Blast Management & Consulting

Quality Service on Time

Report: Blast Impact Assessment Proposed Kudumane Manganese Resources (KMR) Expansion Project		
Report Date:	10 September 2021	
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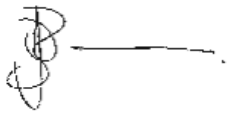
Document Authorised:	JD Zeeman	

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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

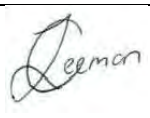
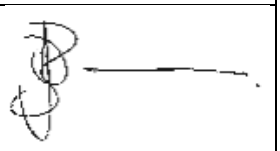
In terms of the NEMA 2014 EIA Regulations contained in GN R982 of 04 December 2014 (as amended by GN R 326 of 07 April 2017) all specialist studies must comply with Appendix 6 of the NEMA EIA Regulations, 2014 (as amended). Table 1 shows the requirements as indicated above.

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	08/07/2021	
JD Zeeman Blast Management & Consulting	Consultant	Report Finalised	10/09/2021	

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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 concentrates on the ground vibration and air blast intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

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, Hydrocencus boreholes and graves.

The location of structures around the Pit areas is such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Hydrocencus Boreholes, Railway Line, planned Attenuation Dam, Mine Buildings, Heritage Sites, Gravel Road and planned diversion R380 Road. Ground vibrations predicted for the pit area ranged between low and very high. The expected levels of ground vibration for some of these structures are high and will require specific mitigations in the way of adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

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

On charges considered it is expected that air blast will be greater than 134 dB at a distance of 458 m and closer to pit boundary. The structures inside the Pit area are expected to be relocated and will then not be of concern as it is currently inside the pit area. Infrastructure at the pit area such as roads, heritage sites and Power lines/Pylons are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 278 m. The absolute minimum unsafe zone is then the 278 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 Burial Ground, Abandoned Cottage and planned R380 diversion road falls within the 500 m range from the pit area.

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

2 Introduction

Kudumane Mineral Resources (Pty) Ltd (KMR) is an established opencast manganese mine located approximately 3 km south-west of the town of Hotazel in the John Taolo Gaetsewe District Municipality in the Northern Cape Province. The centre point of the site is 27°13'26.12"S and 22°55'22.32"E.

KMR has two mining rights; one in respect of the farms York A279 and Telele 312 (Mining Right Ref: NC/30/5/1/2/2/0268 MR) and one over the farms Devon 277, Hotazel 280 and Kipling 271 (Mining Right NC/ 30/5/1/2/2/10053 MR).

The mine is operated under two Environmental Management Programmes (EMPrs), a Water Use Licence (WUL) issued in 2016 and amended WUL authorised in 2018.

KMR intends to expand its current operations, in order extend the life of its operation and improve production capacity, through the inclusion of the following key mining related activities and infrastructure within their approved mining right areas:

- Extension of the existing York and Hotazel Pits;
- Development of two in-stream attenuation dams within the Ga-Mogara River to allow for the expansion of the York and Hotazel Pits; and
- Development of new opencast pits on the farm Kipling 271.

The expansion project will also require the following secondary infrastructure and activities:

- Expansion of waste rock dumps;
- Expansion of ore stockpiles;
- Development of new roads and expansion of existing roads;
- Relocation of Pollution Control Dams (PCDs);
- Storage and reticulation of water via tanks and pipelines;
- Development and expansion of sewerage treatment plants;
- Development of supporting infrastructure such as admin offices ancillary infrastructure;
- Waste and fuel storage areas;
- Development of a contractor's camp; and
- Extension of existing powerlines.

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 Kudumane Manganese Resources (KMR) Expansion 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

Kudumane Mineral Resources (Pty) Ltd (KMR) is an established opencast manganese mine located approximately 3 km south-west of the town of Hotazel in the John Taolo Gaetsewe District Municipality in the Northern Cape Province. The centre point of the site is 27°13'26.12"S and 22°55'22.32"E. Figure 1 shows the Property Layout for the Kudumane Manganese Resources (KMR) Expansion Project.

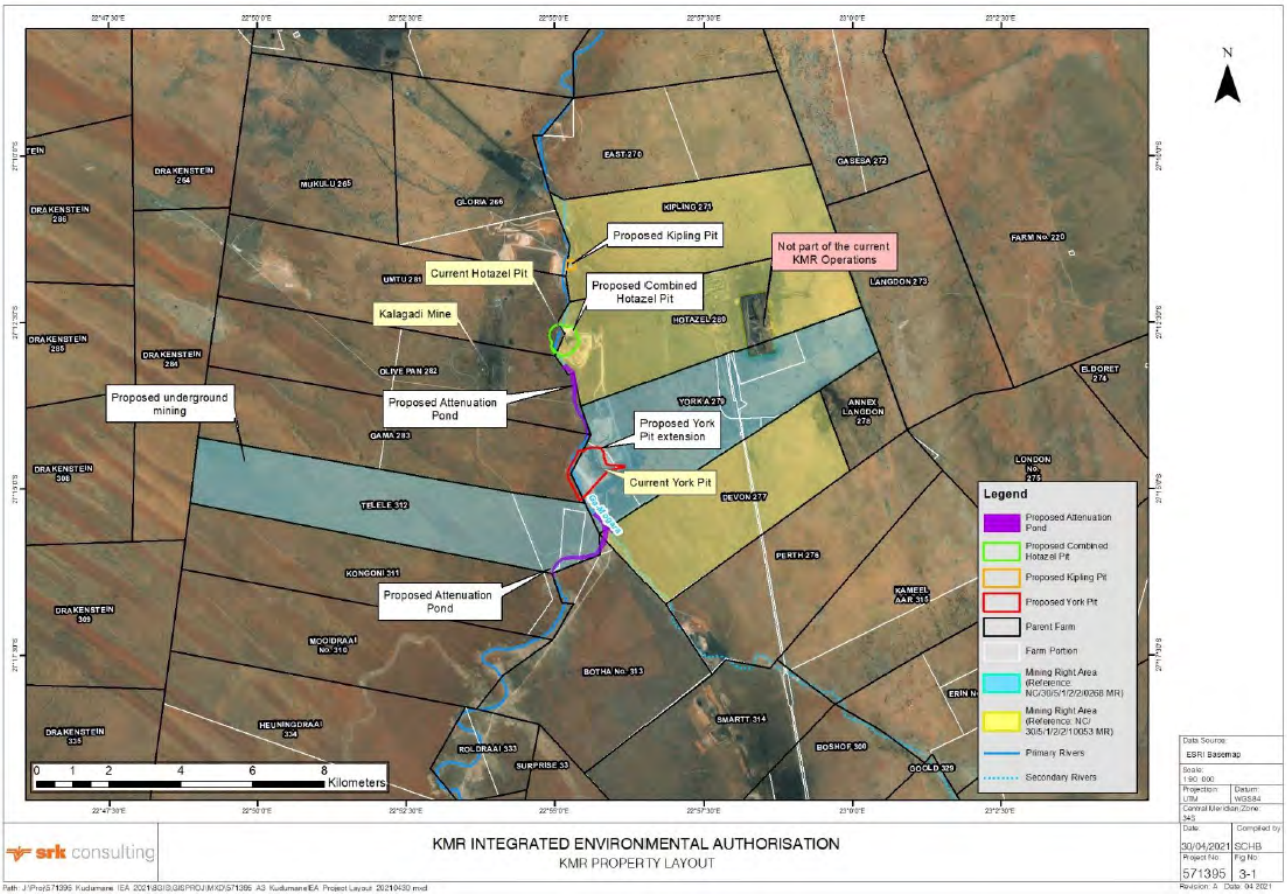

Figure 1: KMR Property Layout

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 15 July 2021. This site visit was done to get understanding of the location and the structures and installations surrounding the proposed new pit areas.

8 Season applicable to the investigation

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

9 Assumptions and Limitations

The following assumptions have been made:

- The project consists of extension of existing pit areas and new pit area where no mining is currently being conducted. Existing operations were visited.
- The anticipated levels of influence estimated in this report are calculated using standard accepted methodology according to international and local regulations.
- The assumption is made that the predictions are a good estimate with significant safety factors to ensure that expected levels are based on worst case scenarios. These will have to be confirmed with actual measurements once the operation is active.
- The limitation is that limited data was available from this operation for a confirmation of the predicted values.
- Drilling and blast designs from the existing York pit was applied in this report. Similar operations are expected for the Hotazel and Kipling pit areas.
- 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 to Figure 4 shows the sensitivity mapping with the identified points of interest (POI) in the surrounding areas for the proposed Project areas. The specific influences will be determined through the work done for this project in this report.

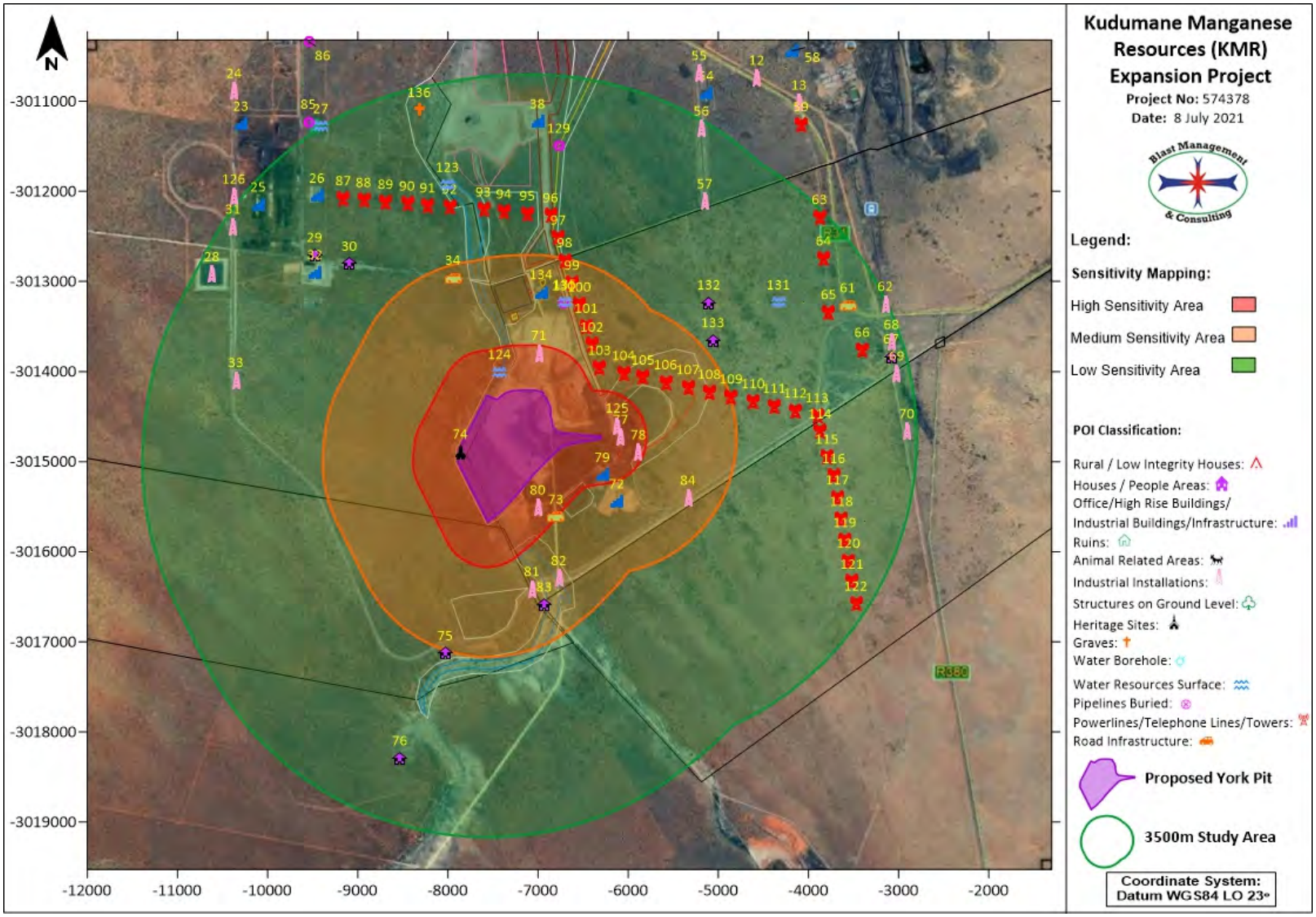

Figure 2: Identified sensitive areas for the York Pit area

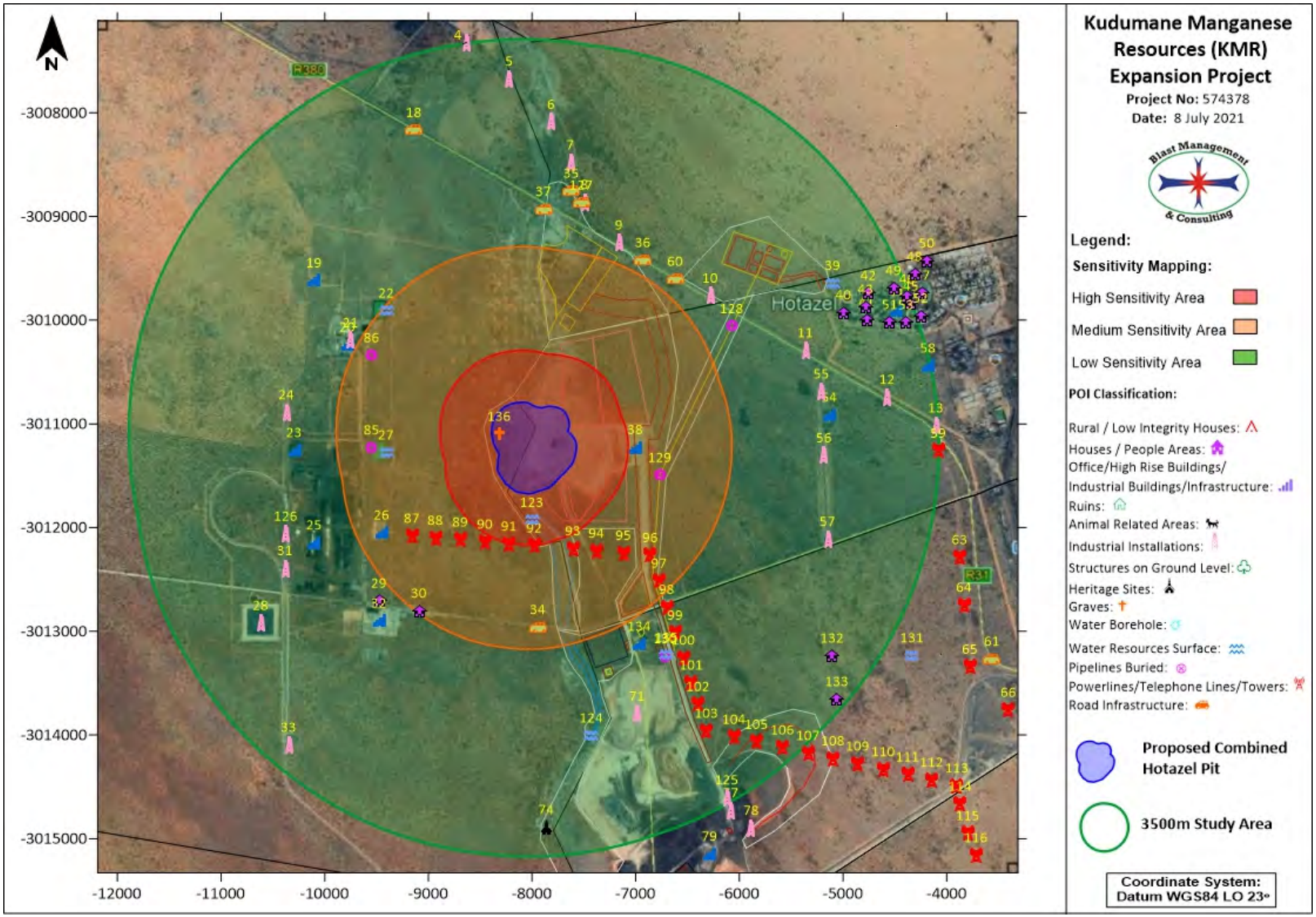

Figure 3: Identified sensitive areas for the combined Hotazel Pit area

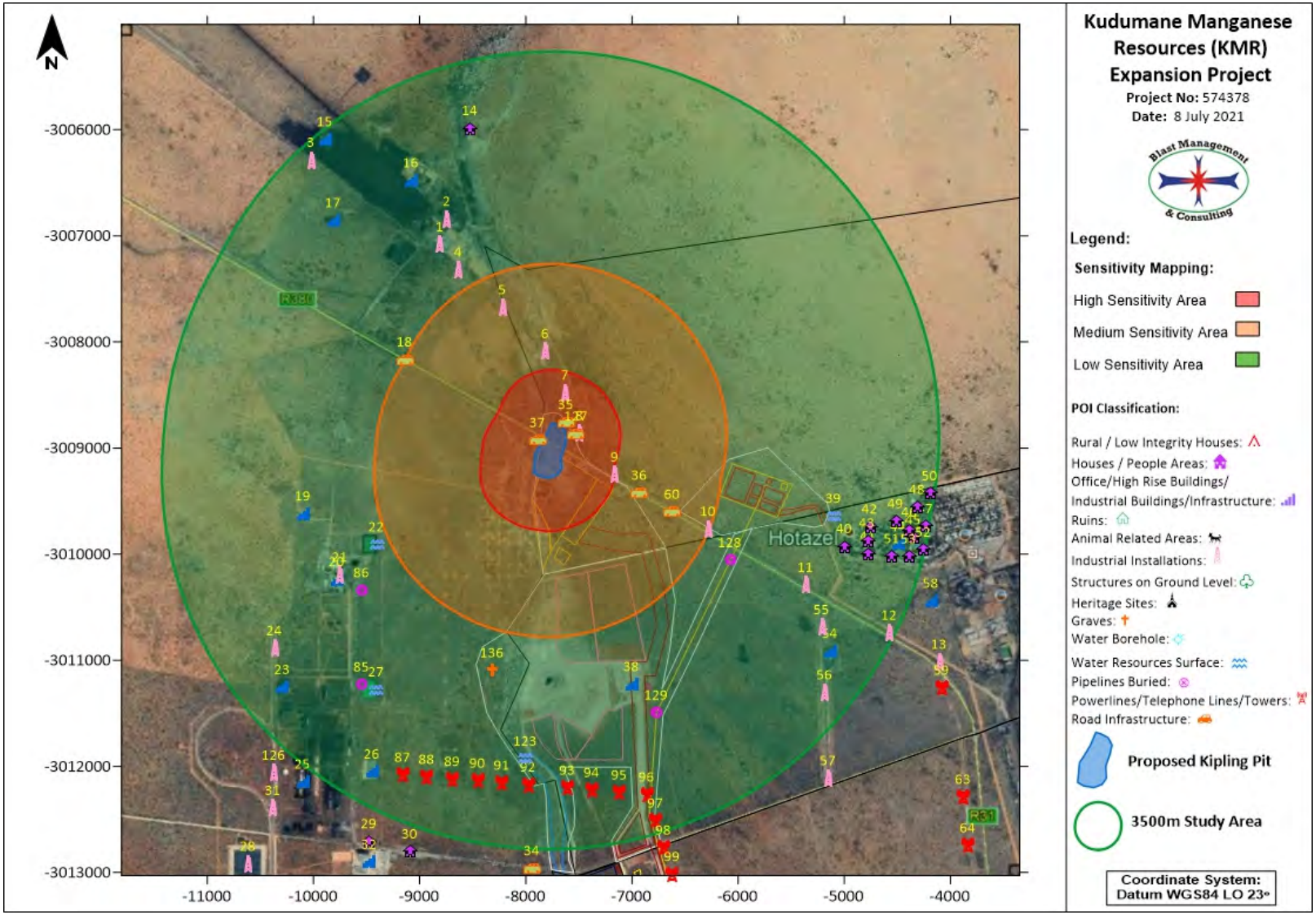

Figure 4: Identified sensitive areas for the Kipling Pit area

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 5 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.

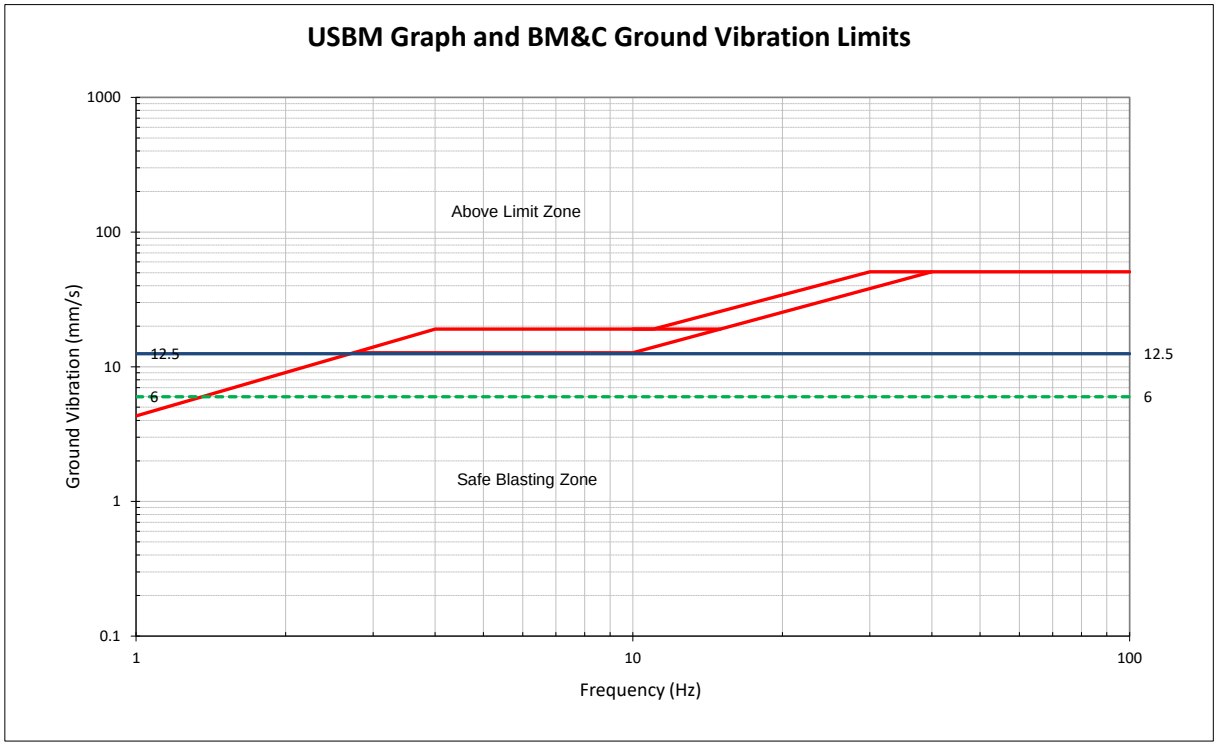

Figure 5: USBM Analysis Graph

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 6). 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 6 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.

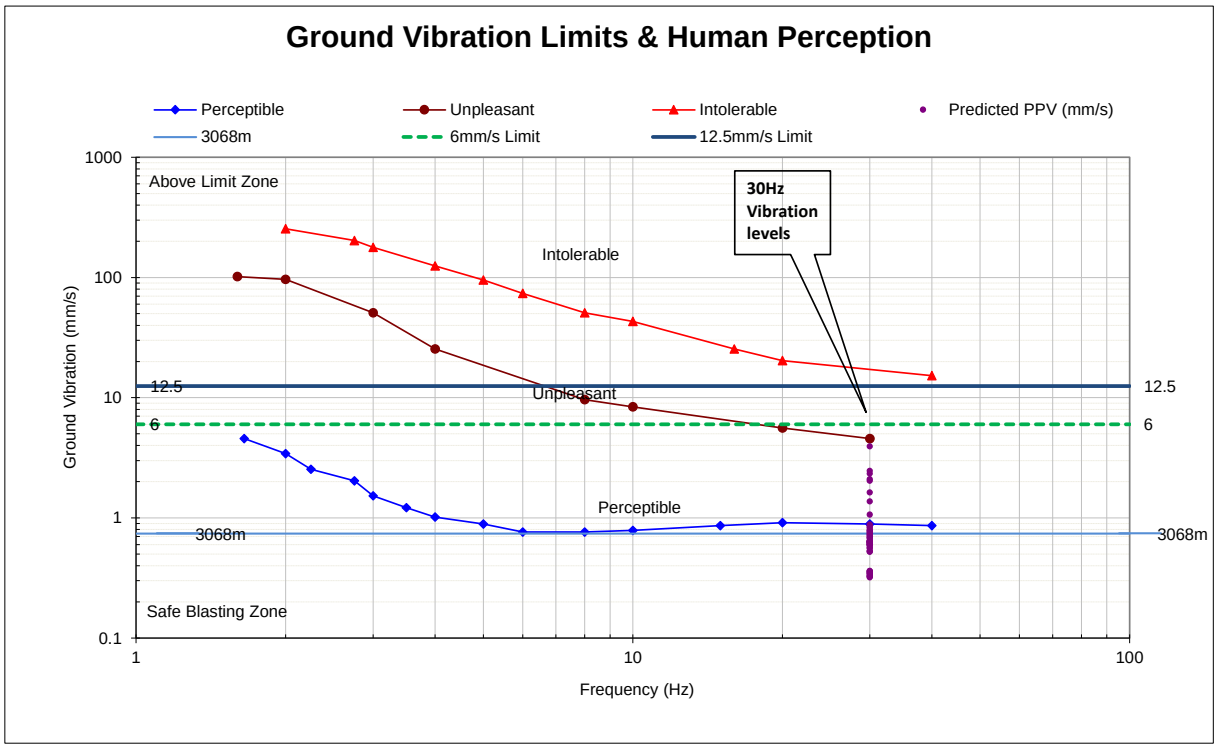


Figure 6: USBM Analysis with Human Perception

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 7 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.

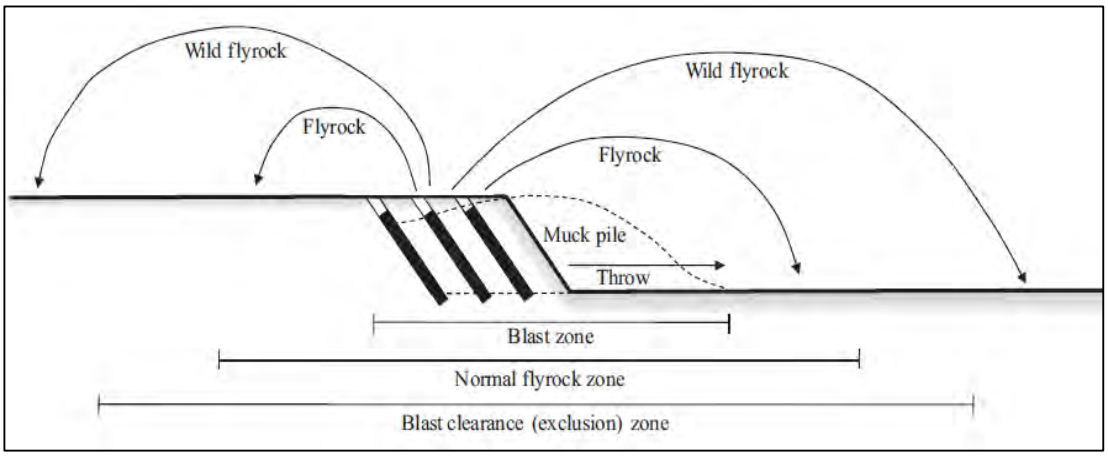


Figure 7: Schematic of fly rock terminology

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.

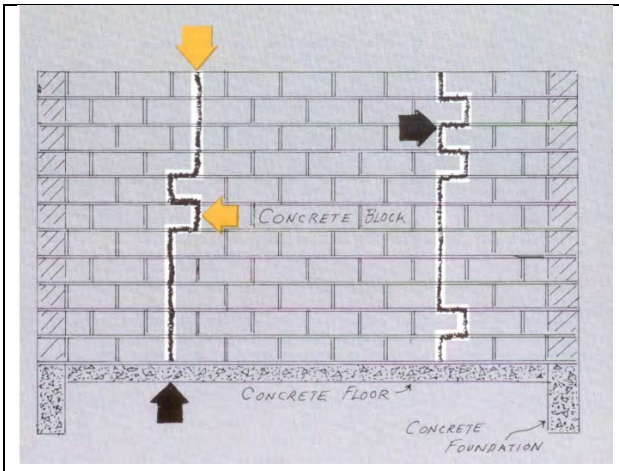
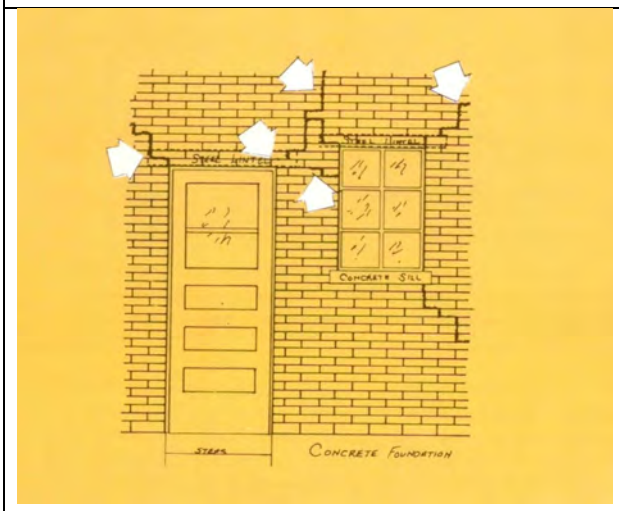
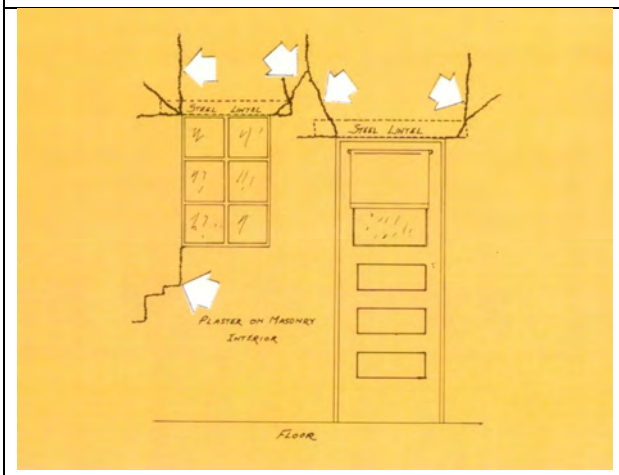
13.9 Cracking of houses and consequent devaluation

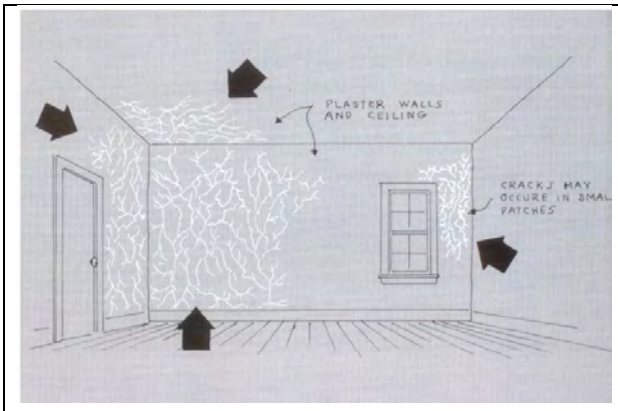
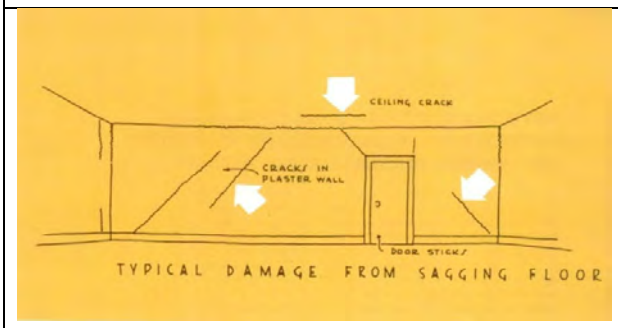
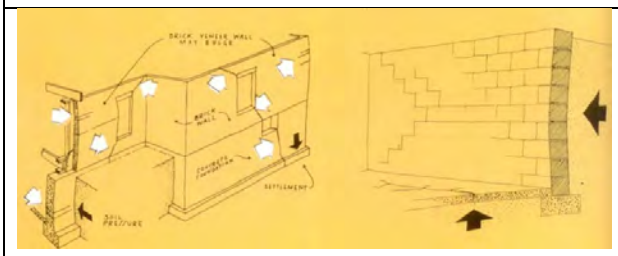
Houses in general have cracks. It is reported that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc. 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 8 below. A typical X crack formation is observed.

Figure 8: Example of blast induced damage.

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

Table 4: Examples of typical non-blasting cracks

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

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

Observing cracks in the form indicated in Figure 8 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

During the site visit blasting was monitored for ground vibration and air blast. Objective of the baseline was to ensure ground vibration and air blast shows typical trends. And confirm the expected levels closer to the blast area. A monitoring program is also in place at the mine currently the measures and confirm ground vibration and air blast levels at strategic positions. Of specific importance is monitor located within Hotazel township. Though limited data from the monitoring program was provided it showed valuable results with the data recorded during the site visit.

Data recorded clearly indicate significant attenuation of ground vibration over a relative short distance – approximately 100 m to 1000 m from the blast ground vibration attenuates from 39 mm/s to 4.44 mm/s. At distance to Hotazel no significant ground vibration is realised at the monitor in town.
Air blast showed high levels very close to the last with significant attenuation over distance. At closest point levels were higher than the microphone's capabilities. It is also observed that levels were less than the general accepted safe blasting limit of 134 dB at approximately 1000 m.

It is safe to say the that expected possible negative influence from ground vibration due to blasting operations will be restricted to distances less than 500 m. This is specific with regards to house structures.
Air blast may have effects over greater distances but is expected to be less than limits no further than a 1000 m.

The detail evaluation done in the report will define the expected levels of ground vibration for the different points of interest identified. Levels will be confirmed if correlating to the baseline data recorded.
Results from recording done is presented below. The graphs clearly indicate attenuation over distance.

Table 5: Baseline Data recorded

Date	Time	Seis. Location	Description	L-PPV	T-PPV	V-PPV	L-Freq	T-Freq	V-Freq	Resultant PPV (mm/s)	Air Blast
2021/07/15	17:20:11	Point 02	Within Mining Area	26.91	27.37	39.31	45.51	40.96	73.14	39.47	150.00*
2021/07/15	17:20:11	Point 01	Within Mining Area	12.85	16.72	13.41	27.68	43.57	26.60	18.45	143.90
2021/07/15	17:20:11	Point 03	Within Mining Area	3.19	3.86	2.49	32.00	33.03	14.95	4.44	133.00
2021/07/15	17:20:11	Point 04	Dyason Cres, Hotazel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* Microphone exceeded capabilities, estimate value was used.

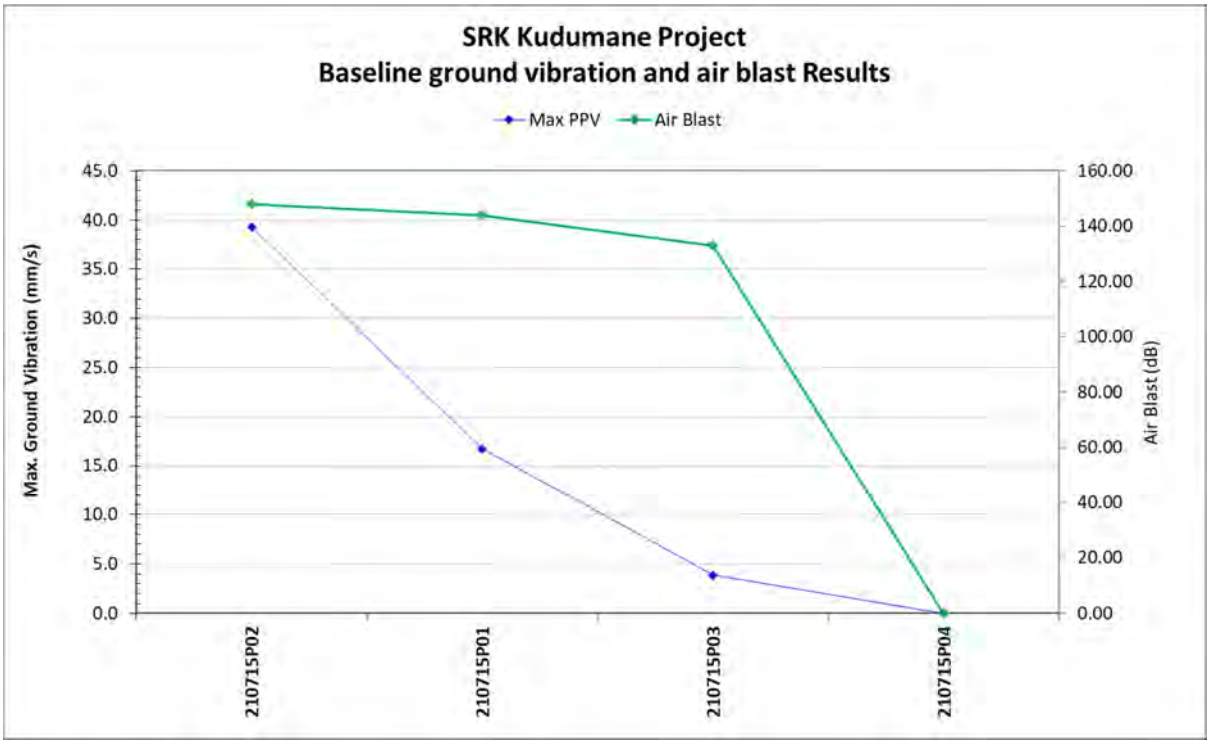


Figure 9: Attenuation of ground vibration and air blast

14.2 Structure profile

As part of the baseline, all possible structures in a possible influence area are identified. The site was reviewed using Google Earth imagery. Information sought during the review was to identify surface structures present in a 3500 m radius from the proposed open pit areas, which will require consideration during modelling of blasting operations, e.g. houses, general structures, power lines, pipelines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the open pit area. The list includes structures and POI within the 3500 m boundary – see Table 7 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 6. The classification used is a BM&C classification and does not relate to any standard or national or international code or practice. Table 6 shows the descriptions for the classifications used.

Table 6: 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

Class	Description
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 7: List of points of interest identified (WGS – LO 23°)

Tag	Description	Classification	Y	X
1	Sewage Plant (Gloria Mine)	6	8807.92	3007080.95
2	Mine Activity	6	8741.54	3006841.10
3	Railway Line	6	10022.50	3006285.67
4	Railway Line	6	8631.30	3007319.29
5	Railway Line	6	8218.01	3007672.85
6	Railway Line	6	7812.22	3008087.95
7	Railway Line	6	7628.32	3008478.02
8	Railway Line	6	7491.02	3008861.93
9	Railway Line	6	7158.28	3009251.00
10	Railway Line	6	6278.60	3009763.47
11	Railway Line	6	5361.28	3010289.83
12	Railway Line	6	4572.16	3010741.22
13	Railway Line	6	4102.67	3011016.33
14	Farm Buildings/Structures	2	8522.64	3005987.03
15	Vent Shaft	3	9888.86	3006090.41
16	Mine Buildings/Structures	3	9078.69	3006478.69
17	Mining Installation	3	9811.19	3006853.37
18	R380 Road	14	9135.92	3008167.17
19	Explosive Magazine	3	10098.52	3009617.51
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	3	9779.82	3010238.01
21	Conveyor	6	9748.20	3010194.20
22	Dam	11	9401.53	3009910.09
23	Mining Plant	3	10290.34	3011252.67
24	Railway Line	6	10366.25	3010887.47
25	Mining Plant	3	10099.76	3012145.28
26	Sub Station	3	9447.83	3012049.58
27	Dam	11	9405.47	3011276.95
28	Return Water Dam	6	10613.91	3012920.62
29	Buildings/Structures	2	9473.78	3012707.32
30	Security Offices	2	9089.47	3012803.12
31	Conveyor Tower	6	10379.64	3012393.03
32	Industrial Structures	3	9472.71	3012899.30
33	Transformer	6	10346.19	3014095.64
34	R31 Road	14	7940.39	3012961.47
35	Gravel Road	14	7617.81	3008754.82

Tag	Description	Classification	Y	X
36	R380 Road	14	6926.81	3009421.69
37	Gravel Road	14	7887.18	3008928.19
38	Mine Buildings/Structures	3	7002.16	3011226.48
39	Reservoir	11	5098.48	3009642.18
40	Houses	2	4995.56	3009926.74
41	Houses	2	4771.81	3009996.50
42	Houses	2	4754.60	3009739.80
43	Hotazel Golf Club	2	4778.30	3009872.48
44	Hotazel Municipal Clinic	3	4485.16	3009903.03
45	Pool	2	4344.47	3009842.17
46	School	2	4380.90	3009772.13
47	Sports field	2	4232.87	3009737.54
48	School	2	4306.89	3009557.20
49	House	2	4511.45	3009690.80
50	Houses	2	4191.01	3009427.98
51	Houses	2	4547.16	3010020.44
52	Hostel	2	4250.10	3009957.68
53	Houses	2	4390.12	3010021.55
54	Airfield Structure	3	5131.60	3010914.58
55	Landing Strip	6	5207.94	3010688.80
56	Landing Strip	6	5182.07	3011303.87
57	Landing Strip	6	5147.09	3012110.25
58	Sub Station	3	4178.69	3010439.20
59	Power lines/Pylons	13	4080.61	3011259.51
60	R380 Road	14	6617.27	3009602.09
61	R31 Road	14	3561.49	3013265.45
62	Railway Line	6	3146.36	3013249.85
63	Power lines/Pylons	13	3874.50	3012287.83
64	Power lines/Pylons	13	3829.69	3012746.14
65	Power lines/Pylons	13	3774.11	3013342.04
66	Power lines/Pylons	13	3404.09	3013760.56
67	Structures	2	3080.91	3013834.46
68	Railway Line	6	3076.38	3013673.62
69	Railway Line	6	3018.61	3014022.09
70	Railway Line	6	2908.55	3014663.46
71	Mine Activity	6	6985.66	3013795.81
72	Mine Buildings/Structures	3	6124.80	3015441.66
73	Gravel Road	14	6797.41	3015614.46
74	Old Farmstead (Inside York Pit Area)	8	7859.09	3014890.11
75	Farm Buildings/Structures	2	8024.94	3017127.66
76	Structure	2	8530.94	3018294.00
77	Rail Loading Bay	6	6080.60	3014728.56
78	Railway Line	6	5884.20	3014897.10
79	Mine Buildings	3	6284.84	3015147.38
80	Return Water Dam	6	7000.03	3015510.87
81	Railway Line	6	7065.66	3016415.45

Tag	Description	Classification	Y	X
82	Railway Line Bridge	6	6764.62	3016293.57
83	Buildings	2	6927.71	3016587.94
84	Transformer	6	5332.00	3015401.59
85	Pipeline	12	9544.11	3011229.67
86	Pipeline	12	9543.14	3010340.03
87	Power Line/Pylon	13	9155.68	3012079.96
88	Power Line/Pylon	13	8929.80	3012099.46
89	Power Line/Pylon	13	8687.77	3012118.69
90	Power Line/Pylon	13	8449.90	3012137.03
91	Power Line/Pylon	13	8220.34	3012156.65
92	Power Line/Pylon	13	7975.90	3012173.35
93	Power Line/Pylon	13	7603.17	3012202.40
94	Power Line/Pylon	13	7375.21	3012224.07
95	Power Line/Pylon	13	7115.45	3012245.75
96	Power Line/Pylon	13	6858.02	3012267.43
97	Power Line/Pylon	13	6773.52	3012513.37
98	Power Line/Pylon	13	6699.01	3012766.64
99	Power Line/Pylon	13	6617.84	3013014.83
100	Power Line/Pylon	13	6539.00	3013256.72
101	Power Line/Pylon	13	6462.36	3013495.53
102	Power Line/Pylon	13	6398.29	3013702.23
103	Power Line/Pylon	13	6315.78	3013961.70
104	Power Line/Pylon	13	6048.44	3014019.59
105	Power Line/Pylon	13	5834.43	3014067.53
106	Power Line/Pylon	13	5580.82	3014121.31
107	Power Line/Pylon	13	5334.33	3014174.13
108	Power Line/Pylon	13	5095.75	3014227.57
109	Power Line/Pylon	13	4856.64	3014278.10
110	Power Line/Pylon	13	4612.16	3014332.35
111	Power Line/Pylon	13	4376.03	3014382.98
112	Power Line/Pylon	13	4144.43	3014434.43
113	Power Line/Pylon	13	3901.37	3014488.85
114	Power Line/Pylon	13	3869.48	3014666.67
115	Power Line/Pylon	13	3794.34	3014947.17
116	Power Line/Pylon	13	3716.24	3015161.15
117	Power Line/Pylon	13	3679.01	3015397.98
118	Power Line/Pylon	13	3633.10	3015638.35
119	Power Line/Pylon	13	3594.51	3015870.45
120	Power Line/Pylon	13	3552.66	3016103.06
121	Power Line/Pylon	13	3513.51	3016333.29
122	Power Line/Pylon	13	3472.08	3016576.66
123	Attenuation Dam (Planned)	11	8000.15	3011927.89
124	Attenuation Dam (Planned)	11	7426.22	3014004.99
125	Railway Line	6	6118.59	3014603.12
126	Railway Line	6	10372.49	3012060.34
127	Diversion R380 Road (Planned)	14	7553.33	3008875.04

Tag	Description	Classification	Y	X
128	Potable Water Pipeline (Planned)	12	6072.55	3010058.55
129	Potable Water Pipeline (Planned)	12	6766.24	3011495.26
130	Potable Water Pipeline (Planned)	12	6712.95	3013242.54
131	Waterhole	11	4333.15	3013233.82
132	Structure	2	5103.39	3013235.08
133	Lodge	2	5057.78	3013654.63
134	Mine Buildings/Structures	3	6963.51	3013121.79
135	Reservoir	11	6699.47	3013228.92
136	H4 - Potential grave (Inside Hotazel Pit Area)	9	8314.60	3011097.13
137	Hydrocensus Borehole (gl27)	10	9806.69	3008560.13
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	10	7988.81	3011012.76
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	10	8030.24	3010837.38
140	Hydrocensus Borehole (Htwm005)	10	7117.45	3011109.07
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	10	8180.82	3011002.25
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	10	8078.87	3011000.63
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	10	8177.08	3011104.19
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	10	8077.92	3011102.91
145	Hydrocensus Borehole (Mk01)	10	10202.71	3008358.45
146	Hydrocensus Borehole (Mk02)	10	7996.77	3008201.05
147	Hydrocensus Borehole (T1)	10	7599.61	3015804.93
148	Hydrocensus Borehole (T2)	10	7396.59	3015802.59
149	Hydrocensus Borehole (T6)	10	7997.46	3016190.79
150	Hydrocensus Borehole (wh02)	10	8016.87	3009442.75
151	Hydrocensus Borehole (windmill 4)	10	7291.18	3014027.95
152	Hydrocensus Borehole (Wu06)	10	7637.36	3013034.65
153	Hydrocensus Borehole (YGW01)	10	5983.75	3015118.14
154	Hydrocensus Borehole ((YGW03)	10	6557.81	3013921.71
155	Hydrocensus Borehole (YGW04)	10	7280.83	3013937.64
156	Hydrocensus Borehole (YGW05)	10	5632.56	3014279.17
157	Hydrocensus Borehole (Ykdw4)	10	7290.29	3014022.51
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	8	7664.18	3010852.50
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	8	7755.22	3010477.04
160	Heritage (KMR 003 - Scatter of stone tools)	8	7714.13	3010181.53
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	8	7599.62	3012917.78
162	Heritage (KMR 005 - Scatter of stone tools)	8	7581.11	3011683.50
163	Heritage (KMR 007 - Burial Ground)	8	8128.79	3010725.86
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	8	8956.55	3010009.51
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	8	8352.30	3011304.42
166	Heritage (KAL03 - Artefacts)	8	8351.25	3011395.28
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	8	8328.47	3011379.75

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 blast design is required to determine possible influences.
During the site visit two typical blasts were observed. The information from these blasts were applied as baseline data and used for input into the evaluation.

Table 8 shows summary technical information for the blasts monitored and applied for this evaluation.

Table 8: Blast design technical information

Technical	
Blast Design - Kudu 559	
Block	BCM 37 241.95
Pattern 1	
Number of Holes	107
Burden	4
Spacing	4.5
Diameter	171
Number of decks per hole	1
Explosives	INNOVEX™ 100
Total Explosives	32 373.82 kg
Hole Powder Factor	1.09
Hole Energy Factor	0.94
Summary	
Total Holes	107
Total Detonators	107
Average Hole Depth	15.6 m
Average Explosives per hole	302.6
Total Explosives	32 373.81 kg
Total Meters Drilled	1 774.7
Average Hole Powder Factor	1.09
Average Hole Energy Factor	0.94
Average Block Powder Factor	0.87
Average Block Energy Factor	0.76
Maximum Instantaneous Charge =	1284.69
Technical	
Blast Design - Kudu 558 C strip Final design	
Block	BCM Not Provided
Pattern 1	
Number of Holes	895

Burden	4
Spacing	4.5
Diameter	171
Number of decks per hole	1
Explosives	INNOVEX™ 100
Total Explosives	149 244.1 kg
Hole Powder Factor	0.96
Hole Energy Factor	0.84
Summary	
Total Holes	895
Total Detonators	895
Average Hole Depth	9.8 m
Average Explosives per hole	166.8
Total Explosives	149 244 kg
Total Meters Drilled	9 667.2
Average Hole Powder Factor	0.96
Average Hole Energy Factor	0.84
Maximum Instantaneous Charge =	386.28

Both blasts were designed and simulated by BME (Bulk Mining Explosives). BME is conducting the blasting operations on site. Both blast designs provide values for Maximum instantaneous charge that is used in the modelling of ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the design for the Kudu 558 C strip and the maximum charge from the design for Kudu 559. The Maximum instantaneous charge relates to the maximum charge associated with the maximum number of blastholes detonating within 8ms of each other. The minimum charge applied relates to 386 kg and the maximum charge applied relates to 1285 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:

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

Where:

PPV = Predicted ground vibration (mm/s)

a = Site constant

b = Site constant

D = Distance (m)

E = Explosive Mass (kg)

Applicable and accepted factors a 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 386 kg and 1285 kg for the Pit areas.

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

No.	Distance (m)	Expected PPV (mm/s) for 386 kg Charge	Expected PPV (mm/s) for 1285 kg Charge
1	50.0	244.7	660.1
2	100.0	125.4	338.1
3	150.0	39.9	107.7
4	200.0	24.8	67.0
5	250.0	17.2	46.4
6	300.0	12.7	34.3
7	400.0	7.9	21.4
8	500.0	5.5	14.8
9	600.0	4.1	10.9
10	700.0	3.1	8.5
11	800.0	2.5	6.8
12	900.0	2.1	5.6
13	1000.0	1.7	4.7
14	1250.0	1.2	3.3
15	1500.0	0.9	2.4
16	1750.0	0.7	1.9
17	2000.0	0.6	1.5
18	2500.0	0.4	1.0
19	3000.0	0.3	0.8
20	3500.0	0.2	0.6

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 10 below. Various types of mining operations are expected to yield different results. The information provided in Figure 10 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 10: Proposed prediction equations

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

Equation 3:

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

Where:

p_s = Air blast level (dB)

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

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

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

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 386 kg Charge	Air blast (dB) for 1285 kg Charge
1	50.0	145.2	147.6
2	100.0	142.7	145.1
3	150.0	138.4	140.9
4	200.0	136.6	139.1
5	250.0	135.2	137.7
6	300.0	134.1	136.6
7	400.0	132.3	134.8
8	500.0	131.0	133.4
9	600.0	129.8	132.3

No.	Distance (m)	Air blast (dB) for 386 kg Charge	Air blast (dB) for 1285 kg Charge
10	700.0	128.9	131.4
11	800.0	128.1	130.5
12	900.0	127.3	129.8
13	1000.0	126.7	129.2
14	1250.0	125.3	127.8
15	1500.0	124.2	126.7
16	1750.0	123.2	125.7
17	2000.0	122.4	124.9
18	2500.0	121.0	123.5
19	3000.0	119.9	122.4
20	3500.0	119.0	121.5

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 7. This section concentrates on the outcome of modelling the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces. In evaluation, the charge mass scenarios selected as indicated in section 14.2 is considered with regards to ground vibration and air blast.

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

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

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

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

17.1 Review of expected ground vibration

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

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

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

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

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

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

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

17.1.1 Ground vibration minimum charge mass per delay – York Pit - 386 kg

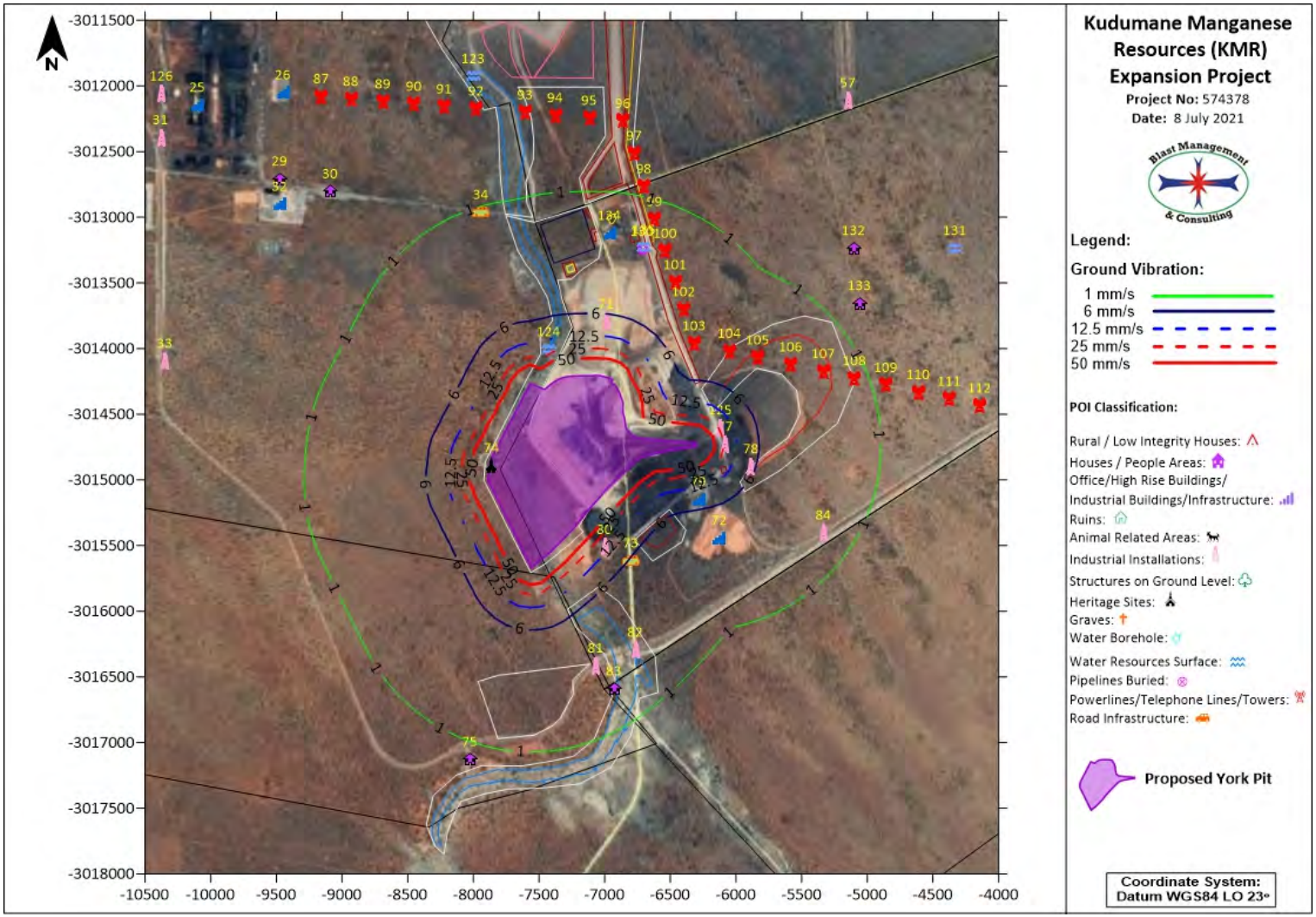


Figure 11: Ground vibration influence from minimum charge per delay for York Pit

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

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
25	Mining Plant	25	3306	386	0.2	Acceptable	Too Low
26	Sub Station	25	2910	386	0.3	Acceptable	Too Low
27	Dam	50	3512	386	0.2	Acceptable	N/A
28	Return Water Dam	25	3324	386	0.2	Acceptable	Too Low
29	Buildings/Structures	12.5	2465	386	0.4	Acceptable	Too Low
30	Security Offices	12.5	2114	386	0.5	Acceptable	Too Low
31	Conveyor Tower	50	3381	386	0.2	Acceptable	Too Low
32	Industrial Structures	50	2347	386	0.4	Acceptable	Too Low
33	Transformer	15	2587	386	0.4	Acceptable	Too Low
34	R31 Road	150	1359	386	1.1	Acceptable	N/A
38	Mine Buildings/Structures	25	2980	386	0.3	Acceptable	Too Low
56	Landing Strip	150	3420	386	0.2	Acceptable	Too Low
57	Landing Strip	150	2783	386	0.3	Acceptable	Too Low
61	R31 Road	150	3100	386	0.3	Acceptable	N/A
62	Railway Line	150	3478	386	0.2	Acceptable	Too Low
63	Power lines/Pylons	75	3432	386	0.2	Acceptable	N/A
64	Power lines/Pylons	75	3160	386	0.3	Acceptable	N/A
65	Power lines/Pylons	75	2876	386	0.3	Acceptable	N/A
66	Power lines/Pylons	75	3050	386	0.3	Acceptable	N/A
67	Structures	12.5	3338	386	0.2	Acceptable	Too Low
68	Railway Line	150	3389	386	0.2	Acceptable	Too Low
69	Railway Line	150	3355	386	0.2	Acceptable	Too Low
70	Railway Line	150	3391	386	0.2	Acceptable	Too Low
71	Mine Activity	200	415	386	7.5	Acceptable	N/A
72	Mine Buildings/Structures	25	717	386	3.0	Acceptable	Perceptible
73	Gravel Road	200	495	386	5.6	Acceptable	N/A
74	Old Farmstead (Inside York Pit Area)	6	-	386	-	-	-
75	Farm Buildings/Structures	12.5	1531	386	0.9	Acceptable	Perceptible
76	Structure	12.5	2799	386	0.3	Acceptable	Too Low
77	Rail Loading Bay	150	219	386	21.4	Acceptable	Intolerable
78	Railway Line	150	441	386	6.7	Acceptable	N/A
79	Mine Buildings	25	399	386	8.0	Acceptable	Unpleasant
80	Return Water Dam	25	273	386	14.9	Acceptable	Unpleasant
81	Railway Line	150	894	386	2.1	Acceptable	N/A
82	Railway Line Bridge	50	986	386	1.8	Acceptable	N/A
83	Buildings	12.5	1114	386	1.5	Acceptable	Perceptible
84	Transformer	15	1168	386	1.4	Acceptable	N/A
87	Power Line/Pylon	75	2705	386	0.3	Acceptable	N/A
88	Power Line/Pylon	75	2562	386	0.4	Acceptable	N/A
89	Power Line/Pylon	75	2425	386	0.4	Acceptable	N/A
90	Power Line/Pylon	75	2307	386	0.4	Acceptable	N/A
91	Power Line/Pylon	75	2210	386	0.5	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
92	Power Line/Pylon	75	2134	386	0.5	Acceptable	N/A
93	Power Line/Pylon	75	2037	386	0.5	Acceptable	N/A
94	Power Line/Pylon	75	1991	386	0.6	Acceptable	N/A
95	Power Line/Pylon	75	1961	386	0.6	Acceptable	N/A
96	Power Line/Pylon	75	1948	386	0.6	Acceptable	N/A
97	Power Line/Pylon	75	1714	386	0.7	Acceptable	N/A
98	Power Line/Pylon	75	1480	386	0.9	Acceptable	N/A
99	Power Line/Pylon	75	1259	386	1.2	Acceptable	N/A
100	Power Line/Pylon	75	1057	386	1.6	Acceptable	N/A
101	Power Line/Pylon	75	883	386	2.1	Acceptable	N/A
102	Power Line/Pylon	75	762	386	2.7	Acceptable	N/A
103	Power Line/Pylon	75	682	386	3.3	Acceptable	N/A
104	Power Line/Pylon	75	741	386	2.9	Acceptable	N/A
105	Power Line/Pylon	75	799	386	2.5	Acceptable	N/A
106	Power Line/Pylon	75	934	386	2.0	Acceptable	N/A
107	Power Line/Pylon	75	1108	386	1.5	Acceptable	N/A
108	Power Line/Pylon	75	1300	386	1.1	Acceptable	N/A
109	Power Line/Pylon	75	1509	386	0.9	Acceptable	N/A
110	Power Line/Pylon	75	1732	386	0.7	Acceptable	N/A
111	Power Line/Pylon	75	1953	386	0.6	Acceptable	N/A
112	Power Line/Pylon	75	2175	386	0.5	Acceptable	N/A
113	Power Line/Pylon	75	2410	386	0.4	Acceptable	N/A
114	Power Line/Pylon	75	2430	386	0.4	Acceptable	N/A
115	Power Line/Pylon	75	2512	386	0.4	Acceptable	N/A
116	Power Line/Pylon	75	2616	386	0.4	Acceptable	N/A
117	Power Line/Pylon	75	2700	386	0.3	Acceptable	N/A
118	Power Line/Pylon	75	2811	386	0.3	Acceptable	N/A
119	Power Line/Pylon	75	2929	386	0.3	Acceptable	N/A
120	Power Line/Pylon	75	3063	386	0.3	Acceptable	N/A
121	Power Line/Pylon	75	3206	386	0.3	Acceptable	N/A
122	Power Line/Pylon	75	3368	386	0.2	Acceptable	N/A
123	Attenuation Dam (Planned)	50	2380	386	0.4	Acceptable	N/A
124	Attenuation Dam (Planned)	50	240	386	18.4	Acceptable	N/A
125	Railway Line	150	214	386	22.2	Acceptable	N/A
129	Potable Water Pipeline (Planned)	50	2725	386	0.3	Acceptable	N/A
130	Potable Water Pipeline (Planned)	50	1014	386	1.7	Acceptable	N/A
131	Waterhole	150	2463	386	0.4	Acceptable	N/A
132	Structure	12.5	1904	386	0.6	Acceptable	Too Low
133	Lodge	12.5	1634	386	0.8	Acceptable	Perceptible
134	Mine Buildings/Structures	25	1088	386	1.5	Acceptable	Perceptible
135	Reservoir	50	1030	386	1.7	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
136	H4 - Potential grave (Inside Hotazel Pit Area)	50	3258	386	0.2	Acceptable	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	50	3278	386	0.2	Acceptable	N/A
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	50	3459	386	0.2	Acceptable	N/A
140	Hydrocensus Borehole (Htwm005)	50	3098	386	0.3	Acceptable	N/A
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	50	3323	386	0.2	Acceptable	N/A
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	50	3307	386	0.2	Acceptable	N/A
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	50	3222	386	0.3	Acceptable	N/A
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	50	3206	386	0.3	Acceptable	N/A
147	Hydrocensus Borehole (T1)	50	142	386	43.7	Acceptable	N/A
148	Hydrocensus Borehole (T2)	50	206	386	23.7	Acceptable	N/A
149	Hydrocensus Borehole (T6)	50	682	386	3.3	Acceptable	N/A
151	Hydrocensus Borehole (windmill 4)	50	186	386	28.1	Acceptable	N/A
152	Hydrocensus Borehole (Wu06)	50	1229	386	1.2	Acceptable	N/A
153	Hydrocensus Borehole (YGW01)	50	488	386	5.7	Acceptable	N/A
154	Hydrocensus Borehole ((YGW03)	50	496	386	5.6	Acceptable	N/A
155	Hydrocensus Borehole (YGW04)	50	275	386	14.7	Acceptable	N/A
156	Hydrocensus Borehole (YGW05)	50	798	386	2.5	Acceptable	N/A
157	Hydrocensus Borehole (Ykdw4)	50	191	386	26.8	Acceptable	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	6	3383	386	0.2	Acceptable	Too Low
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	6	1334	386	1.1	Acceptable	Perceptible
162	Heritage (KMR 005 - Scatter of stone tools)	150	2548	386	0.4	Acceptable	Too Low
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	150	3066	386	0.3	Acceptable	Too Low
166	Heritage (KAL03 - Artefacts)	150	2978	386	0.3	Acceptable	Too Low
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	150	2987	386	0.3	Acceptable	Too Low

17.1.2 Ground vibration maximum charge mass per delay – York Pit - 1285 kg

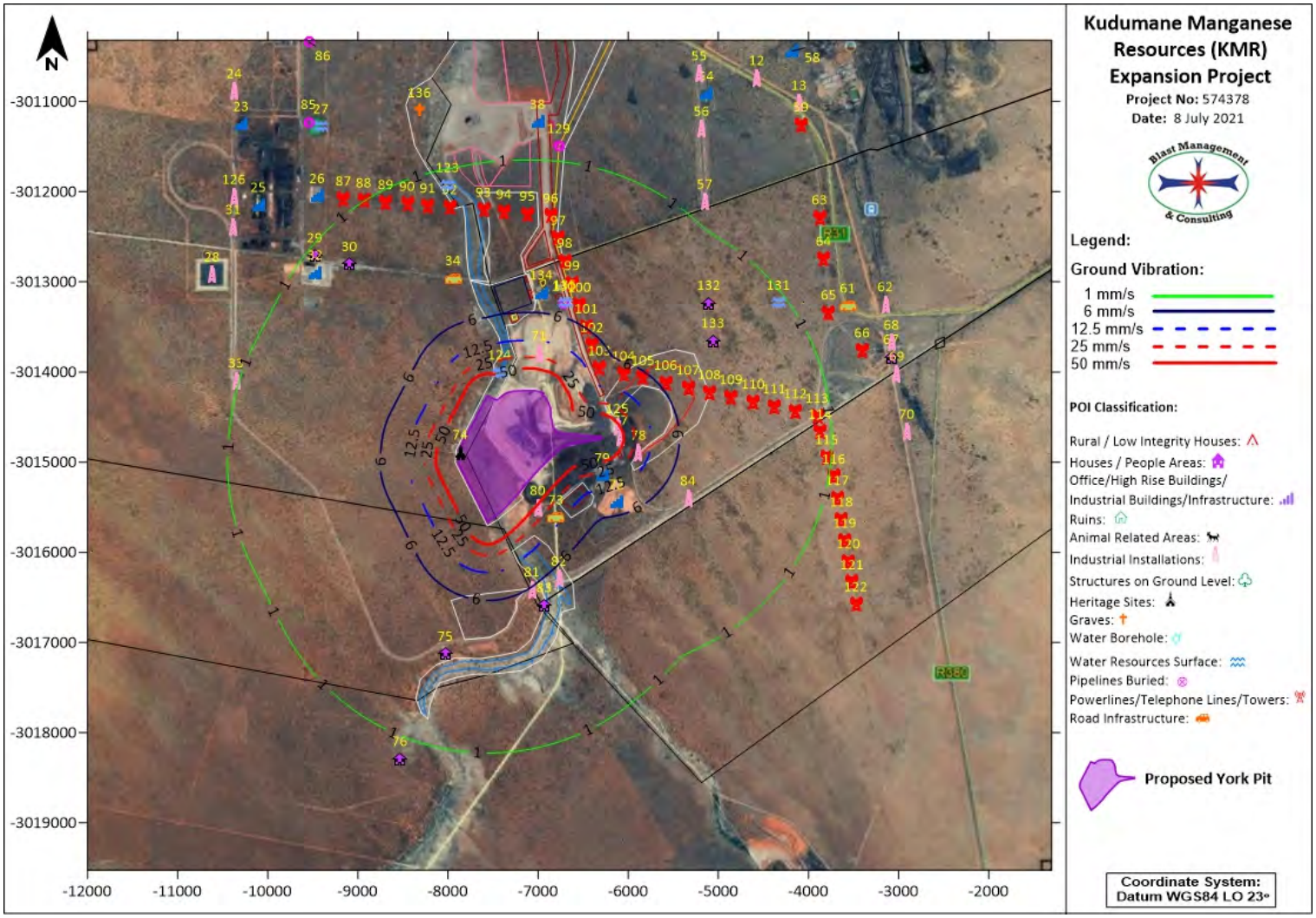


Figure 12: Ground vibration influence from maximum charge per delay for York Pit

Table 12: Ground vibration evaluation for maximum charge for York Pit

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
25	Mining Plant	25	3306	1285	0.7	Acceptable	Too Low
26	Sub Station	25	2910	1285	0.8	Acceptable	N/A
27	Dam	50	3512	1285	0.6	Acceptable	N/A
28	Return Water Dam	25	3324	1285	0.6	Acceptable	Too Low
29	Buildings/Structures	12.5	2465	1285	1.1	Acceptable	Perceptible
30	Security Offices	12.5	2114	1285	1.4	Acceptable	Perceptible
31	Conveyor Tower	50	3381	1285	0.6	Acceptable	Too Low
32	Industrial Structures	50	2347	1285	1.2	Acceptable	Perceptible
33	Transformer	15	2587	1285	1.0	Acceptable	N/A
34	R31 Road	150	1359	1285	2.8	Acceptable	N/A
38	Mine Buildings/Structures	25	2980	1285	0.8	Acceptable	Perceptible
56	Landing Strip	150	3420	1285	0.6	Acceptable	Too Low
57	Landing Strip	150	2783	1285	0.9	Acceptable	N/A
61	R31 Road	150	3100	1285	0.7	Acceptable	N/A
62	Railway Line	150	3478	1285	0.6	Acceptable	Too Low
63	Power lines/Pylons	75	3432	1285	0.6	Acceptable	N/A
64	Power lines/Pylons	75	3160	1285	0.7	Acceptable	N/A
65	Power lines/Pylons	75	2876	1285	0.8	Acceptable	N/A
66	Power lines/Pylons	75	3050	1285	0.7	Acceptable	N/A
67	Structures	12.5	3338	1285	0.6	Acceptable	Too Low
68	Railway Line	150	3389	1285	0.6	Acceptable	Too Low
69	Railway Line	150	3355	1285	0.6	Acceptable	Too Low
70	Railway Line	150	3391	1285	0.6	Acceptable	Too Low
71	Mine Activity	200	415	1285	20.1	Acceptable	N/A
72	Mine Buildings/Structures	25	717	1285	8.1	Acceptable	Unpleasant
73	Gravel Road	200	495	1285	15.0	Acceptable	N/A
74	Old Farmstead (Inside York Pit Area)	6	-	1285	-	-	-
75	Farm Buildings/Structures	12.5	1531	1285	2.3	Acceptable	Perceptible
76	Structure	12.5	2799	1285	0.9	Acceptable	Perceptible
77	Rail Loading Bay	150	219	1285	57.8	Acceptable	Intolerable
78	Railway Line	150	441	1285	18.2	Acceptable	N/A
79	Mine Buildings	25	399	1285	21.5	Acceptable	Intolerable
80	Return Water Dam	25	273	1285	40.2	Problematic	N/A
81	Railway Line	150	894	1285	5.7	Acceptable	N/A
82	Railway Line Bridge	50	986	1285	4.8	Acceptable	N/A
83	Buildings	12.5	1114	1285	3.9	Acceptable	Perceptible
84	Transformer	15	1168	1285	3.6	Acceptable	N/A
87	Power Line/Pylon	75	2705	1285	0.9	Acceptable	N/A
88	Power Line/Pylon	75	2562	1285	1.0	Acceptable	N/A
89	Power Line/Pylon	75	2425	1285	1.1	Acceptable	N/A
90	Power Line/Pylon	75	2307	1285	1.2	Acceptable	N/A
91	Power Line/Pylon	75	2210	1285	1.3	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
92	Power Line/Pylon	75	2134	1285	1.3	Acceptable	N/A
93	Power Line/Pylon	75	2037	1285	1.5	Acceptable	N/A
94	Power Line/Pylon	75	1991	1285	1.5	Acceptable	N/A
95	Power Line/Pylon	75	1961	1285	1.5	Acceptable	N/A
96	Power Line/Pylon	75	1948	1285	1.6	Acceptable	N/A
97	Power Line/Pylon	75	1714	1285	1.9	Acceptable	N/A
98	Power Line/Pylon	75	1480	1285	2.5	Acceptable	N/A
99	Power Line/Pylon	75	1259	1285	3.2	Acceptable	N/A
100	Power Line/Pylon	75	1057	1285	4.3	Acceptable	N/A
101	Power Line/Pylon	75	883	1285	5.8	Acceptable	N/A
102	Power Line/Pylon	75	762	1285	7.4	Acceptable	N/A
103	Power Line/Pylon	75	682	1285	8.9	Acceptable	N/A
104	Power Line/Pylon	75	741	1285	7.7	Acceptable	N/A
105	Power Line/Pylon	75	799	1285	6.8	Acceptable	N/A
106	Power Line/Pylon	75	934	1285	5.3	Acceptable	N/A
107	Power Line/Pylon	75	1108	1285	4.0	Acceptable	N/A
108	Power Line/Pylon	75	1300	1285	3.1	Acceptable	N/A
109	Power Line/Pylon	75	1509	1285	2.4	Acceptable	N/A
110	Power Line/Pylon	75	1732	1285	1.9	Acceptable	N/A
111	Power Line/Pylon	75	1953	1285	1.6	Acceptable	N/A
112	Power Line/Pylon	75	2175	1285	1.3	Acceptable	N/A
113	Power Line/Pylon	75	2410	1285	1.1	Acceptable	N/A
114	Power Line/Pylon	75	2430	1285	1.1	Acceptable	N/A
115	Power Line/Pylon	75	2512	1285	1.0	Acceptable	N/A
116	Power Line/Pylon	75	2616	1285	1.0	Acceptable	N/A
117	Power Line/Pylon	75	2700	1285	0.9	Acceptable	N/A
118	Power Line/Pylon	75	2811	1285	0.9	Acceptable	N/A
119	Power Line/Pylon	75	2929	1285	0.8	Acceptable	N/A
120	Power Line/Pylon	75	3063	1285	0.7	Acceptable	N/A
121	Power Line/Pylon	75	3206	1285	0.7	Acceptable	N/A
122	Power Line/Pylon	75	3368	1285	0.6	Acceptable	N/A
123	Attenuation Dam (Planned)	50	2380	1285	1.1	Acceptable	N/A
124	Attenuation Dam (Planned)	50	240	1285	49.5	Acceptable	N/A
125	Railway Line	150	214	1285	59.8	Acceptable	N/A
129	Potable Water Pipeline (Planned)	50	2725	1285	0.9	Acceptable	N/A
130	Potable Water Pipeline (Planned)	50	1014	1285	4.6	Acceptable	N/A
131	Waterhole	150	2463	1285	1.1	Acceptable	N/A
132	Structure	12.5	1904	1285	1.6	Acceptable	Perceptible
133	Lodge	12.5	1634	1285	2.1	Acceptable	Perceptible
134	Mine Buildings/Structures	25	1088	1285	4.1	Acceptable	Perceptible
135	Reservoir	50	1030	1285	4.5	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
136	H4 - Potential grave (Inside Hotazel Pit Area)	50	3258	1285	0.7	Acceptable	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	50	3278	1285	0.7	Acceptable	N/A
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	50	3459	1285	0.6	Acceptable	N/A
140	Hydrocensus Borehole (Htwm005)	50	3098	1285	0.7	Acceptable	N/A
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	50	3323	1285	0.6	Acceptable	N/A
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	50	3307	1285	0.7	Acceptable	N/A
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	50	3222	1285	0.7	Acceptable	N/A
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	50	3206	1285	0.7	Acceptable	N/A
147	Hydrocensus Borehole (T1)	50	142	1285	117.9	Problematic	N/A
148	Hydrocensus Borehole (T2)	50	206	1285	64.0	Problematic	N/A
149	Hydrocensus Borehole (T6)	50	682	1285	8.9	Acceptable	N/A
151	Hydrocensus Borehole (windmill 4)	50	186	1285	75.8	Problematic	N/A
152	Hydrocensus Borehole (Wu06)	50	1229	1285	3.3	Acceptable	N/A
153	Hydrocensus Borehole (YGW01)	50	488	1285	15.4	Acceptable	N/A
154	Hydrocensus Borehole ((YGW03)	50	496	1285	15.0	Acceptable	N/A
155	Hydrocensus Borehole (YGW04)	50	275	1285	39.6	Acceptable	N/A
156	Hydrocensus Borehole (YGW05)	50	798	1285	6.8	Acceptable	N/A
157	Hydrocensus Borehole (Ykdw4)	50	191	1285	72.4	Problematic	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	6	3383	1285	0.6	Acceptable	Too Low
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	6	1334	1285	2.9	Acceptable	Perceptible
162	Heritage (KMR 005 - Scatter of stone tools)	150	2548	1285	1.0	Acceptable	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	150	3066	1285	0.7	Acceptable	Too Low
166	Heritage (KAL03 - Artefacts)	150	2978	1285	0.8	Acceptable	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	150	2987	1285	0.8	Acceptable	N/A

17.1.3 Ground vibration minimum charge mass per delay – Hotazel Pit - 386 kg

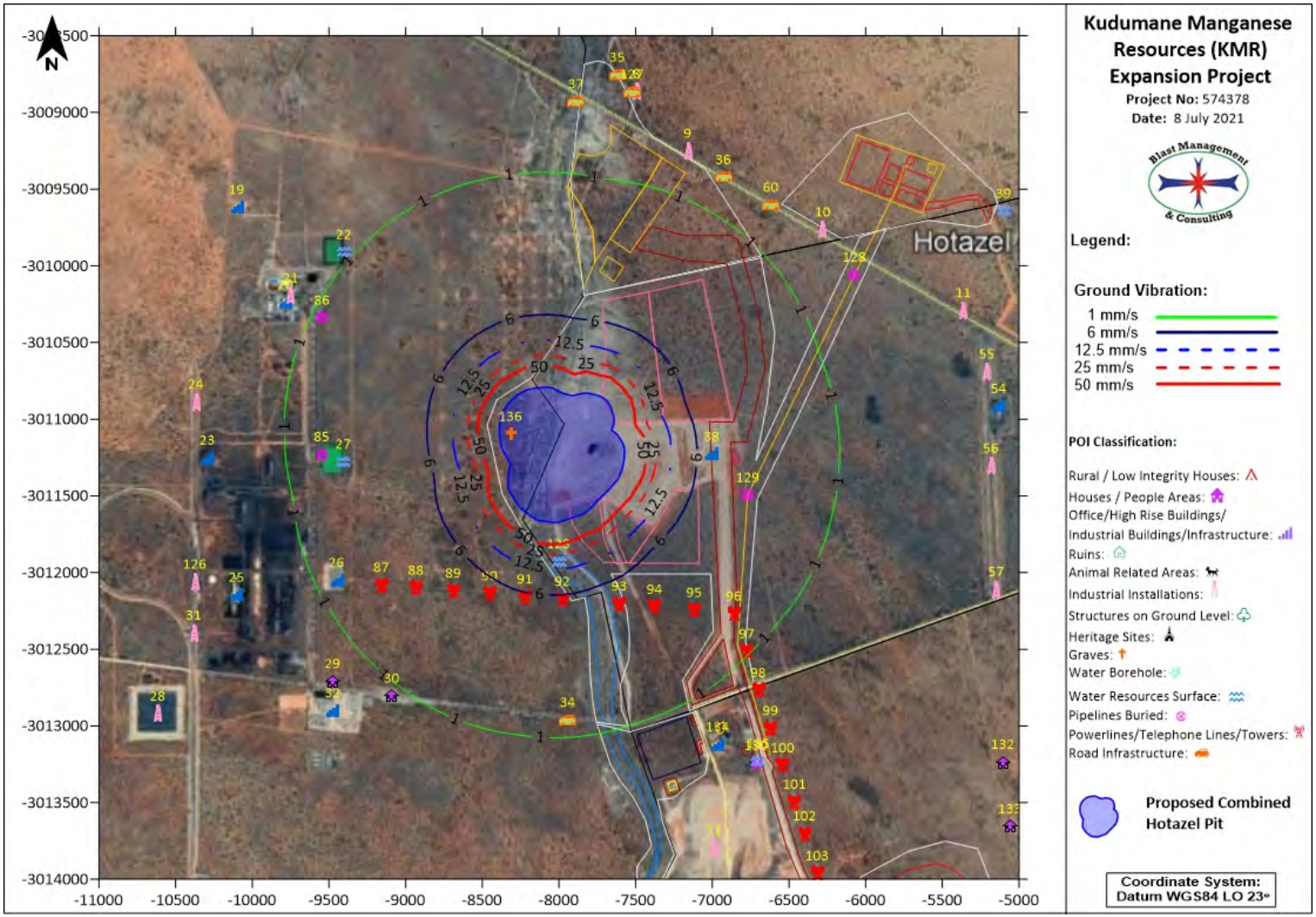


Figure 13: Ground vibration influence from minimum charge per delay for Hotazel Pit

Table 13: Ground vibration evaluation for minimum charge for Hotazel Pit

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
4	Railway Line	150	3510	386	0.2	Acceptable	Too Low
5	Railway Line	150	3121	386	0.3	Acceptable	Too Low
6	Railway Line	150	2716	386	0.3	Acceptable	Too Low
7	Railway Line	150	2355	386	0.4	Acceptable	Too Low
8	Railway Line	150	1994	386	0.6	Acceptable	Too Low
9	Railway Line	150	1699	386	0.7	Acceptable	Too Low
10	Railway Line	150	1799	386	0.7	Acceptable	Too Low
11	Railway Line	150	2384	386	0.4	Acceptable	Too Low
12	Railway Line	150	3036	386	0.3	Acceptable	Too Low
13	Railway Line	150	3475	386	0.2	Acceptable	Too Low
18	R380 Road	150	2801	386	0.3	Acceptable	N/A
19	Explosive Magazine	25	2184	386	0.5	Acceptable	Too Low
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	25	1585	386	0.8	Acceptable	Perceptible
21	Conveyor	150	1578	386	0.8	Acceptable	N/A
22	Dam	50	1457	386	0.9	Acceptable	N/A
23	Mining Plant	25	1908	386	0.6	Acceptable	Too Low
24	Railway Line	150	1985	386	0.6	Acceptable	Too Low
25	Mining Plant	25	1900	386	0.6	Acceptable	Too Low
26	Sub Station	25	1265	386	1.2	Acceptable	N/A
27	Dam	50	1032	386	1.7	Acceptable	N/A
28	Return Water Dam	25	2710	386	0.3	Acceptable	Too Low
29	Buildings/Structures	12.5	1662	386	0.8	Acceptable	Too Low
30	Security Offices	12.5	1480	386	0.9	Acceptable	Perceptible
31	Conveyor Tower	50	2254	386	0.5	Acceptable	Too Low
32	Industrial Structures	50	1797	386	0.7	Acceptable	Too Low
33	Transformer	15	3273	386	0.2	Acceptable	Too Low
34	R31 Road	150	1290	386	1.1	Acceptable	N/A
35	Gravel Road	200	2085	386	0.5	Acceptable	N/A
36	R380 Road	150	1639	386	0.8	Acceptable	N/A
37	Gravel Road	200	1873	386	0.6	Acceptable	N/A
38	Mine Buildings/Structures	25	571	386	4.4	Acceptable	Perceptible
39	Reservoir	50	2865	386	0.3	Acceptable	N/A
40	Houses	12.5	2846	386	0.3	Acceptable	Too Low
41	Houses	12.5	3035	386	0.3	Acceptable	Too Low
42	Houses	12.5	3139	386	0.3	Acceptable	Too Low
43	Hotazel Golf Club	25	3069	386	0.3	Acceptable	Too Low
44	Hotazel Municipal Clinic	25	3336	386	0.2	Acceptable	Too Low
45	Pool	25	3489	386	0.2	Acceptable	Too Low
46	School	25	3477	386	0.2	Acceptable	Too Low
49	House	12.5	3383	386	0.2	Acceptable	Too Low
51	Houses	12.5	3241	386	0.3	Acceptable	Too Low
53	Houses	12.5	3390	386	0.2	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
54	Airfield Structure	50	2458	386	0.4	Acceptable	Too Low
55	Landing Strip	150	2419	386	0.4	Acceptable	Too Low
56	Landing Strip	150	2392	386	0.4	Acceptable	Too Low
57	Landing Strip	150	2564	386	0.4	Acceptable	Too Low
58	Sub Station	25	3477	386	0.2	Acceptable	Too Low
59	Power lines/Pylons	75	3492	386	0.2	Acceptable	N/A
60	R380 Road	150	1667	386	0.8	Acceptable	N/A
71	Mine Activity	200	2340	386	0.4	Acceptable	Too Low
74	Old Farmstead (Inside York Pit Area)	6	3220	386	0.3	Acceptable	Too Low
85	Pipeline	50	1163	386	1.4	Acceptable	N/A
86	Pipeline	50	1328	386	1.1	Acceptable	N/A
87	Power Line/Pylon	75	1029	386	1.7	Acceptable	N/A
88	Power Line/Pylon	75	854	386	2.3	Acceptable	N/A
89	Power Line/Pylon	75	693	386	3.2	Acceptable	N/A
90	Power Line/Pylon	75	568	386	4.4	Acceptable	N/A
91	Power Line/Pylon	75	504	386	5.4	Acceptable	N/A
92	Power Line/Pylon	75	502	386	5.5	Acceptable	N/A
93	Power Line/Pylon	75	632	386	3.7	Acceptable	N/A
94	Power Line/Pylon	75	763	386	2.7	Acceptable	N/A
95	Power Line/Pylon	75	951	386	1.9	Acceptable	N/A
96	Power Line/Pylon	75	1148	386	1.4	Acceptable	N/A
97	Power Line/Pylon	75	1382	386	1.0	Acceptable	N/A
98	Power Line/Pylon	75	1614	386	0.8	Acceptable	N/A
99	Power Line/Pylon	75	1853	386	0.6	Acceptable	N/A
100	Power Line/Pylon	75	2091	386	0.5	Acceptable	N/A
101	Power Line/Pylon	75	2328	386	0.4	Acceptable	N/A
102	Power Line/Pylon	75	2534	386	0.4	Acceptable	N/A
103	Power Line/Pylon	75	2796	386	0.3	Acceptable	N/A
104	Power Line/Pylon	75	2995	386	0.3	Acceptable	N/A
105	Power Line/Pylon	75	3164	386	0.3	Acceptable	N/A
106	Power Line/Pylon	75	3368	386	0.2	Acceptable	N/A
123	Attenuation Dam (Planned)	50	255	386	16.6	Acceptable	N/A
124	Attenuation Dam (Planned)	50	2403	386	0.4	Acceptable	N/A
125	Railway Line	150	3447	386	0.2	Acceptable	Too Low
126	Railway Line	150	2131	386	0.5	Acceptable	Too Low
127	Diversion R380 Road (Planned)	150	1972	386	0.6	Acceptable	N/A
128	Potable Water Pipeline (Planned)	50	1809	386	0.7	Acceptable	N/A
129	Potable Water Pipeline (Planned)	50	839	386	2.3	Acceptable	N/A
130	Potable Water Pipeline (Planned)	50	1977	386	0.6	Acceptable	N/A
132	Structure	12.5	3116	386	0.3	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
133	Lodge	12.5	3415	386	0.2	Acceptable	Too Low
134	Mine Buildings/Structures	25	1742	386	0.7	Acceptable	Too Low
135	Reservoir	50	1974	386	0.6	Acceptable	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	50	-	386	-	-	-
137	Hydrocensus Borehole (gl27)	50	2750	386	0.3	Acceptable	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	50	-	386	-	-	-
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	50	-	386	-	-	-
140	Hydrocensus Borehole (Htwm005)	50	464	386	6.2	Acceptable	N/A
141	Hydrocensus Borehole (KSX23) - Inside Hotazel Pit Area	50	-	386	-	-	-
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	50	-	386	-	-	-
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	50	-	386	-	-	-
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	50	-	386	-	-	-
145	Hydrocensus Borehole (Mk01)	50	3146	386	0.3	Acceptable	N/A
146	Hydrocensus Borehole (Mk02)	50	2592	386	0.4	Acceptable	N/A
150	Hydrocensus Borehole (wh02)	50	1350	386	1.1	Acceptable	N/A
151	Hydrocensus Borehole (windmill 4)	50	2461	386	0.4	Acceptable	N/A
152	Hydrocensus Borehole (Wu06)	50	1411	386	1.0	Acceptable	N/A
154	Hydrocensus Borehole ((YGW03)	50	2638	386	0.4	Acceptable	N/A
155	Hydrocensus Borehole (YGW04)	50	2378	386	0.4	Acceptable	N/A
156	Hydrocensus Borehole (YGW05)	50	3455	386	0.2	Acceptable	N/A
157	Hydrocensus Borehole (Ykdw4)	50	2456	386	0.4	Acceptable	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	6	37	386	396.5	Problematic	Intolerable
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	150	358	386	9.5	Acceptable	N/A
160	Heritage (KMR 003 - Scatter of stone tools)	150	656	386	3.5	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	6	1309	386	1.1	Acceptable	Perceptible
162	Heritage (KMR 005 - Scatter of stone tools)	150	225	386	20.5	Acceptable	N/A
163	Heritage (KMR 007 - Burial Ground)	50	68	386	146.3	Problematic	N/A
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	150	1078	386	1.5	Acceptable	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	150	30	386	553.2	Problematic	N/A
166	Heritage (KAL03 - Artefacts)	150	21	386	1056.7	Problematic	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	150	-	386	-	-	-

17.1.4 Ground vibration maximum charge mass per delay – Hotazel Pit - 1285 kg

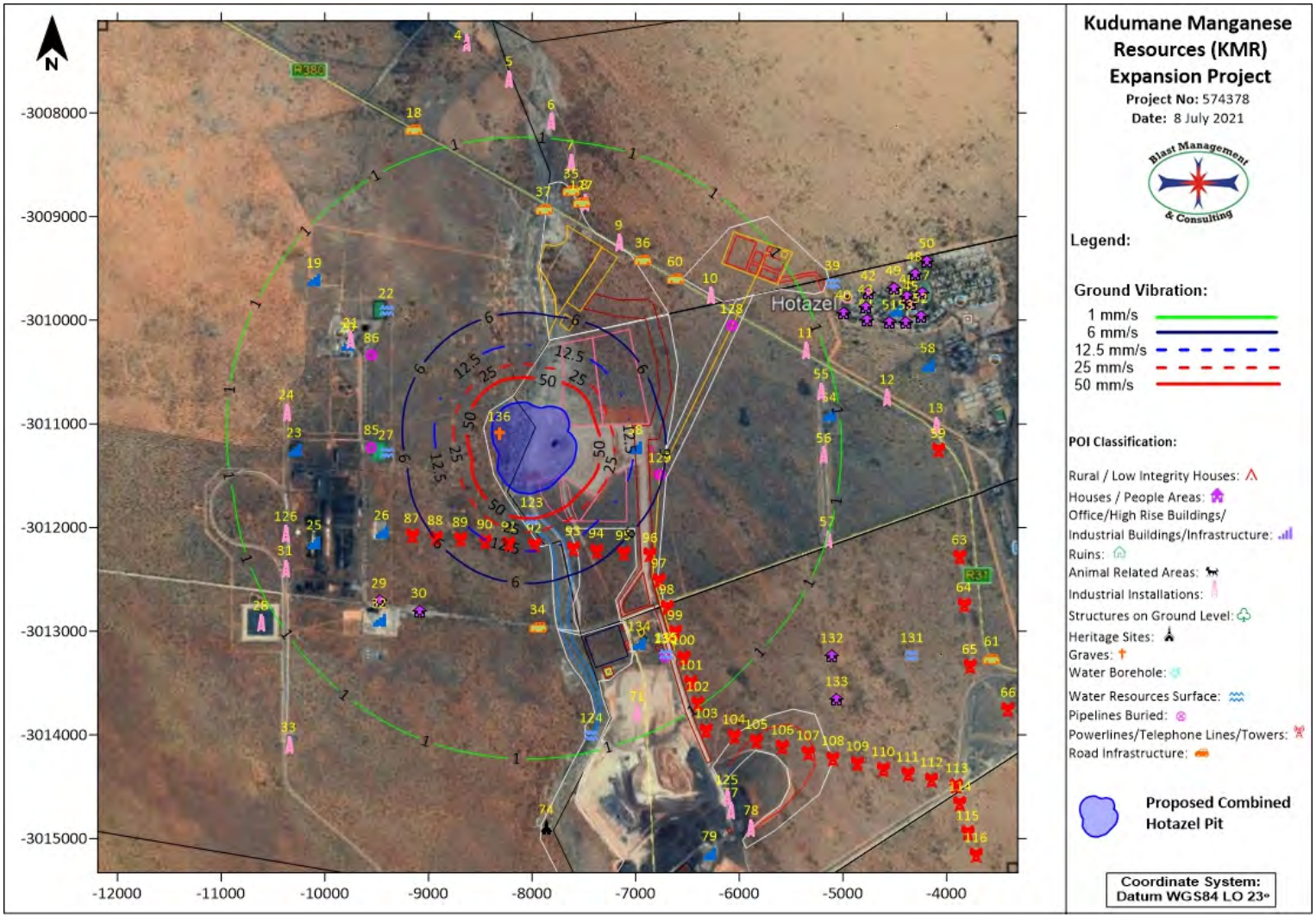


Figure 14: Ground vibration influence from maximum charge per delay for Hotazel Pit

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

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
4	Railway Line	150	3510	1285	0.6	Acceptable	N/A
5	Railway Line	150	3121	1285	0.7	Acceptable	N/A
6	Railway Line	150	2716	1285	0.9	Acceptable	N/A
7	Railway Line	150	2355	1285	1.1	Acceptable	N/A
8	Railway Line	150	1994	1285	1.5	Acceptable	N/A
9	Railway Line	150	1699	1285	2.0	Acceptable	N/A
10	Railway Line	150	1799	1285	1.8	Acceptable	N/A
11	Railway Line	150	2384	1285	1.1	Acceptable	N/A
12	Railway Line	150	3036	1285	0.8	Acceptable	N/A
13	Railway Line	150	3475	1285	0.6	Acceptable	N/A
18	R380 Road	150	2801	1285	0.9	Acceptable	N/A
19	Explosive Magazine	25	2184	1285	1.3	Acceptable	Perceptible
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	25	1585	1285	2.2	Acceptable	Perceptible
21	Conveyor	150	1578	1285	2.2	Acceptable	N/A
22	Dam	50	1457	1285	2.5	Acceptable	N/A
23	Mining Plant	25	1908	1285	1.6	Acceptable	N/A
24	Railway Line	150	1985	1285	1.5	Acceptable	N/A
25	Mining Plant	25	1900	1285	1.6	Acceptable	N/A
26	Sub Station	25	1265	1285	3.2	Acceptable	N/A
27	Dam	50	1032	1285	4.5	Acceptable	N/A
28	Return Water Dam	25	2710	1285	0.9	Acceptable	N/A
29	Buildings/Structures	12.5	1662	1285	2.0	Acceptable	Perceptible
30	Security Offices	12.5	1480	1285	2.5	Acceptable	Perceptible
31	Conveyor Tower	50	2254	1285	1.2	Acceptable	N/A
32	Industrial Structures	50	1797	1285	1.8	Acceptable	Perceptible
33	Transformer	15	3273	1285	0.7	Acceptable	Too Low
34	R31 Road	150	1290	1285	3.1	Acceptable	N/A
35	Gravel Road	200	2085	1285	1.4	Acceptable	N/A
36	R380 Road	150	1639	1285	2.1	Acceptable	N/A
37	Gravel Road	200	1873	1285	1.7	Acceptable	N/A
38	Mine Buildings/Structures	25	571	1285	11.9	Acceptable	Unpleasant
39	Reservoir	50	2865	1285	0.8	Acceptable	N/A
40	Houses	12.5	2846	1285	0.8	Acceptable	Perceptible
41	Houses	12.5	3035	1285	0.8	Acceptable	Too Low
42	Houses	12.5	3139	1285	0.7	Acceptable	Too Low
43	Hotazel Golf Club	25	3069	1285	0.7	Acceptable	Too Low
44	Hotazel Municipal Clinic	25	3336	1285	0.6	Acceptable	Too Low
45	Pool	25	3489	1285	0.6	Acceptable	Too Low
46	School	25	3477	1285	0.6	Acceptable	Too Low
49	House	12.5	3383	1285	0.6	Acceptable	Too Low
51	Houses	12.5	3241	1285	0.7	Acceptable	Too Low
53	Houses	12.5	3390	1285	0.6	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
54	Airfield Structure	50	2458	1285	1.1	Acceptable	N/A
55	Landing Strip	150	2419	1285	1.1	Acceptable	N/A
56	Landing Strip	150	2392	1285	1.1	Acceptable	N/A
57	Landing Strip	150	2564	1285	1.0	Acceptable	N/A
58	Sub Station	25	3477	1285	0.6	Acceptable	N/A
59	Power lines/Pylons	75	3492	1285	0.6	Acceptable	N/A
60	R380 Road	150	1667	1285	2.0	Acceptable	N/A
71	Mine Activity	200	2340	1285	1.2	Acceptable	N/A
74	Old Farmstead (Inside York Pit Area)	6	3220	1285	0.7	Acceptable	Too Low
85	Pipeline	50	1163	1285	3.7	Acceptable	N/A
86	Pipeline	50	1328	1285	2.9	Acceptable	N/A
87	Power Line/Pylon	75	1029	1285	4.5	Acceptable	N/A
88	Power Line/Pylon	75	854	1285	6.1	Acceptable	N/A
89	Power Line/Pylon	75	693	1285	8.6	Acceptable	N/A
90	Power Line/Pylon	75	568	1285	12.0	Acceptable	N/A
91	Power Line/Pylon	75	504	1285	14.6	Acceptable	N/A
92	Power Line/Pylon	75	502	1285	14.7	Acceptable	N/A
93	Power Line/Pylon	75	632	1285	10.1	Acceptable	N/A
94	Power Line/Pylon	75	763	1285	7.4	Acceptable	N/A
95	Power Line/Pylon	75	951	1285	5.1	Acceptable	N/A
96	Power Line/Pylon	75	1148	1285	3.7	Acceptable	N/A
97	Power Line/Pylon	75	1382	1285	2.8	Acceptable	N/A
98	Power Line/Pylon	75	1614	1285	2.1	Acceptable	N/A
99	Power Line/Pylon	75	1853	1285	1.7	Acceptable	N/A
100	Power Line/Pylon	75	2091	1285	1.4	Acceptable	N/A
101	Power Line/Pylon	75	2328	1285	1.2	Acceptable	N/A
102	Power Line/Pylon	75	2534	1285	1.0	Acceptable	N/A
103	Power Line/Pylon	75	2796	1285	0.9	Acceptable	N/A
104	Power Line/Pylon	75	2995	1285	0.8	Acceptable	N/A
105	Power Line/Pylon	75	3164	1285	0.7	Acceptable	N/A
106	Power Line/Pylon	75	3368	1285	0.6	Acceptable	N/A
123	Attenuation Dam (Planned)	50	255	1285	44.9	Acceptable	N/A
124	Attenuation Dam (Planned)	50	2403	1285	1.1	Acceptable	N/A
125	Railway Line	150	3447	1285	0.6	Acceptable	N/A
126	Railway Line	150	2131	1285	1.4	Acceptable	N/A
127	Diversion R380 Road (Planned)	150	1972	1285	1.5	Acceptable	N/A
128	Potable Water Pipeline (Planned)	50	1809	1285	1.8	Acceptable	N/A
129	Potable Water Pipeline (Planned)	50	839	1285	6.3	Acceptable	N/A
130	Potable Water Pipeline (Planned)	50	1977	1285	1.5	Acceptable	N/A
132	Structure	12.5	3116	1285	0.7	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
133	Lodge	12.5	3415	1285	0.6	Acceptable	Too Low
134	Mine Buildings/Structures	25	1742	1285	1.9	Acceptable	Perceptible
135	Reservoir	50	1974	1285	1.5	Acceptable	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	50	-	1285	-	-	-
137	Hydrocensus Borehole (gl27)	50	2750	1285	0.9	Acceptable	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	50	-	1285	-	-	-
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	50	-	1285	-	-	-
140	Hydrocensus Borehole (Htwm005)	50	464	1285	16.7	Acceptable	N/A
141	Hydrocensus Borehole (KSX23) - Inside Hotazel Pit Area	50	-	1285	-	-	-
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	50	-	1285	-	-	-
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	50	-	1285	-	-	-
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	50	-	1285			
145	Hydrocensus Borehole (Mk01)	50	3146	1285	0.7	Acceptable	N/A
146	Hydrocensus Borehole (Mk02)	50	2592	1285	1.0	Acceptable	N/A
150	Hydrocensus Borehole (wh02)	50	1350	1285	2.9	Acceptable	N/A
151	Hydrocensus Borehole (windmill 4)	50	2461	1285	1.1	Acceptable	N/A
152	Hydrocensus Borehole (Wu06)	50	1411	1285	2.7	Acceptable	N/A
154	Hydrocensus Borehole ((YGW03)	50	2638	1285	1.0	Acceptable	N/A
155	Hydrocensus Borehole (YGW04)	50	2378	1285	1.1	Acceptable	N/A
156	Hydrocensus Borehole (YGW05)	50	3455	1285	0.6	Acceptable	N/A
157	Hydrocensus Borehole (Ykdw4)	50	2456	1285	1.1	Acceptable	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	6	37	1285	1069.5	Problematic	Intolerable
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	150	358	1285	25.7	Acceptable	N/A
160	Heritage (KMR 003 - Scatter of stone tools)	150	656	1285	9.4	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
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	6	1309	1285	3.0	Acceptable	Perceptible
162	Heritage (KMR 005 - Scatter of stone tools)	150	225	1285	55.2	Acceptable	N/A
163	Heritage (KMR 007 - Burial Ground)	50	68	1285	394.7	Problematic	N/A
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	150	1078	1285	4.2	Acceptable	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	150	30	1285	1492.1	Problematic	N/A
166	Heritage (KAL03 - Artefacts)	150	21	1285	2850.0	Problematic	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	150	-	1285	-	-	-

17.1.5 Ground vibration minimum charge mass per delay – Kipling Pit - 386 kg

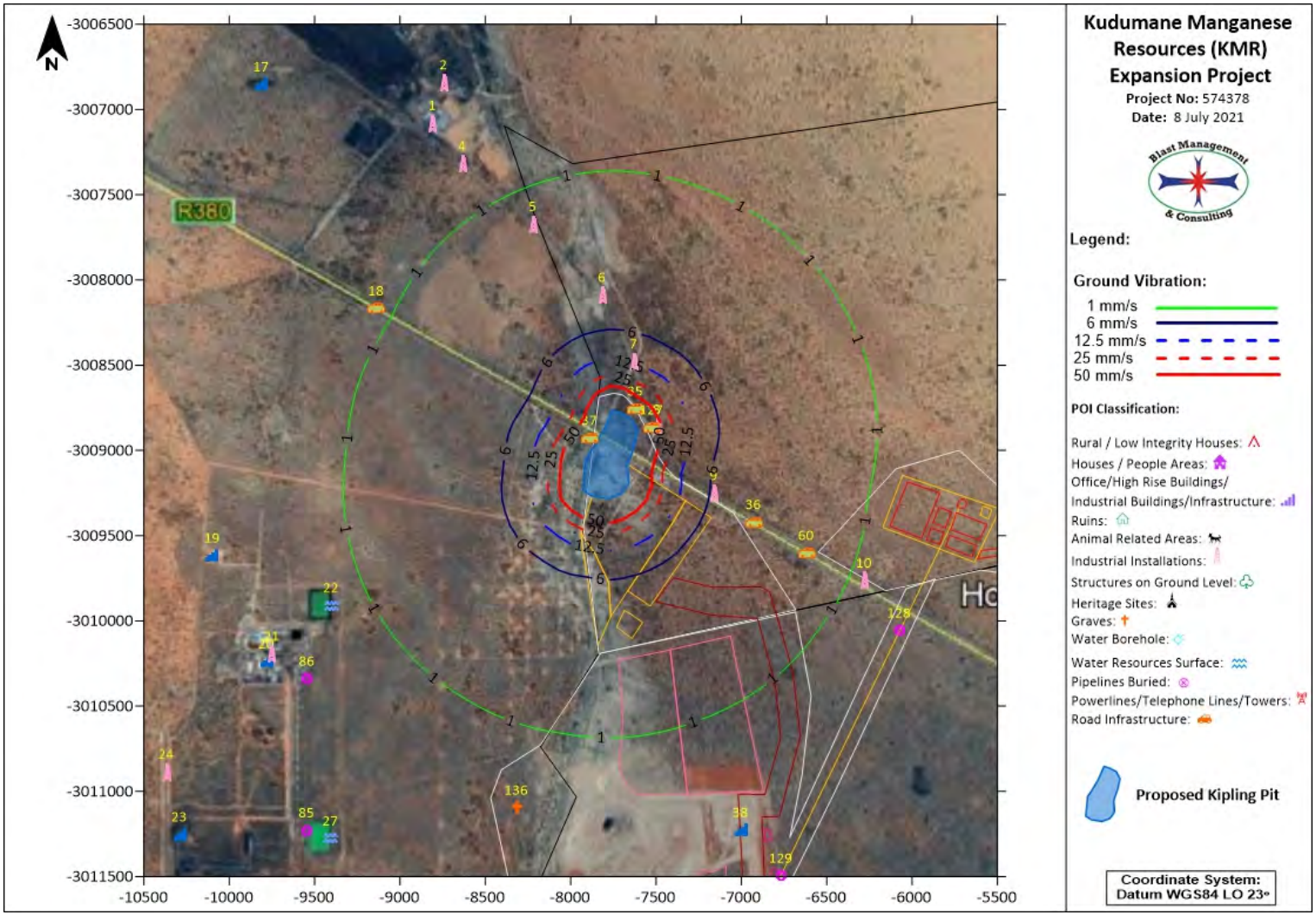


Figure 15: Ground vibration influence from minimum charge per delay for Kipling Pit

Table 15: Ground vibration evaluation for minimum charge for Kipling Pit

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Sewage Plant (Gloria Mine)	50	1986	386	0.6	Acceptable	Too Low
2	Mine Activity	200	2162	386	0.5	Acceptable	N/A
3	Railway Line	150	3359	386	0.2	Acceptable	N/A
4	Railway Line	150	1691	386	0.7	Acceptable	N/A
5	Railway Line	150	1186	386	1.3	Acceptable	N/A
6	Railway Line	150	679	386	3.3	Acceptable	N/A
7	Railway Line	150	311	386	12.0	Acceptable	N/A
8	Railway Line	150	117	386	59.8	Acceptable	N/A
9	Railway Line	150	505	386	5.4	Acceptable	N/A
10	Railway Line	150	1493	386	0.9	Acceptable	N/A
11	Railway Line	150	2545	386	0.4	Acceptable	N/A
12	Railway Line	150	3452	386	0.2	Acceptable	N/A
14	Farm Buildings/Structures	12.5	2882	386	0.3	Acceptable	Too Low
15	Vent Shaft	50	3421	386	0.2	Acceptable	N/A
16	Mine Buildings/Structures	25	2642	386	0.4	Acceptable	Too Low
17	Mining Installation	25	2806	386	0.3	Acceptable	N/A
18	R380 Road	150	1501	386	0.9	Acceptable	N/A
19	Explosive Magazine	25	2204	386	0.5	Acceptable	Too Low
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	25	2107	386	0.5	Acceptable	Too Low
21	Conveyor	150	2059	386	0.5	Acceptable	N/A
22	Dam	50	1622	386	0.8	Acceptable	N/A
23	Mining Plant	25	3108	386	0.3	Acceptable	N/A
24	Railway Line	150	2947	386	0.3	Acceptable	N/A
26	Sub Station	25	3195	386	0.3	Acceptable	N/A
27	Dam	50	2521	386	0.4	Acceptable	N/A
35	Gravel Road	200	64	386	162.9	Acceptable	N/A
36	R380 Road	150	767	386	2.7	Acceptable	N/A
37	Gravel Road	200	45	386	296.1	Problematic	N/A
38	Mine Buildings/Structures	25	2091	386	0.5	Acceptable	Too Low
39	Reservoir	50	2600	386	0.4	Acceptable	N/A
40	Houses	12.5	2763	386	0.3	Acceptable	Too Low
41	Houses	12.5	2997	386	0.3	Acceptable	Too Low
42	Houses	12.5	2956	386	0.3	Acceptable	Too Low
43	Hotazel Golf Club	25	2960	386	0.3	Acceptable	Too Low
44	Hotazel Municipal Clinic	25	3253	386	0.2	Acceptable	Too Low
45	Pool	25	3378	386	0.2	Acceptable	Too Low
46	School	25	3329	386	0.2	Acceptable	Too Low
47	Sports field	50	3470	386	0.2	Acceptable	Too Low
48	School	25	3368	386	0.2	Acceptable	Too Low
49	House	12.5	3187	386	0.3	Acceptable	Too Low
50	Houses	12.5	3459	386	0.2	Acceptable	Too Low
51	Houses	12.5	3220	386	0.3	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
52	Hostel	12.5	3494	386	0.2	Acceptable	Too Low
53	Houses	12.5	3372	386	0.2	Acceptable	Too Low
54	Airfield Structure	50	3056	386	0.3	Acceptable	N/A
55	Landing Strip	150	2870	386	0.3	Acceptable	N/A
56	Landing Strip	150	3248	386	0.2	Acceptable	N/A
60	R380 Road	150	1119	386	1.5	Acceptable	N/A
85	Pipeline	50	2568	386	0.4	Acceptable	N/A
86	Pipeline	50	1958	386	0.6	Acceptable	N/A
87	Power Line/Pylon	75	3090	386	0.3	Acceptable	N/A
88	Power Line/Pylon	75	3021	386	0.3	Acceptable	N/A
89	Power Line/Pylon	75	2964	386	0.3	Acceptable	N/A
90	Power Line/Pylon	75	2926	386	0.3	Acceptable	N/A
91	Power Line/Pylon	75	2907	386	0.3	Acceptable	N/A
92	Power Line/Pylon	75	2897	386	0.3	Acceptable	N/A
93	Power Line/Pylon	75	2924	386	0.3	Acceptable	N/A
94	Power Line/Pylon	75	2968	386	0.3	Acceptable	N/A
95	Power Line/Pylon	75	3035	386	0.3	Acceptable	N/A
96	Power Line/Pylon	75	3122	386	0.3	Acceptable	N/A
97	Power Line/Pylon	75	3382	386	0.2	Acceptable	N/A
123	Attenuation Dam (Planned)	50	2654	386	0.3	Acceptable	N/A
127	Diversion R380 Road (Planned)	150	54	386	216.9	Problematic	N/A
128	Potable Water Pipeline (Planned)	50	1806	386	0.7	Acceptable	N/A
129	Potable Water Pipeline (Planned)	50	2428	386	0.4	Acceptable	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	50	1881	386	0.6	Acceptable	N/A
137	Hydrocensus Borehole (gl27)	50	1956	386	0.6	Acceptable	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	50	1742	386	0.7	Acceptable	N/A
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	50	1574	386	0.8	Acceptable	N/A
140	Hydrocensus Borehole (Htwm005)	50	1941	386	0.6	Acceptable	N/A
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	50	1761	386	0.7	Acceptable	N/A
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	50	1743	386	0.7	Acceptable	N/A
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	50	1861	386	0.6	Acceptable	N/A
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	50	1844	386	0.6	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
145	Hydrocensus Borehole (Mk01)	50	2392	386	0.4	Acceptable	N/A
146	Hydrocensus Borehole (Mk02)	50	614	386	3.9	Acceptable	N/A
150	Hydrocensus Borehole (wh02)	50	223	386	20.7	Acceptable	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	6	1573	386	0.8	Acceptable	Perceptible
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	150	1194	386	1.3	Acceptable	N/A
160	Heritage (KMR 003 - Scatter of stone tools)	150	900	386	2.1	Acceptable	N/A
162	Heritage (KMR 005 - Scatter of stone tools)	150	2408	386	0.4	Acceptable	N/A
163	Heritage (KMR 007 - Burial Ground)	50	1480	386	0.9	Acceptable	N/A
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	150	1289	386	1.1	Acceptable	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	150	2092	386	0.5	Acceptable	N/A
166	Heritage (KAL03 - Artefacts)	150	2180	386	0.5	Acceptable	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	150	2160	386	0.5	Acceptable	N/A

17.1.6 Ground vibration maximum charge mass per delay – Kipling Pit - 1285 kg

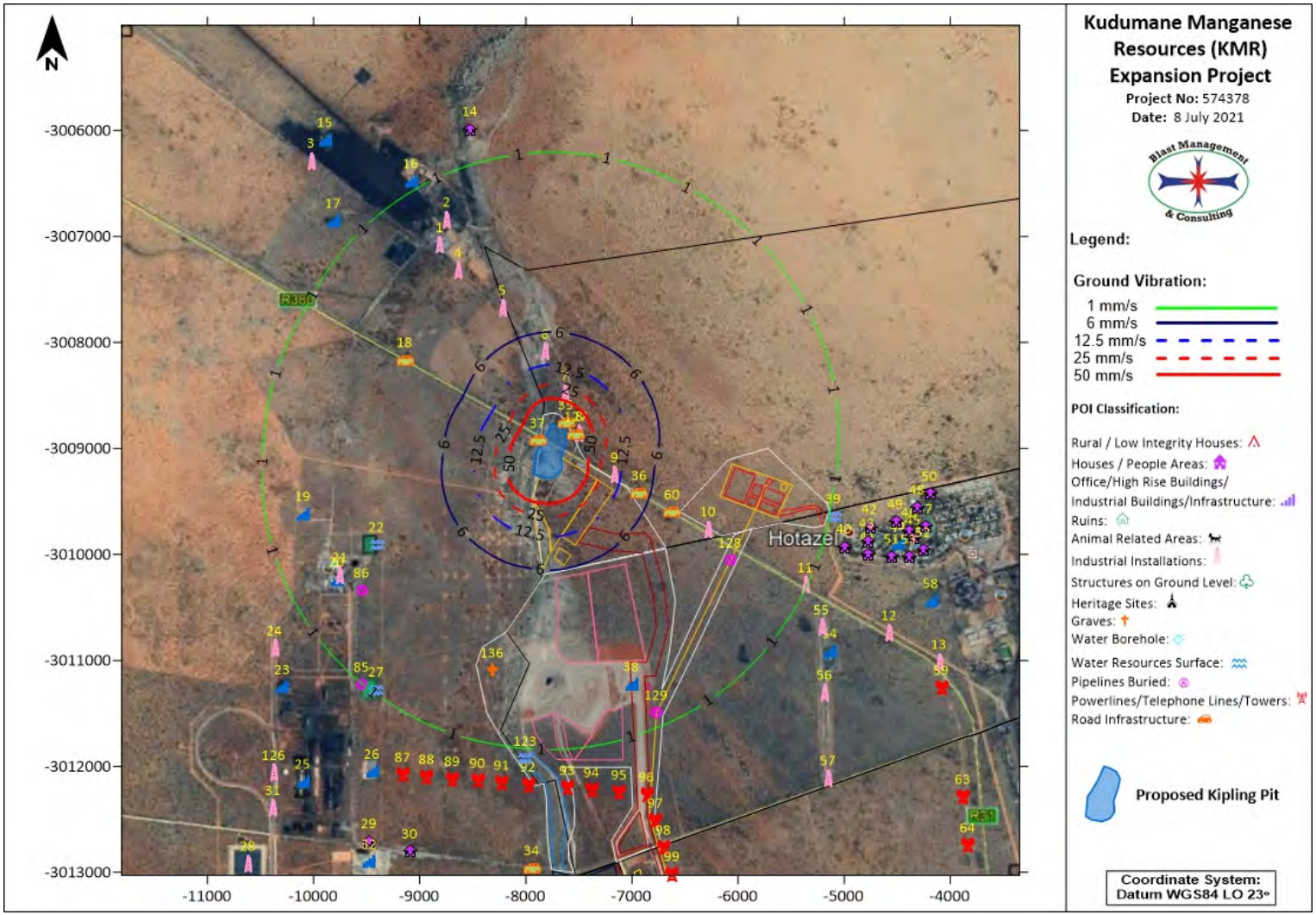


Figure 16: Ground vibration influence from maximum charge per delay for Kipling Pit

Table 16: Ground vibration evaluation for maximum charge for Kipling Pit

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Sewage Plant (Gloria Mine)	50	1986	1285	1.5	Acceptable	Perceptible
2	Mine Activity	200	2162	1285	1.3	Acceptable	Perceptible
3	Railway Line	150	3359	1285	0.6	Acceptable	N/A
4	Railway Line	150	1691	1285	2.0	Acceptable	N/A
5	Railway Line	150	1186	1285	3.6	Acceptable	N/A
6	Railway Line	150	679	1285	8.9	Acceptable	N/A
7	Railway Line	150	311	1285	32.3	Acceptable	N/A
8	Railway Line	150	117	1285	161.4	Problematic	N/A
9	Railway Line	150	505	1285	14.6	Acceptable	N/A
10	Railway Line	150	1493	1285	2.4	Acceptable	N/A
11	Railway Line	150	2545	1285	1.0	Acceptable	N/A
12	Railway Line	150	3452	1285	0.6	Acceptable	N/A
14	Farm Buildings/Structures	12.5	2882	1285	0.8	Acceptable	Perceptible
15	Vent Shaft	50	3421	1285	0.6	Acceptable	Too Low
16	Mine Buildings/Structures	25	2642	1285	0.9	Acceptable	Perceptible
17	Mining Installation	25	2806	1285	0.9	Acceptable	Perceptible
18	R380 Road	150	1501	1285	2.4	Acceptable	N/A
19	Explosive Magazine	25	2204	1285	1.3	Acceptable	Perceptible
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	25	2107	1285	1.4	Acceptable	Perceptible
21	Conveyor	150	2059	1285	1.4	Acceptable	N/A
22	Dam	50	1622	1285	2.1	Acceptable	N/A
23	Mining Plant	25	3108	1285	0.7	Acceptable	N/A
24	Railway Line	150	2947	1285	0.8	Acceptable	Perceptible
26	Sub Station	25	3195	1285	0.7	Acceptable	N/A
27	Dam	50	2521	1285	1.0	Acceptable	N/A
35	Gravel Road	200	64	1285	439.3	Problematic	N/A
36	R380 Road	150	767	1285	7.3	Acceptable	N/A
37	Gravel Road	200	45	1285	798.7	Problematic	N/A
38	Mine Buildings/Structures	25	2091	1285	1.4	Acceptable	Perceptible
39	Reservoir	50	2600	1285	1.0	Acceptable	N/A
40	Houses	12.5	2763	1285	0.9	Acceptable	Perceptible
41	Houses	12.5	2997	1285	0.8	Acceptable	Perceptible
42	Houses	12.5	2956	1285	0.8	Acceptable	Perceptible
43	Hotazel Golf Club	25	2960	1285	0.8	Acceptable	Perceptible
44	Hotazel Municipal Clinic	25	3253	1285	0.7	Acceptable	Too Low
45	Pool	25	3378	1285	0.6	Acceptable	Too Low
46	School	25	3329	1285	0.6	Acceptable	Too Low
47	Sports field	50	3470	1285	0.6	Acceptable	Too Low
48	School	25	3368	1285	0.6	Acceptable	Too Low
49	House	12.5	3187	1285	0.7	Acceptable	Too Low
50	Houses	12.5	3459	1285	0.6	Acceptable	Too Low
51	Houses	12.5	3220	1285	0.7	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
52	Hostel	12.5	3494	1285	0.6	Acceptable	Too Low
53	Houses	12.5	3372	1285	0.6	Acceptable	Too Low
54	Airfield Structure	50	3056	1285	0.7	Acceptable	N/A
55	Landing Strip	150	2870	1285	0.8	Acceptable	N/A
56	Landing Strip	150	3248	1285	0.7	Acceptable	N/A
60	R380 Road	150	1119	1285	3.9	Acceptable	N/A
85	Pipeline	50	2568	1285	1.0	Acceptable	N/A
86	Pipeline	50	1958	1285	1.6	Acceptable	N/A
87	Power Line/Pylon	75	3090	1285	0.7	Acceptable	N/A
88	Power Line/Pylon	75	3021	1285	0.8	Acceptable	N/A
89	Power Line/Pylon	75	2964	1285	0.8	Acceptable	N/A
90	Power Line/Pylon	75	2926	1285	0.8	Acceptable	N/A
91	Power Line/Pylon	75	2907	1285	0.8	Acceptable	N/A
92	Power Line/Pylon	75	2897	1285	0.8	Acceptable	N/A
93	Power Line/Pylon	75	2924	1285	0.8	Acceptable	N/A
94	Power Line/Pylon	75	2968	1285	0.8	Acceptable	N/A
95	Power Line/Pylon	75	3035	1285	0.8	Acceptable	N/A
96	Power Line/Pylon	75	3122	1285	0.7	Acceptable	N/A
97	Power Line/Pylon	75	3382	1285	0.6	Acceptable	N/A
123	Attenuation Dam (Planned)	50	2654	1285	0.9	Acceptable	N/A
127	Diversion R380 Road (Planned)	150	54	1285	584.9	Problematic	N/A
128	Potable Water Pipeline (Planned)	50	1806	1285	1.8	Acceptable	N/A
129	Potable Water Pipeline (Planned)	50	2428	1285	1.1	Acceptable	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	50	1881	1285	1.7	Acceptable	N/A
137	Hydrocensus Borehole (gl27)	50	1956	1285	1.6	Acceptable	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	50	1742	1285	1.9	Acceptable	N/A
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	50	1574	1285	2.2	Acceptable	N/A
140	Hydrocensus Borehole (Htwm005)	50	1941	1285	1.6	Acceptable	N/A
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	50	1761	1285	1.9	Acceptable	N/A
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	50	1743	1285	1.9	Acceptable	N/A
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	50	1861	1285	1.7	Acceptable	N/A
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	50	1844	1285	1.7	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
145	Hydrocensus Borehole (Mk01)	50	2392	1285	1.1	Acceptable	N/A
146	Hydrocensus Borehole (Mk02)	50	614	1285	10.5	Acceptable	N/A
150	Hydrocensus Borehole (wh02)	50	223	1285	55.9	Problematic	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	6	1573	1285	2.2	Acceptable	Perceptible
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	150	1194	1285	3.5	Acceptable	N/A
160	Heritage (KMR 003 - Scatter of stone tools)	150	900	1285	5.6	Acceptable	N/A
162	Heritage (KMR 005 - Scatter of stone tools)	150	2408	1285	1.1	Acceptable	N/A
163	Heritage (KMR 007 - Burial Ground)	50	1480	1285	2.5	Acceptable	N/A
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	150	1289	1285	3.1	Acceptable	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	150	2092	1285	1.4	Acceptable	N/A
166	Heritage (KAL03 - Artefacts)	150	2180	1285	1.3	Acceptable	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	150	2160	1285	1.3	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 areas. The influences will also vary with distance from the pit areas. The model used for evaluation does indicate significant levels. It will be imperative to ensure that the monitoring program is continued to confirm levels of ground vibration to ensure that ground vibration levels are not exceeded. Additional monitoring points may need to be considered.

The distances between structures and the pit areas are a contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated 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.

York Pit: The minimum and maximum charge used indicated six POI's (of which one is inside the Pit area) that is a concern in relation to possible structural damage. On a human perception scale eight POI's were identified where vibration levels may be perceptible and higher for the minimum charge and twelve POI's for the maximum charge. This includes only POI's where people would normally be present.

Hotazel Pit: Minimum and maximum charge used indicated no POI's that is of concern. This excludes POI's located inside the pit area and heritage sites that consists mainly of scattered artifacts. Minimum charge on a human perception scale indicated three POI's and seven POI's for maximum charge where vibration levels may be perceptible and higher. This includes only POI's where people would normally be present.

Kipling Pit: One POI might be of concern on minimum charge and the maximum charge indicated three POI's in relation to possible structural damage. Gravel roads within range is considered not to be problematic though levels may be high. On a human perception scale eight POI's were only identified associated with the maximum charge.

Perceptible levels of vibration that may be experienced up to 3068 m for all Pit areas. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 363 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have lesser influence on these points.

The evaluation mainly considered a distance up to 3500 m from the pit areas. The closest structures observed are the Hydrocencus Boreholes, Railway Line, planned Attenuation Dam, Mine Buildings, Heritage Sites, Gravel Road and planned diversion R380 Road. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human

perception. The ground vibration levels predicted for these POI's ranged between 0.1 mm/s and 2850 mm/s for structures surrounding all open pit areas.

The nearest public houses are located as follows from the nearest pit boundary:

- York Pit: 1114 m
- Hotazel Pit: 1480 m
- Kipling Pit: 2763 m

Ground vibration level predicted at these buildings/schools where people may be present is:

- York Pit: 3.9 mm/s
- Hotazel Pit: 2.5 mm/s
- Kipling Pit: 0.9 mm/s

These were calculated for the maximum charge. In view of this specific mitigations will be required.

Structure conditions ranged from industrial construction to poor condition structures.

Various Heritage Sites which include Old structures, burial ground, scatter of stone age artifacts and abandoned Farmhouse were identified by the Heritage Specialist. One of these sites falls inside Hotazel Pit. It is uncertain what the Heritage Specialist recommended for these sites as it could be problematic in terms of potential structural damage.

Water boreholes identified are at close proximity and six of these boreholes falls inside Hotazel pit area. There are twenty-one water boreholes identified within the mining rights area and it is uncertain what the long-term plan will be for these boreholes. A mitigation plan will be required to determine if these boreholes will be retained or replaced.

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

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 17 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 17 that up to a distance of 3068 m people may experience levels of ground vibration as perceptible.

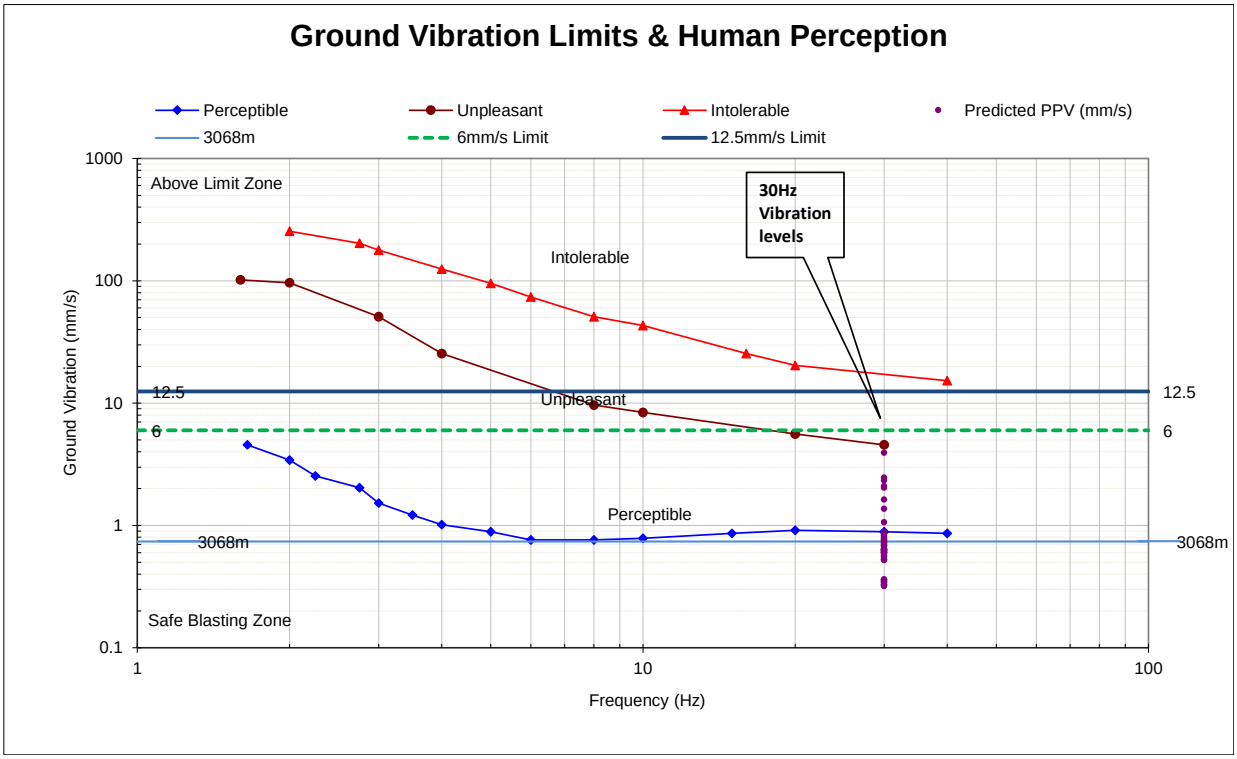


Figure 17: The effect of ground vibration with human perception and vibration limits

17.4 Vibration impact on roads

The planned R380 diversion road is at an approximate distance of 54 m from the Kipling Pit area and will require specific consideration regarding effects from blasting operations. The R380 road is at closest distance of 1639 m to the Hotazel Pit. The R31 provincial road is at closest distance of 1359 m (York Pit) and 1290 m (Hotazel Pit). 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. POI 74 falls within the York Pit area. It must be confirmed if this structure can be destroyed. The nearest houses are approximately 1114 m (York Pit) and 2763 m (Kipling Pit) from the planned operation. The Heritage (KMR 001 - Historical Site - Abandoned Cottage) is closest at 37 m from the Hotazel Pit area. The Heritage specialist recommended that no mitigation is required, and the structure can be demolished. These buildings are located such that levels of ground vibration predicted may lead to complaints but not damaging.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 3068 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 1655 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 – York Pit - 386 kg

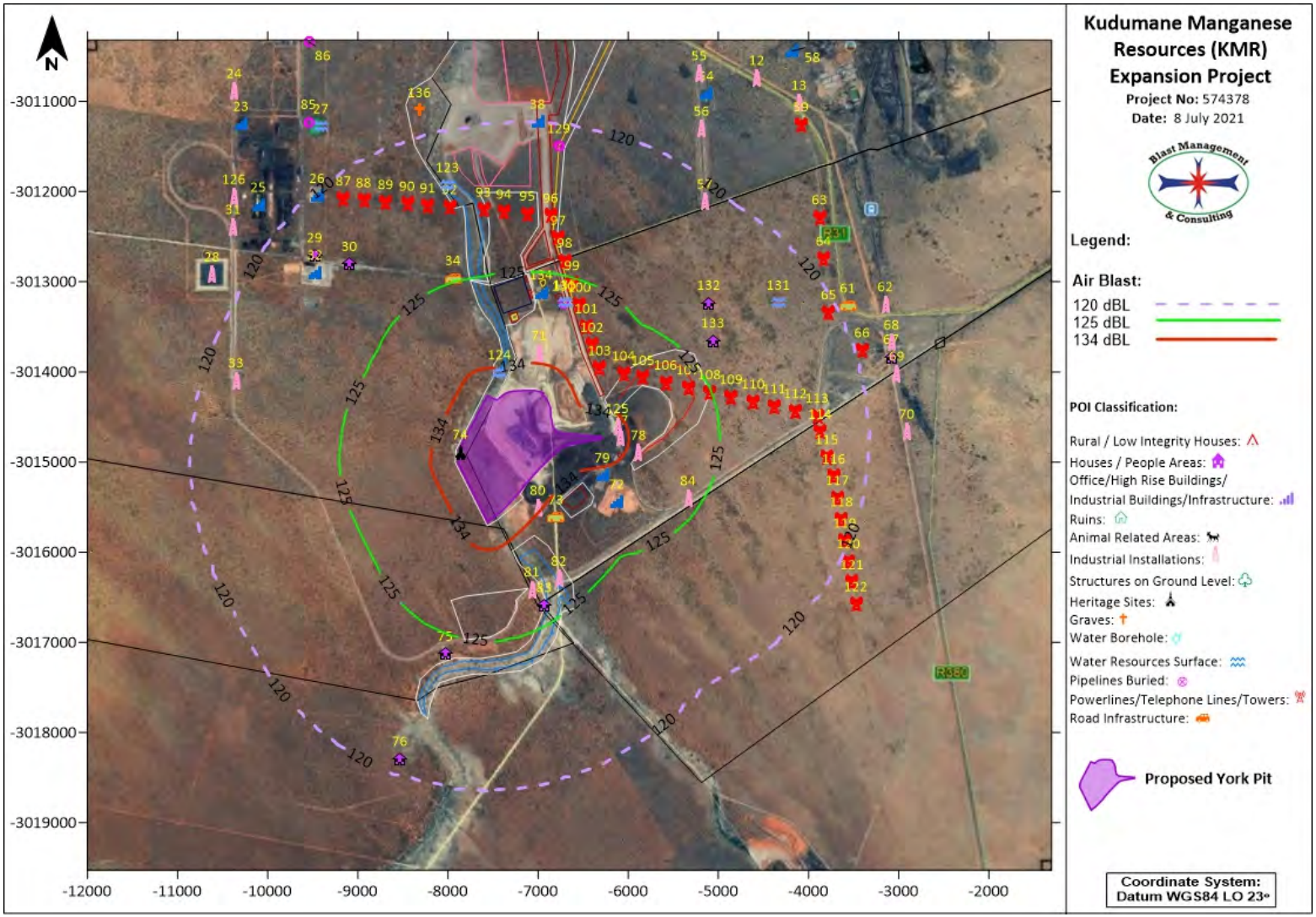


Figure 18: Air blast influence from minimum charge for York Pit

Table 17: Air blast evaluation for minimum charge for York Pit

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
25	Mining Plant	3306	119.3	Acceptable
26	Sub Station	2910	120.1	N/A
27	Dam	3512	118.9	N/A
28	Return Water Dam	3324	119.3	N/A
29	Buildings/Structures	2465	121.1	Complaint
30	Security Offices	2114	122.1	Complaint
31	Conveyor Tower	3381	119.2	N/A
32	Industrial Structures	2347	121.4	Complaint
33	Transformer	2587	120.9	N/A
34	R31 Road	1359	124.8	N/A
38	Mine Buildings/Structures	2980	120.0	Acceptable
56	Landing Strip	3420	119.1	N/A
57	Landing Strip	2783	120.4	N/A
61	R31 Road	3100	119.7	N/A
62	Railway Line	3478	119.0	N/A
63	Power lines/Pylons	3432	119.1	N/A
64	Power lines/Pylons	3160	119.6	N/A
65	Power lines/Pylons	2876	120.2	N/A
66	Power lines/Pylons	3050	119.8	N/A
67	Structures	3338	119.3	Acceptable
68	Railway Line	3389	119.2	N/A
69	Railway Line	3355	119.2	N/A
70	Railway Line	3391	119.2	N/A
71	Mine Activity	415	132.1	N/A
72	Mine Buildings/Structures	717	128.7	Complaint
73	Gravel Road	495	131.0	N/A
74	Old Farmstead (Inside York Pit Area)	-	-	-
75	Farm Buildings/Structures	1531	124.1	Complaint
76	Structure	2799	120.3	Complaint
77	Rail Loading Bay	219	136.1	N/A
78	Railway Line	441	131.7	N/A
79	Mine Buildings	399	132.4	Complaint
80	Return Water Dam	273	134.7	N/A
81	Railway Line	894	127.4	N/A
82	Railway Line Bridge	986	126.8	N/A
83	Buildings	1114	126.0	Complaint
84	Transformer	1168	125.7	N/A
87	Power Line/Pylon	2705	120.6	N/A
88	Power Line/Pylon	2562	120.9	N/A
89	Power Line/Pylon	2425	121.2	N/A
90	Power Line/Pylon	2307	121.5	N/A
91	Power Line/Pylon	2210	121.8	N/A
92	Power Line/Pylon	2134	122.0	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
93	Power Line/Pylon	2037	122.3	N/A
94	Power Line/Pylon	1991	122.5	N/A
95	Power Line/Pylon	1961	122.6	N/A
96	Power Line/Pylon	1948	122.6	N/A
97	Power Line/Pylon	1714	123.4	N/A
98	Power Line/Pylon	1480	124.3	N/A
99	Power Line/Pylon	1259	125.3	N/A
100	Power Line/Pylon	1057	126.4	N/A
101	Power Line/Pylon	883	127.5	N/A
102	Power Line/Pylon	762	128.4	N/A
103	Power Line/Pylon	682	129.0	N/A
104	Power Line/Pylon	741	128.5	N/A
105	Power Line/Pylon	799	128.1	N/A
106	Power Line/Pylon	934	127.1	N/A
107	Power Line/Pylon	1108	126.1	N/A
108	Power Line/Pylon	1300	125.1	N/A
109	Power Line/Pylon	1509	124.2	N/A
110	Power Line/Pylon	1732	123.3	N/A
111	Power Line/Pylon	1953	122.6	N/A
112	Power Line/Pylon	2175	121.9	N/A
113	Power Line/Pylon	2410	121.3	N/A
114	Power Line/Pylon	2430	121.2	N/A
115	Power Line/Pylon	2512	121.0	N/A
116	Power Line/Pylon	2616	120.8	N/A
117	Power Line/Pylon	2700	120.6	N/A
118	Power Line/Pylon	2811	120.3	N/A
119	Power Line/Pylon	2929	120.1	N/A
120	Power Line/Pylon	3063	119.8	N/A
121	Power Line/Pylon	3206	119.5	N/A
122	Power Line/Pylon	3368	119.2	N/A
123	Attenuation Dam (Planned)	2380	121.4	N/A
124	Attenuation Dam (Planned)	240	135.5	N/A
125	Railway Line	214	136.2	N/A
129	Potable Water Pipeline (Planned)	2725	120.5	N/A
130	Potable Water Pipeline (Planned)	1014	126.6	N/A
131	Waterhole	2463	121.1	N/A
132	Structure	1904	122.7	Complaint
133	Lodge	1634	123.7	Complaint
134	Mine Buildings/Structures	1088	126.2	Complaint
135	Reservoir	1030	126.5	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	3258	119.4	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	3278	119.4	N/A
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	3459	119.0	N/A
140	Hydrocensus Borehole (Htwm005)	3098	119.7	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	3323	119.3	N/A
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	3307	119.3	N/A
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	3222	119.5	N/A
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	3206	119.5	N/A
147	Hydrocensus Borehole (T1)	142	138.7	N/A
148	Hydrocensus Borehole (T2)	206	136.4	N/A
149	Hydrocensus Borehole (T6)	682	129.0	N/A
151	Hydrocensus Borehole (windmill 4)	186	137.1	N/A
152	Hydrocensus Borehole (Wu06)	1229	125.4	N/A
153	Hydrocensus Borehole (YGW01)	488	131.1	N/A
154	Hydrocensus Borehole ((YGW03)	496	131.0	N/A
155	Hydrocensus Borehole (YGW04)	275	134.6	N/A
156	Hydrocensus Borehole (YGW05)	798	128.1	N/A
157	Hydrocensus Borehole (Ykdw4)	191	136.9	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	3383	119.2	Acceptable
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	1334	124.9	Complaint
162	Heritage (KMR 005 - Scatter of stone tools)	2548	120.9	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	3066	119.8	N/A
166	Heritage (KAL03 - Artefacts)	2978	120.0	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	2987	120.0	N/A

17.7.2 Air blast maximum charge mass per delay – York Pit - 1285 kg

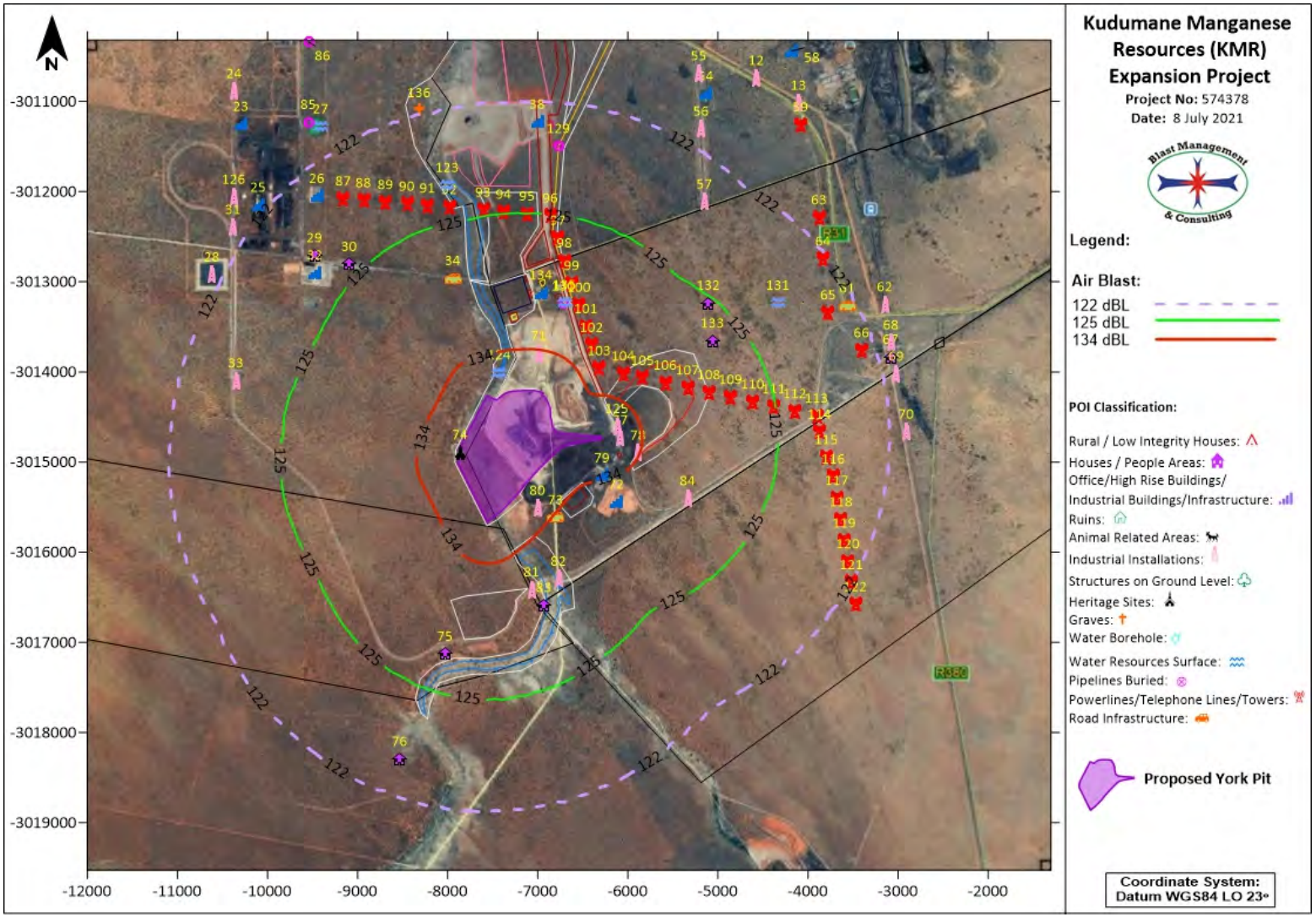


Figure 19: Air blast influence from maximum charge for York Pit

Table 18: Air blast influence from maximum charge for York Pit

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
25	Mining Plant	3306	121.8	Complaint
26	Sub Station	2910	122.6	N/A
27	Dam	3512	121.4	N/A
28	Return Water Dam	3324	121.7	N/A
29	Buildings/Structures	2465	123.6	Complaint
30	Security Offices	2114	124.6	Complaint
31	Conveyor Tower	3381	121.6	N/A
32	Industrial Structures	2347	123.9	Complaint
33	Transformer	2587	123.3	N/A
34	R31 Road	1359	127.3	N/A
38	Mine Buildings/Structures	2980	122.4	Complaint
56	Landing Strip	3420	121.6	N/A
57	Landing Strip	2783	122.8	N/A
61	R31 Road	3100	122.2	N/A
62	Railway Line	3478	121.5	N/A
63	Power lines/Pylons	3432	121.6	N/A
64	Power lines/Pylons	3160	122.1	N/A
65	Power lines/Pylons	2876	122.7	N/A
66	Power lines/Pylons	3050	122.3	N/A
67	Structures	3338	121.7	Complaint
68	Railway Line	3389	121.6	N/A
69	Railway Line	3355	121.7	N/A
70	Railway Line	3391	121.6	N/A
71	Mine Activity	415	134.6	N/A
72	Mine Buildings/Structures	717	131.2	Complaint
73	Gravel Road	495	133.5	N/A
74	Old Farmstead (Inside York Pit Area)	-	-	-
75	Farm Buildings/Structures	1531	126.5	Complaint
76	Structure	2799	122.8	Complaint
77	Rail Loading Bay	219	138.5	N/A
78	Railway Line	441	134.2	N/A
79	Mine Buildings	399	134.8	Problematic
80	Return Water Dam	273	137.2	N/A
81	Railway Line	894	129.8	N/A
82	Railway Line Bridge	986	129.2	N/A
83	Buildings	1114	128.5	Complaint
84	Transformer	1168	128.2	N/A
87	Power Line/Pylon	2705	123.0	N/A
88	Power Line/Pylon	2562	123.4	N/A
89	Power Line/Pylon	2425	123.7	N/A
90	Power Line/Pylon	2307	124.0	N/A
91	Power Line/Pylon	2210	124.3	N/A
92	Power Line/Pylon	2134	124.5	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
93	Power Line/Pylon	2037	124.8	N/A
94	Power Line/Pylon	1991	124.9	N/A
95	Power Line/Pylon	1961	125.0	N/A
96	Power Line/Pylon	1948	125.1	N/A
97	Power Line/Pylon	1714	125.8	N/A
98	Power Line/Pylon	1480	126.7	N/A
99	Power Line/Pylon	1259	127.7	N/A
100	Power Line/Pylon	1057	128.8	N/A
101	Power Line/Pylon	883	129.9	N/A
102	Power Line/Pylon	762	130.8	N/A
103	Power Line/Pylon	682	131.5	N/A
104	Power Line/Pylon	741	131.0	N/A
105	Power Line/Pylon	799	130.5	N/A
106	Power Line/Pylon	934	129.6	N/A
107	Power Line/Pylon	1108	128.5	N/A
108	Power Line/Pylon	1300	127.5	N/A
109	Power Line/Pylon	1509	126.6	N/A
110	Power Line/Pylon	1732	125.8	N/A
111	Power Line/Pylon	1953	125.0	N/A
112	Power Line/Pylon	2175	124.4	N/A
113	Power Line/Pylon	2410	123.7	N/A
114	Power Line/Pylon	2430	123.7	N/A
115	Power Line/Pylon	2512	123.5	N/A
116	Power Line/Pylon	2616	123.2	N/A
117	Power Line/Pylon	2700	123.1	N/A
118	Power Line/Pylon	2811	122.8	N/A
119	Power Line/Pylon	2929	122.6	N/A
120	Power Line/Pylon	3063	122.3	N/A
121	Power Line/Pylon	3206	122.0	N/A
122	Power Line/Pylon	3368	121.7	N/A
123	Attenuation Dam (Planned)	2380	123.8	N/A
124	Attenuation Dam (Planned)	240	137.9	N/A
125	Railway Line	214	138.7	N/A
129	Potable Water Pipeline (Planned)	2725	123.0	N/A
130	Potable Water Pipeline (Planned)	1014	129.1	N/A
131	Waterhole	2463	123.6	N/A
132	Structure	1904	125.2	Complaint
133	Lodge	1634	126.1	Complaint
134	Mine Buildings/Structures	1088	128.6	Complaint
135	Reservoir	1030	129.0	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	3258	121.9	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	3278	121.9	N/A
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	3459	121.5	N/A
140	Hydrocensus Borehole (Htwm005)	3098	122.2	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	3323	121.7	N/A
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	3307	121.8	N/A
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	3222	122.0	N/A
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	3206	122.0	N/A
147	Hydrocensus Borehole (T1)	142	141.2	N/A
148	Hydrocensus Borehole (T2)	206	138.9	N/A
149	Hydrocensus Borehole (T6)	682	131.5	N/A
151	Hydrocensus Borehole (windmill 4)	186	139.5	N/A
152	Hydrocensus Borehole (Wu06)	1229	127.9	N/A
153	Hydrocensus Borehole (YGW01)	488	133.6	N/A
154	Hydrocensus Borehole ((YGW03)	496	133.5	N/A
155	Hydrocensus Borehole (YGW04)	275	137.1	N/A
156	Hydrocensus Borehole (YGW05)	798	130.5	N/A
157	Hydrocensus Borehole (Ykdw4)	191	139.4	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	3383	121.6	Complaint
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	1334	127.4	Complaint
162	Heritage (KMR 005 - Scatter of stone tools)	2548	123.4	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	3066	122.3	N/A
166	Heritage (KAL03 - Artefacts)	2978	122.4	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	2987	122.4	N/A

17.7.3 Air blast minimum charge mass per delay – Hotazel Pit - 386 kg

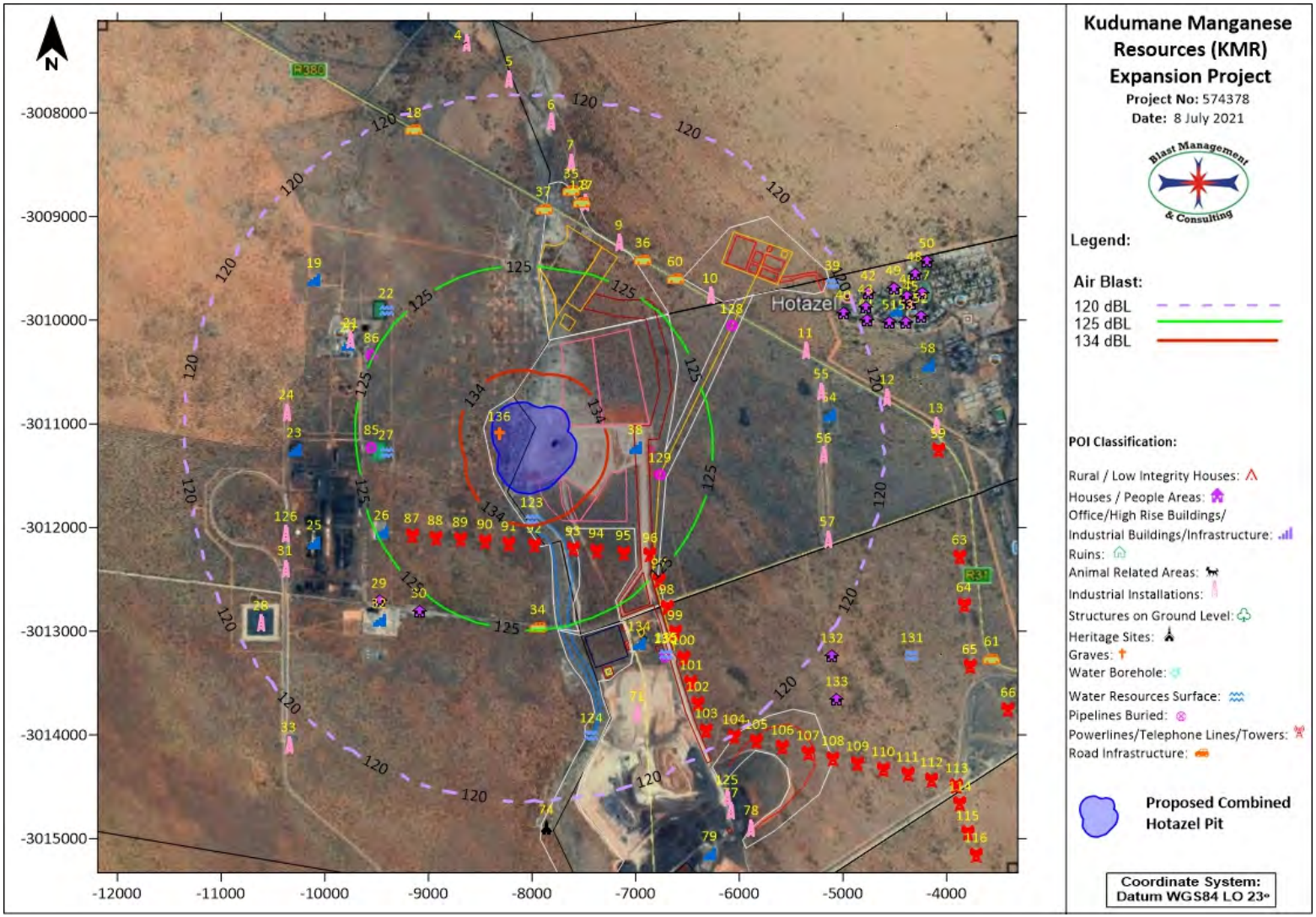


Figure 20: Air blast influence from minimum charge for Hotazel Pit

Table 19: Air blast evaluation for minimum charge for Hotazel Pit

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
4	Railway Line	3510	118.9	N/A
5	Railway Line	3121	119.7	N/A
6	Railway Line	2716	120.5	N/A
7	Railway Line	2355	121.4	N/A
8	Railway Line	1994	122.4	N/A
9	Railway Line	1699	123.4	N/A
10	Railway Line	1799	123.1	N/A
11	Railway Line	2384	121.4	N/A
12	Railway Line	3036	119.9	N/A
13	Railway Line	3475	119.0	N/A
18	R380 Road	2801	120.3	N/A
19	Explosive Magazine	2184	121.9	N/A
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	1585	123.8	Complaint
21	Conveyor	1578	123.9	N/A
22	Dam	1457	124.4	N/A
23	Mining Plant	1908	122.7	Complaint
24	Railway Line	1985	122.5	N/A
25	Mining Plant	1900	122.7	Complaint
26	Sub Station	1265	125.2	N/A
27	Dam	1032	126.5	N/A
28	Return Water Dam	2710	120.5	N/A
29	Buildings/Structures	1662	123.6	Complaint
30	Security Offices	1480	124.3	Complaint
31	Conveyor Tower	2254	121.7	N/A
32	Industrial Structures	1797	123.1	Complaint
33	Transformer	3273	119.4	Acceptable
34	R31 Road	1290	125.1	N/A
35	Gravel Road	2085	122.2	N/A
36	R380 Road	1639	123.6	N/A
37	Gravel Road	1873	122.8	N/A
38	Mine Buildings/Structures	571	130.1	Complaint
39	Reservoir	2865	120.2	N/A
40	Houses	2846	120.2	Complaint
41	Houses	3035	119.9	Acceptable
42	Houses	3139	119.6	Acceptable
43	Hotazel Golf Club	3069	119.8	Acceptable
44	Hotazel Municipal Clinic	3336	119.3	Acceptable
45	Pool	3489	119.0	N/A
46	School	3477	119.0	Acceptable
49	House	3383	119.2	Acceptable
51	Houses	3241	119.5	Acceptable
53	Houses	3390	119.2	Acceptable
54	Airfield Structure	2458	121.2	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
55	Landing Strip	2419	121.2	N/A
56	Landing Strip	2392	121.3	N/A
57	Landing Strip	2564	120.9	N/A
58	Sub Station	3477	119.0	Acceptable
59	Power lines/Pylons	3492	119.0	N/A
60	R380 Road	1667	123.5	N/A
71	Mine Activity	2340	121.5	N/A
74	Old Farmstead (Inside York Pit Area)	3220	119.5	Acceptable
85	Pipeline	1163	125.8	N/A
86	Pipeline	1328	124.9	N/A
87	Power Line/Pylon	1029	126.5	N/A
88	Power Line/Pylon	854	127.7	N/A
89	Power Line/Pylon	693	129.0	N/A
90	Power Line/Pylon	568	130.2	N/A
91	Power Line/Pylon	504	130.9	N/A
92	Power Line/Pylon	502	130.9	N/A
93	Power Line/Pylon	632	129.5	N/A
94	Power Line/Pylon	763	128.3	N/A
95	Power Line/Pylon	951	127.0	N/A
96	Power Line/Pylon	1148	125.8	N/A
97	Power Line/Pylon	1382	124.7	N/A
98	Power Line/Pylon	1614	123.7	N/A
99	Power Line/Pylon	1853	122.9	N/A
100	Power Line/Pylon	2091	122.2	N/A
101	Power Line/Pylon	2328	121.5	N/A
102	Power Line/Pylon	2534	121.0	N/A
103	Power Line/Pylon	2796	120.4	N/A
104	Power Line/Pylon	2995	120.0	N/A
105	Power Line/Pylon	3164	119.6	N/A
106	Power Line/Pylon	3368	119.2	N/A
123	Attenuation Dam (Planned)	255	135.1	N/A
124	Attenuation Dam (Planned)	2403	121.3	N/A
125	Railway Line	3447	119.1	N/A
126	Railway Line	2131	122.0	N/A
127	Diversion R380 Road (Planned)	1972	122.5	N/A
128	Potable Water Pipeline (Planned)	1809	123.0	N/A
129	Potable Water Pipeline (Planned)	839	127.8	N/A
130	Potable Water Pipeline (Planned)	1977	122.5	N/A
132	Structure	3116	119.7	Acceptable
133	Lodge	3415	119.1	Acceptable
134	Mine Buildings/Structures	1742	123.3	Complaint
135	Reservoir	1974	122.5	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	-	-	-
137	Hydrocensus Borehole (gl27)	2750	120.5	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	-	-	-
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	-	-	-
140	Hydrocensus Borehole (Htwm005)	464	131.4	N/A
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	-	-	-
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	-	-	-
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	-	-	-
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	-	-	-
145	Hydrocensus Borehole (Mk01)	3146	119.6	N/A
146	Hydrocensus Borehole (Mk02)	2592	120.8	N/A
150	Hydrocensus Borehole (wh02)	1350	124.8	N/A
151	Hydrocensus Borehole (windmill 4)	2461	121.1	N/A
152	Hydrocensus Borehole (Wu06)	1411	124.6	N/A
154	Hydrocensus Borehole ((YGW03)	2638	120.7	N/A
155	Hydrocensus Borehole (YGW04)	2378	121.4	N/A
156	Hydrocensus Borehole (YGW05)	3455	119.0	N/A
157	Hydrocensus Borehole (Ykdw4)	2456	121.2	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	37	147.0	Problematic
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	358	133.0	N/A
160	Heritage (KMR 003 - Scatter of stone tools)	656	129.3	N/A
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	1309	125.0	Complaint
162	Heritage (KMR 005 - Scatter of stone tools)	225	135.9	N/A
163	Heritage (KMR 007 - Burial Ground)	68	143.2	N/A
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	1078	126.2	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	30	148.2	N/A
166	Heritage (KAL03 - Artefacts)	21	150.6	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	-	-	-

17.7.4 Air blast maximum charge mass per delay – Hotazel Pit - 1285 kg

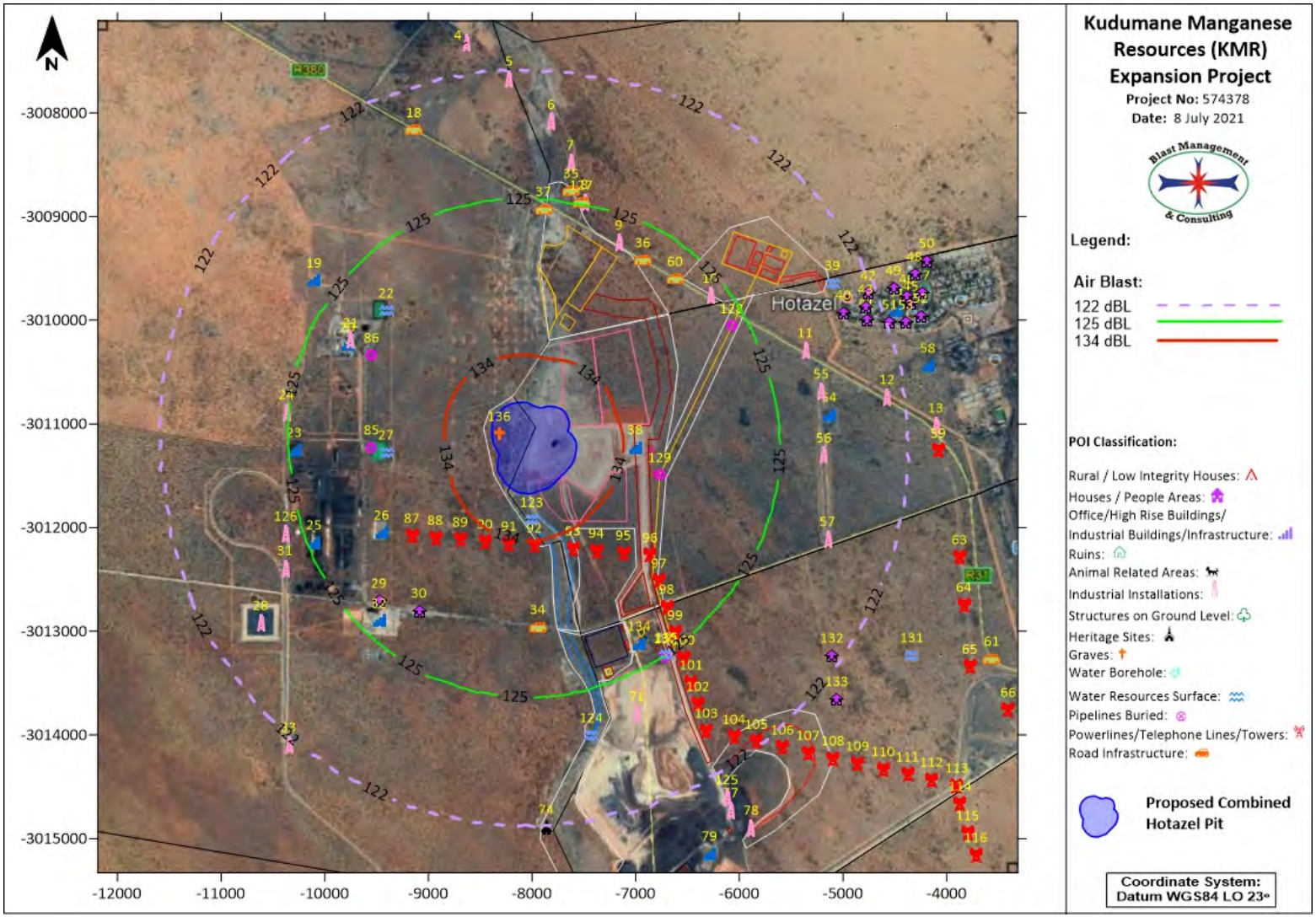


Figure 21: Air blast influence from maximum charge for Hotazel Pit

Table 20: Air blast evaluation for maximum charge for Hotazel Pit

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
4	Railway Line	3510	121.4	N/A
5	Railway Line	3121	122.2	N/A
6	Railway Line	2716	123.0	N/A
7	Railway Line	2355	123.9	N/A
8	Railway Line	1994	124.9	N/A
9	Railway Line	1699	125.9	N/A
10	Railway Line	1799	125.5	N/A
11	Railway Line	2384	123.8	N/A
12	Railway Line	3036	122.3	N/A
13	Railway Line	3475	121.5	N/A
18	R380 Road	2801	122.8	N/A
19	Explosive Magazine	2184	124.4	N/A
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	1585	126.3	Complaint
21	Conveyor	1578	126.4	N/A
22	Dam	1457	126.8	N/A
23	Mining Plant	1908	125.2	Complaint
24	Railway Line	1985	124.9	N/A
25	Mining Plant	1900	125.2	Complaint
26	Sub Station	1265	127.7	N/A
27	Dam	1032	129.0	N/A
28	Return Water Dam	2710	123.0	N/A
29	Buildings/Structures	1662	126.0	Complaint
30	Security Offices	1480	126.7	Complaint
31	Conveyor Tower	2254	124.1	N/A
32	Industrial Structures	1797	125.5	Complaint
33	Transformer	3273	121.9	N/A
34	R31 Road	1290	127.6	N/A
35	Gravel Road	2085	124.6	N/A
36	R380 Road	1639	126.1	N/A
37	Gravel Road	1873	125.3	N/A
38	Mine Buildings/Structures	571	132.6	Complaint
39	Reservoir	2865	122.7	N/A
40	Houses	2846	122.7	Complaint
41	Houses	3035	122.3	Complaint
42	Houses	3139	122.1	Complaint
43	Hotazel Golf Club	3069	122.3	Complaint
44	Hotazel Municipal Clinic	3336	121.7	Complaint
45	Pool	3489	121.5	N/A
46	School	3477	121.5	Complaint
49	House	3383	121.6	Complaint
51	Houses	3241	121.9	Complaint
53	Houses	3390	121.6	Complaint
54	Airfield Structure	2458	123.6	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
55	Landing Strip	2419	123.7	N/A
56	Landing Strip	2392	123.8	N/A
57	Landing Strip	2564	123.4	N/A
58	Sub Station	3477	121.5	N/A
59	Power lines/Pylons	3492	121.5	N/A
60	R380 Road	1667	126.0	N/A
71	Mine Activity	2340	123.9	N/A
74	Old Farmstead (Inside York Pit Area)	3220	122.0	Complaint
85	Pipeline	1163	128.2	N/A
86	Pipeline	1328	127.4	N/A
87	Power Line/Pylon	1029	129.0	N/A
88	Power Line/Pylon	854	130.1	N/A
89	Power Line/Pylon	693	131.4	N/A
90	Power Line/Pylon	568	132.6	N/A
91	Power Line/Pylon	504	133.4	N/A
92	Power Line/Pylon	502	133.4	N/A
93	Power Line/Pylon	632	132.0	N/A
94	Power Line/Pylon	763	130.8	N/A
95	Power Line/Pylon	951	129.5	N/A
96	Power Line/Pylon	1148	128.3	N/A
97	Power Line/Pylon	1382	127.2	N/A
98	Power Line/Pylon	1614	126.2	N/A
99	Power Line/Pylon	1853	125.4	N/A
100	Power Line/Pylon	2091	124.6	N/A
101	Power Line/Pylon	2328	124.0	N/A
102	Power Line/Pylon	2534	123.4	N/A
103	Power Line/Pylon	2796	122.8	N/A
104	Power Line/Pylon	2995	122.4	N/A
105	Power Line/Pylon	3164	122.1	N/A
106	Power Line/Pylon	3368	121.7	N/A
123	Attenuation Dam (Planned)	255	137.6	N/A
124	Attenuation Dam (Planned)	2403	123.8	N/A
125	Railway Line	3447	121.5	N/A
126	Railway Line	2131	124.5	N/A
127	Diversion R380 Road (Planned)	1972	125.0	N/A
128	Potable Water Pipeline (Planned)	1809	125.5	N/A
129	Potable Water Pipeline (Planned)	839	130.2	N/A
130	Potable Water Pipeline (Planned)	1977	125.0	N/A
132	Structure	3116	122.2	Complaint
133	Lodge	3415	121.6	Complaint
134	Mine Buildings/Structures	1742	125.8	Complaint
135	Reservoir	1974	125.0	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	-	-	-
137	Hydrocensus Borehole (gl27)	2750	122.9	N/A

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	-	-	-
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	-	-	-
140	Hydrocensus Borehole (Htwm005)	464	133.9	N/A
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	-	-	-
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	-	-	-
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	-	-	-
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	-	-	-
145	Hydrocensus Borehole (Mk01)	3146	122.1	N/A
146	Hydrocensus Borehole (Mk02)	2592	123.3	N/A
150	Hydrocensus Borehole (wh02)	1350	127.3	N/A
151	Hydrocensus Borehole (windmill 4)	2461	123.6	N/A
152	Hydrocensus Borehole (Wu06)	1411	127.0	N/A
154	Hydrocensus Borehole ((YGW03)	2638	123.2	N/A
155	Hydrocensus Borehole (YGW04)	2378	123.8	N/A
156	Hydrocensus Borehole (YGW05)	3455	121.5	N/A
157	Hydrocensus Borehole (Ykdw4)	2456	123.6	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	37	149.4	Problematic
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	358	135.5	N/A
160	Heritage (KMR 003 - Scatter of stone tools)	656	131.8	N/A
161	Heritage (KMR 004 - Historical Site - Abandoned Farmhouse)	1309	127.5	Complaint
162	Heritage (KMR 005 - Scatter of stone tools)	225	138.4	N/A
163	Heritage (KMR 007 - Burial Ground)	68	145.7	N/A
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	1078	128.7	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	30	150.7	N/A
166	Heritage (KAL03 - Artefacts)	21	153.1	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	-	-	-

17.7.5 Air blast minimum charge mass per delay – Kipling Pit - 386 kg

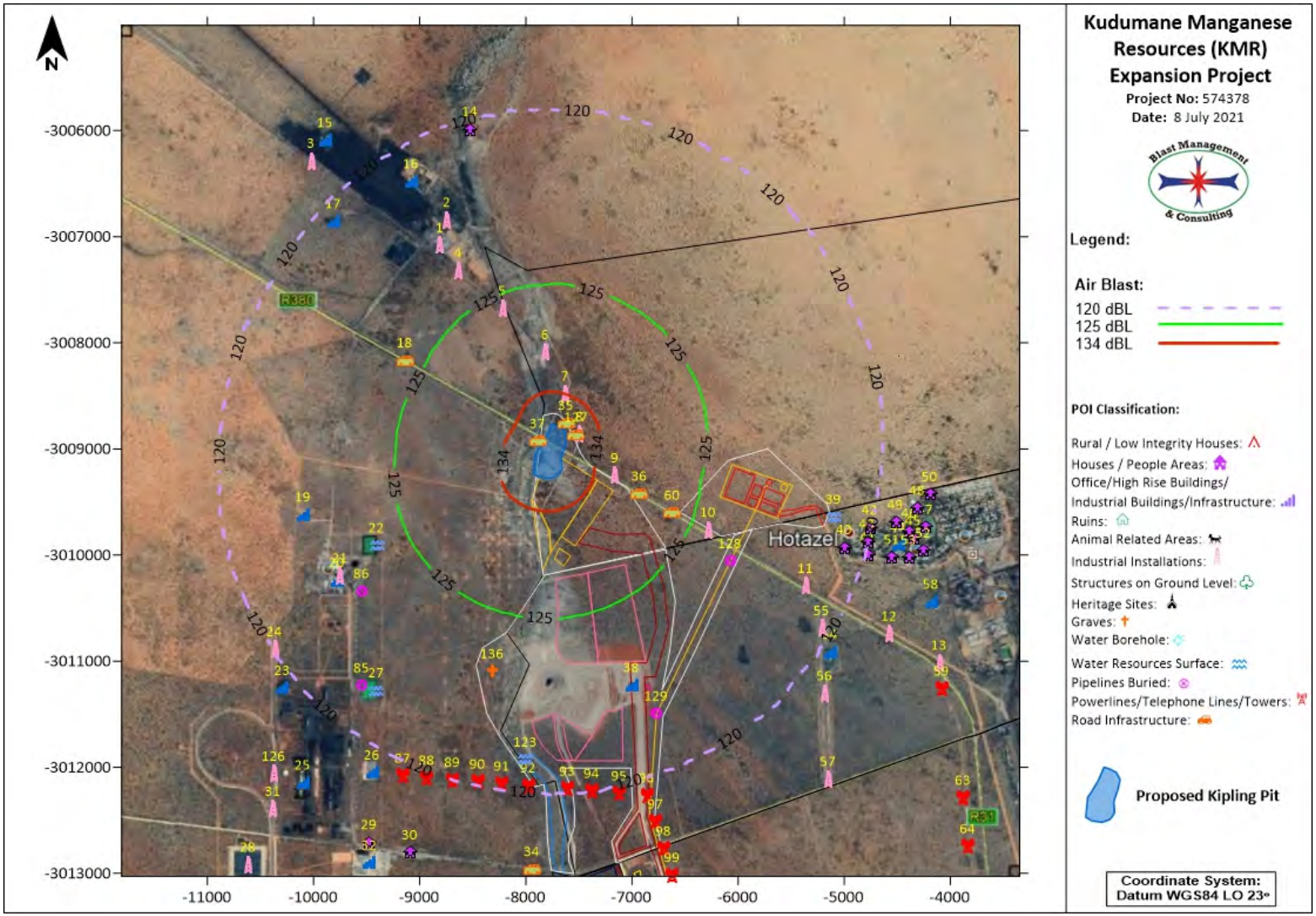


Figure 22: Air blast influence from minimum charge for Kipling Pit

Table 21: Air blast evaluation for minimum charge for Kipling Pit

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Sewage Plant (Gloria Mine)	1986	122.5	N/A
2	Mine Activity	2162	122.0	N/A
3	Railway Line	3359	119.2	N/A
4	Railway Line	1691	123.4	N/A
5	Railway Line	1186	125.6	N/A
6	Railway Line	679	129.1	N/A
7	Railway Line	311	133.9	N/A
8	Railway Line	117	139.9	N/A
9	Railway Line	505	130.9	N/A
10	Railway Line	1493	124.2	N/A
11	Railway Line	2545	120.9	N/A
12	Railway Line	3452	119.1	N/A
14	Farm Buildings/Structures	2882	120.2	Complaint
15	Vent Shaft	3421	119.1	Acceptable
16	Mine Buildings/Structures	2642	120.7	Complaint
17	Mining Installation	2806	120.3	Complaint
18	R380 Road	1501	124.2	N/A
19	Explosive Magazine	2204	121.8	N/A
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	2107	122.1	Complaint
21	Conveyor	2059	122.2	N/A
22	Dam	1622	123.7	N/A
23	Mining Plant	3108	119.7	Acceptable
24	Railway Line	2947	120.0	N/A
26	Sub Station	3195	119.6	Acceptable
27	Dam	2521	121.0	N/A
35	Gravel Road	64	143.6	N/A
36	R380 Road	767	128.3	N/A
37	Gravel Road	45	145.9	N/A
38	Mine Buildings/Structures	2091	122.2	Complaint
39	Reservoir	2600	120.8	N/A
40	Houses	2763	120.4	Complaint
41	Houses	2997	120.0	Acceptable
42	Houses	2956	120.0	Acceptable
43	Hotazel Golf Club	2960	120.0	Acceptable
44	Hotazel Municipal Clinic	3253	119.4	Acceptable
45	Pool	3378	119.2	N/A
46	School	3329	119.3	Acceptable
47	Sports field	3470	119.0	Acceptable
48	School	3368	119.2	Acceptable
49	House	3187	119.6	Acceptable
50	Houses	3459	119.0	Acceptable
51	Houses	3220	119.5	Acceptable
52	Hostel	3494	119.0	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
53	Houses	3372	119.2	Acceptable
54	Airfield Structure	3056	119.8	Acceptable
55	Landing Strip	2870	120.2	N/A
56	Landing Strip	3248	119.5	N/A
60	R380 Road	1119	126.0	N/A
85	Pipeline	2568	120.9	N/A
86	Pipeline	1958	122.6	N/A
87	Power Line/Pylon	3090	119.7	N/A
88	Power Line/Pylon	3021	119.9	N/A
89	Power Line/Pylon	2964	120.0	N/A
90	Power Line/Pylon	2926	120.1	N/A
91	Power Line/Pylon	2907	120.1	N/A
92	Power Line/Pylon	2897	120.1	N/A
93	Power Line/Pylon	2924	120.1	N/A
94	Power Line/Pylon	2968	120.0	N/A
95	Power Line/Pylon	3035	119.9	N/A
96	Power Line/Pylon	3122	119.7	N/A
97	Power Line/Pylon	3382	119.2	N/A
123	Attenuation Dam (Planned)	2654	120.7	N/A
127	Diversion R380 Road (Planned)	54	144.7	N/A
128	Potable Water Pipeline (Planned)	1806	123.1	N/A
129	Potable Water Pipeline (Planned)	2428	121.2	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	1881	122.8	N/A
137	Hydrocensus Borehole (gl27)	1956	122.6	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	1742	123.3	N/A
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	1574	123.9	N/A
140	Hydrocensus Borehole (Htwm005)	1941	122.6	N/A
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	1761	123.2	N/A
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	1743	123.3	N/A
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	1861	122.9	N/A
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	1844	122.9	N/A
145	Hydrocensus Borehole (Mk01)	2392	121.3	N/A
146	Hydrocensus Borehole (Mk02)	614	129.7	N/A
150	Hydrocensus Borehole (wh02)	223	135.9	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	1573	123.9	Complaint
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	1194	125.6	N/A
160	Heritage (KMR 003 - Scatter of stone tools)	900	127.3	N/A
162	Heritage (KMR 005 - Scatter of stone tools)	2408	121.3	N/A
163	Heritage (KMR 007 - Burial Ground)	1480	124.3	N/A
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	1289	125.1	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	2092	122.2	N/A
166	Heritage (KAL03 - Artefacts)	2180	121.9	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	2160	122.0	N/A

17.7.6 Air blast maximum charge mass per delay – Kipling Pit - 1285 kg

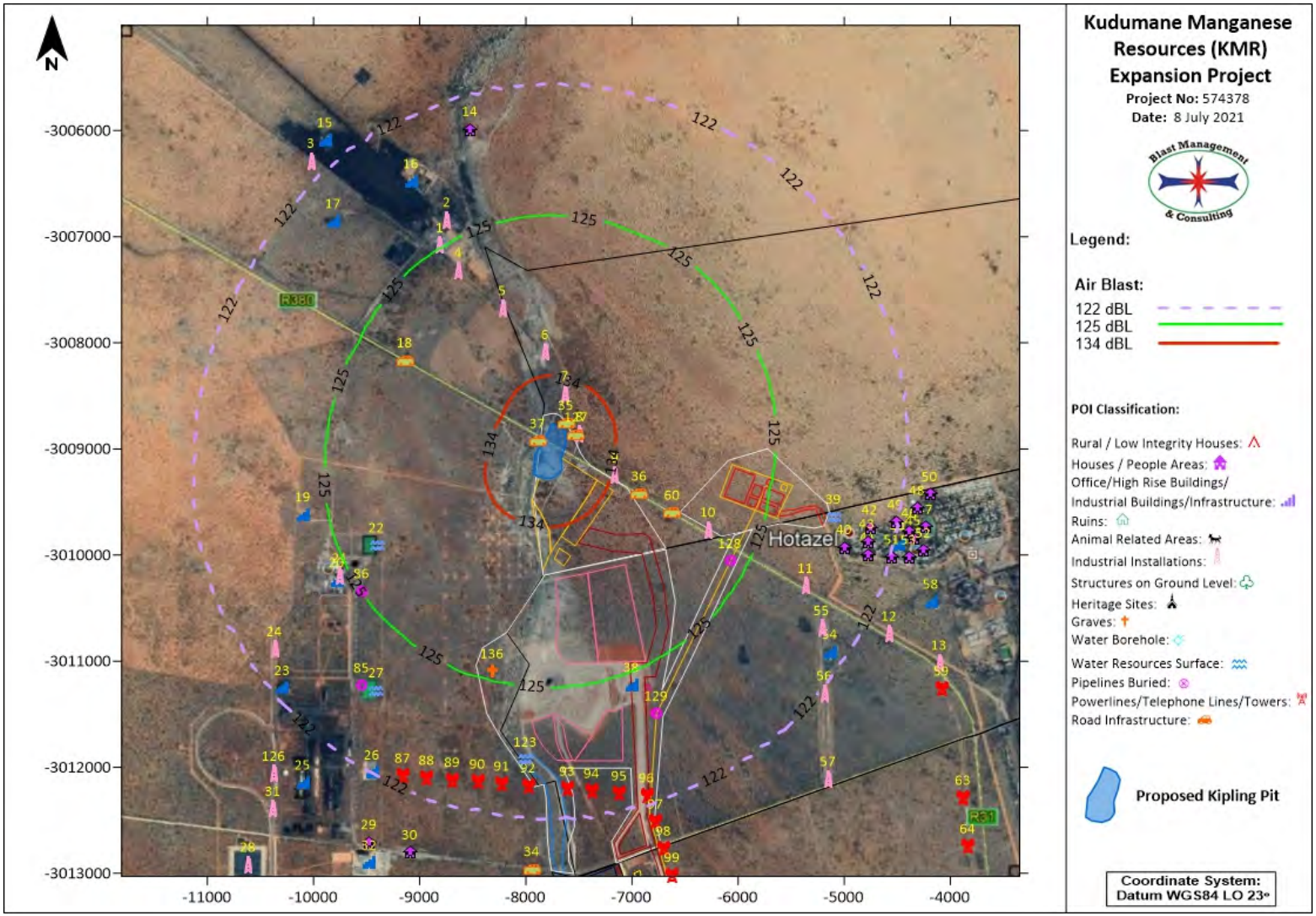


Figure 23: Air blast influence from maximum charge for Kipling Pit

Table 22: Air blast evaluation for maximum charge for Kipling Pit

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Sewage Plant (Gloria Mine)	1986	124.9	N/A
2	Mine Activity	2162	124.4	N/A
3	Railway Line	3359	121.7	N/A
4	Railway Line	1691	125.9	N/A
5	Railway Line	1186	128.1	N/A
6	Railway Line	679	131.5	N/A
7	Railway Line	311	136.3	N/A
8	Railway Line	117	142.4	N/A
9	Railway Line	505	133.4	N/A
10	Railway Line	1493	126.7	N/A
11	Railway Line	2545	123.4	N/A
12	Railway Line	3452	121.5	N/A
14	Farm Buildings/Structures	2882	122.7	Complaint
15	Vent Shaft	3421	121.6	N/A
16	Mine Buildings/Structures	2642	123.2	Complaint
17	Mining Installation	2806	122.8	Complaint
18	R380 Road	1501	126.7	N/A
19	Explosive Magazine	2204	124.3	N/A
20	Mine Buildings/Structures (Kalagadi Manganese Mine)	2107	124.6	Complaint
21	Conveyor	2059	124.7	N/A
22	Dam	1622	126.2	N/A
23	Mining Plant	3108	122.2	Complaint
24	Railway Line	2947	122.5	N/A
26	Sub Station	3195	122.0	N/A
27	Dam	2521	123.5	N/A
35	Gravel Road	64	146.1	N/A
36	R380 Road	767	130.8	N/A
37	Gravel Road	45	148.3	N/A
38	Mine Buildings/Structures	2091	124.6	Complaint
39	Reservoir	2600	123.3	N/A
40	Houses	2763	122.9	Complaint
41	Houses	2997	122.4	Complaint
42	Houses	2956	122.5	Complaint
43	Hotazel Golf Club	2960	122.5	Complaint
44	Hotazel Municipal Clinic	3253	121.9	Complaint
45	Pool	3378	121.7	N/A
46	School	3329	121.7	Complaint
47	Sports field	3470	121.5	Complaint
48	School	3368	121.7	Complaint
49	House	3187	122.0	Complaint
50	Houses	3459	121.5	Complaint
51	Houses	3220	122.0	Complaint
52	Hostel	3494	121.5	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
53	Houses	3372	121.7	Complaint
54	Airfield Structure	3056	122.3	Complaint
55	Landing Strip	2870	122.7	N/A
56	Landing Strip	3248	121.9	N/A
60	R380 Road	1119	128.5	N/A
85	Pipeline	2568	123.4	N/A
86	Pipeline	1958	125.0	N/A
87	Power Line/Pylon	3090	122.2	N/A
88	Power Line/Pylon	3021	122.4	N/A
89	Power Line/Pylon	2964	122.5	N/A
90	Power Line/Pylon	2926	122.6	N/A
91	Power Line/Pylon	2907	122.6	N/A
92	Power Line/Pylon	2897	122.6	N/A
93	Power Line/Pylon	2924	122.6	N/A
94	Power Line/Pylon	2968	122.5	N/A
95	Power Line/Pylon	3035	122.3	N/A
96	Power Line/Pylon	3122	122.2	N/A
97	Power Line/Pylon	3382	121.6	N/A
123	Attenuation Dam (Planned)	2654	123.1	N/A
127	Diversion R380 Road (Planned)	54	147.2	N/A
128	Potable Water Pipeline (Planned)	1806	125.5	N/A
129	Potable Water Pipeline (Planned)	2428	123.7	N/A
136	H4 - Potential grave (Inside Hotazel Pit Area)	1881	125.3	N/A
137	Hydrocensus Borehole (gl27)	1956	125.0	N/A
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	1742	125.7	N/A
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	1574	126.4	N/A
140	Hydrocensus Borehole (Htwm005)	1941	125.1	N/A
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	1761	125.7	N/A
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	1743	125.7	N/A
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	1861	125.3	N/A
144	Hydrocensus Borehole (KU20-13) -- Inside Hotazel Pit Area	1844	125.4	N/A
145	Hydrocensus Borehole (Mk01)	2392	123.8	N/A
146	Hydrocensus Borehole (Mk02)	614	132.2	N/A
150	Hydrocensus Borehole (wh02)	223	138.4	N/A
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	1573	126.4	Complaint
159	Heritage (KMR 002 - Single fragment of a broken lithic blade)	1194	128.1	N/A
160	Heritage (KMR 003 - Scatter of stone tools)	900	129.8	N/A
162	Heritage (KMR 005 - Scatter of stone tools)	2408	123.8	N/A
163	Heritage (KMR 007 - Burial Ground)	1480	126.7	N/A
164	Heritage (KAL01 - Scatter of Stone Age artefacts)	1289	127.6	N/A
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	2092	124.6	N/A
166	Heritage (KAL03 - Artefacts)	2180	124.4	N/A
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	2160	124.4	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 115.6 and 149.4 dB for all the POI's considered. This includes the nearest points such as the Heritage Sites, Mine Buildings/Structures, Sewage Plant, Explosives Magazine, Transformer, Farm Buildings and Houses. These levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints.

Minimum charge predictions identified that twelve POI's (York Pit); four POI's (Hotazel Pit) and seven POI's (Kipling Pit) at pit areas could experience levels of air blast that could lead to complaints. Maximum charge predictions indicate that thirteen POI's (York Pit); twenty-nine POI's (Hotazel Pit) and twenty-seven POI's (Kipling Pit) at pit areas could experience air blast that could lead to complaints. One POI's at York Pit and one POI at Hotazel Pit were identified where damage may be induced.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 458 m and closer to pit boundary. Infrastructure at the pit areas such as roads, railway line, graves, power lines/pylons are present, but air blast does not have any influence on these installations.

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

17.9 Fly-rock unsafe zone

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

Calculations are also used to help and assist determining safe distances. A safe distance from blasting is calculated following rules and guidelines from the International Society of Explosives Engineers (ISEE) Blasters Handbook. Using this calculation, the minimum safe distances can be determined that should be cleared of people, animals and equipment. Figure 24 shows the results from the ISEE calculations for fly rock range based on a 171 mm diameter blast hole and 4.5 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 278 m.

The absolute minimum unsafe zone is then the 278 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 25 to Figure 27 shows the area around the Pits that incorporates the 278 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.

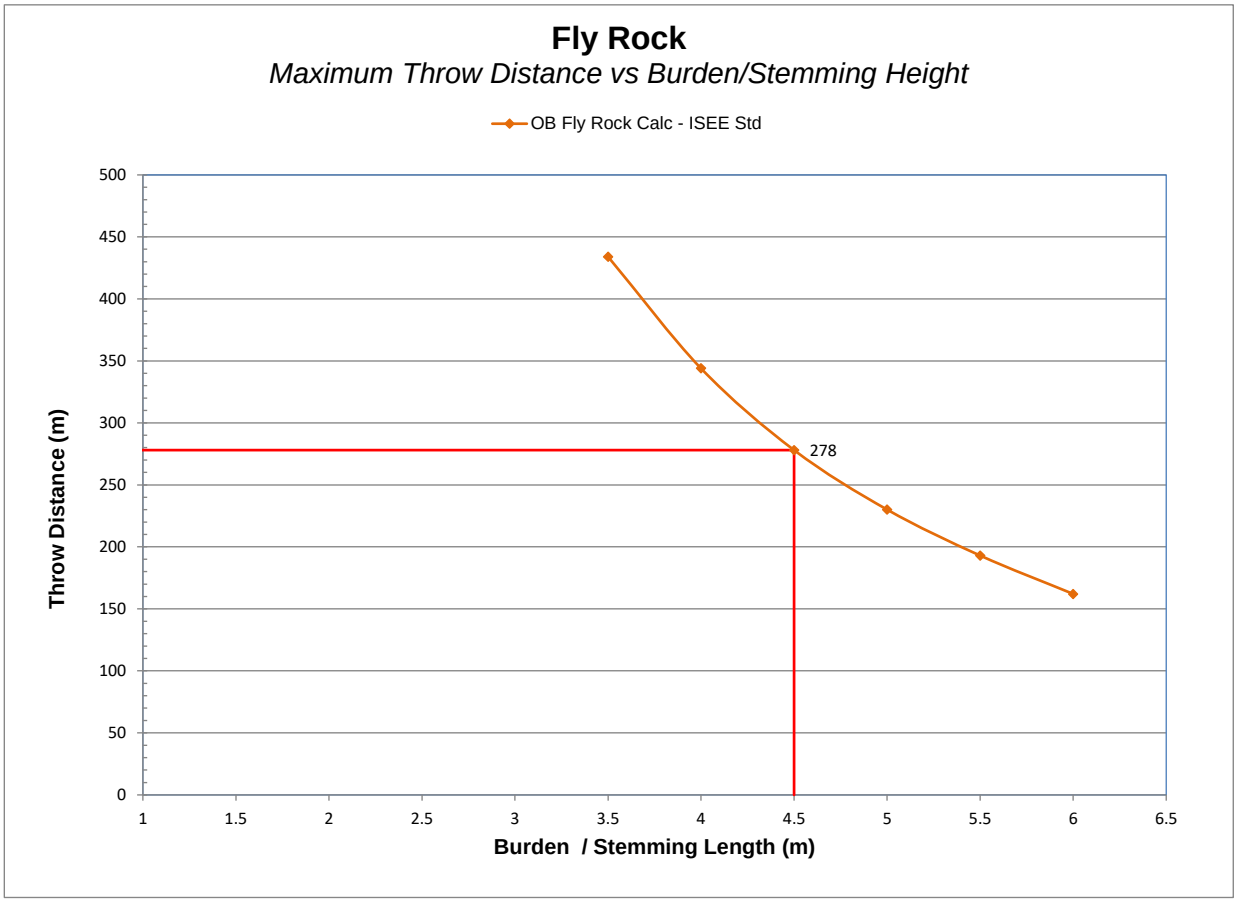


Figure 24: Fly rock prediction calculation

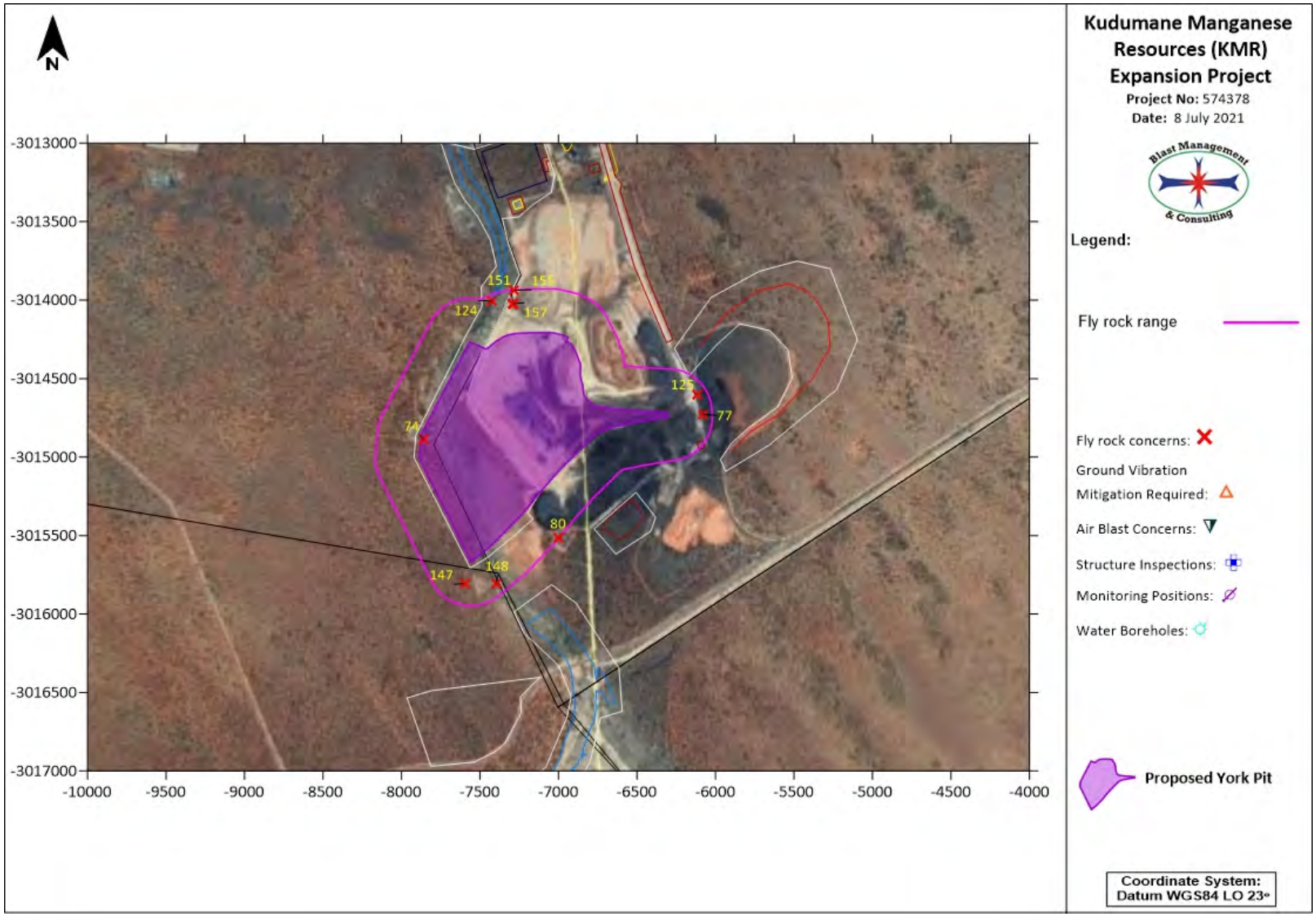


Figure 25: Predicted Fly Rock Exclusion Zone for the York Pit area

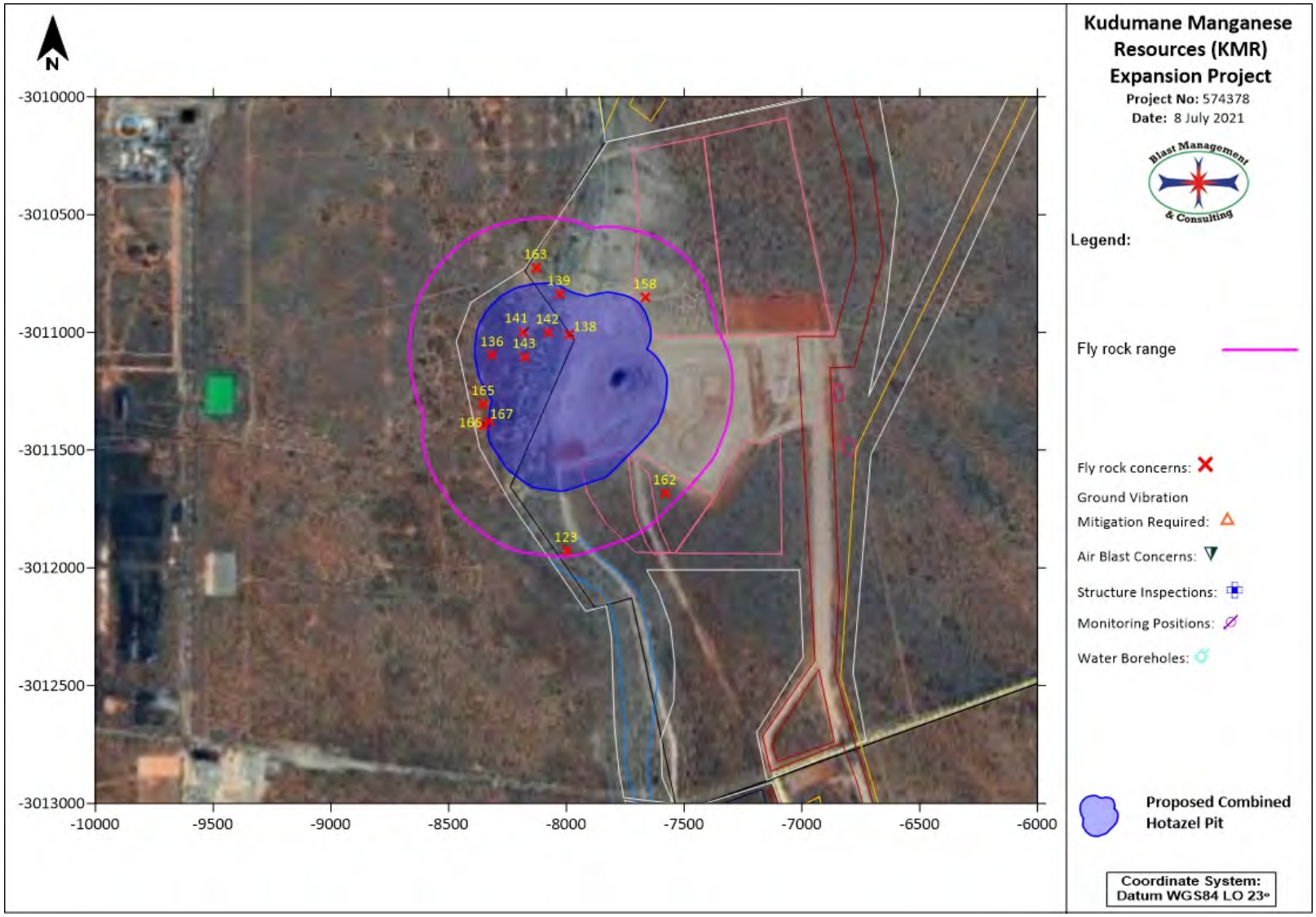


Figure 26: Predicted Fly Rock Exclusion Zone for the Hotazel Pit area

Figure 27: Predicted Fly Rock Exclusion Zone for the Kipling Pit area

Review of the calculated unsafe zone showed ten POI's for the York Pit area, thirteen POI's for Hotazel Pit area and five POI's for the Kipling pit area are within the unsafe zone. Table 23 below shows the POI's of concern and coordinates.

Table 23: Fly rock concern POI's

Tag	Description	Y	X
	York Pit		
74	Old Farmstead (Inside York Pit Area)	7859.09	3014890.11
77	Rail Loading Bay	6080.60	3014728.56
80	Return Water Dam	7000.03	3015510.87
124	Attenuation Dam (Planned)	7426.22	3014004.99
125	Railway Line	6118.59	3014603.12
147	Hydrocensus Borehole (T1)	7599.61	3015804.93
148	Hydrocensus Borehole (T2)	7396.59	3015802.59
151	Hydrocensus Borehole (windmill 4)	7291.18	3014027.95
155	Hydrocensus Borehole (YGW04)	7280.83	3013937.64
157	Hydrocensus Borehole (Ykdw4)	7290.29	3014022.51
	Hotazel Pit		
123	Attenuation Dam (Planned)	8000.15	3011927.89
136	H4 - Potential grave (Inside Hotazel Pit Area)	8314.60	3011097.13
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	7988.81	3011012.76
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	8030.24	3010837.38
141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	8180.82	3011002.25
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	8078.87	3011000.63
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	8177.08	3011104.19
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	7664.18	3010852.50
162	Heritage (KMR 005 - Scatter of stone tools)	7581.11	3011683.50
163	Heritage (KMR 007 - Burial Ground)	8128.79	3010725.86
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	8352.30	3011304.42
166	Heritage (KAL03 - Artefacts)	8351.25	3011395.28
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	8328.47	3011379.75
	Kipling Pit		
8	Railway Line	7491.02	3008861.93
35	Gravel Road	7617.81	3008754.82
37	Gravel Road	7887.18	3008928.19
127	Diversion R380 Road (Planned)	7553.33	3008875.04
150	Hydrocensus Borehole (wh02)	8016.87	3009442.75

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. The impact assessment and evaluation below were used for analysis and evaluation of aspects discussed in this report. The outcome of the analysis is provided in Table 28 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.

18.1 Assessment Criteria

The criteria for the description and assessment of environmental impacts were drawn from SRK to comply 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 24: 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 25: 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
	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 26: 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 27: 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

Please note that the Loss of Resources aspect will not affect the overall significance rating of the impact.

18.2 Assessment

The assessment done was based on evaluating the points of interested that showed expected levels greater than limits. 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.

Table 28: Impact 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																	
Hydrocensus Borehole	-	4	4	2	8	4	56	**Moderate**	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, using electronic initiation instead of shock tube systems to obtain single hole firing.	3	4	2	2	1	24	**Low**	57.1
Heritage (KMR 001 - Historical Site - Abandoned Cottage)	-	4	4	2	8	4	56	**Moderate**		3	4	2	2	1	24	**Low**	57.1
Railway Line	-	5	4	2	8	4	70	**High**		3	4	2	4	1	30	**Moderate**	57.1
Diversion R380 Road (Planned)	-	5	4	2	8	4	70	**High**		3	4	2	4	1	30	**Moderate**	57.1
ACTIVITY: Air Blast																	
Operational																	
Farm Buildings/Structures	-	3	4	2	4	4	30	**Moderate**	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, use of specific stemming materials to manage air blast, increased stemming lengths to reduce air blast effect. Used of specific stemming to manage fly rock - crushed aggregate of specific size. Re-design with increased stemming lengths.	3	4	2	2	1	24	**Low**	20.0
Houses	-	3	4	2	4	4	30	**Moderate**		3	4	2	2	1	24	**Low**	20.0
Hotazel Municipal Clinic	-	3	4	2	4	4	30	**Moderate**		3	4	2	2	1	24	**Low**	20.0
School	-	3	4	2	4	4	30	**Moderate**		3	4	2	2	1	24	**Low**	20.0
ACTIVITY: Fly Rock																	
Operational																	
Rail Loading Bay	-	4	4	2	6	4	48	**Moderate**	Specific blast design to be done, shorter blast holes, smaller diameter blast hole, use of specific stemming materials to manage air blast, increased stemming lengths to reduce air blast effect. Used of specific stemming to manage fly rock - crushed aggregate of specific size. Re-design with increased stemming lengths.	3	4	2	2	1	24	**Low**	50.0
Return Water Dam	-	4	4	2	6	4	48	**Moderate**		3	4	2	2	1	24	**Low**	50.0
Attenuation Dam (Planned)	-	4	4	2	6	4	48	**Moderate**		3	4	2	2	1	24	**Low**	50.0
Railway Line	-	4	4	2	8	4	56	**Moderate**		3	4	2	2	1	24	**Low**	57.1
Heritage (KMR 001 - Historical Site - Abandoned Cottage)	-	4	4	2	4	4	40	**Moderate**		3	4	2	2	1	24	**Low**	40.0
Diversion R380 Road (Planned)	-	4	4	2	8	4	56	**Moderate**		3	4	2	2	1	24	**Low**	57.1

18.3 Mitigations

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

Specific impacts are expected at the following POI's identified. Table 29 shows list of POI's that will need to be considered and
Table 30 the POI's that needs specific attention due to location of the infrastructure.. Figure 28 to Figure 30 shows the location of these POI's in relation to the pit areas.

Table 29: Structures identified as problematic in and around the project area

Tag	Description	Classification	Y	X
	York Pit			
80	Return Water Dam	6	7000.03	3015510.87
147	Hydrocensus Borehole (T1)	10	7599.61	3015804.93
148	Hydrocensus Borehole (T2)	10	7396.59	3015802.59
151	Hydrocensus Borehole (windmill 4)	10	7291.18	3014027.95
157	Hydrocensus Borehole (Ykdw4)	10	7290.29	3014022.51
	Hotazel Pit			
158	Heritage (KMR 001 - Historical Site - Abandoned Cottage)	8	7664.18	3010852.50
163	Heritage (KMR 007 - Burial Ground)	8	8128.79	3010725.86
165	Heritage (KAL02 - Scatter of Stone Age artefacts)	8	8352.30	3011304.42
166	Heritage (KAL03 - Artefacts)	8	8351.25	3011395.28
	Kipling Pit			
8	Railway Line	6	7491.02	3008861.93
35	Gravel Road	14	7617.81	3008754.82
37	Gravel Road	14	7887.18	3008928.19
127	Diversion R380 Road (Planned)	14	7553.33	3008875.04
150	Hydrocensus Borehole (wh02)	10	8016.87	3009442.75

Table 30: Structures identified inside the planned pit area

Tag	Description	Classification	Y	X
	York Pit			
74	Old Farmstead (Inside York Pit Area)	8	7859.09	3014890.11
	Hotazel Pit			
136	H4 - Potential grave (Inside Hotazel Pit Area)	9	8314.60	3011097.13
138	Hydrocensus Borehole (HTDW 002) - Inside Hotazel Pit Area	10	7988.81	3011012.76
139	Hydrocensus Borehole (HTWM 004) - Inside Hotazel Pit Area	10	8030.24	3010837.38

141	Hydrocensus Borehole (KSX23) - - Inside Hotazel Pit Area	10	8180.82	3011002.25
142	Hydrocensus Borehole (KU20-09) - Inside Hotazel Pit Area	10	8078.87	3011000.63
143	Hydrocensus Borehole (KU20-12) - Inside Hotazel Pit Area	10	8177.08	3011104.19
167	Heritage (KAL04 -Scatter of Stone Age Artefacts) - Inside Hotazel Pit Area)	8	8328.47	3011379.75