shows the area around the Pit that incorporates the 291 m unsafe zone. Any blasting conducted within the pit boundary will have safe boundaries that is based on the specific blast. This report uses the edge of pit area as basis.

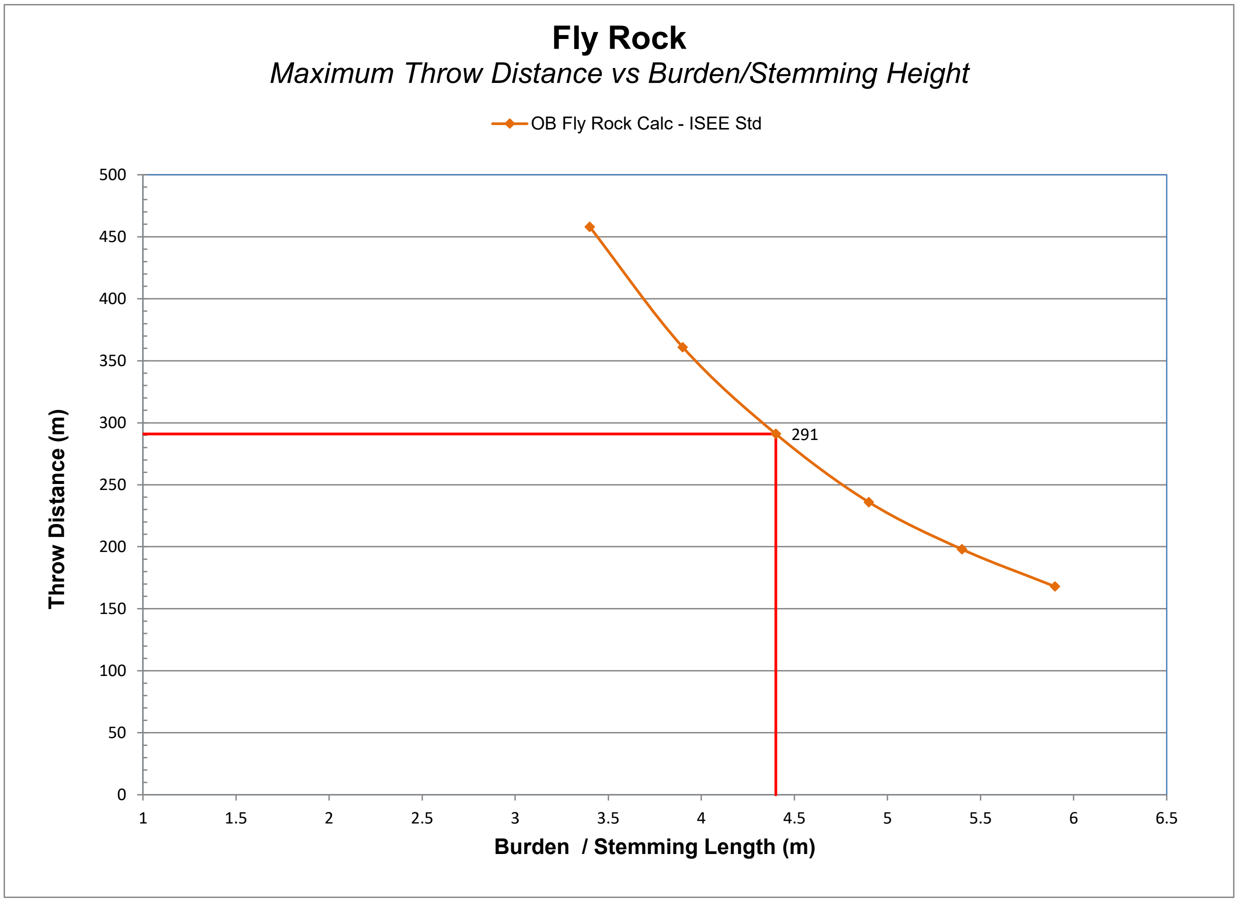


Figure 13: Fly rock prediction calculation

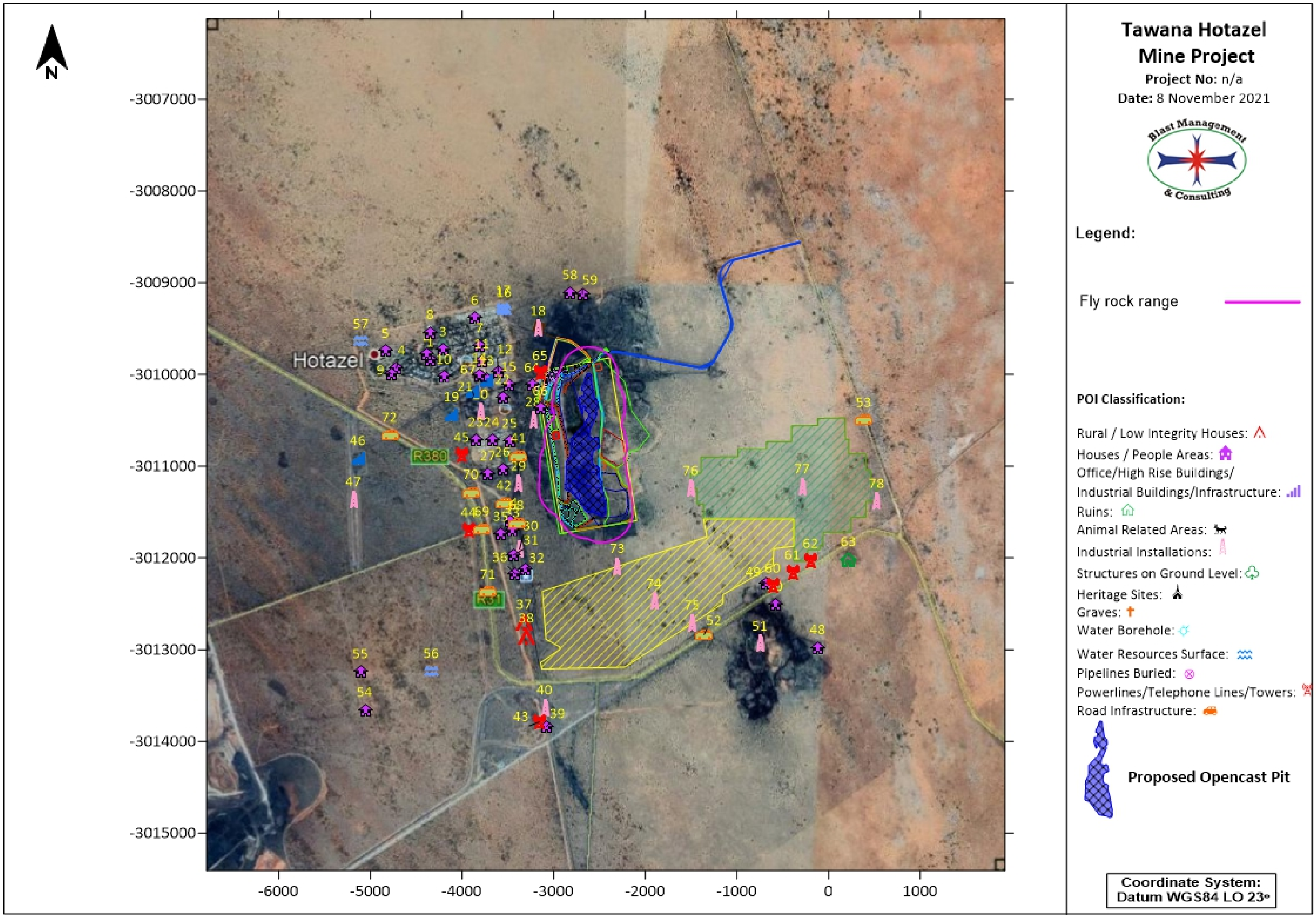


Figure 14: Predicted Fly Rock Exclusion Zone for the Pit area

Review of the calculated unsafe zone showed that there are no POI's that are within the unsafe zone.

17.10 Noxious fumes

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

18 Potential Environmental Impact Assessment: Operational Phase

The following is the impact assessment of the various concerns covered by this report.

18.1 Assessment Criteria

The following assessment methodology was applied. The matrix below in Table 16 was used for analysis and evaluation of aspects discussed in this report. The outcome of the analysis is provided in Table 19 with before mitigation and after mitigation. This risk assessment is a one-sided analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation.
The criteria for the description and assessment of environmental impacts are to comply with the EIA Regulations of 2014 (as amended) promulgated under NEMA, which states the following:

An environmental impact assessment report must contain all information that is necessary for the competent authority to consider the application and to reach a decision, and must include –

an assessment of each identified potentially significant impact, including –

(i) cumulative impacts;
(ii) the nature, significance and consequence of the impact and risk;
(iii) the extent and duration of the impact and risk;
(iv) the probability of the impact and risk occurring;
(v) the degree to which the impact and risk can be reversed;
(vi) the degree to which the impact and risk may cause irreplaceable loss of resources; and
(vii) the degree to which the impact and risk can be mitigated.

Based on the above, the Impact Assessment Methodology requires that each potential impact identified is clearly described (providing the nature of the impact) and be assessed in terms of the following factors:

Table 15: Impact Assessment Methodology

Extend (spatial scale)	Will the impact affect the national, regional, or local environment, or only that of the site?
Duration (temporal scale)	How long will the impact last?
Magnitude (severity)	Will the impact be of high, moderate, or low severity?
Probability (likelihood of occurring)	How likely is it that the impact may occur?

To enable a scientific approach for the determination of the environmental significance (importance) of each identified potential impact, a numerical value has been linked to each factor.

Table 16: Impact Assessment Criteria

Occurrence	**Duration:**	**Probability:**
	5 – Permanent	5 – Definite/don't know
	4 - Long-term (ceases with the operational life)	4 – Highly probable
	3 - Medium-term (5-15 years)	3 – Medium probability
	2 - Short-term (0-5 years)	2 – Low probability
	1 – Immediate	1 – Improbable
		0 – None
Severity	**Extent/scale:**	**Magnitude:**
	5 – International	10 - Very high/uncertain
	4 – National	8 – High
	3 – Regional	6 – Moderate
	2 – Local	4 – Low
	1 – Site only	2 – Minor
	0 – None	

Once the above factors had been ranked for each identified potential impact, the environmental significance of each impact can be calculated using the following formula:

Significance = (duration + extend + magnitude) x probability

The maximum value that can be calculated for the environmental significance of any impact is 100. The environmental significance of any identified potential impact is then rated as either: high, moderate or low on the following basis:

Table 17: Environmental Significance

Significance value	Environmental significance impact
More than 60	High (H)
Between 30 and 60	Moderate (M)
Less than 30	Low (L)

In order to **assess the degree** to which the potential impact can be reversed and be mitigated, each identified potential impact will need to be assessed twice.

- **Firstly**, the potential impact will be assessed and rated prior to implementing any mitigation and management measures; and
- **Secondly**, the potential impact will be assessed and rated after the proposed mitigation and management measures have been implemented.

The purpose of this dual rating of the impact before and after mitigation is to indicate that the significance rating of the initial impact is and should be higher in relation to the significance of the impact after mitigation measures have been implemented.

In order to assess the degree to which the potential impact can cause irreplaceable loss of resources, the following classes (%) will be used and will need to be selected based on the specialist informed decision and discretion:

Table 18: Impact Rating

5	100%	Permanent loss
4	75% - 99%	Significant loss
3	50% - 74%	Moderate loss
2	25% - 49%	Minor loss
1	0% - 24%	Limited loss

18.2 Assessment

The assessment done was based on evaluating the points of interested that showed reasonable expected levels. This is however based on the worst-case scenario where blasting is done at the shortest distance from pit area to the point of interest. In after mitigation consideration was given to the fact that blasting will not be constantly at the short distance and the period of time that the influence may be present is significantly reduced due to that only areas or blocks will be blasted at a time.

18.2.1 Assessment

Table 19: Risk Assessment Outcome before and after mitigation

Blasting		Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation (%)
		P	D	E	M	LoR		Significance		P	D	E	M	LoR		Significance	
ACTIVITY: Ground Vibration																	
Operational																	
Communication Tower	-	3	4	2	4	2	30	Moderate	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, apply designs provided.	3	4	2	2	1	24	Low	20.0
Fuel	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Houses	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Lodge	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Low-cost Houses	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Powerline	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
R31 Road	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Railway	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Reservoirs	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Road	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Ruins	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
School	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Sewage Plant	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Shops	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
South 32 Operations	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Structure	-	3	4	2	4	2	30	Moderate		3	4	2	2	1	24	Low	20.0
Substation	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
Solar Facilities	-	3	4	2	2	2	24	Low		3	4	2	2	1	24	Low	0.0
ACTIVITY: Air Blast																	
Operational																	
Communication Tower	-	3	4	2	4	4	30	Moderate	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, ensure design provided is applied, use of proper stemming procedures and stemming materials as recommended in the designs.	3	4	2	2	1	24	Low	20.0
Fuel	-	3	4	2	2	4	24	Low		3	4	2	2	1	24	Low	0.0
Houses	-	3	4	2	2	4	24	Low		3	4	2	2	1	24	Low	0.0
Lodge	-	3	4	2	2	4	24	Low		3	4	2	2	1	24	Low	0.0
Low-cost Houses	-	3	4	2	2	4	24	Low		3	4	2	2	1	24	Low	0.0
Powerline	-	3	4	2	2	4	24	Low		3	4	2	2	1	24	Low	0.0
R31 Road	-	3	4	2	2	4	24	Low		3	4	2	2	1	24	Low	0.0

Railway	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
Reservoirs	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
Road	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
Ruins	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
School	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
Sewage Plant	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
Shops	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
South 32 Operations	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
Structure	-	3	4	2	4	4	**30**	**Moderate**		3	4	2	2	1	**24**	**Low**	20.0
Substation	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
Solar Facilities	-	3	4	2	2	4	**24**	**Low**		3	4	2	2	1	**24**	**Low**	0.0
ACTIVITY: Fly Rock																	
Operational																	
Communication Tower	-	3	4	2	4	4	**30**	**Moderate**	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, ensure design provided is applied, use of proper stemming procedures and stemming materials as recommended in the designs.	2	4	2	2	1	**16**	**Low**	46.7
Fuel	-	2	4	2	2	4	**16**	**Low**		2	4	2	2	1	**16**	**Low**	0.0
Houses	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Lodge	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Low-cost Houses	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Powerline	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
R31 Road	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Railway	-	3	4	2	4	4	**30**	**Moderate**		2	4	2	2	1	**16**	**Low**	46.7
Reservoirs	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Road	-	3	4	2	4	4	**30**	**Moderate**		2	4	2	2	1	**16**	**Low**	46.7
Ruins	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
School	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Sewage Plant	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Shops	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
South 32 Operations	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Structure	-	2	4	2	4	4	**20**	**Low**		1	4	2	4	1	**10**	**Low**	50.0
Substation	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0
Solar Facilities	-	1	4	2	2	4	**8**	**Low**		1	4	2	2	1	**8**	**Low**	0.0

18.3 Mitigations

18.3.1 Ground Vibration

In review of the evaluations made in this report no specific mitigation will be required with regards to ground vibration provided blasting done according to the blast designs provided. Changes to the blast designs must however be re-evaluated for possible influence from 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.

18.3.2 Air Blast and Fly rock

Based on the recommended designs applied in this evaluation no additional mitigations are considered. Blasting operations in this pit area will however require meticulous application of stemming lengths and correct stemming material in order to manage air blast properly. The information from the proposed blast design is sufficient guidance to manage air blast properly.

19 Closure Phase: Impact Assessment and Mitigation Measures

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

20 Alternatives (Comparison and Recommendation)

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

21 Monitoring

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

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

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.

Seven 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. The size of the pit area and not knowing where blasting will be started at this stage makes exact recommendations for blast monitoring points difficult. However monitoring positions are indicated in Figure 15 and Table 20 lists the positions with coordinates. These points will need to be re-defined with an availability of a detailed mining plan and after the first blasts done and the monitoring programme defined.

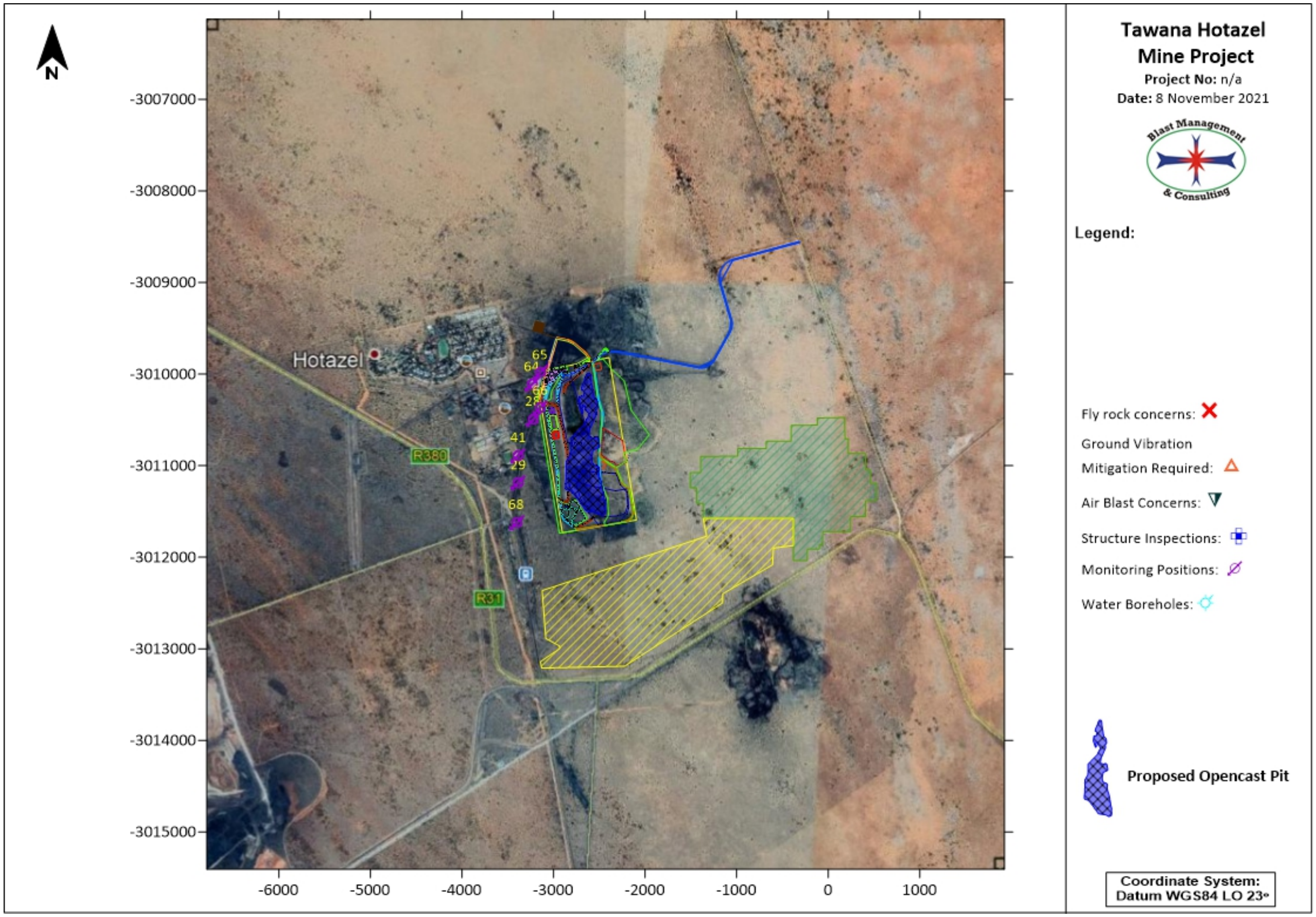


Figure 15: Suggested monitoring positions

Table 20: List of possible monitoring positions

Tag	Description	Y	X
10	Houses	4193.64	3010026.93
20	South 32 Operations	3793.40	3010406.43
25	Houses	3477.56	3010726.14
26	Structures	3554.73	3011034.77
65	Communication Tower	3144.41	3009987.06
73	Hotazel Solar Facility	2302.56	3012091.18
76	Hotazel 2 Solar Facility	1502.10	3011240.65

22 Recommendations

The following recommendations are proposed.

22.1 Regulatory requirements – MHSA Reg. 4.16(2)

Regulatory requirements indicate specific requirements for all non-mining structures and installations within 500 m from the mining operation. Three POI's are observed within 500 m from the mining area. The mine will have to apply for the necessary authorisations as prescribed in the various acts, and specifically Mine Health and Safety Act Reg 4.16 as well as recommendations regarding infrastructure within the pit area. Table 21 shows list of these installations. Figure 16 below shows the 500 m boundary around the opencast pit areas. The location of non-mining installations is clearly observed.

Table 21: List of possible installations within the regulatory 500 m

Tag	Description	Y	X
28	Railway	3220.77	3010491.29
65	Communication Tower	3144.41	3009987.06
66	Structure	3141.44	3010372.93

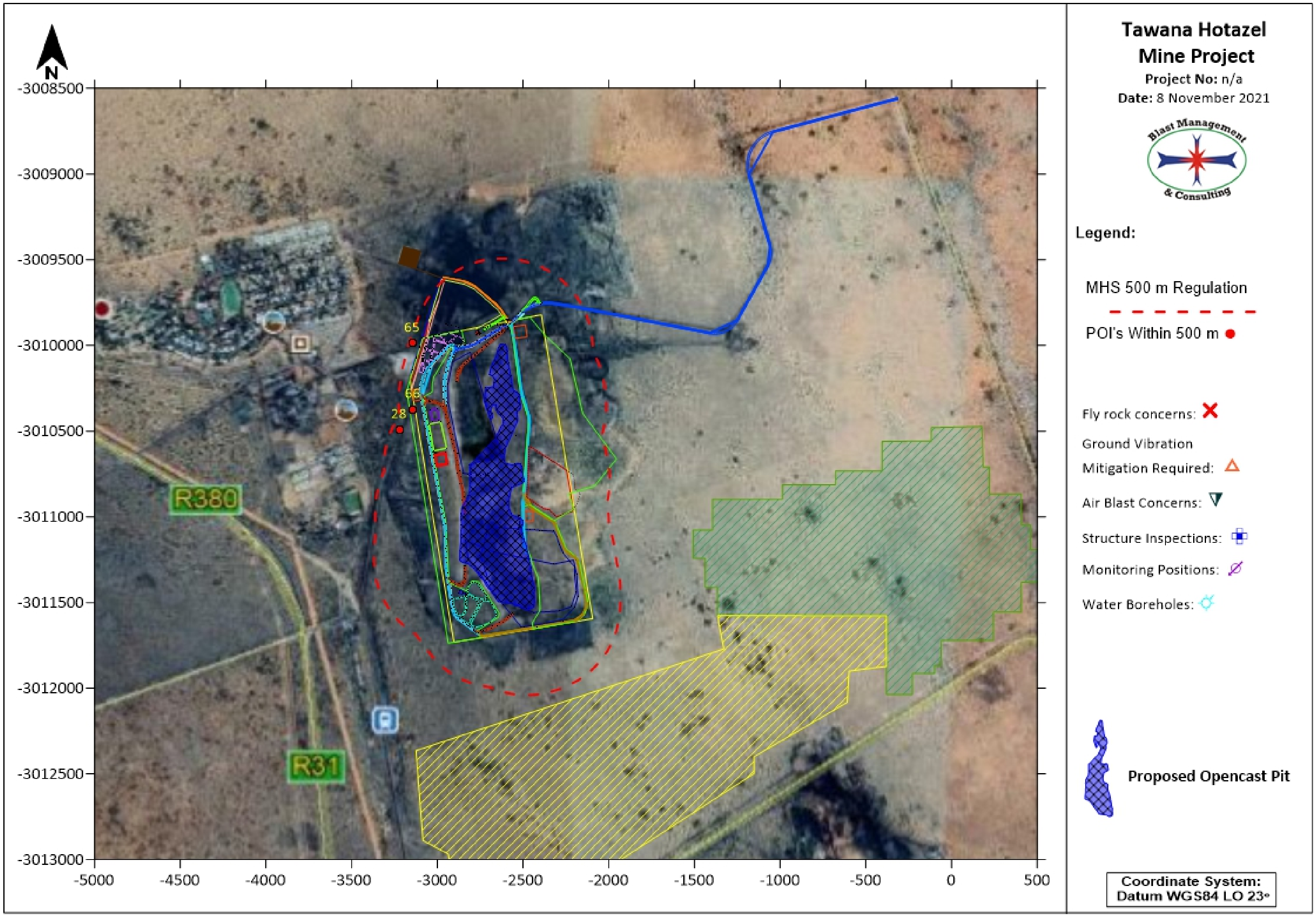


Figure 16: Regulatory 500 m range for the opencast area

22.1 Regulatory requirements – MHSA Reg. 17.6(a)

On review of the pit area's location, there is no private infrastructure within 100 m from the pit area. Mine Health and Safety act regulation 17.6(a) may not be required. A final inspection of area and structures must be done prior to dismissing this requirement. Figure 17 shows the Pit areas with 100 m boundary that indicate no infrastructure are within the 100 m.

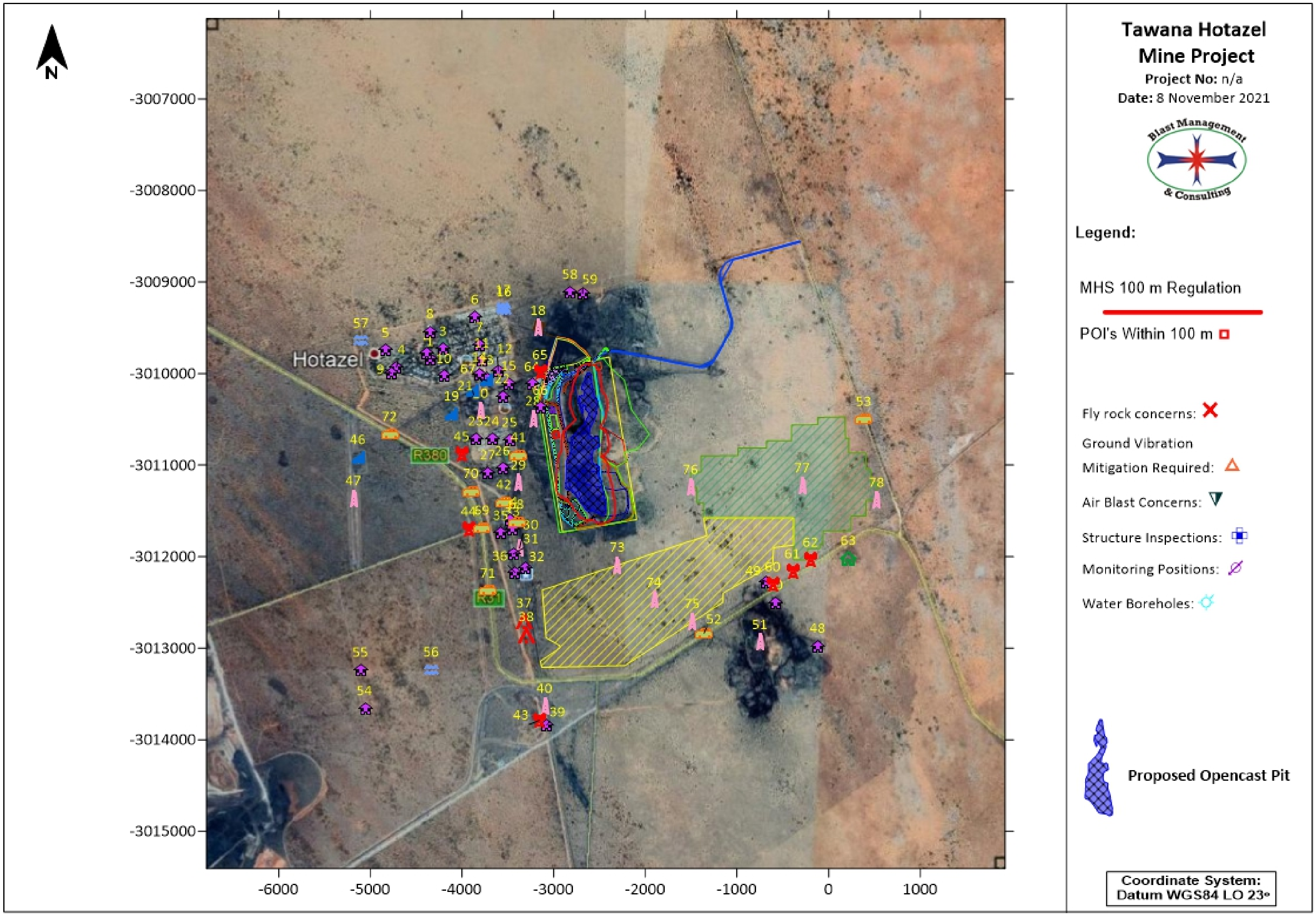


Figure 17: Regulatory 100 m range for pit area

22.2 Blast Designs

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

22.3 Test Blasting

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

22.4 Stemming length

The current proposed stemming lengths used provides for 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.

22.5 Safe blasting distance and evacuation

Calculated minimum safe distance is 291 m. The final blast designs that may be used will determine the final decision on safe distance to evacuate people and animals. This distance may be greater pending the final code of practice of the mine and responsible blaster's decision on safe distance. The blaster has a legal obligation concerning the safe distance and he needs to determine this distance.

22.6 Road management

The R31 Provincial road is at an approximate distance of 1008 m from the Pit area and will require no specific consideration regarding effects from blasting operations. The R380 road is at closest distance of 1950 m. There are other Roads and Gravel roads in the vicinity of the Project area but are all expected to be within the recommended limits. There may however be people and animals on these routes and will require careful planning to maintain safe blasting radius. It will be required that clearance distances are set, and road travel managed during blasting operations.

22.7 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 area. At 1500 m the expected level of ground vibration will be perceptible. Figure 18 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.

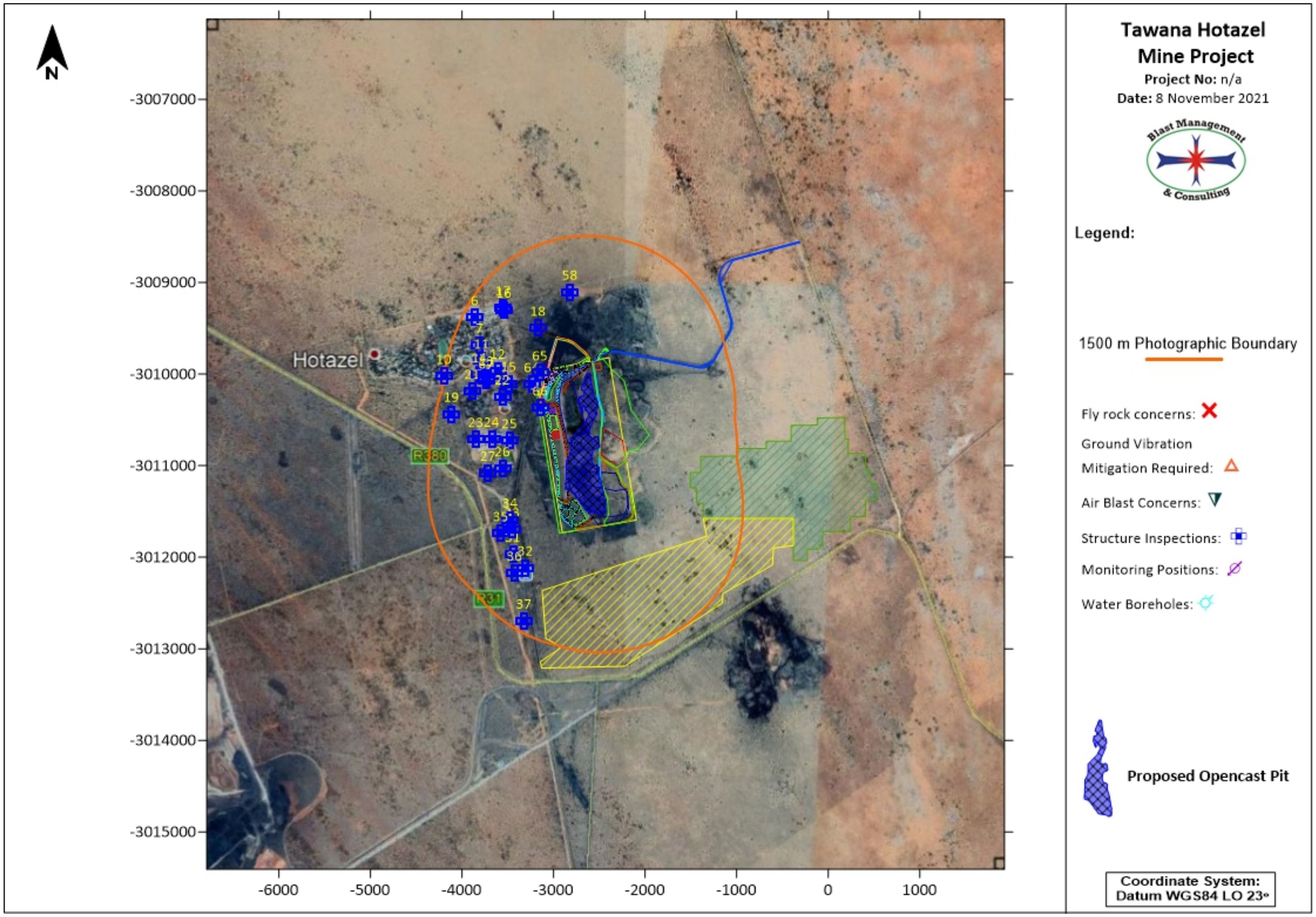


Figure 18: 1500 m area around opencast pit areas identified for structure inspections.

Table 22: List of structures identified for inspections

Tag	Description	Y	X
6	Houses	3857.20	3009383.68
7	Houses	3804.09	3009684.48
10	Houses	4193.64	3010026.93
11	Houses	3782.10	3009859.77
12	Houses	3604.33	3009968.82
13	Shops	3729.63	3010043.68
14	Shops	3806.10	3010009.66
15	Houses	3487.00	3010106.22
16	Reservoirs	3538.83	3009300.20
17	Reservoir	3546.79	3009277.61
18	Sewage Plant	3165.73	3009500.08
19	Substation	4112.05	3010438.06
21	South32 Offices	3884.66	3010188.66
22	Structures	3552.69	3010248.81
23	Houses	3846.40	3010713.54
24	Houses	3673.16	3010711.01
25	Houses	3477.56	3010726.14
26	Structures	3554.73	3011034.77
27	Structures	3713.58	3011081.10
31	Houses	3441.68	3011971.33
32	Railway Structure	3303.36	3012116.03
33	Structures	3447.82	3011701.85
34	Structures	3469.59	3011594.46
35	Structures	3574.36	3011741.52
36	Houses	3421.70	3012173.44
37	Low-cost Houses	3319.63	3012697.51
58	Structures - Shooting Range	2816.56	3009107.21
64	Structures	3233.16	3010115.46
65	Communication Tower	3144.41	3009987.06
66	Structure	3141.44	3010372.93
67	Fuel	3728.67	3010077.23

22.8 Recommended ground vibration and air blast levels

The ground vibration and air blast levels limits recommended for blasting operations in this area are provided in Table 23.

Table 23: 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	

Structure Description	Ground Vibration Limit (mm/s)	Air Blast Limit (dBL)
Rural building – Mud houses	6	

22.9 Blasting times

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

22.10 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.

22.11 Video monitoring of each blast

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

22.12 Air traffic control

The South 32 airstrip is located directly west of the pit area at 2313 m away. It is recommended that communication be setup to ensure that there is no air traffic at time of blasting.

23 Comments and Response

South 32	Comment	Questions	Response:
Blasting	Blasting damage from ground vibration, air blast and fly rock. Committed blasting limitations ground vibration- max of peak particulate velocity of 6mm/s to the closest house Fly rock range- within a range of 300m radius Lesser sensitive or medium sensitivity is the 500 m to 1500 m reference area. The 1500m radius is considered as a range where influence may be less but still requires active monitoring.	Compensation strategy for possible building damages and injuries from fly rock	All recommendations made in this report were done so to prevent damages and injuries. BMC can unfortunately not comment on a compensation strategy. It should be remembered that the scoping phase analysis does not have blast plans and parameters and is based on general experience expected from opencast operations. The modelling of data from planned parameters is better indicators.
		How far is the closest house from a closest blasting block?	The nearest house to the pit area is 658 m based on the maps available at time of the report.
		How will it be monitored?	Recommendation is made for ground vibration, air blast and video monitoring using seismographs and video camera. The use of drone footage may also be considered.
		What will be a blasting impact on Provest plant close to mine workings?	The drill and blast parameters set to be used do show expected vibrations of 6.6 mm/s at closest structure at 417 m. If the plant is further away expected vibrations will be less. Under definition of a plant should be well within safe criteria.
Impacts Identified	Potential impact - Blasting damage from ground vibration, air blast and fly rock.	Vibration travels faster than noise and there is community next to the pit, why would its impact be minimal?	The nearest houses are 658 m from the pit. Expected levels of ground vibration is 3.1 mm/s. This is well within the general accepted safe limit of 12.5 mm/s applied.
		Is there no chance of cracking sewage facility?	The sewage plant is located 728 m from the pit area. Expected vibration is 2.6 mm/s. It is well below reason concern of damage to the plant.
Airstrip	Proposed THM is located within 8 km of the Hotazel	What is mining impact? (blasting)?	The airstrip is located 2313 m from the pit area. There is no concern with regards to ground vibration, air blast or fly rock. It may be a good

<table>
<tr>
<td></td>
<td>Airstrip
desktop analysis identified several existing structures within the 8 km of the aerodrome reference point which may be considered obstacles restricting the overhead movement of air traffic (including the processing plant, power lines, telecommunication tower, rail loadout facility railway structures)</td>
<td></td>
<td>to communicate with the airstrip prior to blasting for confirmation of air traffic clearance.</td>
</tr>
<tr>
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<tr>
<td>Hotazel Solar PV facilities to the south/south-east of the site</td>
<td>The proposed mine is indicated to be located a minimum of approximately 535m from the Hotazel Solar PV facilities, with the key mine components located nearby being the open-cast mining pits, in-pit dumps and the RoM pads. Activities at these areas could pose the following risks to the Hotazel Solar PV facilities:</td>
<td>Damage to infrastructure as a result of vibrations, fly rock impact and/ explosions and fire</td>
<td>There is no specific limits for solar installations. A conservative 25 mm/s vibration and air blast 134 dB as applied. These are similar for normal well build houses where people will reside.
The nearest point between the pit area and the two solar farms are 758 m and 946 m. The expected levels of ground vibration and air blast expected are as follows:
<table>
<tr><th>Facility</th><th>Distance (m)</th><th>PPV (mm/s)</th><th>Air blast (dB)</th></tr>
<tr><td>Hotazel Solar Facility</td><td>578</td><td>3.8</td><td>129.8</td></tr>
<tr><td>Hotazel 2 Solar Facility</td><td>946</td><td>1.7</td><td>126.7</td></tr>
</table>
These levels are well within accepted norms for safe blasting.

Fly rock unsafe zone was calculated to 291 m. The solar facilities are located outside of this zone. However a general clearance zone of 500 m is normally applied by mines. It will however still be required by the blasting team to ensure that all is done not to create fly rock.</td>
</tr>
<tr>
<td></td>
<td>In terms of vibration, given that the Hotazel Solar PV facilities are within the 1500m “medium sensitivity” zone, please clarify the expected vibration anticipated at the property/ cadastral</td>
<td>Vibration monitoring must be done at various points (the siting of the points to be recommended by the relevant specialist) along the shared</td>
<td>Part of the monitoring program recommended includes two locations at closest point between the pit and the solar facilities. These points are intended to act as governing the ground vibration and air blast yielded by blasting. The monitoring positions are located such that it should be best location for strictest control. Any distance further will indicate lower levels.</td>
</tr>
</table>

	boundaries shared by the proposed mine and Hotazel Solar PV facilities. Furthermore, the vibration assessment must please explicitly confirm the risk of damage to the Hotazel solar facilities infrastructure as a result of vibrations caused by the proposed mine. Please also include the following specification in the Operational Environmental Management Programme (EMPr):	cadastral boundaries and the results of the monitoring are to be regularly provided to a representative of ABO Wind Hotazel PV (Pty) Ltd and/or Hotazel Solar Facility 2 (Pty) Ltd, or whichever entity is operating the Hotazel solar facilities (as per whatever is relevant at the time).	It should be remembered that the scoping phase analysis does not have blast plans and parameters and is based on general experience expected from opencast operations. The modelling of data from planned parameters is better indicators.
	The specifications in the Construction Environmental Management Programme must also include mitigation measures for dust, as well as the requirement that the contractor communicate (ahead of time) with ABO Wind Hotazel PV (Pty) Ltd and/or Hotazel Solar Facility 2 (Pty) Ltd / the Hotazel solar facilities operator (whichever is applicable at the time) when activities that would produce a lot of dust (e.g., excavations, blasting, etc.) are programmed to occur. These specifications must also require that stockpiles must be located as far from the property boundary of the Hotazel solar facilities as possible		Dust from blasting may be expected. The blast designs are however such that the type of blasting to be done is well restricted. It is believed that this will also contribute to control on dust emissions directly from the blast. Considerations can be given to wind directions at time of blast not to exacerbate the effect. The air quality specialist to define dust emissions and distribution of dust.

	(the north-east corner of the site appears to have the fewest surrounding receptors, so that would be an adequate location).		

24 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.

25 Project Result

In view of the data evaluated it is the opinion of the author that the project can be executed successfully with proper management and control on the aspects of ground vibration, air blast and fly rock. Specific problems were identified, and recommendations made.

26 Conclusion

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

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

The location of structures around the Pit area is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Structures, Railway Line and Communication Tower. Ground vibration at structures and installations is well below any specific concern for inducing damage.

Air blast predicted also showed more concerns for opencast blasting. 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 pit is located such that "free blasting" – meaning no controls on blast preparation – will not be possible.

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 290 m and closer to pit boundary. Infrastructure at the pit areas such as roads, power lines/pylons are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 291 m. The absolute minimum unsafe zone is then the 291 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Structures, Railway Line and Communication Tower falls within the 500 m range from the pit area.

The pit area is located such that specific concerns were identified and addressed in the report.

This concludes this investigation for the proposed Tawana Hotazel Mine (THM) Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

27 Curriculum Vitae of Author

J D Zeeman was a member of the Permanent Force - SA Ammunition Core for period January 1983 to January 1990. During this period, work involved testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition.
From July 1992 to December 1995, Mr Zeeman worked at AECI Explosives Ltd. Initial work involved testing science on small scale laboratory work and large-scale field work. Later, work entailed managing various testing facilities and testing projects. Due to restructuring of the Technical Department, Mr Zeeman was retrenched but fortunately was able to take up an appointment with AECI Explosives Ltd.'s Pumpable Emulsion Explosives Group for underground applications.
From December 1995 to June 1997 Mr Zeeman provided technical support to the Underground Bulk Systems Technology business unit and performed project management on new products.
Mr Zeeman started Blast Management & Consulting in June 1997. The main areas of focus are Pre-blast monitoring, Insitu monitoring, Post-blast monitoring and specialized projects.

Mr Zeeman holds the following qualifications:

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

Member: International Society of Explosives Engineers

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

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

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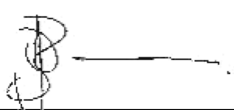
Declaration of Independence by Specialist

I, JD Zeeman, in my capacity as a specialist consultant, hereby declare that I –

- act as an independent specialist;
  Where **"independent"** in relation **a specialist** means the following, as defined in GN982 of 2014 (*as amended*):
  (a) that such EAP, **specialist** or person has no business, financial, personal or other interest in the activity or application in respect of which that EAP, specialist or person is appointed in terms of these Regulations; or
  (b) that there are no circumstances that may compromise the objectivity of that EAP, specialist or person in performing such work;
  excluding -
  (i) normal remuneration for a specialist permanently employed by the EAP; or
  (ii) fair remuneration for work performed in connection with that activity, application or environmental audit;
- 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;
- do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- based on information provided to me by the project proponent and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional ability; and
- undertake to have my work peer reviewed on a regular basis by a competent specialist in the field of study for which I am registered.



Signature of the Specialist

Blast Management and Consulting (PTY) Ltd

Name of Company:

25/08/2021

Date