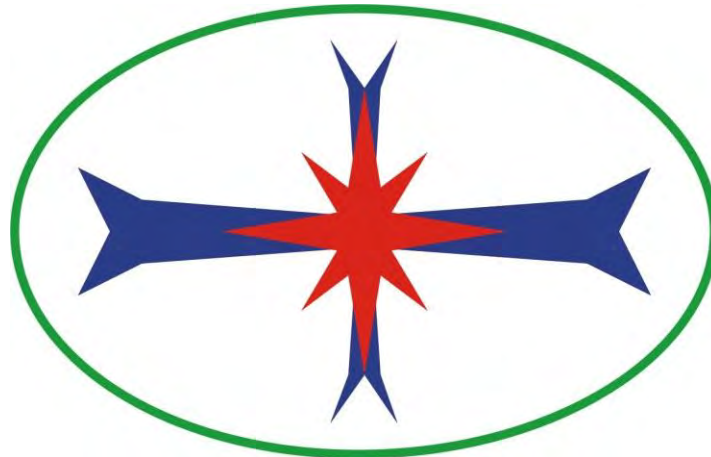
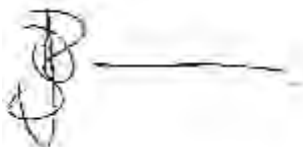


Blast Management & Consulting



Quality Service on Time

Report: Blast Impact Assessment The proposed Kokoseb Gold Project on EPL 4818, Erongo Region - Namibia		
Report Date:	29 October 2025	
BM&C Ref No:	ECC_Kokoseb Gold Mine Project_EIAReport_251029V02	
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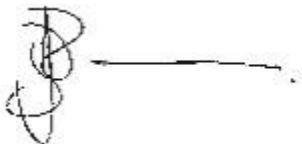
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A declaration that the specialist is independent in a form as may be specified by the competent authority.

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- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the relevant legislation and any guidelines that have relevance to the proposed activity;
- I will comply with the applicable legislation;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct.



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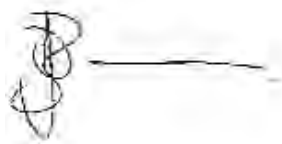
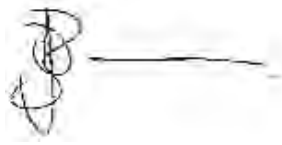
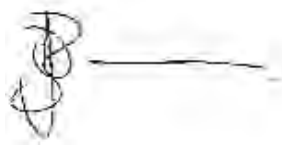
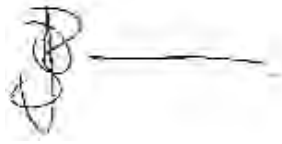
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List of Acronyms used in this Report

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)
ESIA	Environmental and Social Impact Assessment
Freq.	Frequency
GRP	Gas Release Pulse
I&AP	Interested and Affected Parties
k	Factor value
L	Maximum Throw (m)
M	Charge Height
m (SH)	Stemming height
M/S	Magnitude/Severity
Mc	Charge mass per metre column.
NO	Nitrogen Monoxide
NO ₂	Nitrogen Dioxide
NO _x	Nitrogen Oxide
NO _x 's	Noxious Fumes
POI	Points of Interest
PPV	Peak Particle Velocity
RPP	Rock Pressure Pulse
USBM	United States Bureau of Mines
WGS 84	Coordinates (South African)

List of Units used in this Report

%	percentage
cm	centimetre
dB	decibel
dB	linear decibel
g/cm ³	gram per cubic centimetre
Hz	frequency
kg	kilogram
kg/m ³	kilogram per cubic metre
kg/t	kilogram per tonne
km	kilometre
kPa	kilopascal
m	metre

m ²	metre squared
mm/s	millimetres per second
mm/s ²	millimetres per second square
ms	milliseconds
Pa	Pascal
ppm	parts per million

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1 Executive Summary

Blast Management & Consulting (BMC) was contracted by Environmental Compliance Consultancy (ECC) as part of the Environmental and Social Impact Assessment (ESIA) to perform an initial review of possible impacts concerning blasting operations in the proposed opencast mining operation.

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 conducted over a general area as wide as 3500 m from the mining area considered and specific POIs located as far as 18.6 km. The range of structures observed is typical of roads, low-cost houses, and heritage sites.

Various houses located around the pit area was identified for relocation as well as re-routing of the D3714. The closest POI observed is associated with area of wildlife animal activity. The nearest private houses/structures, that will not be relocated, are located 2270 m from the pit. The ground vibration levels predicted for all POIs ranged between none and 66.2 mm/s. The relocation process of affected farmers or community groups within the mine blast buffer zone to safer grounds reduces the possible impact from ground vibration, air blast and flyrock significantly.

The expected levels of ground vibration at the nearest houses are low with no specific mitigations required. POI 32 was identified as a wildlife area with no surface structure present. The expected ground vibration level at this POI is not considered problematic though greater than an estimated limit. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Review of the heritage sites surrounding the planned mining area ranges in distances from 2.7 km to 15 km. There is no impact possible from blasting operations on these sites.

The air blast predicted showed some limited concerns for opencast blasting. The current accepted limit on air blast is 134 dB(L). Damages are only expected to occur at levels greater than 134 dB(L). None of the houses/structures identified, that will not be relocated, showed exceedances of the limits. Air blast levels at the nearest houses are however greater than 120 dB(L) which could lead to complaints. Prediction shows that the air blast will be greater than 134 dB(L) at a distance of 370 m and closer to the pit boundary. It is maintained that if basic blasting principles and stemming control are not exercised, this effect could be greater with a greater range of complaints. The pits are located such that “free blasting” – meaning no controls on blast preparation – will not be possible.

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 519 m. The absolute minimum unsafe zone is then 519 m. This calculation is a guideline, and any distance cleared should not be less than. One POI – POI 32 - is found within this range. 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 its occurrence can never be eliminated.

Generally, 500 m is applied for a safe blasting/clearance distance; however, the calculated unsafe zone for fly rock is 519 m, therefore, this should be used as the clearance distance. Specific actions will be required when blasting is done within 519 m of structures. The wildlife animal activity (Main Hill/Ridge Habitat 4) fall within the 519 m range from the pit area.

The planned mine accommodation houses are located 3.1 km away from the planned pit area. Assessment of impacts indicated there is no concern regarding impacts from ground vibration, air blast and fly rock.

The pit area is located such that specific concerns were identified and addressed in the report. There are public areas located close to the pit boundary. Specific mitigation will be required for these concerns. Recommendations have been made regarding these.

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

2 Introduction

Damaran Exploration Namibia (Pty) Ltd (Damaran Exploration) is seeking to develop the Kokoseb Gold Project (the Project) within the Erongo Region in Namibia. The Project is expected to produce 1,367,000 oz of gold with a life of mine (LoM) of a minimum of 11 years. The Project will be undertaken in the exclusive prospecting licence (EPL) 4818 area, where the gold resource is located and covering an area of 33,667 ha. An environmental clearance certificate and mining licence (ML) will be applied for over EPL 4818.

The EPL is located approximately 15 km from Okombahe, 30 km from Uis and 90 km from Omaruru town in the Erongo Region. The closest main road is the C36, which borders the EPL and the road D3714, which runs through the proposed Project footprint. The EPL4818 traverses the Okombahe Reserve, the western portion of the EPL falling within the Tsiseb Conservancy.

The proposed infrastructure will include one large open pit and a smaller pit, waste rock dumps (WRDs), a tailings storage facility (TSF), a processing plant and other supporting infrastructure such as a mining infrastructure, an accommodation village and administrative buildings.

The mining method will be conventional open-pit mining using drilling and blasting techniques, hydraulic excavators and diesel-powered truck hauling of material to be processed. The ore zone will be drilled with holes of a diameter of up to 171 mm and blasted at 10 m benches. Blasting will be undertaken using ammonium nitrate fuel oil (ANFO) that will be mixed on-site. Ore will be hauled from the open pit to the run-of-mine (ROM) pad stockpile, low-grade stockpile and then the primary crusher at the processing plant. Waste material from excavation will be hauled to the WRDs, and topsoil will be hauled to allocated topsoil stockpiles.

Figure 1 Indicates the Kokoseb Project Location.

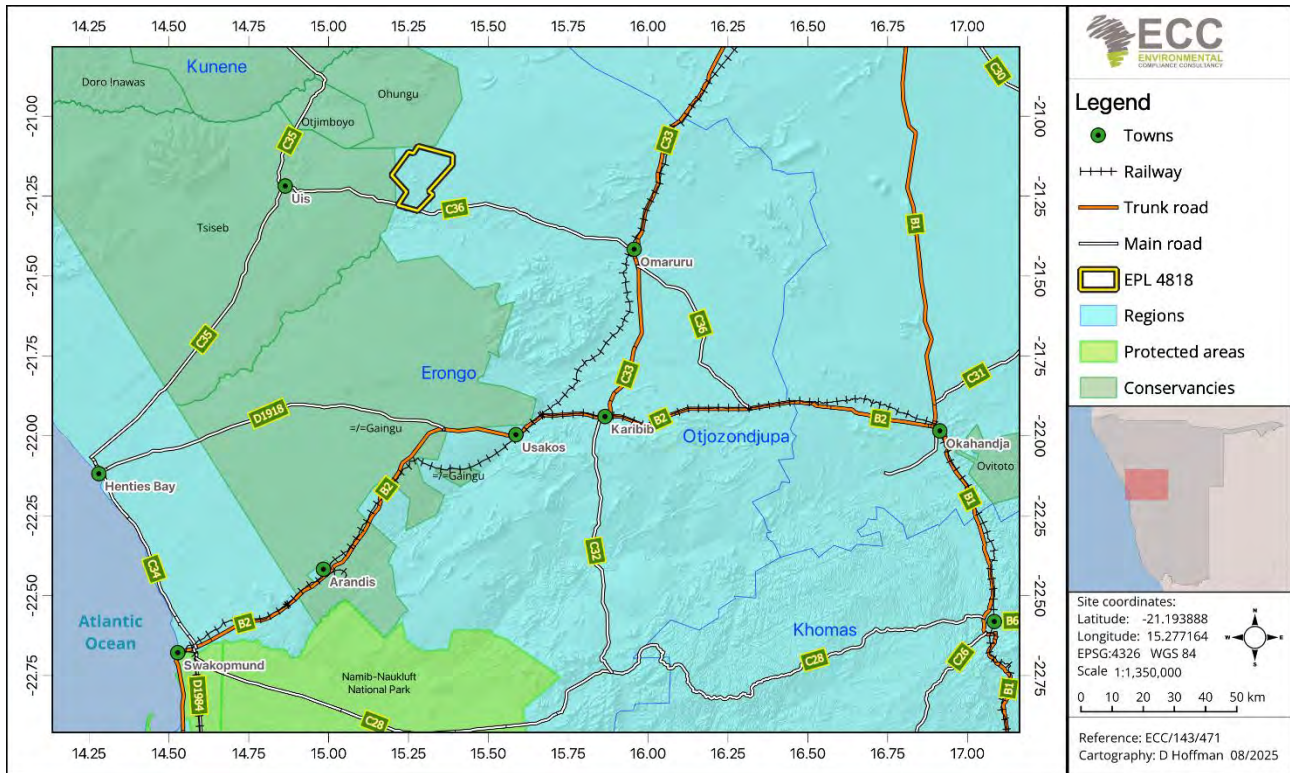


Figure 1: Project Location

3 Objectives

The objectives of this document are to outline the expected environmental effects that blasting operations could have on the surrounding environment and to propose 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 surroundings, and the possible influence on nearby private installations, houses and the owners or occupants.

The objectives were dealt with whilst considering specific protocols. The protocols applied in this document are based on the author's experience, guidelines taken from literature research, client requirements and Namibian legislation. There is, however, no direct reference in the following Namibian acts to requirements and limits on the effect of ground vibration and air blast and some of the aspects addressed in this report:

- Environmental Management Act 7 Of 2007, (Gg 3966).
- Government Notice Ministry Of Labour No. 156, 1997, Labour Act, 1992: Regulations Relating To The Health And Safety Of Employees At Work.
- Government Notice, Ministry Of Mines And Energy No. 1999, Regulations Made Under Section 138a Of The Minerals (Prospecting And Mining) Act, 33 Of 1992, As Amended: Health And Safety Of Persons Employed Or Otherwise Present In Or At Mines.
- Government Notice 143 Of 1968, Mines, Works And Minerals Ordinance 20 Of 1968, Section 95 Regulations Made Under The Provisions Of The Mines, Works And Minerals Ordinance, 1968 (Ordinance 20 Of 1968).

- Minerals (Prospecting And Mining) Act 33 Of 1992, (Gg 564).
- Mineral Act, 1992.

The guidelines and safe blasting criteria applied are based on internationally accepted standards, guidelines from South African legislation and recommended safe blasting criteria for ground vibration and air blast published by the United States Bureau of Mines (USBM).

4 Scope of blast impact study

The terms of reference for the ground vibration, air blast and fly rock assessment due to blasting operations were as follows:

- Review background information of the proposed site.
- Review blasting operation requirements.
- Undertake 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 the fly rock unsafe zone;
 - Discussion on the occurrence of noxious fumes and dangers of fumes;
 - Evaluate the location of blasting operations in relation to surrounding areas according to the regulations from the applicable Acts.
- Compile impact assessment using standardised methodology provided by ECC.
- Develop mitigation measures to reduce/minimise impacts identified.
- Make recommendations for further consideration in the design of the project.

5 Study area

The EPL is located approximately 15 km from Okombahe, 30 km from Uis and 90 km from Omaruru town in the Erongo Region. The closest main road is the C36 and borders the EPL and the road D3714 which runs through the proposed project footprint. The EPL4818 traverses through Okombahe Reserve, on the western portion of the EPL which falls within the Tsiseb Conservancy. The centre point of the site is 21° 9'47.21"S and 15°14'47.12"E.

Figure 2 shows the Layout of the proposed Kokoseb Gold Mine Project.

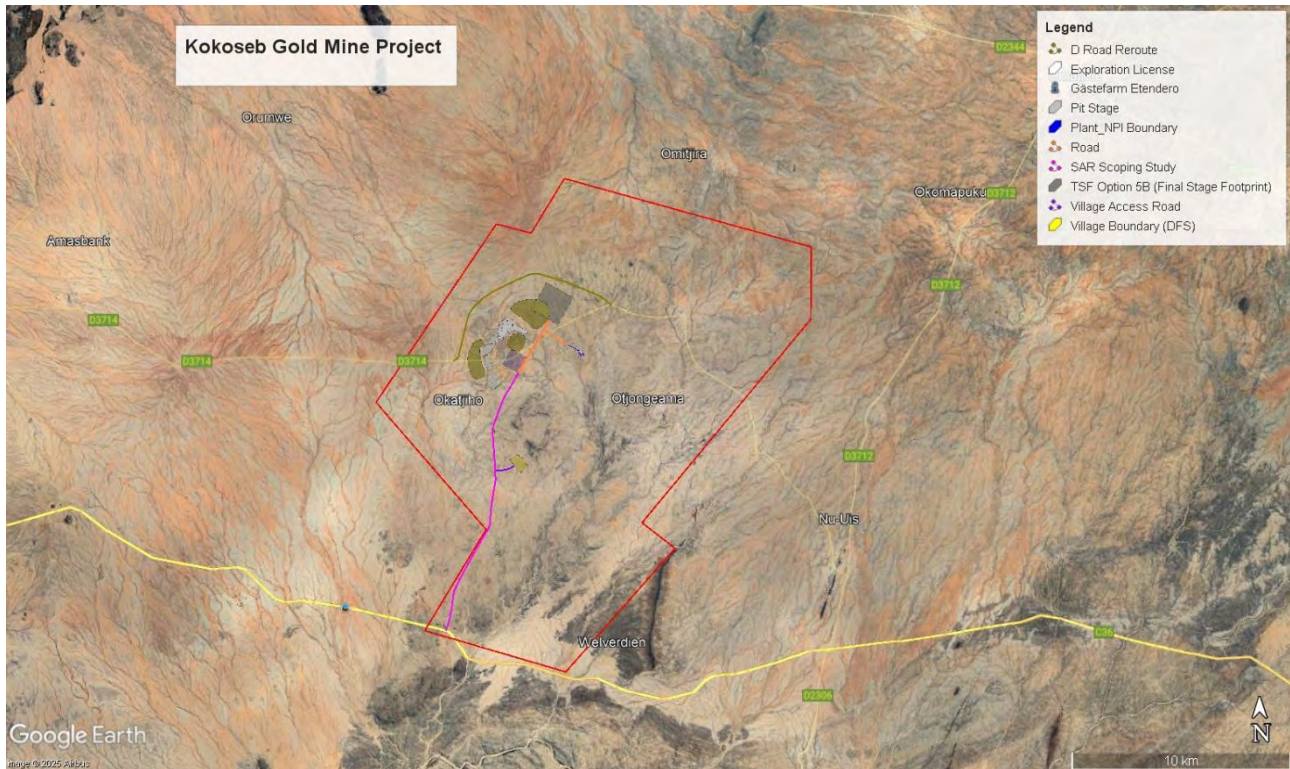


Figure 2: Layout of the proposed Kokoseb Gold Mine Project

6 Methodology

The detailed plan of study consists of the following sections:

- A desktop impact assessment study was done.
- Site evaluation: This consists of evaluation of the mining operations and the possible influences from blasting operations. The methodology is modelling the expected impact based on the expected drilling and blasting information provided for the project. Various accepted mathematical equations are applied to determine the attenuation of ground vibration, air blast and fly rock. These values are then calculated over the distance investigated from site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors then gives an indication of the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels then gives an indication of the possible mitigation measures to be applied. The possible environmental or social impacts are then addressed in the detailed EIA phase investigation.
- Reporting: All data is prepared in a single report and provided for review.

7 Season applicable to the investigation

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

8 Assumptions and Limitations

The following assumptions have been made:

- 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 site is evaluated as a new operation with no drilling and blasting being done. No confirmation of the predicted values could be made.
- Blasting operations assume a 165 mm diameter blast hole with Emulsion explosives as received from the client.
- Basic blast design parameters were provided. BMC used the parameters and did timing of the blast based on what is considered best practice.
- There are houses/structures very close to the pit area. It is assumed that relocation of these households/infrastructure will be considered.
- The work done is based on the author's knowledge and information provided by the project applicant.

9 Legal Requirements

The following acts and guidelines contain references that will apply to the study. There are currently no direct references to ground vibration and air blast limits within the Namibian Acts and Regulations about blasting operations. The shortfall in direct legislation is supported by international standards and other guidelines, as well as relevant project experience of the consultants.

The following acts and supporting international guidelines are considered:

- Ground vibration and air blast are also evaluated according to the USBM (United States Bureau of Mines) guidelines for safe blasting,
- Ground vibration and air blast are also evaluated according to guidelines as published under the South African Mine Health And Safety Act, 1996 (Act No. 29 Of 1996), Guideline For A Mandatory Code Of Practice For Minimum Standards On Ground Vibrations, Noise, Air-Blast And Flyrock Near Surface Structures And Communities To Be Protected, and
- Experience and knowledge of Blast Management and Consulting.

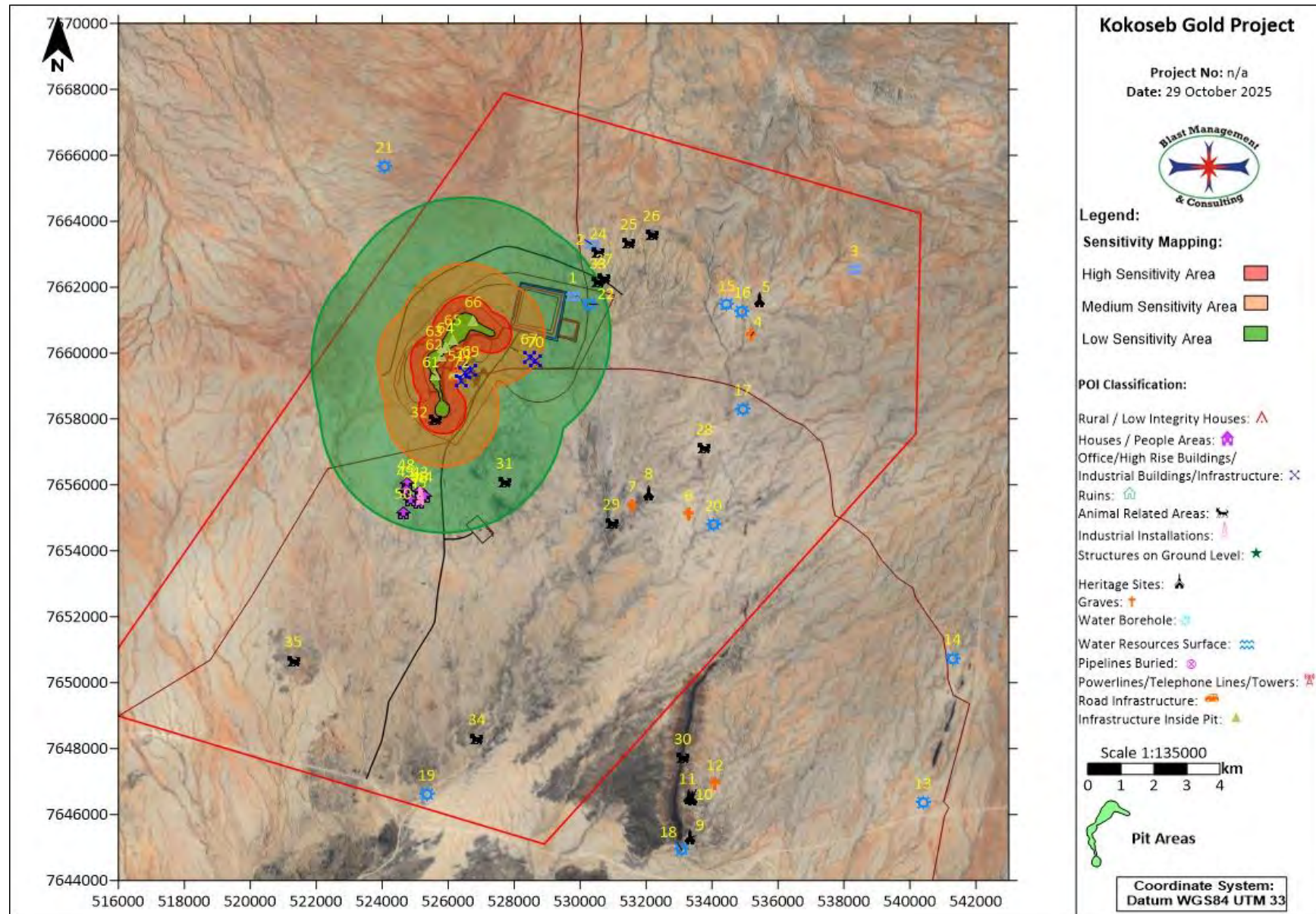
10 Sensitivity of Project

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 to 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 proposed pit 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 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 low-sensitivity area. In this area, it is relatively certain that influences will be low with a low possibility of damage and a limited possibility of upsetting people.

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

**Figure 3: Identified sensitive areas**

Blast Management and Consulting (PTY) LTD

BBBEE Level 2 Company

ISO9001:2015 Accredited

Directors: JD Zeeman

11 Consultation process

Consultation was only done with the proponent via ECC. No other consultation with external parties was undertaken. The work done is based on the author's knowledge, information provided by the proponent, and information captured by the ECC environmental team during their site visits. BMC conducted a desktop study.

12 Influence from blasting operations

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

12.1 Ground vibration limitations on structures

Ground vibration is measured in velocity with units of millimetres per second (mm/s). Ground vibration can also be reported in units of acceleration or displacement if required. Different types of structures have different tolerances to ground vibration. A steel structure or a concrete structure will have a higher resistance to vibrations than a well-built brick and mortar house. A brick-and-mortar house will be more resistant to vibrations than a poorly constructed or a traditionally built mud house. Different ground vibration limits are then applicable to the different types of structures to prevent damage. 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 slower 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 damage.

Guidelines applied in this document consist of the USBM criteria according to the report RI8507¹. And levels recommended by BMC as safe for the structures observed.

1. Siskind, D. E., Stagg, M.S., Kopp, J. W. and Dowding, C. H. (1980). Structural Response and Damage Produced by Ground Vibration from Surface Mine Blasting. Report of Investigations 8507. US Bureau of Mines.

The USBM criteria for safe blasting are applied as the industry standard where private structures are of concern. Ground vibration amplitude and frequency are recorded and analysed. The data is then evaluated accordingly. The USBM graph is used for plotting data and evaluating the data. **Figure 4** Below provides a graphic representation of the USBM analysis for safe ground vibration levels. The USBM graph is divided mainly into two parts. The red lines in the figure are the USBM criteria:

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

Added to the USBM graph are a blue line and a green dotted line that represent 6 mm/s² And 12.5 mm/s, additional criteria that are applied by BMC. These represent traditional mud structures and structures of lesser proper construction. A 25 mm/s limit is applied to general houses of proper construction – structures built to official building specifications.

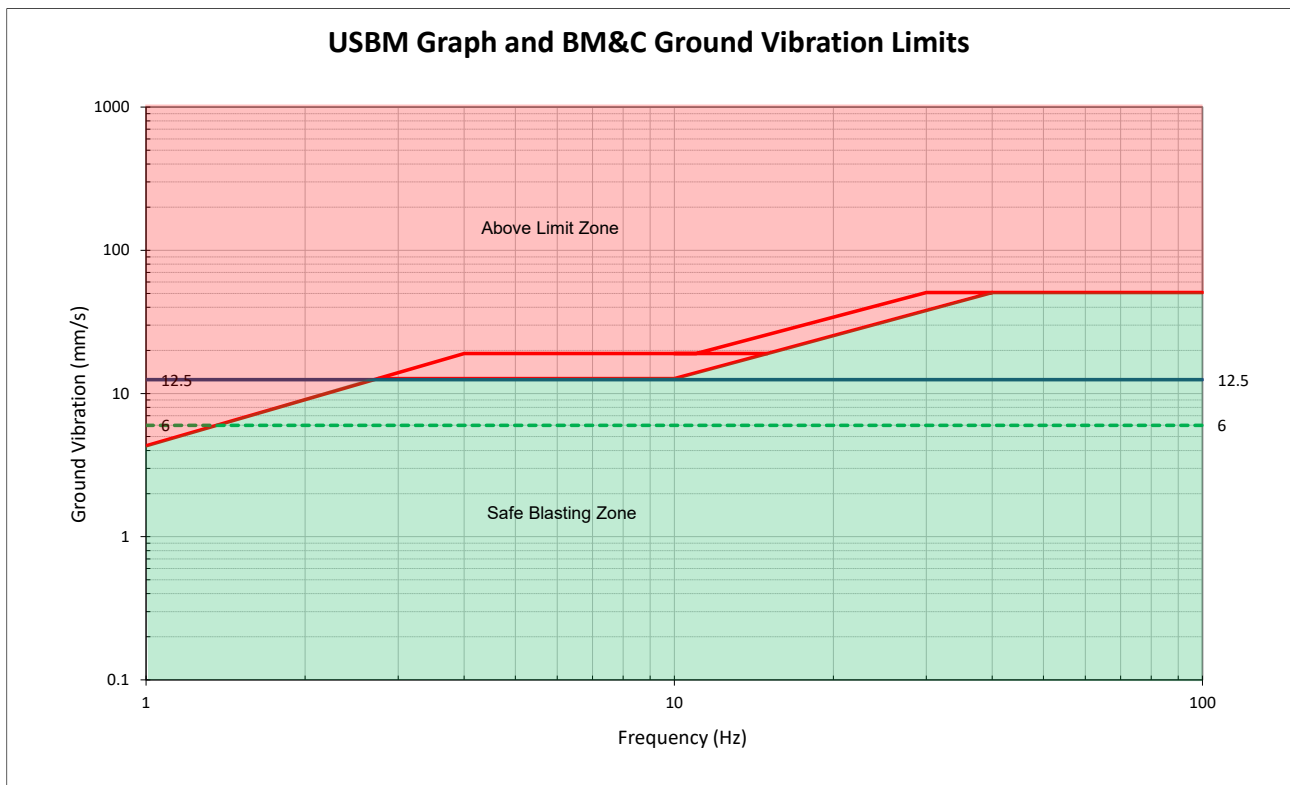


Figure 4: USBM Analysis Graph

The following additional limitations used by BMC in general and that should be considered were determined through research and prescribed by the various institutions, such as Eskom, Transnet, and Randwater Board in South Africa. These are as follows:

² South African Mine Health And Safety Act, 1996 (Act No. 29 Of 1996)

- National roads/tar roads: 150 mm/s (BMC).
- Steel pipelines: 50 mm/s (Rand Water Board).
- Electrical lines: 75 mm/s (Eskom).
- Fuel pipelines: 25 mm/s (Transnet).
- Railways: 150 mm/s (BMC).
- Concrete less than 3 days old: 5 mm/s³.
- Concrete after 10 days: 200 mm/s⁴.
- 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/s⁵.

Considering the above limitations, BMC's 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/s⁶. The 6 mm/s limit is used due to unknowns on how these structures will react to blasting. There is also no specific scientific data available that would indicate otherwise.
- Input from other consultants in the field locally and internationally.

12.2 Ground vibration limitations and human perceptions

A further aspect of ground vibration and frequency of vibration that must be considered is human perception. It should be realised 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

³ 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.

⁴ 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.

⁵ 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.

⁶ South African Mine Health And Safety Act, 1996 (Act No. 29 Of 1996)

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 perceive ground vibration levels of 0.8 mm/s as perceptible (See Figure 5). This guideline helps with managing ground vibration and the complaints that could be received due to blast-induced ground vibration.

Indicated on Figure 5 It is a blue solid line that indicates a ground vibration level of 12.5 mm/s and a green dotted line that indicates a ground vibration level of 6 mm/s. These are levels that are used in the evaluation.

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

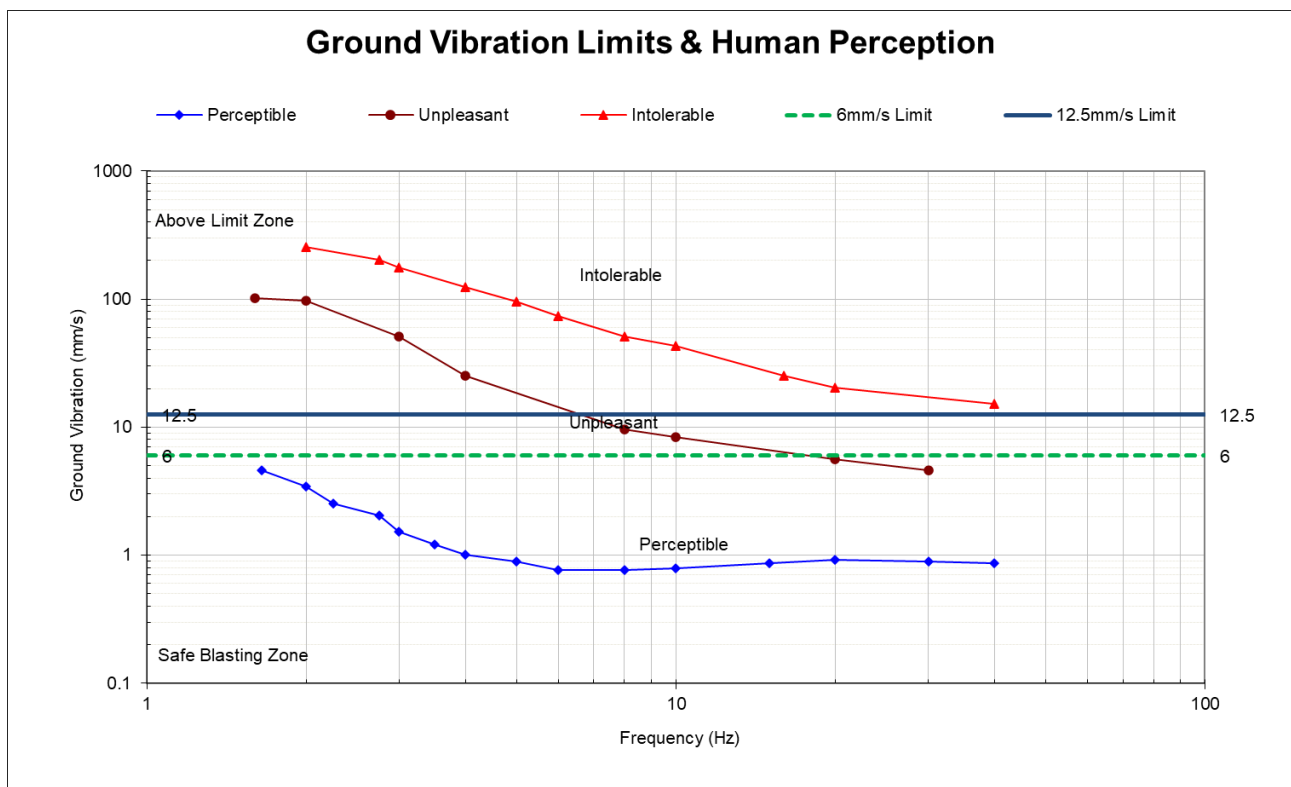


Figure 5: Ground Vibration and Human Perception

12.3 Air blast limitations on structures

Air blast or air-overpressure is a pressure wave generated from the blasting process. Air blast is measured as pressure in pascals (Pa) and reported as a decibel value (dB(L)). 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 the 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 USBM general recommended limit for air blast is 134 dBL. The USBM also indicates that the level is reduced to 128 dB(L) in proximity of hospitals, schools, and sensitive areas where people congregate. Based on work carried out by Siskind *et al.* (1980), monitored air blast amplitudes up to 135 dBL 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 1**). Levels given in **Table 1** Are at the point of measurement. The weakest points on a structure are the windows and ceilings. **Table 2** Provides air blast limits applied.

Table 1: Damage Causing Levels for Air Blast

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

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

Table 2: Air Blast Limits

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

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

12.4 Air blast limitations and human perceptions

Considering human perceptions and the misunderstanding about ground vibration and air blast, BMC generally recommends that blasting be done in such a way that air blast levels are kept below 120 dB(L). 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 to the structure.

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

12.5 Fly rock

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

Fly rock can be categorised as follows:

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

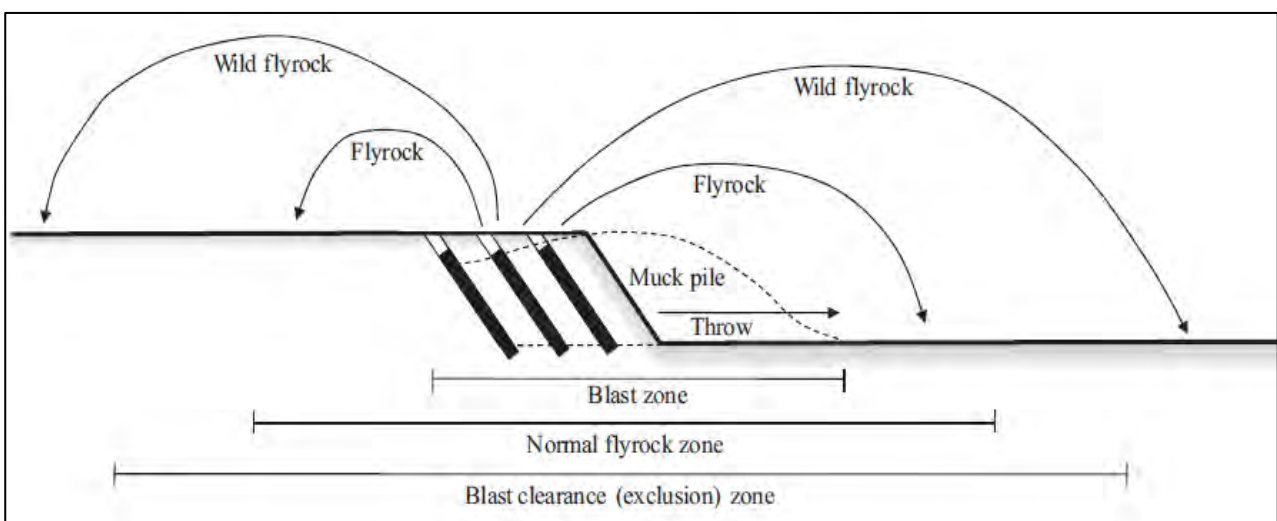


Figure 6: Schematic of fly rock terminology

Fly rock from blasting can result under the following conditions:

- When burdens are too small, rock elements can be propelled out of the free face area of the blast.
- When burdens are too large and the movement of blast material is restricted, and the 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 the 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 an 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 flyrock 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 the mine code of practice. BMC uses a prediction calculation defined by the International Society of Explosives Engineers (ISEE) to assist with determining the minimum distance.

12.6 Noxious Fumes

Explosives used in the mining environment are required to be oxygen-balanced. Oxygen balance refers to the stoichiometry of the chemical reaction and the nature of gases produced from the detonation of the explosives. The creation of poisonous fumes such as nitrous oxides and carbon monoxide is particularly undesirable. These fumes present themselves as red brown cloud after the blast has detonated. It has been reported by Rowland, Mainiero, and Hurd that 10 ppm to 20 ppm can be mildly irritating. Exposure to 150 ppm or more (no time period given) has been reported by Rowland, Mainiero, and Hurd could cause death from pulmonary oedema. It has been predicted.⁷ that 50% lethality would occur following exposure to 174 ppm for 1 hour. Anybody exposed must be taken to the hospital for proper treatment.

Factors contributing to undesirable fumes are typically: poor quality control on explosive manufacture, damage to the 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.

⁷ Rowland, J.H.(III), Mainiero R., and Hurd D.A.(Jr.), Factors Affecting Fumes Production of an Emulsion and Anfo/Emulsion Blends

12.7 Vibration impact on provincial and national roads

The influence of ground vibration on tarred roads is expected when levels are 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 is a minimum distance between the structure and blast hole to prevent any cracks from forming in 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. It is therefore important that blasting must be controlled in the vicinity of roads. Air blast from blasting does not have an 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 the ground. Fly rock will have a greater influence on the road as damage from falling debris may impact the road surface if no control on fly rock is considered.

12.8 Vibration will upset adjacent communities

The effects of ground vibration and air blast will impact 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 described above – people will experience ground vibration and air blast 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. “Good neighborhood” can be achieved through extensive communication with neighbours and nearby communities. Concerns raised should be recorded and addressed adequately.

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 neighborhood. Surveys inherently present challenges, 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 taken 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 more proficient operators, and can 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 following:

- Correct blast design is essential and should include a survey of the face profile prior to design, ensuring appropriate burden to avoid over-confinement of charges which may increase vibration by a factor of two,
- The setting-out and drilling of blasts should be as accurate as possible and the drilled holes should be surveyed for deviation along their lengths and, if necessary, the blast design adjusted,
- Correct charging is obviously vital, and if free poured bulk explosive is used, its rise during loading should be checked. This is especially important in fragmented ground to avoid accidental overcharging,

- Correct stemming will help control air blast and fly rock and will also aid the control of ground vibration. Controlling the length of the stemming column is important; too short and premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used,
- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

12.9 Cracking of houses and consequent devaluation

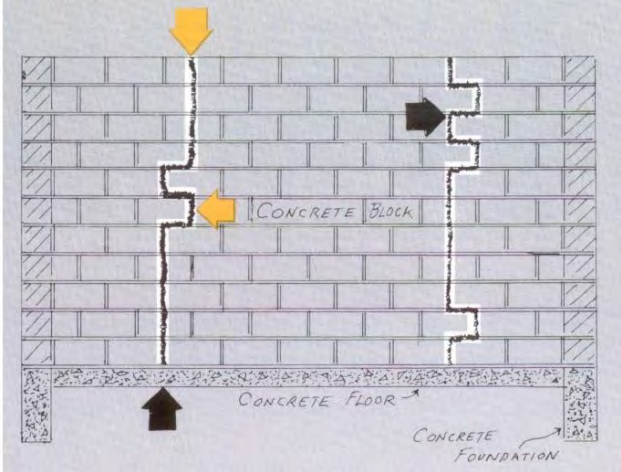
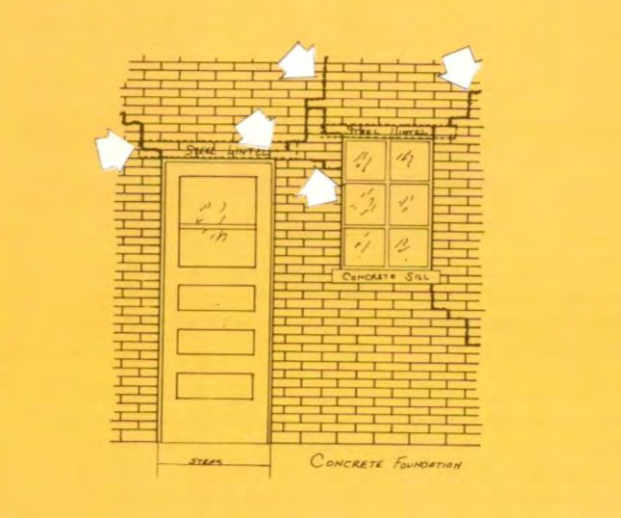
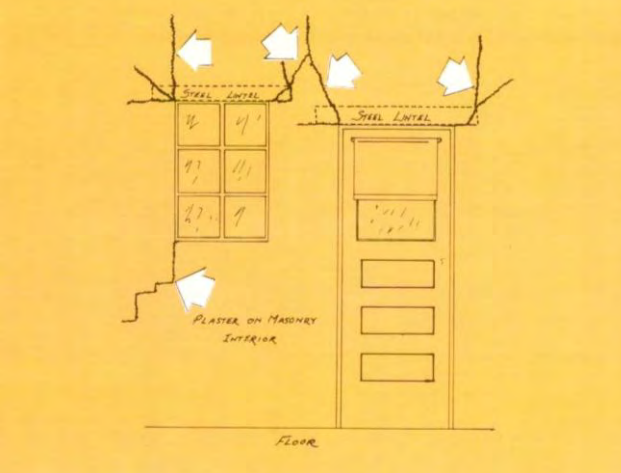
Houses in general have cracks. It is reported by Oriard that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water and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

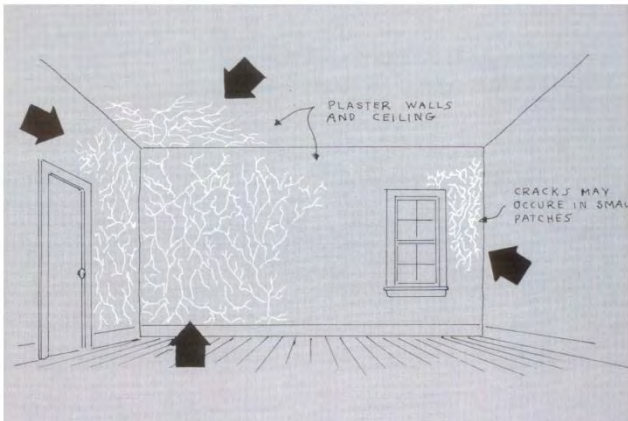
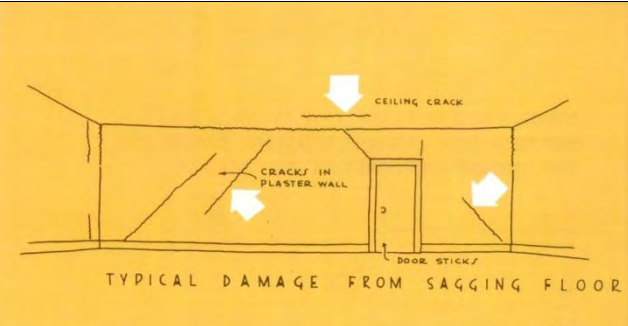
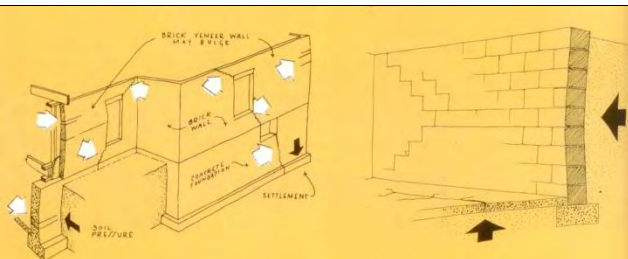


Figure 7: Example of blast induced damage.

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

Table 3: Examples of typical non-blasting cracks

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

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

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

13 Baseline Structure Profile

The site was reviewed using Google Earth imagery to obtain an overview of the surroundings. All possible structures in a possible influence area were identified. Information sought during the review was to identify surface structures present in a 3500 m radius from the proposed open pit area, which will require consideration during modelling of blasting operations, e.g., houses, general structures, power lines, pipelines, reservoirs, mining activity, roads, shops, schools, gathering places, possible historical sites, etc. A list was prepared of all structures in the vicinity of the open

pit area. The list includes structures and POI within the 3500 m boundary – see **Table 5** below. A list of structure locations was required to determine the allowable ground vibration limits and air blast limits. **Figure 3** 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 4**. The classification used is a BMC classification and does not relate to any standard or national, or international code or practice. **Table 4** shows the descriptions for the classifications used.

Table 4: POI Classification used

Class	Description
1	Rural buildings and structures of poor construction
2	Private houses and people sensitive areas
3	Office, high-rise buildings, and industrial buildings / Infrastructure
4	Ruins
5	Animal-related installations and animal-sensitive areas
6	Industrial installations
7	Earth-like structures – no surface structure
8	Heritage sites (buildings, infrastructure, activity)
9	Graves
10	Water borehole
11	Water resources surface
12	Pipelines buried
13	Powerlines / Telephone Lines / Towers
14	Road infrastructure
15	Infrastructure inside the pit

Table 5: List of points of interest identified (WGS84 – UTM 33)

Tag	Description	Classification	Y	X
1	Heritage Site (Site 01 - Historic Water Pool)	11	7661708.27	529786.52
2	Heritage Site (Site 02 - Historic Water Pool)	11	7663302.24	530348.69
3	Heritage Site (Site 03 - Historic Water Pool)	11	7662529.63	538336.77
4	Heritage Site (Site 04 - Graveyard at Aniswept)	9	7660529.73	535179.67
5	Heritage Site (Site 05 - Built Ruin)	8	7661619.62	535450.79
6	Heritage Site (Site 06 - Christian Graves with 4 unmarked graves)	9	7655096.64	533295.84
7	Heritage Site (Site 07 - Hamas Village Second Gravesite - Ancient)	9	7655371.80	531582.41
8	Heritage Site (Site 08 - Historic Well)	8	7655759.73	532083.11
9	Heritage Site (Site 09 - Prehistoric Rock Art)	8	7645310.83	533320.35
10	Heritage Site (Site 10 - Historic Mine Shaft)	8	7646539.77	533297.45
11	Heritage Site (Site 11 - Old Mining Ruins)	8	7646510.55	533402.89
12	Heritage Site (Site 12 - Christian Graves)	9	7646914.11	534088.68
13	Borehole	10	7646361.61	540395.72
14	Borehole	10	7650730.80	541288.39
15	Borehole	10	7661458.00	534446.00
16	Borehole	10	7661259.01	534919.79
17	Borehole	10	7658304.17	534934.27
18	Borehole	10	7644928.30	533080.42
19	Borehole	10	7646613.20	525356.48
20	Borehole	10	7654786.83	534044.70
21	Borehole	10	7665660.80	524077.52
22	Borehole	10	7661489.53	530279.65

Tag	Description	Classification	Y	X
23	Village Houses (Katora)	2	7660154.19	525570.82
24	Granite Dome 1	5	7663031.38	530557.96
25	Granite Dome 2	5	7663329.11	531484.26
26	Granite Dome 3	5	7663593.40	532170.67
27	Wildlife Animal Activity (Black Rhino Rubbing Post)	5	7662265.23	530735.12
28	Wildlife Animal Activity (Raptor Nest)	5	7657101.16	533773.30
29	Wildlife Animal Activity (Main Hill/Ridge Habitat 1)	5	7654833.17	530956.56
30	Wildlife Animal Activity (Main Hill/Ridge Habitat 2)	5	7647713.06	533120.14
31	Wildlife Animal Activity (Main Hill/Ridge Habitat 3)	5	7656072.55	527710.15
32	Wildlife Animal Activity (Main Hill/Ridge Habitat 4)	5	7657968.37	525622.14
33	Wildlife Animal Activity (Main Hill/Ridge Habitat 5)	5	7662137.01	530546.62
34	Wildlife Animal Activity (Main Hill/Ridge Habitat 6)	5	7648302.97	526875.14
35	Wildlife Animal Activity (Main Hill/Ridge Habitat 7)	5	7650663.20	521316.11
36	Village Houses	2	7658807.26	527916.78
37	Village Houses	2	7658673.30	527940.92
38	Village Houses	2	7658409.27	527789.75
39	Village	2	7655071.10	526880.52
40	Village	2	7654781.53	526551.06
41	Village	2	7654523.07	527377.90
42	Village	2	7654238.01	527043.98
43	Village Houses	2	7655803.85	525151.89
44	Village Houses	2	7655662.42	525286.48
45	Village Houses	2	7655487.22	525093.00
46	Cement Dam	6	7655654.38	525128.63
47	Village Houses	2	7655552.35	524854.54
48	Village Houses	2	7656034.99	524739.25
49	Village Houses	2	7655816.24	524704.60
50	Village Houses	2	7655157.39	524640.53
51	D3714 Road	14	7659333.18	526255.22
52	Village Houses	2	7658477.83	527495.06
53	Village Houses	2	7658770.06	527401.64
54	Village Houses	2	7658761.62	527063.97
55	Village Houses	2	7660101.32	526140.01
56	Village Houses	2	7660338.20	525703.78
57	Village Houses	2	7659997.61	525455.43
58	Village Houses	2	7659989.13	525213.56
59	Village Houses	2	7659987.57	525124.17
60	Village Houses	2	7659582.24	525252.86
61	D3714 Road (Inside Pit Area)	15	7659334.12	525601.32
62	Village Houses (Inside Pit Area)	15	7659899.26	525774.30
63	Village Houses (Inside Pit Area)	15	7660168.92	525820.76
64	Village Houses (Inside Pit Area)	15	7660183.16	525926.38
65	Village Houses (Inside Pit Area)	15	7660415.94	526150.65
66	Village Houses (Inside Pit Area)	15	7660974.55	526769.50

14 Blasting Operations

In order to evaluate the possible influence of blasting operations with regard to ground vibration, air blast, and fly rock, a planned blast design is required to determine possible influences. Blasting is planned as part of the Kokoseb open-pit mining operation.

This report concentrates on the drilling and blasting of the overburden. The overburden blasts are considered a worst-case scenario and are used as an indicator of possible influence.

Blast design parameters were provided by the proponent. Using the data provided, JKSimblast blast design software was used to design and simulate the blast. This designed blast was applied for the evaluation done in this report. The simulation of the blast provided the best prediction possible. **Table 6** Shows a summary of the technical information received and used for design purposes on JKSimblast. Outcome of the design on JKSimblast is summarised in **Table 7**. **Figure 8** Below shows the blast layout with blast holes, simulation, and maximum charge mass per delay. **Figure 9** Shows a simulation with maximum charge per delay from the typical timing applied. **Figure 10** Shows a simulation with the number of blast holes per delay from the typical timing applied.

Table 6: Blast design technical information

Blast Description:	Weathered	Fresh
B/H Diameter (mm):	165	165
Bench Height (m)	10	10
Burden (m):	4.6	4
Spacing (m):	5.3	4.6
Average Depth (m):	11	11
Explosive Type:	Emulsion	Emulsion
Explosive Charge / BH (kg)	145.4	145.4
P/F Blasthole (kg/m ³):	0.6	0.8
Stemming Length (m):	3	3
Accessories Type: Shock Tube / Electronic	Nonel	Nonel
Downhole delay (ms):	25 - 50	25 - 50
Surface Timing - Inter hole (ms):	8 - 25	8 - 25
Surface Timing - Inter row (ms):	50 - 100	50 - 100
Booster / Primer (gr.):	400	400

Table 7: Blast design information from simulation

DESIGN FACTORS FOR:		
Av. Burden	4	m
Av. Spacing	4.6	m
All Hole Lengths	1,080	m
Volume	19,872	m ³
Rock SG	2.65	
Tonnage	52,660.80	tonnes
Marked Holes	108	
Charge Mass	18,589.92	kg
Charge Energy	47,404.28	MJ
POWDER FACTOR	0.935	kg/m ³
POWDER FACTOR	0.353	kg/t
ENERGY FACTOR	2.385	MJ/m ³
ENERGY FACTOR	0.9	MJ/t



Figure 8: Blast holes layout with charge mass per blast hole

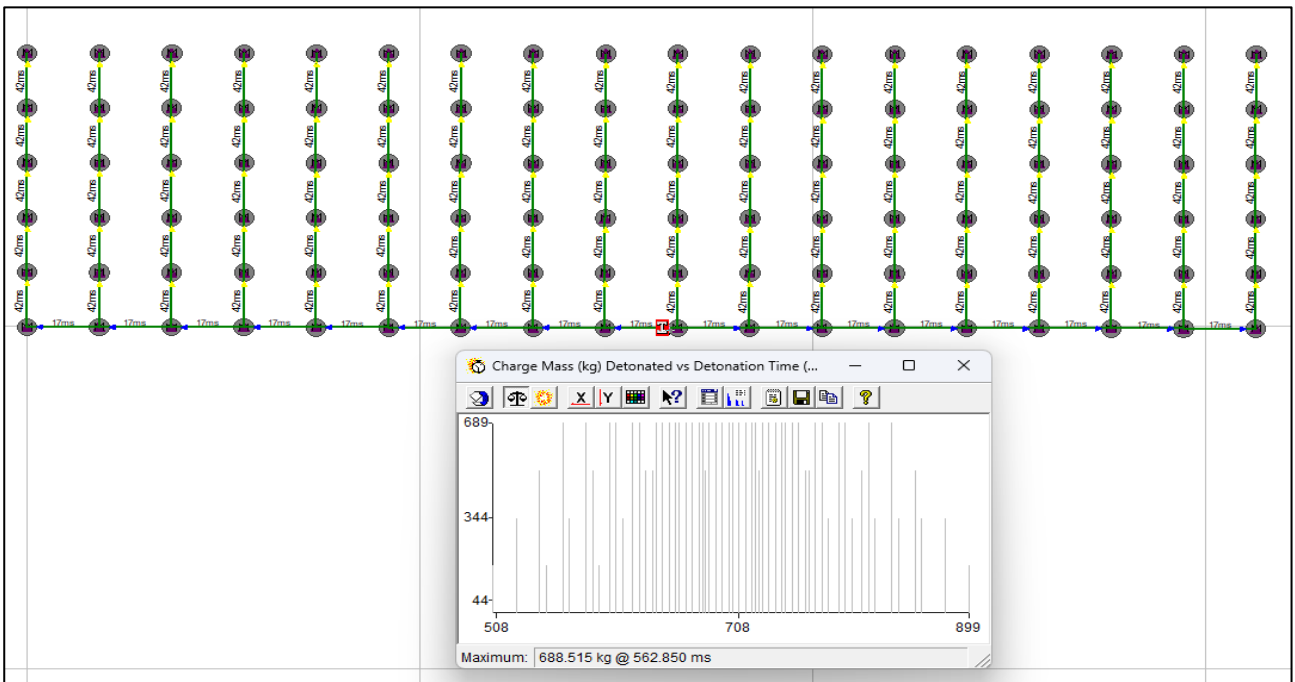


Figure 9: Simulation and charge mass per delay graph

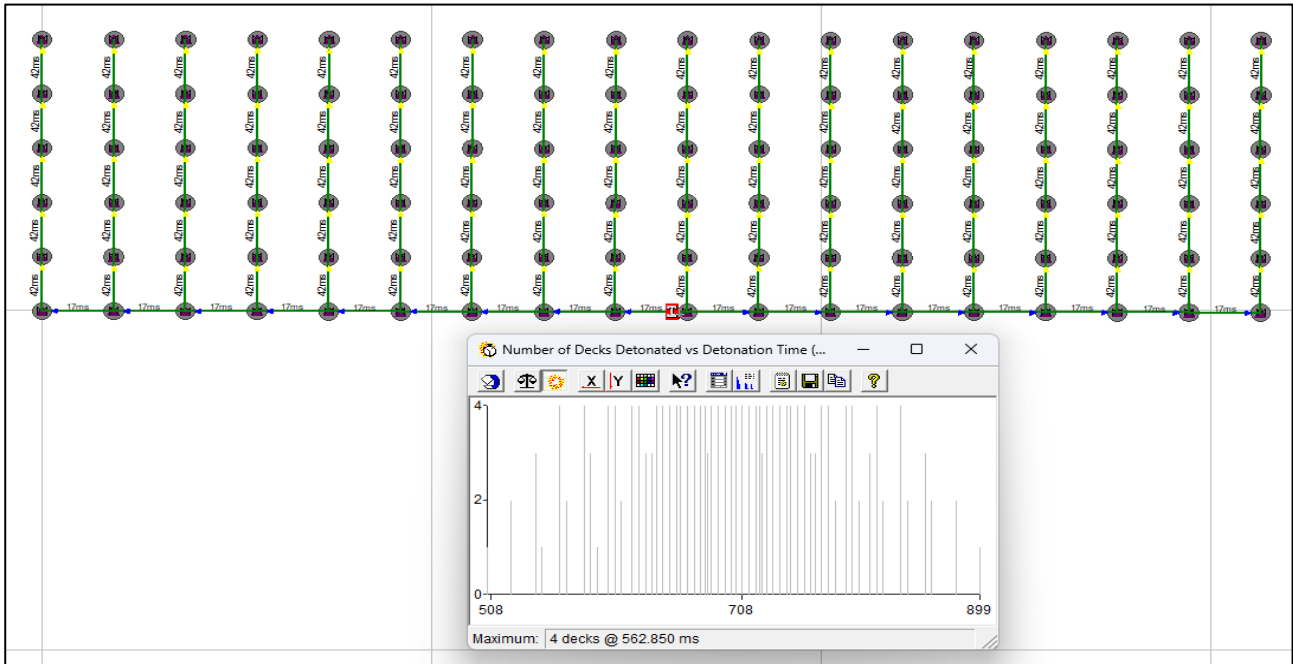


Figure 10: Simulation and number of decks per delay graph

The simulation work done provided information that is applied for predicting ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 165 mm diameter single blast hole, and the maximum charge was extracted from the blast simulation in JKSimblast. The maximum charge relates to the total number of blast holes that detonate simultaneously based on the blast layout and initiation timing of the blast. Thus, the maximum mass of explosives detonating at once. The maximum charge relates to 689 kg. These values were applied in all predictions for ground vibration and air blast.

14.1 Ground Vibration

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

Equation 1:

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

Where:

PPV = Predicted ground vibration (mm/s)

a = Site constant

b = Site constant

D = Distance (m)

E = Explosive Mass (kg)

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

Factors:

a = 1143

b = -1.65

Utilising 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 the expected drilling and charging design, the following **Table 8** Shows expected ground vibration levels (PPV) for various distances calculated at the maximum charge mass. The maximum charge mass is 689 kg for the pit area.

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

No.	Distance (m)	Expected PPV (mm/s) for 689 kg Charge
1	50.0	394.7
2	100.0	202.2
3	150.0	64.4
4	200.0	40.1

No.	Distance (m)	Expected PPV (mm/s) for 689 kg Charge
5	250.0	27.7
6	300.0	20.5
7	400.0	12.8
8	500.0	8.8
9	600.0	6.5
10	700.0	5.1
11	800.0	4.1
12	900.0	3.4
13	1000.0	2.8
14	1250.0	1.9
15	1500.0	1.4
16	1750.0	1.1
17	2000.0	0.9
18	2500.0	0.6
19	3000.0	0.5
20	3500.0	0.4

14.2 Air blast

The prediction of air blast as a pre-operational effect is difficult to define exactly. There are many variables that have an influence on the outcome of an air blast. Air blast is the direct result of 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 have an influence on the outcome of the blast. 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 millibars. This equation does not take temperature or any weather conditions into account.

Equation 2:

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

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 11** Below. Various types of mining operations are expected to yield different results. The information provided in **Figure 11** is based on detailed research that was conducted for each of the different types of mining environments. In this report, the data for “Metal Mine” was applied in the prediction of air blast.

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

Table 26.7 - Air overpressure prediction equations.

Figure 11: Proposed prediction equations

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

Equation 3:

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

Where:

- p_s = Air blast level (dB(L))
 P = Air blast level (Pa (mB x 100))
 P_o = Reference Pressure (2×10^{-5} Pa)

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

As discussed earlier the prediction of air blast is very subjective. Following in **Table 9** below is a summary of values predicted according to Equation 2.

Table 9: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB(L)) for 689 kg Charge
1	50.0	146.3
2	100.0	143.8
3	150.0	139.6
4	200.0	137.8
5	250.0	136.4
6	300.0	135.3
7	400.0	133.5
8	500.0	132.2
9	600.0	131.0
10	700.0	130.1
11	800.0	129.3
12	900.0	128.5
13	1000.0	127.9
14	1250.0	126.5
15	1500.0	125.4
16	1750.0	124.4
17	2000.0	123.6
18	2500.0	122.2
19	3000.0	121.1
20	3500.0	120.2

15 Construction Phase: Impact Assessment and Mitigation Measures

During the construction phase, no drilling and blasting operations are expected. No detailed impact evaluation was done during the construction phase.

16 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 5**. This section concentrates on the outcome of modelling the possible effects of ground vibration, air blast and fly rock specifically to these points of interest or possible interfaces. In the evaluation, the charge mass scenarios were selected as indicated in the section 14 is considered with regard to ground vibration and air blast.

Ground vibration and air blast were calculated from the edge of the pit outline and modelled accordingly. Blasting further away from the pit edge will certainly have less influence on the surroundings. A worst case is then applicable with the calculation from the pit edge. As explained

previously, reference is only made to some structures, and these references cover 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
- Water Borehole Influence

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

16.1 Review of expected ground vibration

Presented herewith are the expected ground vibration level contours and a discussion of relevant influences. Expected ground vibration levels were calculated for each POI identified surrounding the mining area and evaluated with regard to possible structural concerns and human perception. Tables are provided for each of the different charge models with regard 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 the 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 stem from the human perception of information given, and indicators such as “high” or “low” are given for the possibility of damage to a structure. Levels below 0.76 mm/s could be considered to have a negligible possibility of influence.

Ground vibration is calculated and modelled for the pit area at the maximum charge mass at specific distances from the opencast mining area. The charge mass 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 POIs for consideration are also

plotted in this model. Ground vibration predictions were done considering distances ranging from 50 m to 3500 m around the opencast mining area.

The simulation provided shows ground vibration contours only for a limited number of levels. The levels used are considered the basic limits that will be applicable for the type of structures observed surrounding the pit area. These levels are: 6 mm/s, 12.5 mm/s, 25 mm/s and 50 mm/s. This enables immediate review of possible concerns that may apply 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 the proposed limit applicable to Structures / Installations are coloured "Red"
People's Perception Evaluation:
Vibration levels indicated as Intolerable on the human perception scale are coloured "Red"
Vibration levels indicated as Unpleasant on the human perception scale are coloured "Mustard"
Vibration levels indicated as Perceptible on the human perception scale are coloured "Light Green"
POIs that are found inside the pit area are coloured "Olive Green"

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

16.2 Review of expected air blast

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

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

- “Complaint” where people will be complaining due to the experienced effect on structures at levels of 120 dB(L) and higher (not necessarily damaging);
- “Acceptable” if levels are less than 120 dB(L);
- “Low” where there is a very limited possibility that the levels will give rise to any influence on people or structures. Levels below 115 dB(L) could be considered to have a 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 the proposed limit are coloured “Red”
Air blast levels indicated as possible Complaint is coloured “Mustard”
POIs that are found inside the pit area are coloured “Olive Green”

16.2.1 Ground vibration from charge mass per delay – 689 kg

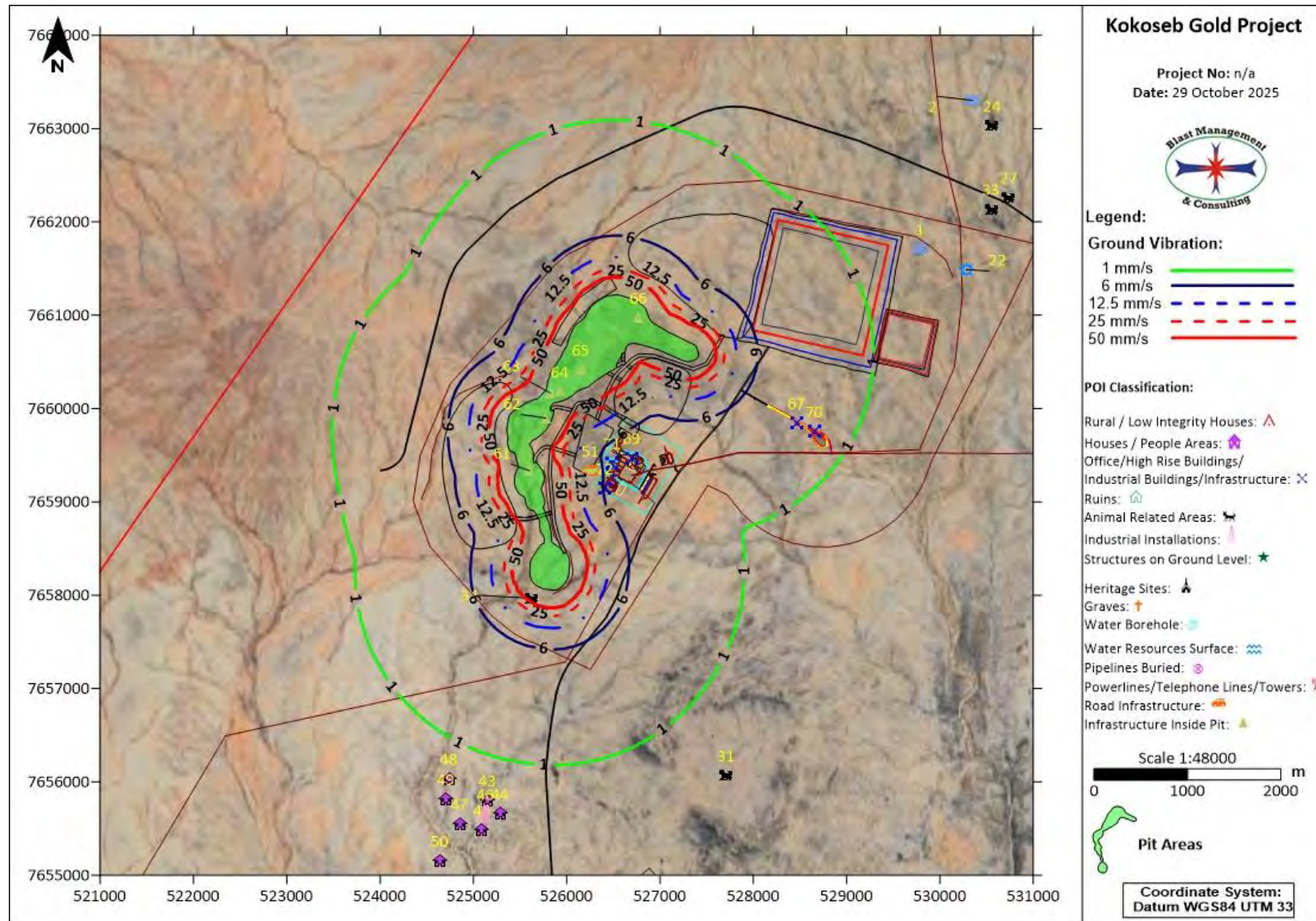


Figure 12: Ground vibration influence from the maximum charge per delay

16.2.2 Air blast from charge mass per delay – 689 kg

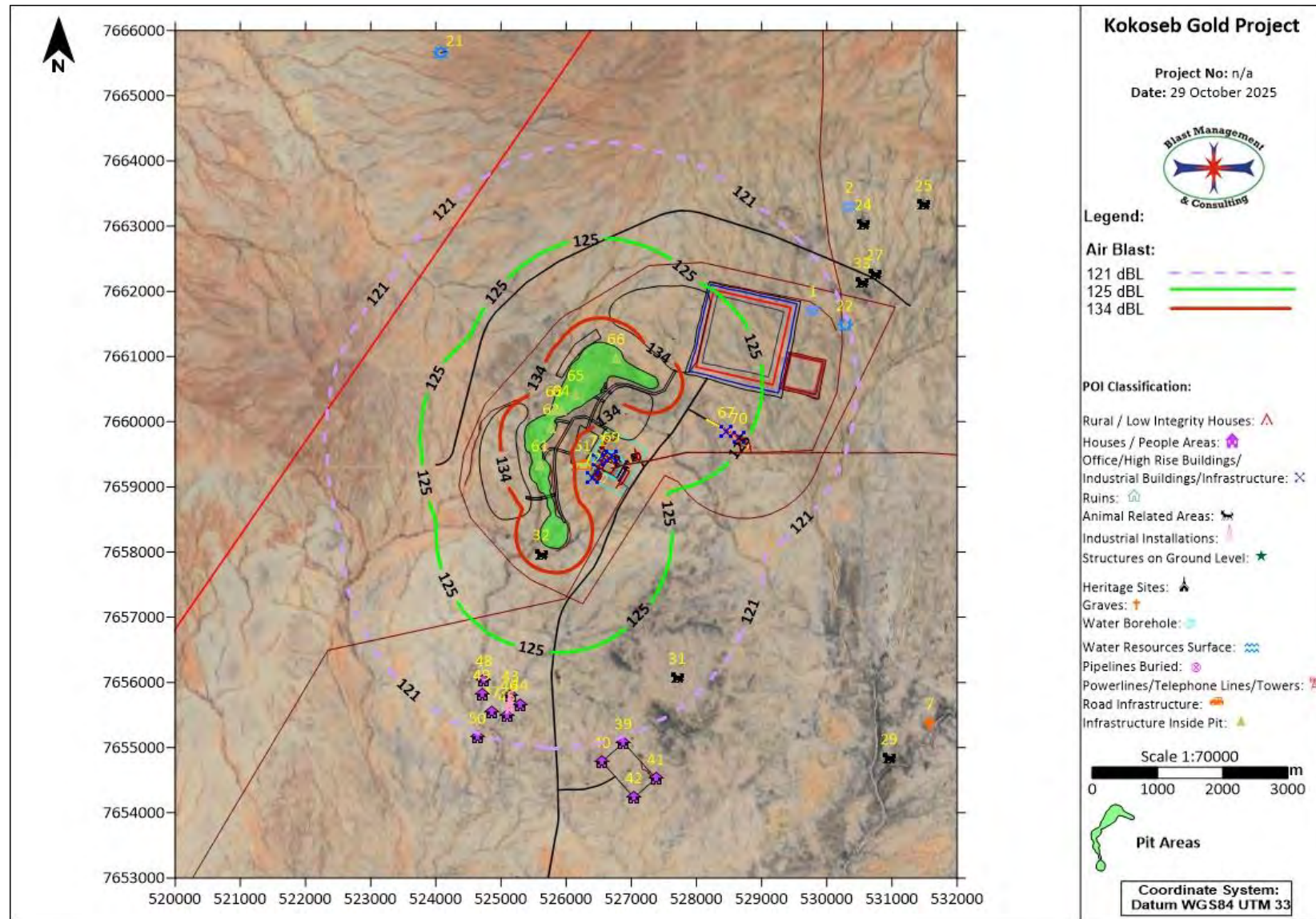


Figure 13: Air blast influence from the maximum charge

Table 10: Ground vibration and Air Blast evaluation for maximum charge

Tag	Description	Ground Vibration Limit (mm/s)	Distance (m)	Max Charge Total Mass/Delay (kg)	Max Charge Predicted PPV (mm/s)	Max Charge Structure Response @ 10Hz	Max Charge Human Tolerance @ 30Hz	Air Blast Limit (dB(L))	Max Charge Air blast (dB(L))	Max Charge Possible Concern
1	Heritage Site (Site 01 - Historic Water Pool)	50	2617	689	0.6	Acceptable	N/A	N/A	N/A	N/A
2	Heritage Site (Site 02 - Historic Water Pool)	50	3966	689	0.3	Acceptable	N/A	N/A	N/A	N/A
3	Heritage Site (Site 03 - Historic Water Pool)	50	11093	689	0.1	Acceptable	N/A	N/A	N/A	N/A
4	Heritage Site (Site 04 - Graveyard at Aniswept)	50	7765	689	0.1	Acceptable	N/A	N/A	N/A	N/A
5	Heritage Site (Site 05 - Built Ruin)	6	8102	689	0.1	Acceptable	Too Low	134	115.0	Acceptable
6	Heritage Site (Site 06 - Christian Graves with 4 unmarked graves)	50	7912	689	0.1	Acceptable	N/A	N/A	N/A	N/A
7	Heritage Site (Site 07 - Hamas Village Second Gravesite - Ancient)	50	6241	689	0.1	Acceptable	N/A	N/A	N/A	N/A
8	Heritage Site (Site 08 - Historic Well)	50	6538	689	0.1	Acceptable	Too Low	N/A	N/A	N/A
9	Heritage Site (Site 09 - Prehistoric Rock Art)	150	14753	689	0.0	Acceptable	Too Low	134	111.3	Acceptable
10	Heritage Site (Site 10 - Historic Mine Shaft)	50	13692	689	0.0	Acceptable	Too Low	134	111.8	Acceptable
11	Heritage Site (Site 11 - Old Mining Ruins)	6	13773	689	0.0	Acceptable	Too Low	134	111.8	Acceptable
12	Heritage Site (Site 12 - Christian Graves)	50	13828	689	0.0	Acceptable	N/A	N/A	N/A	N/A
13	Borehole	50	18609	689	0.0	Acceptable	N/A	N/A	109.9	N/A
14	Borehole	50	16999	689	0.0	Acceptable	N/A	N/A	110.5	N/A
15	Borehole	50	7084	689	0.1	Acceptable	N/A	N/A	115.8	N/A
16	Borehole	50	7535	689	0.1	Acceptable	N/A	N/A	115.4	N/A

Tag	Description	Ground Vibration Limit (mm/s)	Distance (m)	Max Charge Total Mass/Delay (kg)	Max Charge Predicted PPV (mm/s)	Max Charge Structure Response @ 10Hz	Max Charge Human Tolerance @ 30Hz	Air Blast Limit (dB(L))	Max Charge Air blast (dB(L))	Max Charge Possible Concern
17	Borehole	50	7856	689	0.1	Acceptable	N/A	N/A	115.2	N/A
18	Borehole	50	14969	689	0.0	Acceptable	N/A	N/A	111.2	N/A
19	Borehole	50	11453	689	0.1	Acceptable	N/A	N/A	112.9	N/A
20	Borehole	50	8722	689	0.1	Acceptable	N/A	N/A	114.5	N/A
21	Borehole	50	5035	689	0.2	Acceptable	N/A	N/A	117.9	N/A
22	Borehole	50	3003	689	0.5	Acceptable	N/A	N/A	121.1	N/A
23	Village Houses (Katora)	12.5	89	689	152.7	Problematic	Intolerable	134	142.8	Problematic
24	Granite Dome 1	150	3958	689	0.3	Acceptable	N/A	134	119.4	Acceptable
25	Granite Dome 2	150	4889	689	0.2	Acceptable	N/A	134	118.1	Acceptable
26	Granite Dome 3	150	5610	689	0.2	Acceptable	N/A	134	117.3	Acceptable
27	Wildlife Animal Activity (Black Rhino Rubbing Post)	25	3712	689	0.3	Acceptable	N/A	134	119.8	Acceptable
28	Wildlife Animal Activity (Raptor Nest)	25	7241	689	0.1	Acceptable	N/A	134	115.7	Acceptable
29	Wildlife Animal Activity (Main Hill/Ridge Habitat 1)	25	5969	689	0.1	Acceptable	N/A	134	116.9	Acceptable
30	Wildlife Animal Activity (Main Hill/Ridge Habitat 2)	25	12616	689	0.0	Acceptable	N/A	134	112.3	Acceptable
31	Wildlife Animal Activity (Main Hill/Ridge Habitat 3)	25	2681	689	0.6	Acceptable	N/A	134	121.8	Complaint
32	Wildlife Animal Activity (Main Hill/Ridge Habitat 4)	25	148	689	66.2	Problematic	N/A	134	139.7	Problematic
33	Wildlife Animal Activity (Main Hill/Ridge Habitat 5)	25	3489	689	0.4	Acceptable	N/A	134	120.2	Complaint
34	Wildlife Animal Activity (Main Hill/Ridge Habitat 6)	25	9803	689	0.1	Acceptable	N/A	134	113.8	Acceptable
35	Wildlife Animal Activity (Main Hill/Ridge Habitat 7)	25	8624	689	0.1	Acceptable	N/A	134	114.6	Acceptable
36	Village Houses	12.5	1798	689	1.1	Acceptable	Perceptible	134	124.3	Complaint
37	Village Houses	12.5	1933	689	0.9	Acceptable	Perceptible	134	123.8	Complaint
38	Village Houses	12.5	1759	689	1.1	Acceptable	Perceptible	134	124.4	Complaint

Tag	Description	Ground Vibration Limit (mm/s)	Distance (m)	Max Charge Total Mass/Delay (kg)	Max Charge Predicted PPV (mm/s)	Max Charge Structure Response @ 10Hz	Max Charge Human Tolerance @ 30Hz	Air Blast Limit (dB(L))	Max Charge Air blast (dB(L))	Max Charge Possible Concern
39	Village	12.5	3146	689	0.4	Acceptable	Too Low	134	120.8	Complaint
40	Village	12.5	3342	689	0.4	Acceptable	Too Low	134	120.5	Complaint
41	Village	12.5	3835	689	0.3	Acceptable	Too Low	134	119.6	Acceptable
42	Village	12.5	3990	689	0.3	Acceptable	Too Low	134	119.4	Acceptable
43	Village Houses	12.5	2343	689	0.7	Acceptable	Too Low	134	122.6	Complaint
44	Village Houses	12.5	2450	689	0.6	Acceptable	Too Low	134	122.4	Complaint
45	Village Houses	12.5	2664	689	0.6	Acceptable	Too Low	134	121.9	Complaint
46	Cement Dam	50	2494	689	0.6	Acceptable	N/A	N/A	122.3	N/A
47	Village Houses	12.5	2671	689	0.6	Acceptable	Too Low	134	121.8	Complaint
48	Village Houses	12.5	2270	689	0.7	Acceptable	Too Low	134	122.8	Complaint
49	Village Houses	12.5	2482	689	0.6	Acceptable	Too Low	134	122.3	Complaint
50	Village Houses	12.5	3116	689	0.4	Acceptable	Too Low	134	120.9	Complaint
51	D3714 Road	150	500	689	8.8	Acceptable	N/A	N/A	132.2	N/A
52	Village Houses	12.5	1469	689	1.5	Acceptable	Perceptible	134	125.5	Complaint
53	Village Houses	12.5	1425	689	1.6	Acceptable	Perceptible	134	125.7	Complaint
54	Village Houses	12.5	1099	689	2.4	Acceptable	Perceptible	134	127.3	Complaint
55	Village Houses	12.5	81	689	176.6	Problematic	Intolerable	134	143.3	Problematic
56	Village Houses	12.5	103	689	120.4	Problematic	Intolerable	134	141.9	Problematic
57	Village Houses	12.5	6	689	12046.9	Problematic	Intolerable	134	159.1	Problematic
58	Village Houses	12.5	184	689	46.1	Problematic	Intolerable	134	138.3	Problematic
59	Village Houses	12.5	268	689	24.7	Problematic	Intolerable	134	136.0	Problematic
60	Village Houses	12.5	120	689	93.0	Problematic	Intolerable	134	140.9	Problematic
61	D3714 Road (Inside Pit Area)	150	-	689	N/A	N/A	N/A	N/A	N/A	N/A
62	Village Houses (Inside Pit Area)	12.5	-	689	N/A	N/A	N/A	134	N/A	N/A
63	Village Houses (Inside Pit Area)	12.5	-	689	N/A	N/A	N/A	134	N/A	N/A
64	Village Houses (Inside Pit Area)	12.5	-	689	N/A	N/A	N/A	134	N/A	N/A
65	Village Houses (Inside Pit Area)	12.5	-	689	N/A	N/A	N/A	134	N/A	N/A
66	Village Houses (Inside Pit Area)	12.5	-	689	N/A	N/A	N/A	134	N/A	N/A
67	Explosive Magazines	25	1267	689	1.9	Acceptable	Perceptible	134	126.4	Complaint

Tag	Description	Ground Vibration Limit (mm/s)	Distance (m)	Max Charge Total Mass/Delay (kg)	Max Charge Predicted PPV (mm/s)	Max Charge Structure Response @ 10Hz	Max Charge Human Tolerance @ 30Hz	Air Blast Limit (dB(L))	Max Charge Air blast (dB(L))	Max Charge Possible Concern
69	Plant	50	896	689	3.4	Acceptable	Perceptible	134	128.6	Complaint
70	Explosive Magazines	25	1477	689	1.5	Acceptable	Perceptible	134	125.5	Complaint
71	Mine Buildings	25	743	689	4.6	Acceptable	Perceptible	134	129.7	Complaint
72	Mine Buildings	25	659	689	5.6	Acceptable	Perceptible	134	130.5	Complaint

16.3 Summary of ground vibration levels

The opencast operation was evaluated for expected levels of ground vibration from future blasting operations. Review of the site and the surrounding installations/houses/buildings showed that structures vary in distances from the pit area. The influences will also vary with distance from the pit area. The model used for evaluation does indicate significant levels ranging from none to levels as high as 66.2 mm/s over the range 148 m to 18.6 km from the pit boundary. The evaluation considered mainly a distance up to 3500 m from the pit area. There are, however, a few POIs located up to 18.6 km that were considered important to consider as well. The POIs beyond the 3500 m boundary are mainly heritage sites and boreholes. It will be imperative to ensure ongoing monitoring is undertaken to confirm levels of ground vibration to ensure that the restriction on ground vibration levels is not exceeded.

The location of structures around the pit area is such that the charge evaluated showed limited possible influences due to ground vibration. The closest structures observed are the Wildlife Animal Activity (Main Hill/Ridge Habitat 4) and D3714 Road. Only one POI – POI32 - indicated levels greater than the recommended limit of 25 mm/s at 66.2 mm/s. Ground vibration levels expected at the road are 8.0 mm/s, which is well within the limits of 150 mm/s. The rest of the POIs showed expected levels of ground vibration well below the recommended limits and are classified as acceptable concerning structure response. The client is planning that during operations, the D3714 will be diverted around the project infrastructure.

In view of the maximum charge, specific attention will need to be given to specific areas. The maximum charge used indicated one POI of concern in relation to possible impact.

The maximum charge on a human perception scale indicated five POIs where ground vibration may be experienced as perceptible. These are mainly the mine-owned buildings and infrastructure. POIs 67, 69, 70, 71, and 72. Only one POI where vibration levels may be intolerable on a human perception scale is at POI32 - Wildlife Animal Activity (Main Hill/Ridge Habitat 4).

Perceptible levels of vibration may be experienced up to 2011 m and unpleasant up to 745 m, and intolerable up to 336 m. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 268 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have less influence on these points.

The nearest public structures are located at 2270 m from the pit boundary. Ground vibration levels predicted at these buildings, where people may be present, are very low and barely perceptible from the maximum charge. Structure conditions ranged from industrial construction to poor condition structures.

There are ten 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 18.3. A detailed 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 will be sufficient.

16.4 Summary of findings for air blast

Review of the air blast levels predicted for the maximum charge ranges between 109.3 and 139.7 dB(L) for all the POIs considered. This includes the nearest points such as the village houses and wildlife animal activity (Main Hill/Ridge Habitat 4). Air blast levels expected at the houses identified ranged between 120.9 dB(L) and 122.8 dB(L). These levels may contribute to effects such as rattling of roofs or doors, or windows, not expecting any damaging effects. It may lead to complaints.

Maximum charge predictions identified that seven POIs could experience levels of air blast that could lead to complaints. No POIs were identified where damage may be induced.

The current accepted limit on air blast is 134 dB(L). Damages are only expected to occur at levels greater than 134 dB(L). Prediction shows that the air blast will be greater than 134 dB(L) at a distance of 370 m and closer to the pit boundary. Infrastructure at the pit areas, such as roads and mine plant, is present, but air blast does not have any influence on these installations.

The possible negative effects from air blast are expected to be the same as those of ground vibration. It is maintained that if basic blasting principles and stemming control are not exercised, this effect could be greater with a 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.

16.5 Ground Vibration and Human Perception

Considering the effect of ground vibration with regard to human perception, vibration levels calculated were applied to an average of 30 Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 14 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 14 that up to a distance of 2011 m, people may experience levels of ground vibration as perceptible. At 745 m and closer, the perception of ground vibration could be

unpleasant. Closer than 336 m, the levels will be intolerable and generally greater than the limits applied for structures in the area.

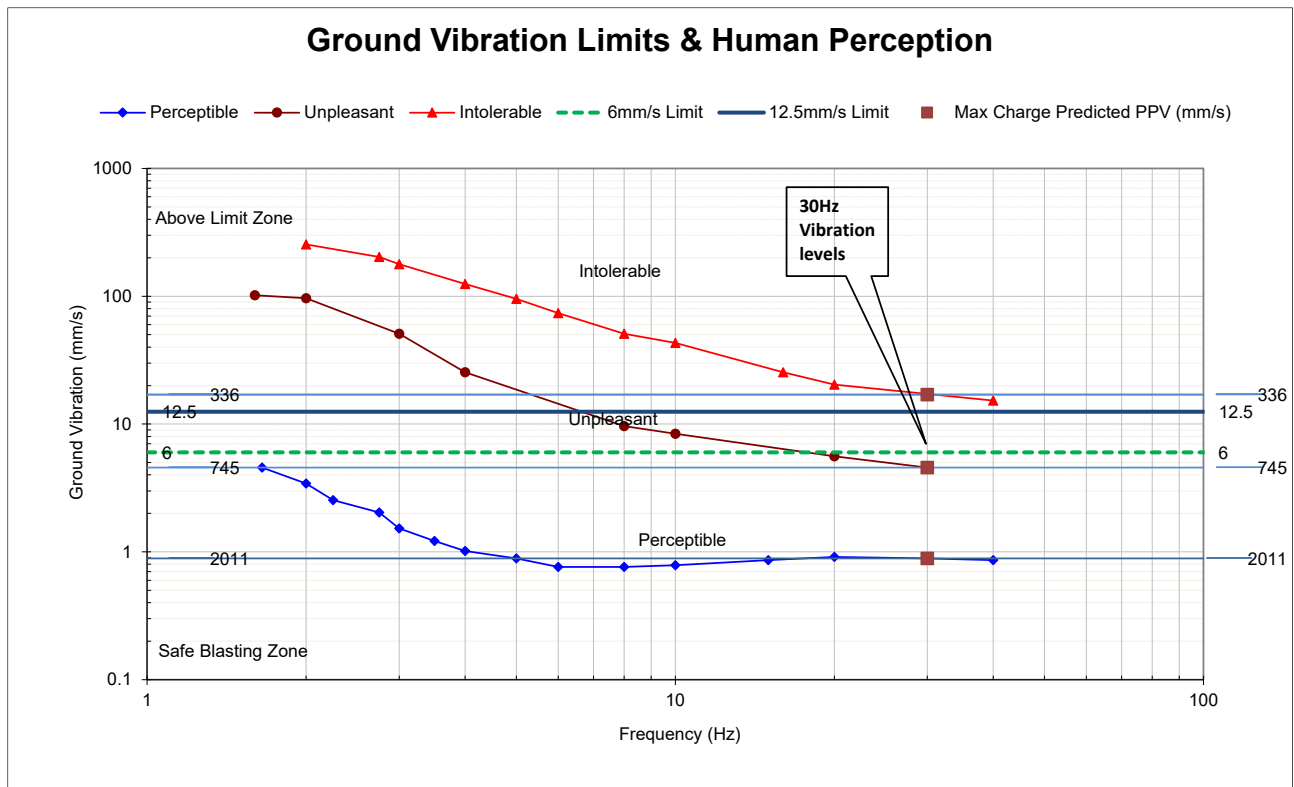


Figure 14: The effect of ground vibration on human perception and vibration limits

16.6 Potential that vibration will upset adjacent communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. The nearest house building/structure is at POI 48 and is approximately 2270 m from the planned operation, as all houses apart from POI 43 – POI 50 will be relocated, as confirmed by the Proponent. These buildings are located such that levels of ground vibration predicted from maximum charge are outside the range of perception, with no concern for possible structural damage. Charge mass per delay greater than the maximum charge will show increased levels of ground vibration and a higher probability of perception.

Ground vibration levels expected from the maximum charge have the possibility of being perceptible up to 2011 m. Lesser charges will certainly reduce this distance, for instance, at a minimum equal to the charge of a single blasthole, this distance is expected to be 1005 m. Within these distance ranges, there will be no houses/structures located except mine-owned infrastructure.

The importance of good public relations cannot be overemphasised. People tend to react negatively to experiencing 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 taken for proper control will be required.

16.7 Cracking of houses and consequent devaluation

The structures found in the areas of concern range from informal building styles to brick, mortar structures, and steel structures. There are various buildings found within a 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, and standards of building applied. Thus, damage in the form of cracks will be present. The exact costing of devaluation for normal cracks observed is difficult to estimate. Mining operations may not 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.

16.8 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 and 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 to determine 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 15 Shows the results from the ISEE calculations for fly rock range based on a 165 mm diameter blast hole and 3 m stemming length. Based on these values, a possible fly rock range with a safety factor of 2 was calculated to be 519 m. The absolute minimum unsafe zone is then 519 m. This calculation is a guideline, and any distance cleared should not be less than. 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 its occurrence can never be eliminated. Figure 16 Shows the area around the Pit area that incorporates the 519 m unsafe zone.

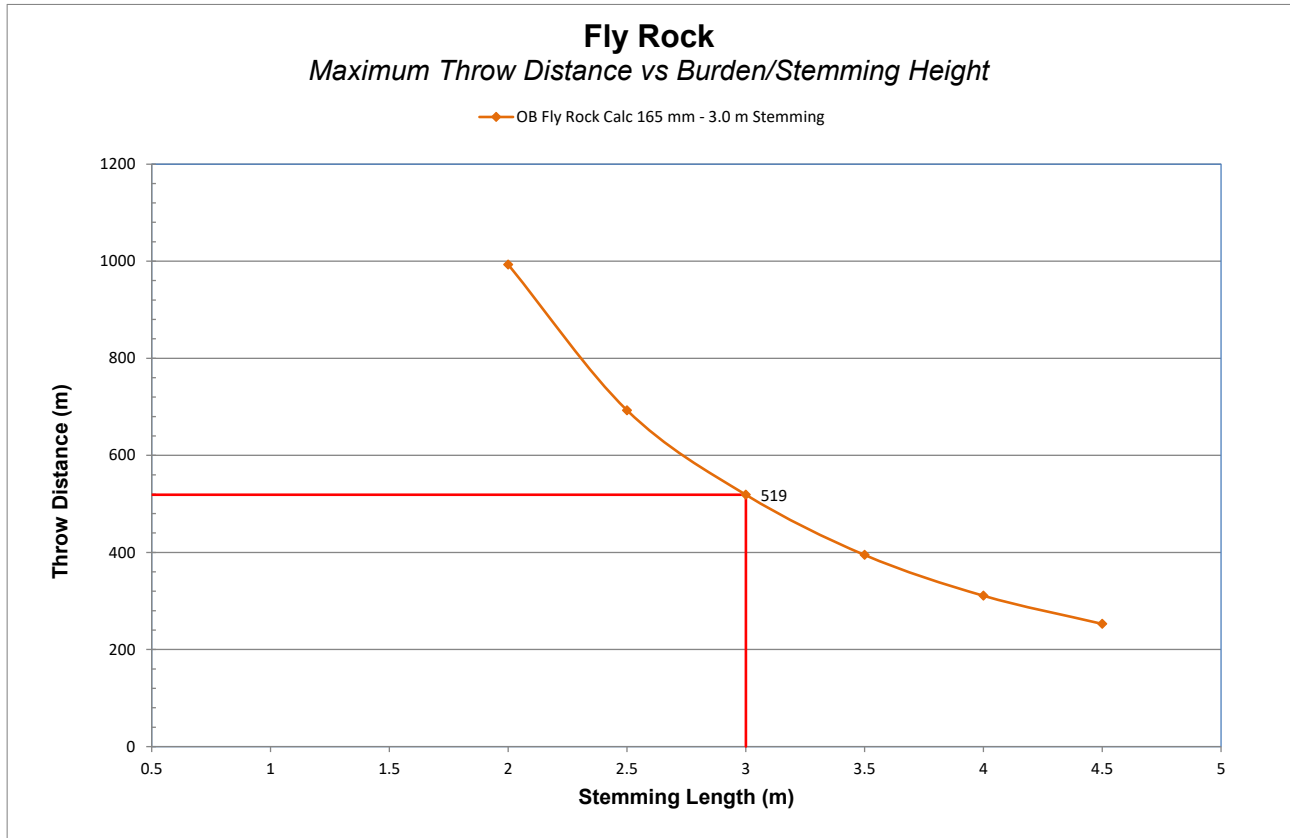


Figure 15: Fly rock prediction calculation

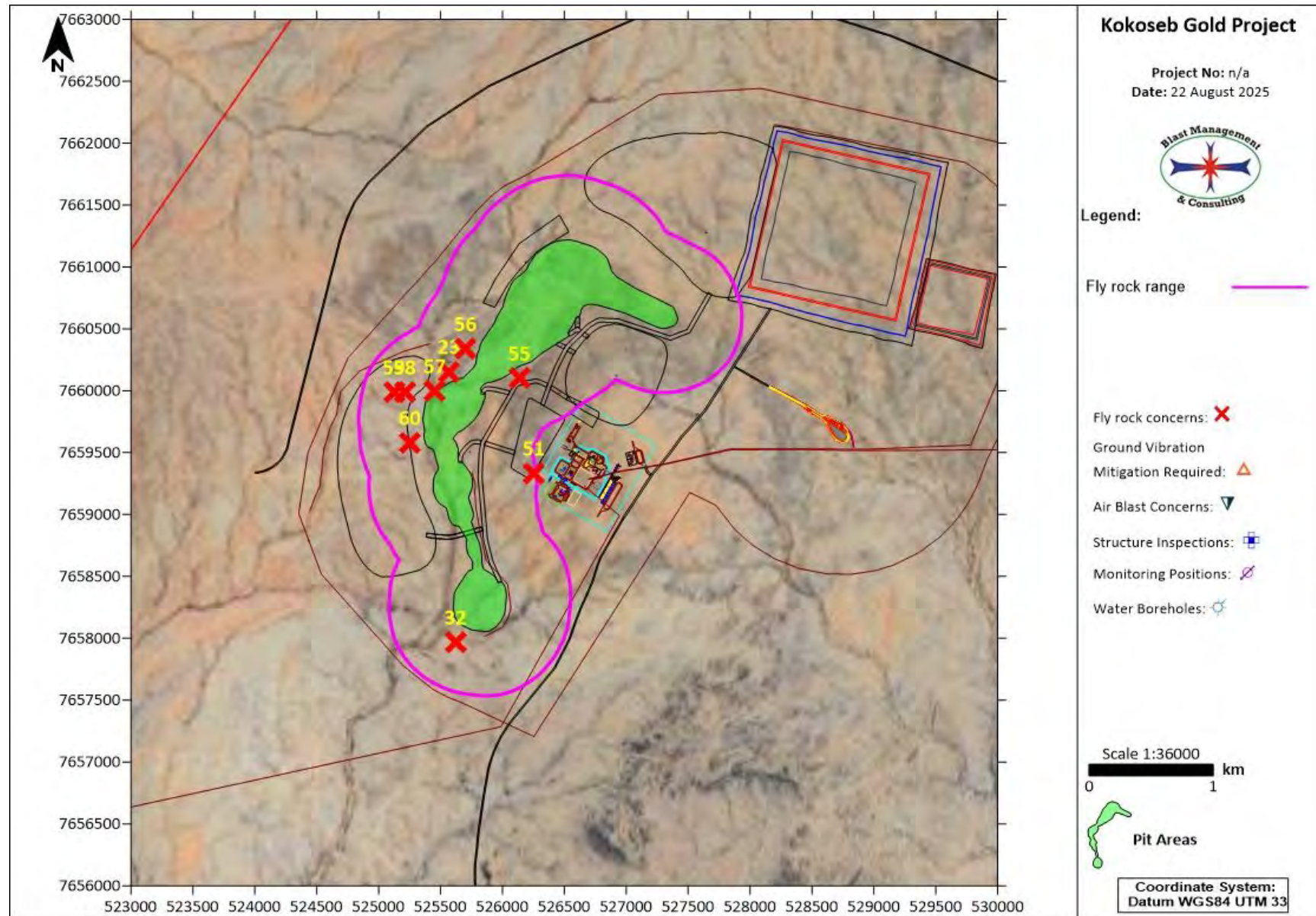


Figure 16: Predicted Fly Rock Exclusion Zone for the Opencast Pit area

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Review of the calculated unsafe zone showed initially nine POIs that are within the unsafe zone. The client intends to relocate the D3714 road, which will make POI51 obsolete. Table 11 below shows the POIs of concern and coordinates.

Table 11: Fly rock concern POIs

Tag	Description	Y	X
23	Village Houses (Katora)	7660154.19	525570.82
32	Wild Life Animal Activity (Main Hill/Ridge Habitat 4)	7657968.37	525622.14
51	D3714 Road	7659333.18	526255.22
55	Village Houses	7660101.32	526140.01
56	Village Houses	7660338.20	525703.78
57	Village Houses	7659997.61	525455.43
58	Village Houses	7659989.13	525213.56
59	Village Houses	7659987.57	525124.17
60	Village Houses	7659582.24	525252.86

16.9 Noxious fumes

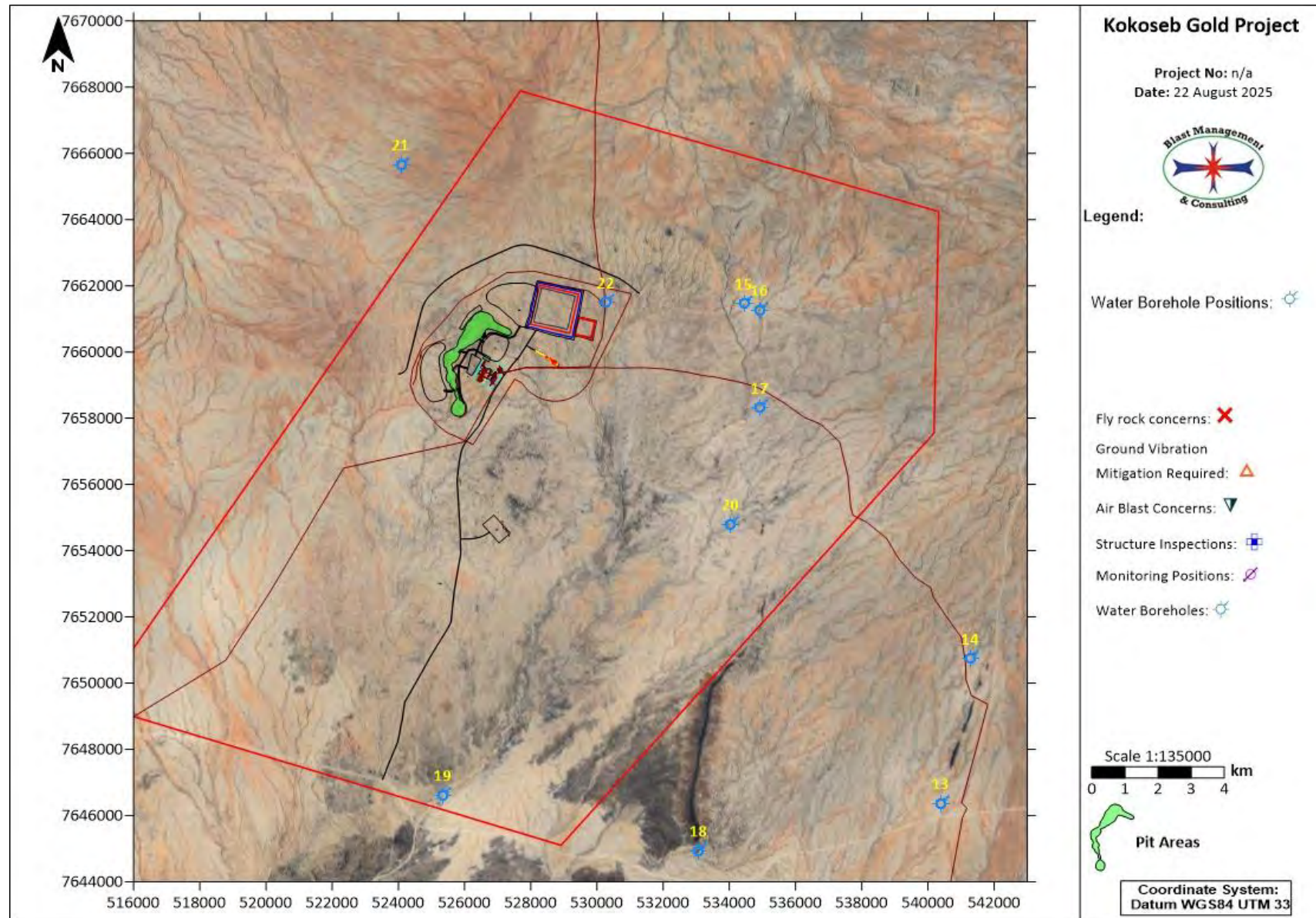
The occurrence of fumes in the form of the NO_x gas is not a given and is very dependent on various factors as discussed in Section 13.6. However, the occurrence of fumes should be closely monitored. Furthermore, nothing can be stated as to fume dispersal to nearby farmsteads, but if anybody is present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

16.10 Water Borehole Influence

A hydro-census was undertaken to identify boreholes within the exclusive prospecting licence area. Location of boreholes for water was evaluated for possible influence from blasting. Table 12 shows all the identified boreholes. Figure 17 shows the location of the boreholes in relation to the pit area.

Table 12: Identified Water Boreholes

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m) to Pit	Predicted PPV (mm/s)
13	Borehole	7646361.61	540395.72	50	18609	0.0
14	Borehole	7650730.80	541288.39	50	16999	0.0
15	Borehole	7661458.00	534446.00	50	7084	0.1
16	Borehole	7661259.01	534919.79	50	7535	0.1
17	Borehole	7658304.17	534934.27	50	7856	0.1
18	Borehole	7644928.30	533080.42	50	14969	0.0
19	Borehole	7646613.20	525356.48	50	11453	0.1
20	Borehole	7654786.83	534044.70	50	8722	0.1
21	Borehole	7665660.80	524077.52	50	5035	0.2
22	Borehole	7661489.53	530279.65	50	3003	0.5

**Figure 17: Location of the Boreholes**

17 Potential Environmental Impact Assessment: Operational Phase

The following is the impact assessment of the various concerns covered by this report. Please note that this is a one-sided evaluation with no input from the proponent or details about changes in operations that may be applied due to the outcome of this report. Blast Management and Consulting consider any one POI indicated as problematic as a guideline for the basis of ranking. The method of assessment is used as prescribed but ranked as best possible according to the evaluation done. The following is the impact assessment of the various concerns covered by this report. The outcome of the analysis is provided in Table 17 Before mitigation and after mitigation.

17.1 Assessment Criteria

The following assessment methodology was applied. The matrix below in Table 13 and Table 14 was used for the analysis and evaluation of the aspects discussed in this report. The outcome of the analysis is provided in Table 17, before mitigation and after mitigation.

The criteria for the description and assessment of environmental impacts were drawn to comply with best practice, which is defined by 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 13: Impact Assessment Methodology

Extent (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 14: 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
Severity		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:

$$\text{Significance} = (\text{duration} + \text{extend} + \text{magnitude}) \times \text{probability}$$

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 15: 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 mitigated, each identified potential impact will need to be assessed twice.

- **Firstly**, the potential impact will be assessed and rated before 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.

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's informed decision and discretion:

Table 16: 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.

The quantification of impacts is calculated mainly for the Operational Phase. No specific blasting is expected for the Construction, Decommissioning, and Post-closure phases.

17.2 Assessment

The assessment done was based on evaluating the points of interest 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 the pit area to the point of interest. After the mitigation assessment, consideration was given to the fact that blasting will not be constantly at the shortest distance between POI and the blasting area, and specific mitigations are applied.

Table 17: Potential Impacts Without and With Mitigation Measures

Nature of the impact		Significance of potential impact BEFORE mitigation						Mitigation Measures	Significance of potential impact AFTER mitigation						Degree of mitigation on (%)			
		P	D	E	M	LoR	Significance		P	D	E	M	LoR	Significance				
ACTIVITY: Blasting																		
Pre-Construction Phase																		
None		-																
Construction Phase																		
None		-																
Operational Phase																		
Ground Vibration - Exceeding Limits and Possible Damage to:																		
1	Heritage Site (Site 01 - Historic Water Pool)	-	1	3	3	2	3	8	Low	1. Do a specific blast design that considers the distance between the point of concern and the blast, specifically for blasts closer than 500 m to the nearest point of concern. 2. Shorter blast holes. 3. Smaller diameter blast hole. 4. Using electronic initiation to ensure single hole firing.	1	3	3	1	3	7	Low	12.5
2	Heritage Site (Site 02 - Historic Water Pool)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
3	Heritage Site (Site 03 - Historic Water Pool)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
4	Heritage Site (Site 04 - Graveyard at Aniswept)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
5	Heritage Site (Site 05 - Built Ruin)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
6	Heritage Site (Site 06 - Christian Graves with 4 unmarked graves)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
7	Heritage Site (Site 07 - Hamas Village Second Gravesite - Ancient)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
8	Heritage Site (Site 08 - Historic Well)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
9	Heritage Site (Site 09 - Prehistoric Rock Art)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
10	Heritage Site (Site 10 - Historic Mine Shaft)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
11	Heritage Site (Site 11 - Old Mining Ruins)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
12	Heritage Site (Site 12 - Christian Graves)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
13	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
14	Borehole	-	1	3	3	2	3	8	Low	5. Use of specialist to assist with drilling and blasting mitigation. 6. Ther following village houses will be relocated: POIs 23, 36, 37, 38, 52, 53, 54, 55, 56, 57, 58, 59, 60 and POI 51.	1	3	3	1	3	7	Low	12.5
15	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
16	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
17	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
18	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
19	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
20	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
21	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
22	Borehole	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
23	Village Houses (Katora)	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
24	Granite Dome 1	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
25	Granite Dome 2	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
26	Granite Dome 3	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
27	Wild Life Animal Activity (Black Rhino Rubbing Post)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
28	Wild Life Animal Activity (Raptor Nest)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
29	Wild Life Animal Activity (Main Hill/Ridge Habitat 1)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
30	Wild Life Animal Activity (Main Hill/Ridge Habitat 2)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
31	Wild Life Animal Activity (Main Hill/Ridge Habitat 3)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
32	Wild Life Animal Activity (Main Hill/Ridge Habitat 4)	-	5	3	3	10	3	80	High		3	3	3	5	3	33	Moderate	58.8
33	Wild Life Animal Activity (Main Hill/Ridge Habitat 5)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
34	Wild Life Animal Activity (Main Hill/Ridge Habitat 6)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
35	Wild Life Animal Activity (Main Hill/Ridge Habitat 7)	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
36	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
37	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
38	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
39	Village	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
40	Village	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
41	Village	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
42	Village	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
43	Village Houses	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
44	Village Houses	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
45	Village Houses	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
46	Cement Dam	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
47	Village Houses	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
48	Village Houses	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
49	Village Houses	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
50	Village Houses	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
51	D3714 Road	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
52	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
53	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
54	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
55	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
56	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
57	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
58	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
59	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
60	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	0	0	Very Low	100.0
67	Explosive Magazines	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
69	Plant	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
70	Explosive Magazines	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
71	Mine Buildings	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
72	Mine Buildings	-	1	3	3	2	3	8	Low		1	3	3	1	3	7	Low	12.5
Air Blast - Exceeding Limits and Possible Damage to:																		
1	Heritage Site (Site 01 - Historic Water Pool)	-	1	3	3	1	3	7	Low	1. Specific blast design to be done. 2. Shorter blast holes. 3. Smaller diameter blast hole. 4. Use of specific stemming materials to manage air blast. 5. Increased	1	3	3	0.5	3	6.5	Low	7.1
2	Heritage Site (Site 02 - Historic Water Pool)	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
3	Heritage Site (Site 03 - Historic Water Pool)	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
4	Heritage Site (Site 04 - Cemetery with 20 unmarked graves)	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
5	Heritage Site (Site 05 - Built Ruin)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
6	Heritage Site (Site 06 - Christian Graves with 4 unmarked graves)	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
7	Heritage Site (Site 07 - Historic Graves - 30 graves)	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
8	Heritage Site (Site 08 - Historic Well)	-	1	3	3	1	3	7	Low	stemming lengths to reduce air blast effect. 6. Ensure proper clearance of unsafe areas prior to blasting. 7. Ther following village houses will be relocated: POIs 23, 36, 37, 38, 52, 53, 54, 55, 56, 57, 58, 59, 60 and POI 51.	1	3	3	0.5	3	6.5	Low	7.1
9	Heritage Site (Site 09 - Prehistoric Rock Art)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
10	Heritage Site (Site 10 - Historic Mine Shaft)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
11	Heritage Site (Site 11 - Built Ruins)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
12	Heritage Site (Site 12 - Christian Graves)	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
13	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
14	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
15	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
16	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
17	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
18	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
19	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
20	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
21	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
22	Borehole	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
23	Village Houses (Katora)	-	5	3	3	10	3	80	High		0	0	0	0	3	0	Very Low	100.0
24	Granite Dome 1	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
25	Granite Dome 2	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
26	Granite Dome 3	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
27	Wild Life Animal Activity (Black Rhino Rubbing Post)	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
28	Wild Life Animal Activity (Raptor Nest)	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
29	Wild Life Animal Activity (Main Hill/Ridge Habitat 1)	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
30	Wild Life Animal Activity (Main Hill/Ridge Habitat 2)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
31	Wild Life Animal Activity (Main Hill/Ridge Habitat 3)	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
32	Wild Life Animal Activity (Main Hill/Ridge Habitat 4)	-	5	3	3	10	3	80	High		3	3	3	5	3	33	Moderate	58.8
33	Wild Life Animal Activity (Main Hill/Ridge Habitat 5)	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
34	Wild Life Animal Activity (Main Hill/Ridge Habitat 6)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
35	Wild Life Animal Activity (Main Hill/Ridge Habitat 7)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
36	Village Houses	-	3	3	3	6	3	36	Moderate		0	0	0	0	3	0	Very Low	100.0
37	Village Houses	-	3	3	3	6	3	36	Moderate		0	0	0	0	3	0	Very Low	100.0
38	Village Houses	-	3	3	3	6	3	36	Moderate		0	0	0	0	3	0	Very Low	100.0
39	Village	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
40	Village	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
41	Village	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
42	Village	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
43	Village Houses	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
44	Village Houses	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
45	Village Houses	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
46	Cement Dam	-	1	3	3	1	3	7	Low		1	3	3	0.5	3	6.5	Low	7.1
47	Village Houses	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
48	Village Houses	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
49	Village Houses	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
50	Village Houses	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
51	D3714 Road	-	1	3	3	1	3	7	Low		0	0	0	0	3	0	Very Low	100.0
52	Village Houses	-	3	3	3	6	3	36	Moderate		0	0	0	0	3	0	Very Low	100.0
53	Village Houses	-	3	3	3	6	3	36	Moderate		0	0	0	0	3	0	Very Low	100.0
54	Village Houses	-	3	3	3	6	3	36	Moderate		0	0	0	0	3	0	Very Low	100.0
55	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	3	0	Very Low	100.0
56	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	3	0	Very Low	100.0
57	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	3	0	Very Low	100.0
58	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	3	0	Very Low	100.0
59	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	3	0	Very Low	100.0
60	Village Houses	-	5	3	3	10	3	80	High		0	0	0	0	3	0	Very Low	100.0
67	Explosive Magazines	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
69	Plant	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
70	Explosive Magazines	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
71	Mine Buildings	-	3	3	3	6	3	36	Moderate	2	3	3	3	3	18	Low	50.0	
72	Mine Buildings	-	3	3	3	6	3	36	Moderate	2	3	3	3	3	18	Low	50.0	
Fly rock - Within Fly Rock Range and possible Damage, fatality or injury to people or animals.																		

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
1	Heritage Site (Site 01 - Historic Water Pool)	-	1	3	3	4	3	10	Low	1. Specific blast design to be done. 2. Shorter blast holes. 3. Smaller diameter blast hole. 4. Use of specific stemming materials to manage air blast. 5. Increased stemming lengths to reduce air blast effect. 6. Ensure proper clearance of unsafe areas prior to blasting. 7. Ther following village houses will be relocated: POIs 23, 36, 37, 38, 52, 53, 54, 55, 56, 57, 58, 59, 60 and POI 51.	1	3	3	2	3	8	Low	20.0
2	Heritage Site (Site 02 - Historic Water Pool)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
3	Heritage Site (Site 03 - Historic Water Pool)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
4	Heritage Site (Site 04 - Cemetery with 20 unmarked graves)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
5	Heritage Site (Site 05 - Built Ruin)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
6	Heritage Site (Site 06 - Christian Graves with 4 unmarked graves)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
7	Heritage Site (Site 07 - Historic Graves - 30 graves)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
8	Heritge Site (Site 08 - Historic Well)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
9	Heritage Site (Site 09 - Prehistoric Rock Art)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
10	Heritage Site (Site 10 - Historic Mine Shaft)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
11	Heritage Site (Site 11 - Built Ruins)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
12	Heritage Site (Site 12 - Christian Graves)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
13	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
14	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
15	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
16	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
17	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
18	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
19	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
20	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
21	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
22	Borehole	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
23	Village Houses (Katora)	-	4	3	3	10	3	64	High		0	0	0	0	3	0	Very Low	100.0
24	Granite Dome 1	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
25	Granite Dome 2	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
26	Granite Dome 3	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
27	Wild Life Animal Activity (Black Rhino Rubbing Post)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
28	Wild Life Animal Activity (Raptor Nest)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
29	Wild Life Animal Activity (Main Hill/Ridge Habitat 1)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
30	Wild Life Animal Activity (Main Hill/Ridge Habitat 2)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
31	Wild Life Animal Activity (Main Hill/Ridge Habitat 3)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
32	Wild Life Animal Activity (Main Hill/Ridge Habitat 4)	-	4	3	3	10	3	64	High		2	3	3	5	3	22	Low	65.6
33	Wild Life Animal Activity (Main Hill/Ridge Habitat 5)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
34	Wild Life Animal Activity (Main Hill/Ridge Habitat 6)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
35	Wild Life Animal Activity (Main Hill/Ridge Habitat 7)	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
36	Village Houses	-	2	3	3	4	3	20	Low		0	0	0	0	3	0	Very Low	100.0
37	Village Houses	-	2	3	3	4	3	20	Low		0	0	0	0	3	0	Very Low	100.0
38	Village Houses	-	2	3	3	4	3	20	Low		0	0	0	0	3	0	Very Low	100.0
39	Village	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
40	Village	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
41	Village	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
42	Village	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
43	Village Houses	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
44	Village Houses	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
45	Village Houses	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
46	Cement Dam	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
47	Village Houses	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
48	Village Houses	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
49	Village Houses	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
50	Village Houses	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
51	D3714 Road	-	4	3	3	10	3	64	High		0	0	0	0	3	0	Very Low	100.0
52	Village Houses	-	2	3	3	4	3	20	Low		0	0	0	0	3	0	Very Low	100.0
53	Village Houses	-	2	3	3	4	3	20	Low		0	0	0	0	3	0	Very Low	100.0
54	Village Houses	-	2	3	3	4	3	20	Low		0	0	0	0	3	0	Very Low	100.0
55	Village Houses	-	4	3	3	10	3	64	High		0	0	0	0	3	0	Very Low	100.0
56	Village Houses	-	4	3	3	10	3	64	High		0	0	0	0	3	0	Very Low	100.0
57	Village Houses	-	4	3	3	10	3	64	High		0	0	0	0	3	0	Very Low	100.0
58	Village Houses	-	4	3	3	10	3	64	High		0	0	0	0	3	0	Very Low	100.0
59	Village Houses	-	4	3	3	10	3	64	High		0	0	0	0	3	0	Very Low	100.0
60	Village Houses	-	4	3	3	10	3	64	High		0	0	0	0	3	0	Very Low	100.0

Nature of the impact			Significance of potential impact BEFORE mitigation							Mitigation Measures	Significance of potential impact AFTER mitigation							Degree of mitigation on (%)
			P	D	E	M	LoR	Significance	P		D	E	M	LoR	Significance			
67	Explosive Magazines	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
69	Plant	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
70	Explosive Magazines	-	1	3	3	4	3	10	Low		1	3	3	2	3	8	Low	20.0
71	Mine Buildings	-	2	3	3	4	3	20	Low		1	3	3	2	3	8	Low	60.0
72	Mine Buildings	-	3	3	3	6	3	36	Moderate		2	3	3	3	3	18	Low	50.0
Closure/Rehabilitation Phase																		
None		-																
Cumulative Impacts																		
Multiple blasts conducted		-	3	3	3	4	3	30	Moderate	Multiple blast initiated simultaneously must be avoided. Time delay between must be facilitated.	2	3	3	3	3	18	Low	40.0

17.3 Mitigations

Impacts are assessed where ground vibration may have an impact on houses/structures or where people may congregate, air blast may impact houses /structures, producing possible damage, and where fly rock may impact structures, people, or animals. Mitigation measures are recommended when these impacts are identified as a concern.

Specific impacts are expected at the following POI's identified. Table 19 shows list of POI's that will need to be considered. Figure 19 shows the location of these POI's in relation to the pit areas.

Table 18: Structures identified as problematic in and around the project area

Tag	Description	Classification	Y	X
23	Village Houses (Katora)	2	7660154.19	525570.82
32	Wildlife Animal Activity (Main Hill/Ridge Habitat 4)	5	7657968.37	525622.14
55	Village Houses	2	7660101.32	526140.01
56	Village Houses	2	7660338.20	525703.78
57	Village Houses	2	7659997.61	525455.43
58	Village Houses	2	7659989.13	525213.56
59	Village Houses	2	7659987.57	525124.17
60	Village Houses	2	7659582.24	525252.86
61	D3714 Road (Inside Pit Area)	15	7659334.12	525601.32
62	Village Houses (Inside Pit Area)	15	7659899.26	525774.30
63	Village Houses (Inside Pit Area)	15	7660168.92	525820.76
64	Village Houses (Inside Pit Area)	15	7660183.16	525926.38
65	Village Houses (Inside Pit Area)	15	7660415.94	526150.65
66	Village Houses (Inside Pit Area)	15	7660974.55	526769.50

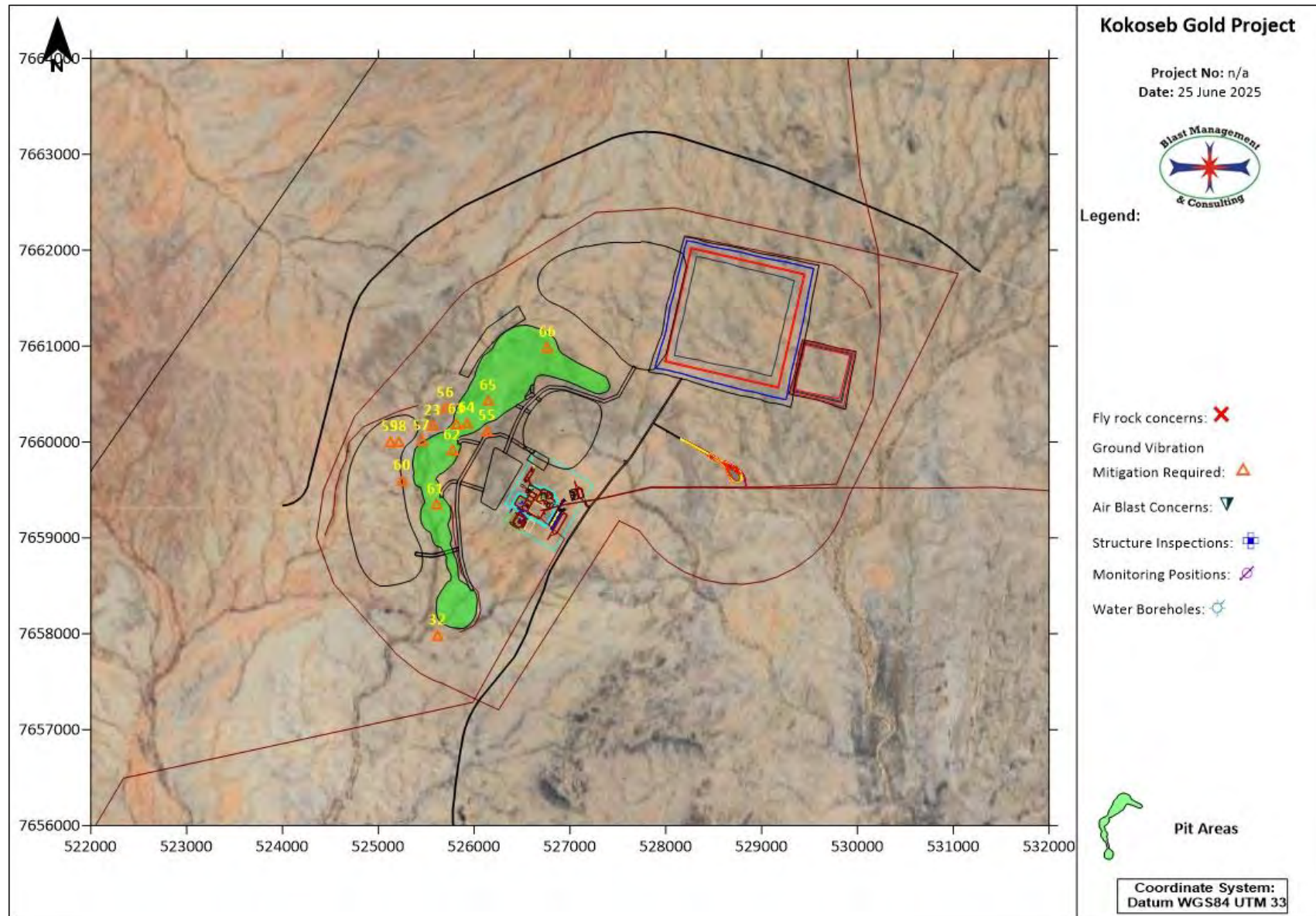


Figure 18: Mitigation POI's

Part of the mitigation measures to be considered is relocation of village houses. The client has indicated that all village houses are planned to be relocated apart from POI 43 – POI 50, which is south of the project site. POIs 39 - 42 are structures for the future mine accommodation.

Considering the relocation planned and based on the modelling done and review of the private structures or non-mining POIs that will be present around the pit area showed mainly one POI – POI32 – indicated as problematic. Ground vibration was identified as problematic, but the POI represents an area where wildlife may be present. There are no surface structures associated with this POI. The expected level of ground vibration is not expected to be of concern. A concern is the flyrock unsafe zone, calculated at 519 m from the pit boundary. POI32 does fall within this range.

The following specific mitigations may be considered:

1. Changes to charging designs to mitigate fly rock, specifically in the southern end of the pit.

Fly rock:

Fly rock is mitigated by the following means:

1. Increasing the stemming length ratio to blasthole diameter – either changing to a smaller diameter blasthole or increasing the actual stemming length.
2. The use of aggregate stemming material of correct size ratio – 10 % of the blasthole diameter.

Specific impacts are expected at the following POIs identified. Table 19 shows list of POI's that will need to be considered. Figure 19 shows the location of these POIs in relation to the pit areas.

Table 19: Structures identified as problematic in and around the project area

Tag	Description	Classification	Y	X
32	Wildlife Animal Activity (Main Hill/Ridge Habitat 4)	5	7657968.37	525622.14

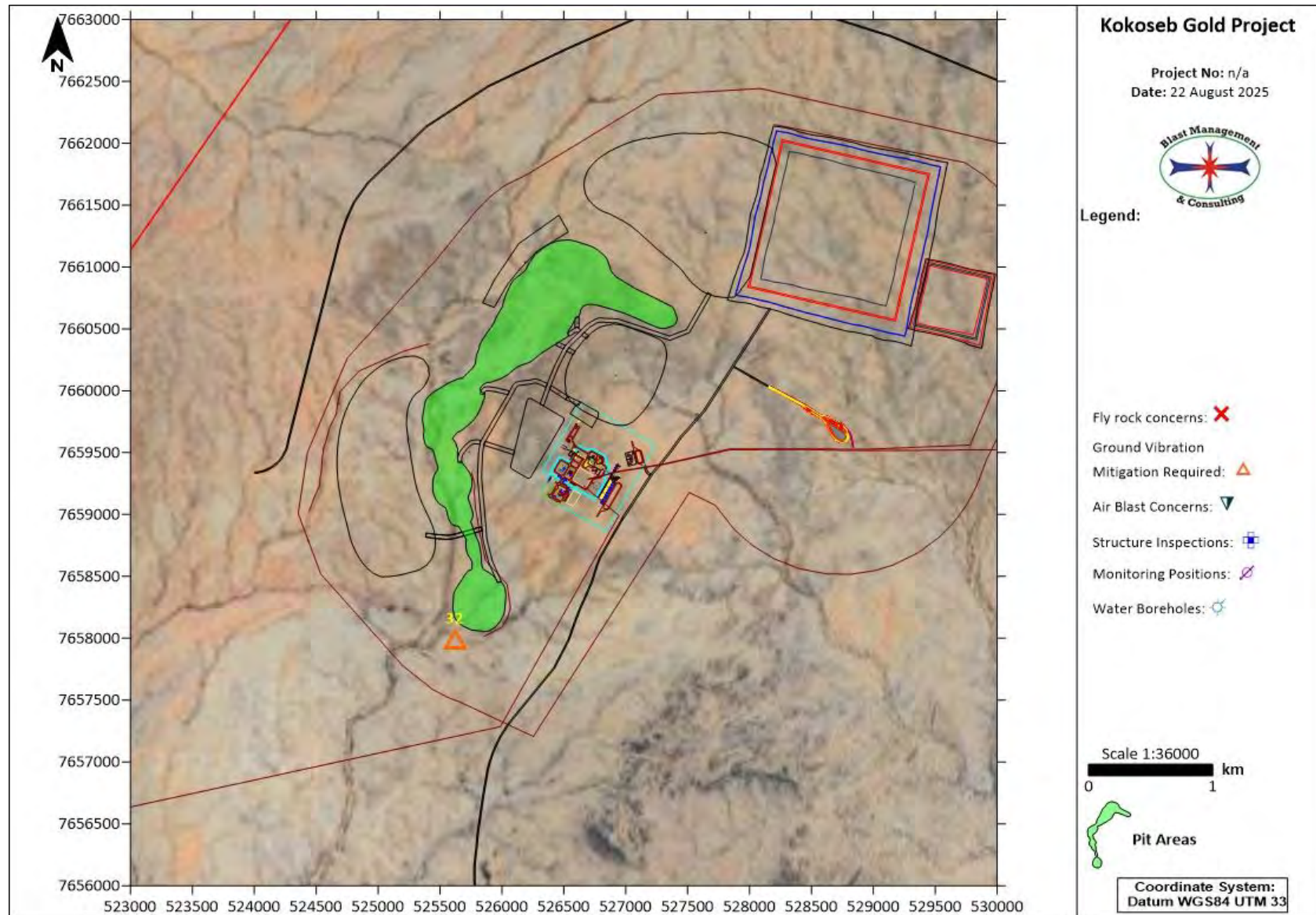


Figure 19: Mitigation POIs

18 Closure Phase: Impact Assessment and Mitigation Measures

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

19 Alternatives (Comparison and Recommendation)

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

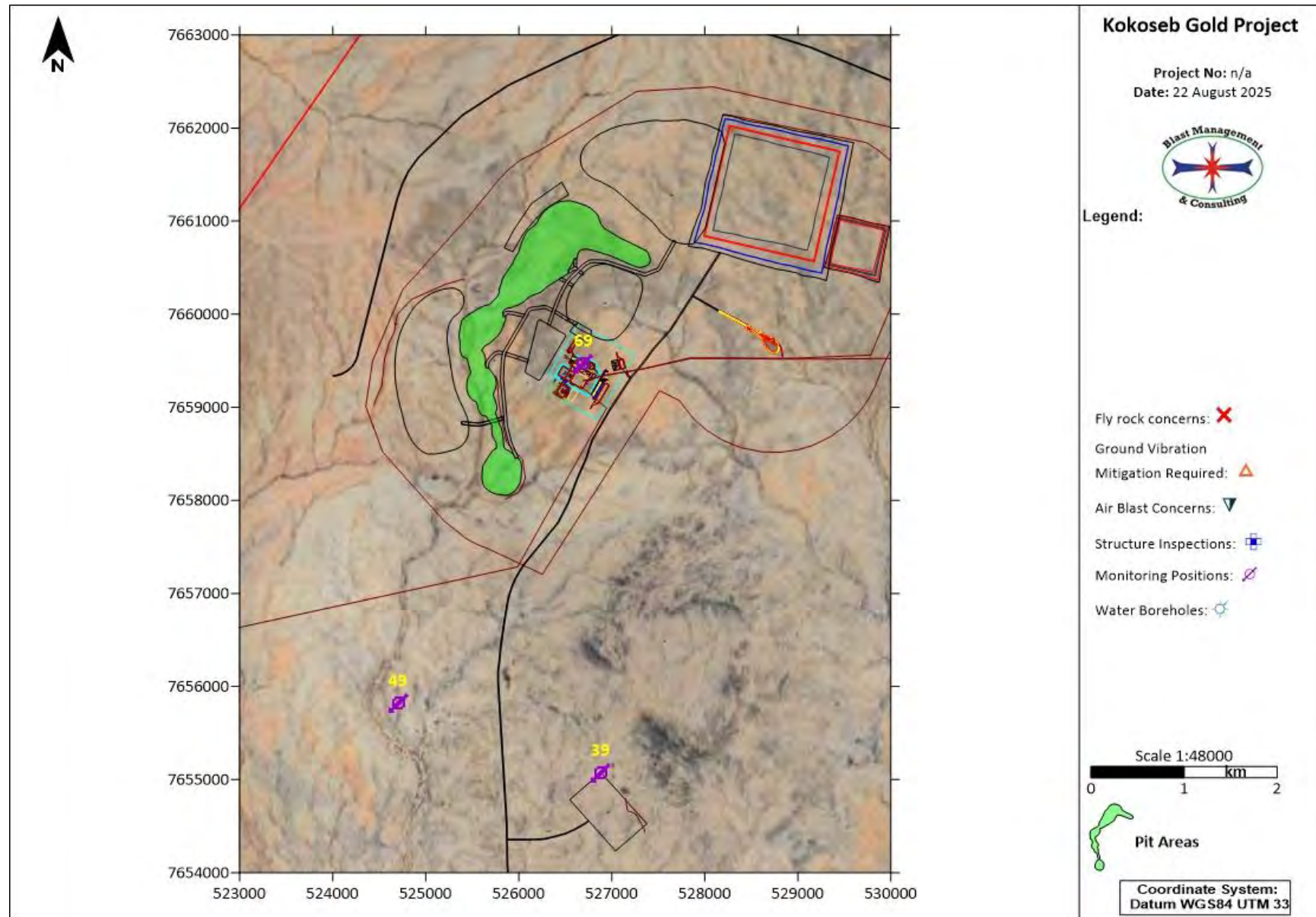
20 Monitoring

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

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

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

Two monitoring points were identified as possible locations that will need to be considered for the pit area. Not all the identified points will be required simultaneously. The identified points are guidelines to consider for the pit area. Monitoring positions are indicated in Figure 20 and Table 20 lists the positions with coordinates. These points will need to be redefined after the first blasts are done and the monitoring programme is defined.

**Figure 20: Suggested monitoring positions**

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Table 20: List of possible monitoring positions

Tag	Description	Y	X
39	Village	7655071.10	526880.52
48	Village Houses	7656034.99	524739.25
69	Plant	7659468.70	526697.00

21 Recommendations

The following recommendations are proposed.

21.1 Unsafe Blasting Range

One non-mining-related POI – POI32, after mitigation, is observed within a 519 m unsafe blasting zone from the pit that needs consideration. Up to 500 m is generally accepted as an unsafe area from blasting operations but in this case expected fly rock range indicated a further distance of 519 m. Table 21 lists these installations. Figure 21 below shows the 519 m boundary around the opencast pit area. The location of non-mining installations is clearly observed.

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

Tag	Description	Y	X
32	Wildlife Animal Activity (Main Hill/Ridge Habitat 4)	7657968.37	525622.14

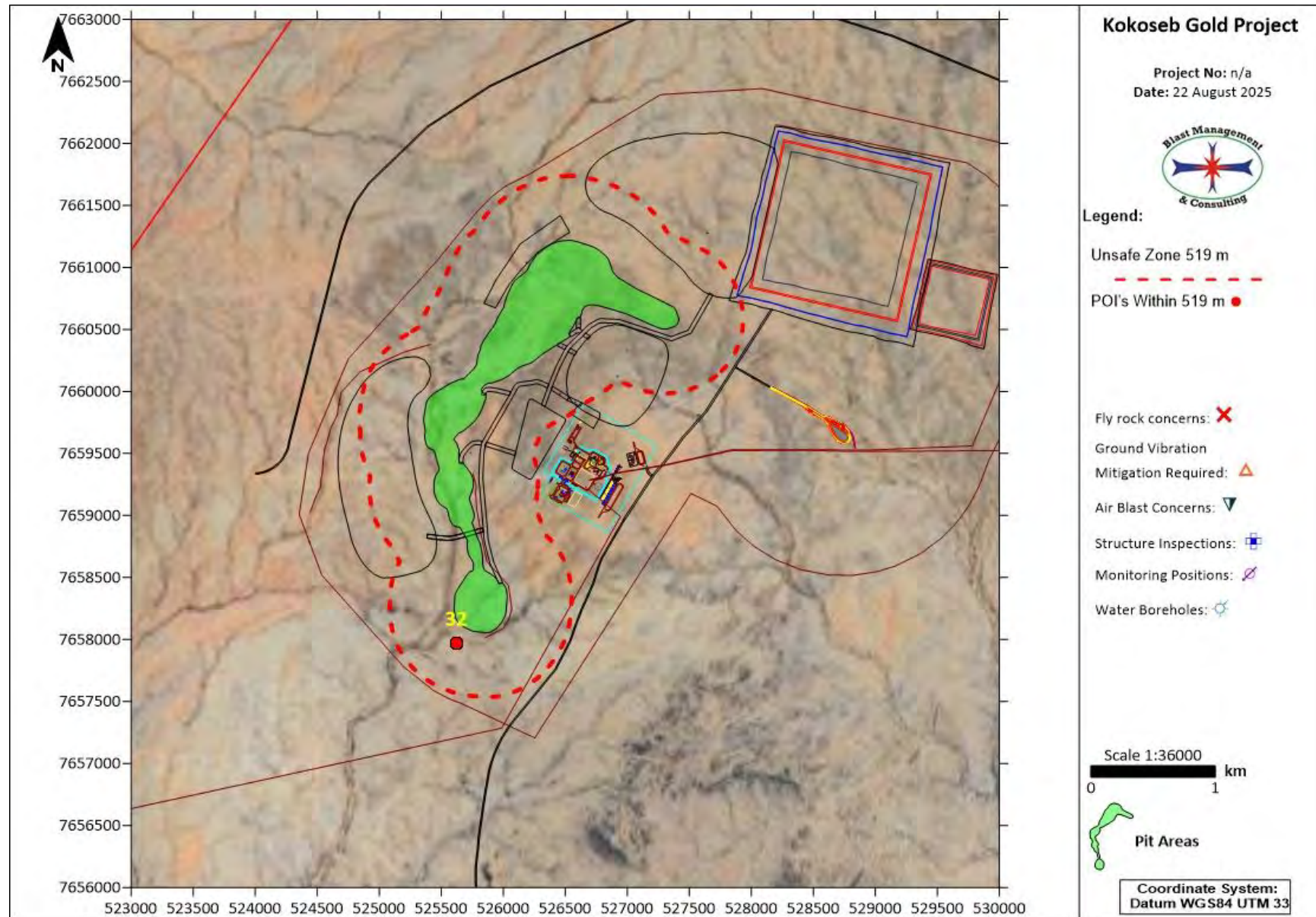


Figure 21: Regulatory 500 M Range For The Opencast Area

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21.2 Relocation

The client indicated that the following village houses will be relocated: POIs 23, 36, 37, 38, 51, 52, 53, 54, 55, 56, 57, 58, 60 and the D3714 Road at POI 51.

21.3 Blast Designs

Blast designs should be reviewed before the first blast. Specific attention should be given to the possible use of electronic initiation rather than conventional timing systems. This will allow for single blast hole firing instead of multiple blast holes. Single blast hole firing will provide single hole firing – thus less charge mass per delay and less influence. Please refer to the section 17.3 for details regarding the mitigations required.

21.4 Test Blasting

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

21.5 Stemming length

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

21.6 Safe blasting distance and evacuation

Calculated minimum safe distance is 519 m. The final blast designs that may be used will determine the final decision on the safe distance to evacuate people and animals. This distance may be greater pending the final code of practice of the mine and the responsible blaster's decision on safe distance. The blaster has a legal obligation concerning the safe distance, and he needs to determine this distance.

21.7 Road management

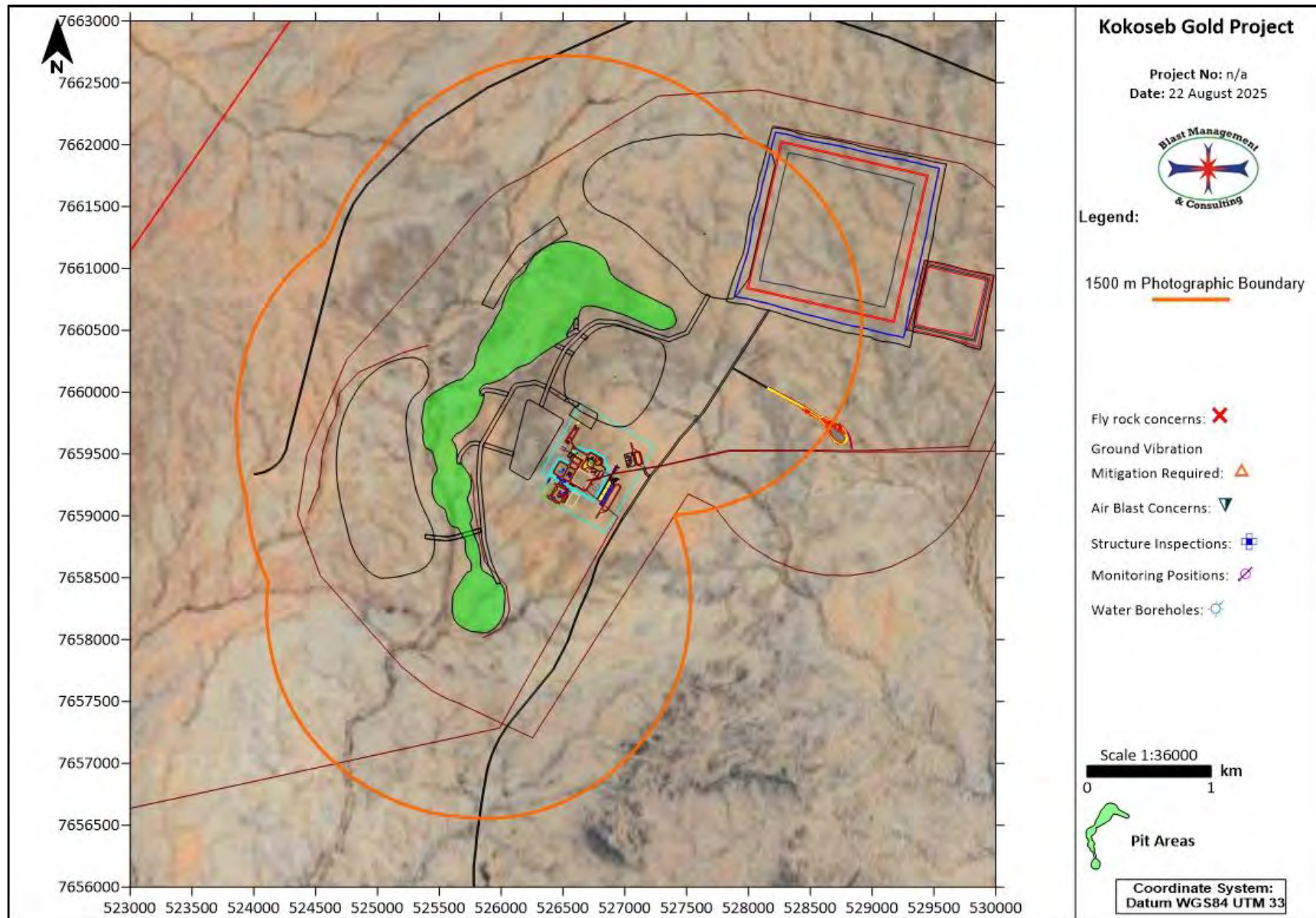
The closest main roads are the C36, which borders the EPL, and the D3714, which runs through the proposed project footprint. The project infrastructure will traverse the road D3714, which will

require re-routing around the mine site. An access road will be constructed from the main road C36 to the mine site. This access road will be the main route to the site; however, during construction and early works, the D3714 will be used until the access route is established. Re-routing of the D3714 road will occur during construction and will be 9.7 km in length, while the new access road will be 12.5 km in length.

There are gravel roads that traverse through the existing approved mining area. There is no specific ground vibration concern for these roads. There are also other smaller gravel roads in the area. These roads are specifically of concern when blasting is done with regard to fly rock concerns more than ground vibration. No specific consideration regarding effects from blasting operations will be required for these roads. There may, however, be people and animals on these routes, and will require careful planning will be required to maintain a safe blasting radius. It will be required that clearance distances be set and road travel managed during blasting operations.

21.8 Photographic Inspections

The option of a photographic survey of all structures up to 1500 m from the pit area is normally recommended. The mine will be operating for a significant number of years. This will give an advantage in any negotiations with regards to complaints from neighbours on structural issues due to blasting. This process can, however, only succeed if done in conjunction with a proper monitoring program. It is expected that ground vibration levels will be significantly less than proposed limits at 1500 m, but this process will ensure a record of the pre-blasting status of the nearest structures to the pit area. At 1500 m, the expected level of ground vibration will be perceptible. In view of the houses that will be relocated, there are no POIs that fall within this range. Figure 22 shows the extent of the range of 1500 m around the pit areas.

**Figure 22: Structure Inspection Range - 1500 m**

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21.9 Recommended ground vibration and air blast levels

The ground vibration and air blast limits recommended for blasting operations in this area are provided in **Table 22**.

Table 22: Recommended ground vibration air blast limits

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

21.10 Blasting times

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

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

21.11 Third-party monitoring

Third-party consultation and monitoring should be considered for all ground vibration and air blast monitoring work. This will bring about an unbiased evaluation of levels and influence from an independent group. Monitoring could be done using permanently installed stations. Audit functions may also be conducted to assist the mine in maintaining a high level of performance with regard to blast results and the effects related to blasting operations. Please refer to section 20 regarding proposed monitoring positions.

21.12 Video monitoring of each blast

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

22 Knowledge Gaps

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

23 Project Result

Specific problems were identified, and recommendations made. The successful resolving of these concerns will allow the project can be executed successfully with proper management and control on the aspects of ground vibration, air blast, and fly rock.

24 Conclusion

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

The evaluation of effects yielded by blasting operations was conducted over a general area as wide as 3500 m from the mining area considered and specific POIs located as far as 18.6 km. The range of structures observed is typical of roads, low-cost houses, and heritage sites.

Various houses located around the pit area was identified for relocation as well as re-routing of the D3714. The closest POI observed is associated with area of wildlife animal activity. The nearest private houses/structures, that will not be relocated, are located 2270 m from the pit. The ground vibration levels predicted for all POIs ranged between none and 66.2 mm/s. The relocation process of affected farmers or community groups within the mine blast buffer zone to safer grounds reduces the possible impact from ground vibration, air blast and flyrock significantly.

The expected levels of ground vibration at the nearest houses are low with no specific mitigations required. POI 32 was identified as a wildlife area with no surface structure present. The expected ground vibration level at this POI is not considered problematic though greater than an estimated limit. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Review of the heritage sites surrounding the planned mining area ranges in distances from 2.7 km to 15 km. There is no impact possible from blasting operations on these sites.

The air blast predicted showed some limited concerns for opencast blasting. The current accepted limit on air blast is 134 dB(L). Damages are only expected to occur at levels greater than 134 dB(L). None of the houses/structures identified, that will not be relocated, showed exceedances of the limits. Air blast levels at the nearest houses are however greater than 120 dB(L) which could lead to complaints. Prediction shows that the air blast will be greater than 134 dB(L) at a distance of 370 m and closer to the pit boundary. It is maintained that if basic blasting principles and stemming control are not exercised, this effect could be greater with a greater range of complaints. The pits are located such that “free blasting” – meaning no controls on blast preparation – will not be possible.

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 519 m. The absolute minimum unsafe zone is then 519 m. This calculation is a guideline, and any distance cleared should

not be less than. One POI – POI 32 - is found within this range. 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 its occurrence can never be eliminated.

Generally, 500 m is applied for a safe blasting/clearance distance; however, the calculated unsafe zone for fly rock is 519 m, therefore, this should be used as the clearance distance. Specific actions will be required when blasting is done within 519 m of structures. The wildlife animal activity (Main Hill/Ridge Habitat 4) fall within the 519 m range from the pit area.

The planned mine accommodation houses are located 3.1 km away from the planned pit area. Assessment of impacts indicated there is no concern regarding impacts from ground vibration, air blast and fly rock.

The pit area is located such that specific concerns were identified and addressed in the report. There are public areas located close to the pit boundary. Specific mitigation will be required for these concerns. Recommendations have been made regarding these.

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

25 Curriculum Vitae of Author

J D Zeeman was a member of the Permanent Force - SA Ammunition Core for the period January 1983 to January 1990. During this period, work involved testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing, and lot acceptance of ammunition.

From July 1992 to December 1995, Mr Zeeman worked at AECI Explosives Ltd. Initial work involved testing science on small-scale laboratory work and large-scale field work. Later, work entailed managing various testing facilities and testing projects. Due to the restructuring of the Technical Department, Mr Zeeman was retrenched, but fortunately was able to take up an appointment with AECI Explosives Ltd.'s Pumpable Emulsion Explosives Group for underground applications.

From December 1995 to June 1997, Mr Zeeman provided technical support to the Underground Bulk Systems Technology business unit and performed project management on new products.

Mr Zeeman started Blast Management & Consulting in June 1997. The main areas of focus are pre-blast monitoring, in situ monitoring, post-blast monitoring, and specialized projects.

Mr Zeeman holds the following qualifications:

1985 - 1987 Diploma: Explosives Technology, Technikon Pretoria

1990 - 1992 BA Degree, University of Pretoria

1994 National Higher Diploma: Explosives Technology, Technikon Pretoria

1997 Project Management Certificate: Damelin College

2000 Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997, with work being done at various levels for all the major mining companies in South Africa. Some of the projects in which BM&C has been involved include:

Iso-Seismic Surveys for Kriel Colliery in conjunction with Bauer & Crosby Pty Ltd.; Iso-Seismic surveys for Impala Platinum Limited; Iso-Seismic surveys for Kromdraai Opencast Mine; Photographic Surveys for Kriel Colliery; Photographic Surveys for Goedeheop Colliery; Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village; Photographic Surveys for Aquarius – Everest South Project; Photographic Surveys for Kromdraai Opencast Mine; Photographic inspections for various other companies, including Landau Colliery, Platinum Joint Venture – three mini-pit areas; Continuous ground vibration and air blast monitoring for various coal mines; Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients, e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road; Monitoring of ground vibration induced on surface in underground mining environment; Monitoring and management of blasting in close relation to water pipelines in opencast mining environment; Specialized testing of explosives characteristics; Supply and service

of seismographs and VOD measurement equipment and accessories; Assistance in protection of ancient mining works for Rhino Minerals (Pty) Ltd.; Planning, design, auditing and monitoring of blasting in new quarry on new road project, Sterkspruit, with Africon, B&E International and Group 5 Roads; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Pandora Joint Venture 180 houses – whole village; Structure Inspections and Reporting for Lonmin Platinum Mine Limpopo Section - 1000 houses / structures.

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

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