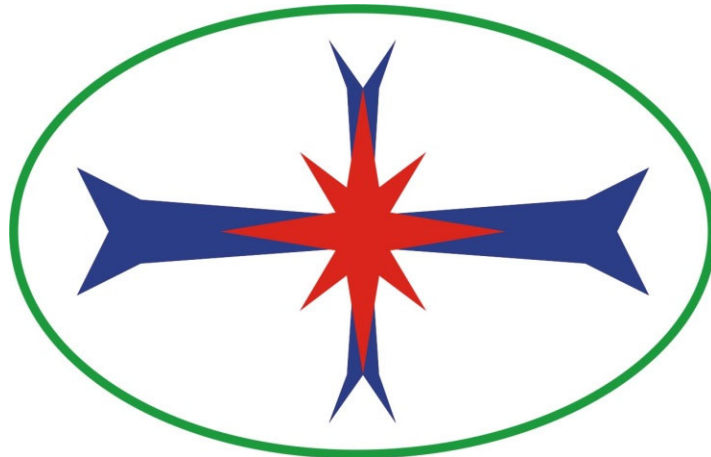
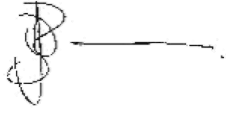


Blast Management & Consulting



Quality Service on Time

Report: Blast Impact Assessment The proposed Haib Copper Project on EPL 3140, Kharas Region - Namibia		
Report Date:	21 October 2025	
BM&C Ref No:	Knight Piésold_Haib Copper Project_EIAReport_251021V00	
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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 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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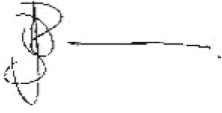
Name & Company	Responsibility	Action	Date	Signature
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List of Acronyms used in this Report

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 Knight Piésold 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 25.3 km. The range of structures observed is typical of Roads, Farm Buildings/Structures, Heritage sites, and the Haib River.

The model used for evaluation does indicate mostly acceptable levels ranging from none to levels as high as 54 mm/s over the range 222 m to 25.3 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 25.3 km that were considered important to consider as well. The POIs beyond the 3500 m boundary are mainly heritage sites, boreholes, existing and planned power lines, and Vioolsdrif town.

Ground vibration levels expected at the Haib river are 1.3 mm/s, which is well within the limits of 200 mm/s. The Farm Buildings/Structures are within limits of 12.5 mm/s at a prediction of 1 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.

Review of the air blast levels predicted for the maximum charge ranges between 84 and 123.4 dB(L) for all the POIs considered. This includes the nearest points, such as the planned Explosives Magazine and planned Mine Refuelling Area. Air blast levels expected at the houses identified ranged between 84 dB(L) and 114.7 dB(L).

Maximum charge predictions identified that two POIs could experience levels of air blast that could lead to complaints. Both POI's are planned Mining Infrastructure. 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 208 m and closer to the pit boundary. Infrastructure at the pit area, such as planned conveyor,

planned power lines, and planned Storm Water Attenuation Dams, is present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range, with a safety factor of 2, was calculated to be 490 m. The absolute minimum unsafe zone is then 490 m. This calculation is a guideline, and any distance cleared should not be less than. Four POIs are found within this range. The occurrence of fly rock can, however, never be 100% excluded. Best practices should be always implemented. 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 490 m, therefore, this should be used as the clearance distance. Specific actions will be required when blasting is done within 490 m of structures.

The planned mine accommodation houses are located 6.6 km away from the planned pit area. Assessment of impacts indicated that ,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 Haib Copper Project. There is no reason to believe that this operation cannot continue if attention is given to the recommendations made.

2 Introduction

Haib is a porphyry copper exploration project located in the Karas Region of southern Namibia, approximately 6 km north of the border with South Africa, and between 12 km and 15 km east of the tarred B1 highway that connects Namibia with South Africa.

Haib Minerals is proposing the development and operation of a copper mine and associated infrastructure. The Project comprises a large copper and molybdenum resource to be mined from an open pit and processed through a crushing, milling and flotation concentrator and hydrometallurgical plant as well as a smaller heap leaching facility designed to accommodate oxide material and lower grade mineralisation. The mining throughput is predicted at 87.5 million tonnes per annum (Mtpa) for a life of mine of approximately 19 years with a total of 1.58 billion tonnes of material to be mined. Although the mine development is at an advanced conceptual phase, the key components, and potential options to be further assessed include the following:

1. A single large open pit
2. A concentrator processing plant (crushing, milling and flotation circuit with capacity of 24 Mtpa)
3. A heap leach, solvent extraction and electrowinning plant (capacity of 11 Mtpa with two alternative sites provided)
4. A tailings storage facility (TSF) (three alternatives provided)
5. Two Waste Rock Dumps (WRDs) (192 and 546 Mt)
6. A solar photovoltaic (PV) plant (150 MWp)
7. Two storm water attenuation dams (SWAD) above the open pit
8. Off-channel water storage
9. Water abstraction work, pipeline and associated infrastructure
10. Ancillary infrastructure (access roads, transmission lines, labour accommodation camp, offices etc)

The Haib Project will make use of conventional shovel and truck operations, with bulk open pit mining methods augmented by more selective mining in areas with narrow mineralised zones. The proposed mining practice for the Project involves an open-pit mining method, with drilling and blasting operations occurring on mineralised benches. Rock fragmentation will be undertaken by drilling and blasting, and the Project assumes that all the material to be mined at the Project would require blasting.

Figure 1 Indicates the Haib Copper Project Location.

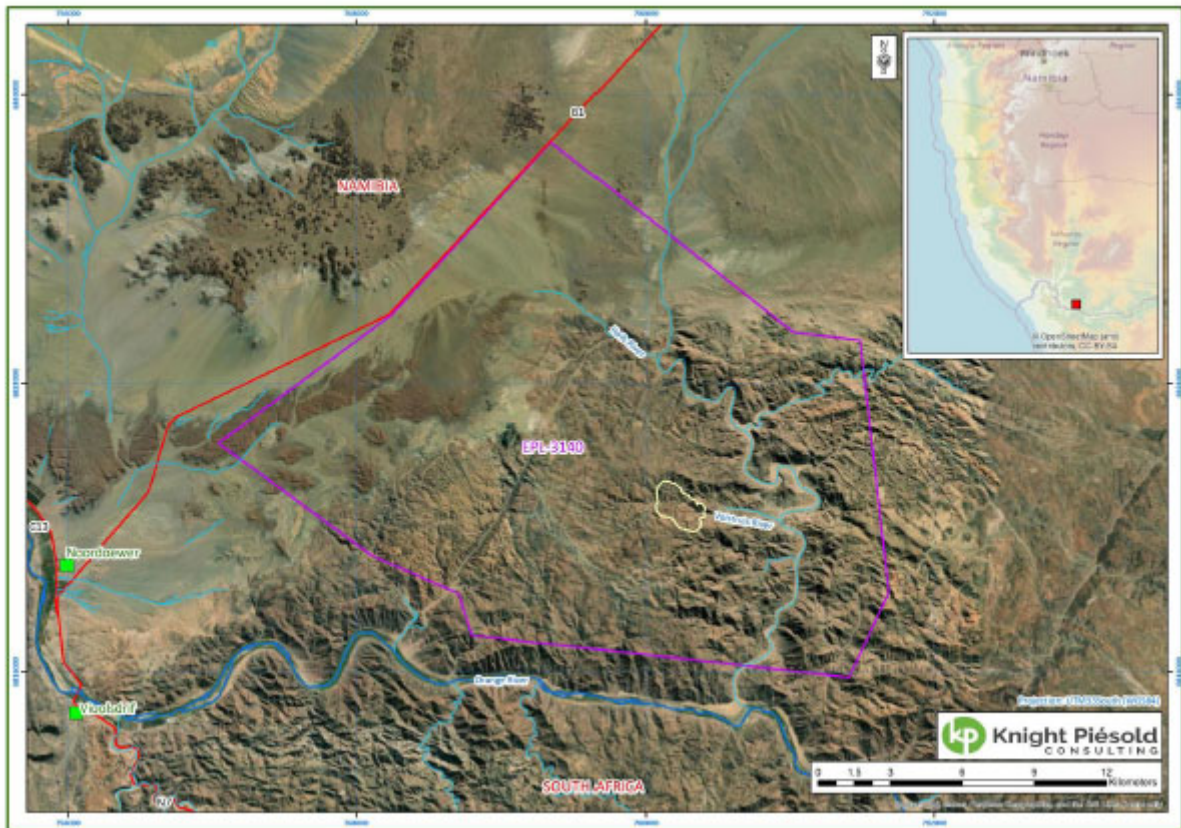


Figure 1: Project Location

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 and infrastructure in surrounding areas;
 - Evaluation of expected air blast levels at specific distances from the operations and possible influence on structures and infrastructure;
 - Evaluation of the fly rock unsafe zone;
 - 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 Knight Piésold.
- Develop mitigation measures to reduce/minimise impacts identified.
- Make recommendations for further consideration in the design of the project.

5 Study area

Haib is a porphyry copper exploration Project located in the Karas Region of southern Namibia, approximately six kilometres (km) north of the border with South Africa and between 12 km and 15 km east of the tarred B1 highway that connects Namibia with South Africa. The centre point of the site is 28°41'27.17"S and 17°52'48.69"E.

Figure 2 shows the Layout of the proposed Haib Copper Project.

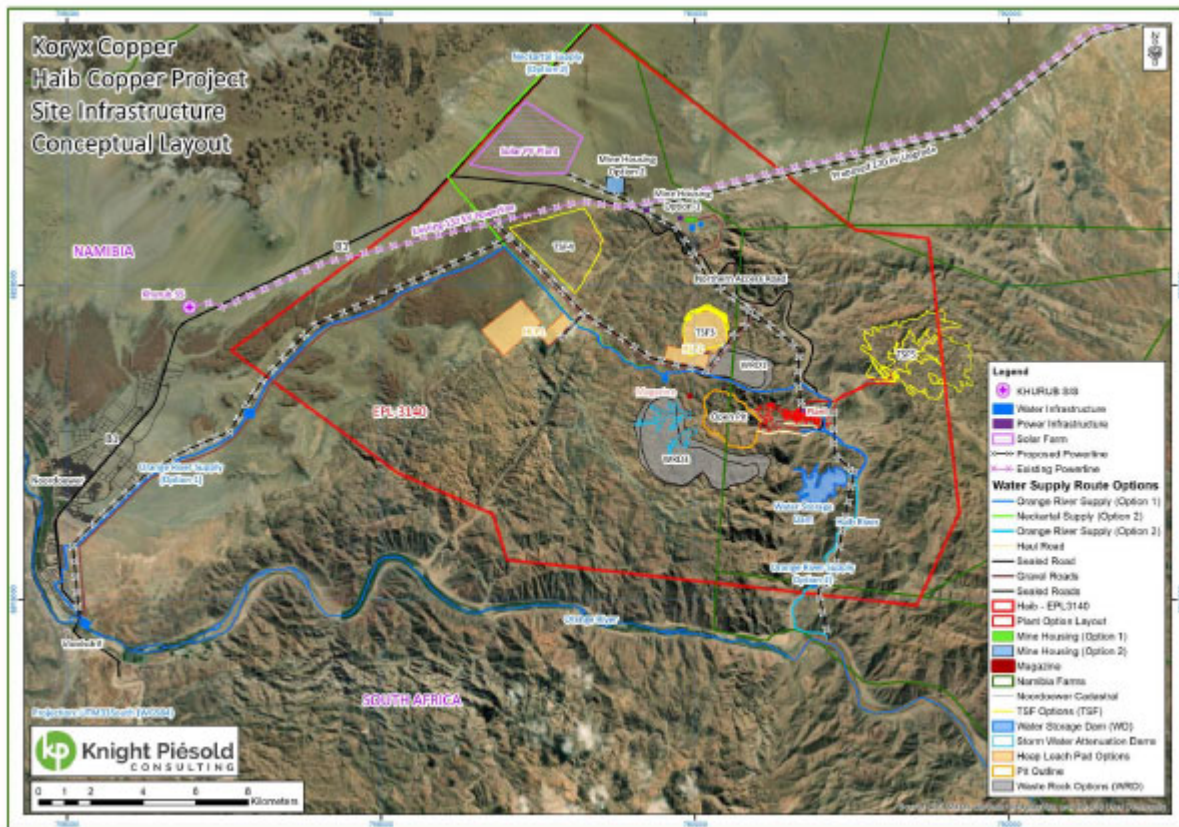


Figure 2: Layout of the proposed Haib Copper Project

6 Methodology

The detailed plan of study consists of the following sections:

- A desktop impact assessment study was done.
- Site evaluation: This consists of the evaluation of the mining operations and the possible influences from blasting operations. The methodology models 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 the site and shown as amplitude level contours. Overlaying these contours on the location of the various receptors then indicates the possible impacts and the expected results of potential impacts. Evaluation of each receptor according to the predicted levels then indicates 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 of blasting operations is not season-bound.

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 structures inside the pit area. It is assumed that relocation of this 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. This 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 Fly rock 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 from 500 m to 1500 m around the pit 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-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 and **Figure 4** shows the identified points within the 3500m influence area. The specific influences will be determined through the work done for this project in this report.

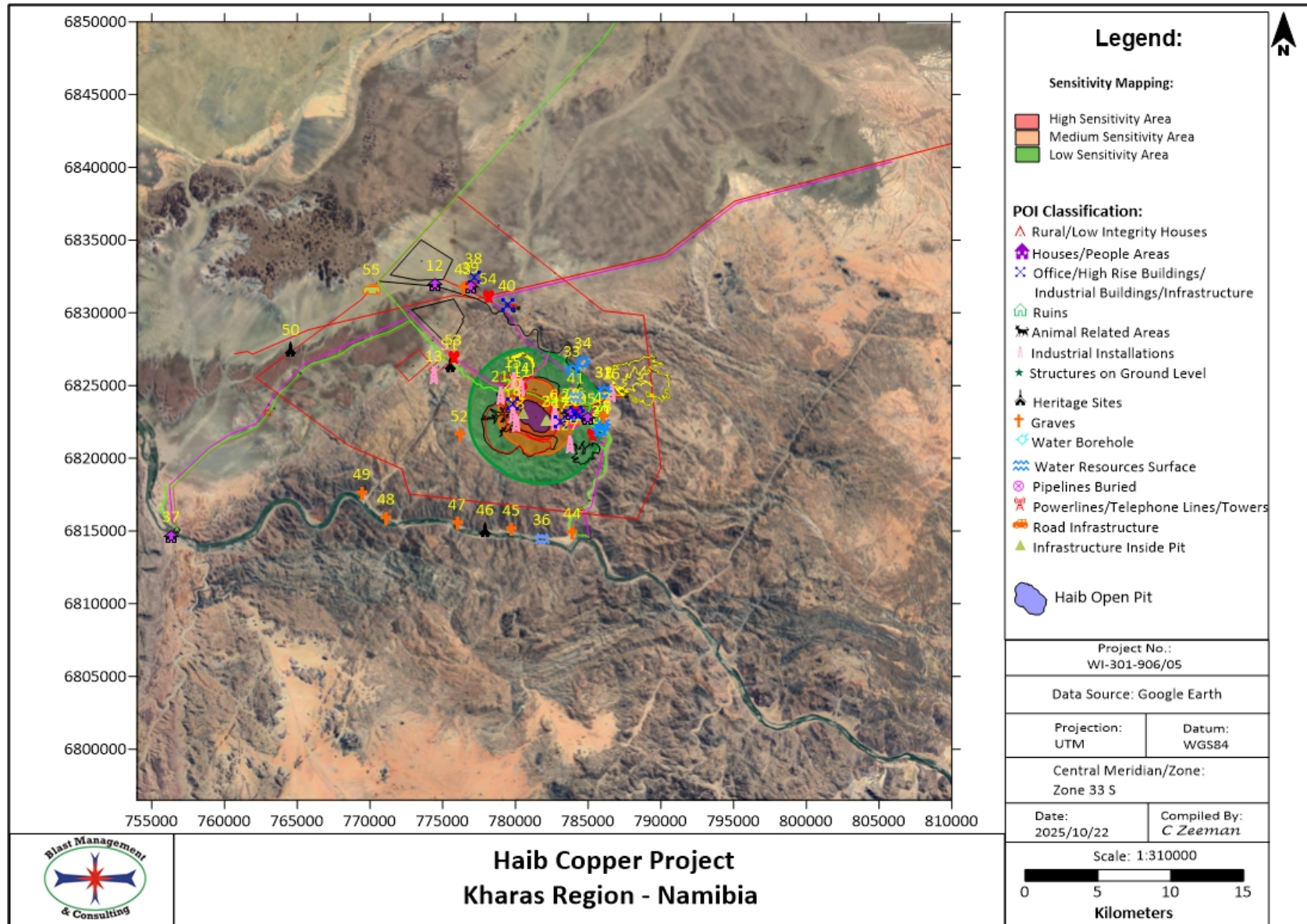


Figure 3: Identified sensitive areas overview

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Directors: JD Zeeman

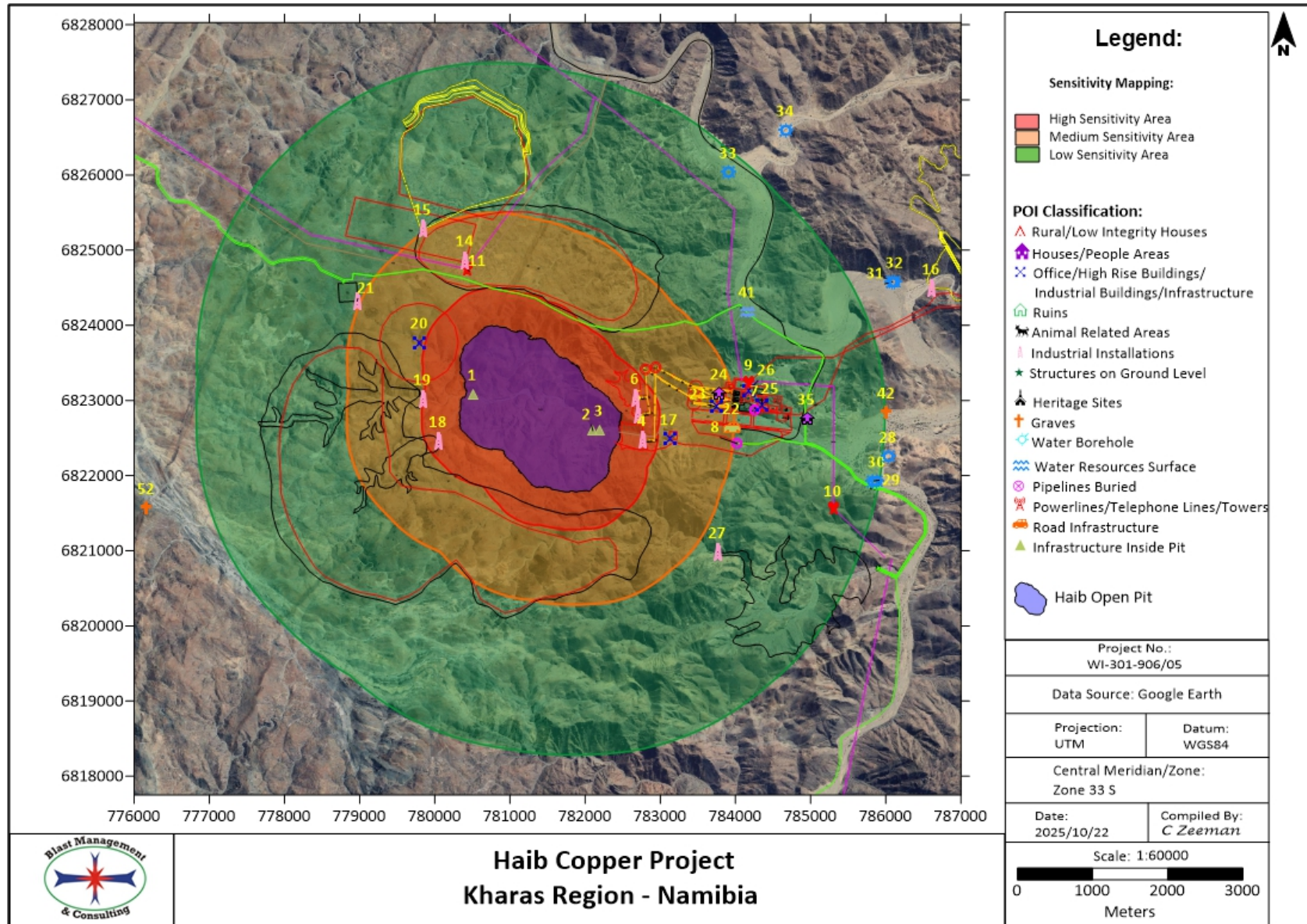


Figure 4: Identified sensitive areas within 3500m

11 Consultation process

Consultation was only done with the proponent via Knight Piésold. 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 Knight Piésold 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 5** Below provides a graphic representation of the USBM analysis for safe ground vibration levels. The USBM graph is divided mainly into two parts. The red lines in the figure represent 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.

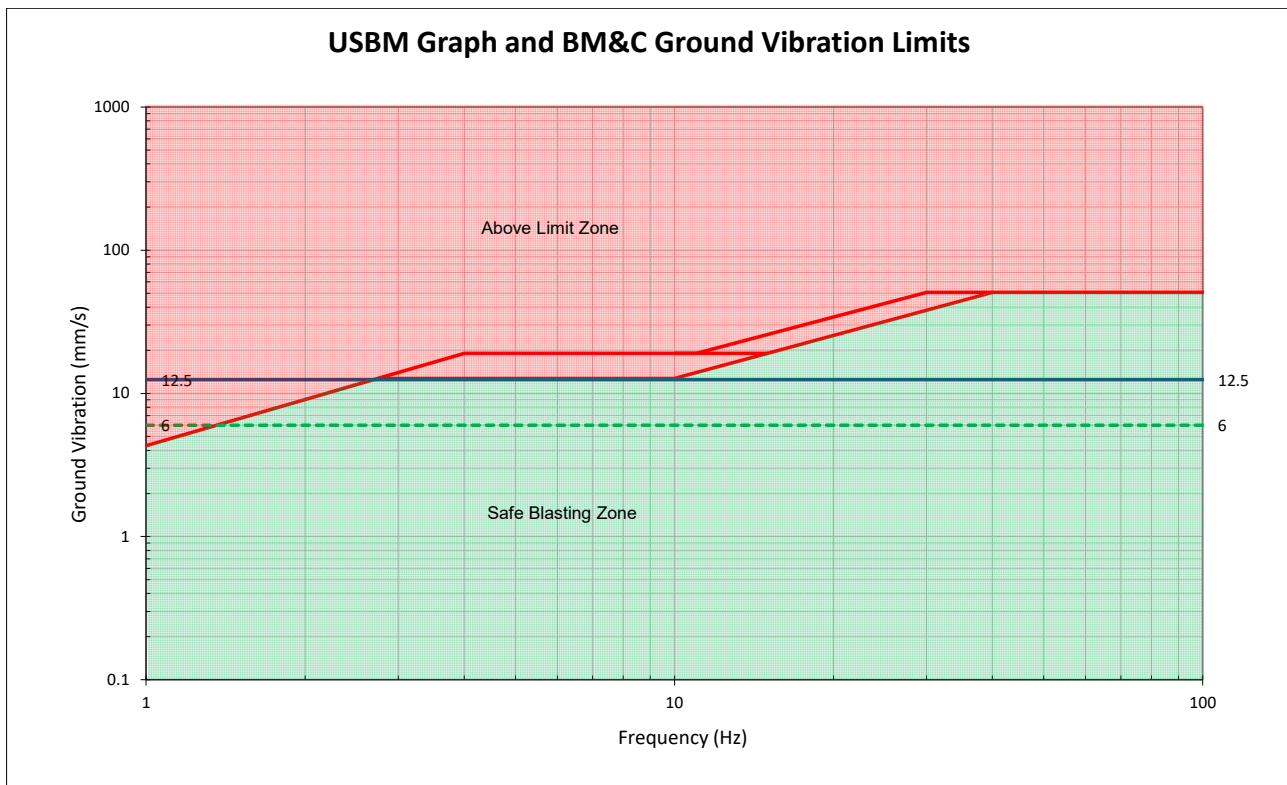


Figure 5: USBM Analysis Graph

The following additional limitations used by BMC in general and that should be considered were determined through research and prescribed by the various South African 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 an 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 6). This guideline helps with managing ground vibration and the complaints that could be received due to blast-induced ground vibration.

Figure 6 indicates the evaluation levels with a blue solid line for a ground vibration of 12.5 mm/s and a green dotted line for 6 mm/s

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

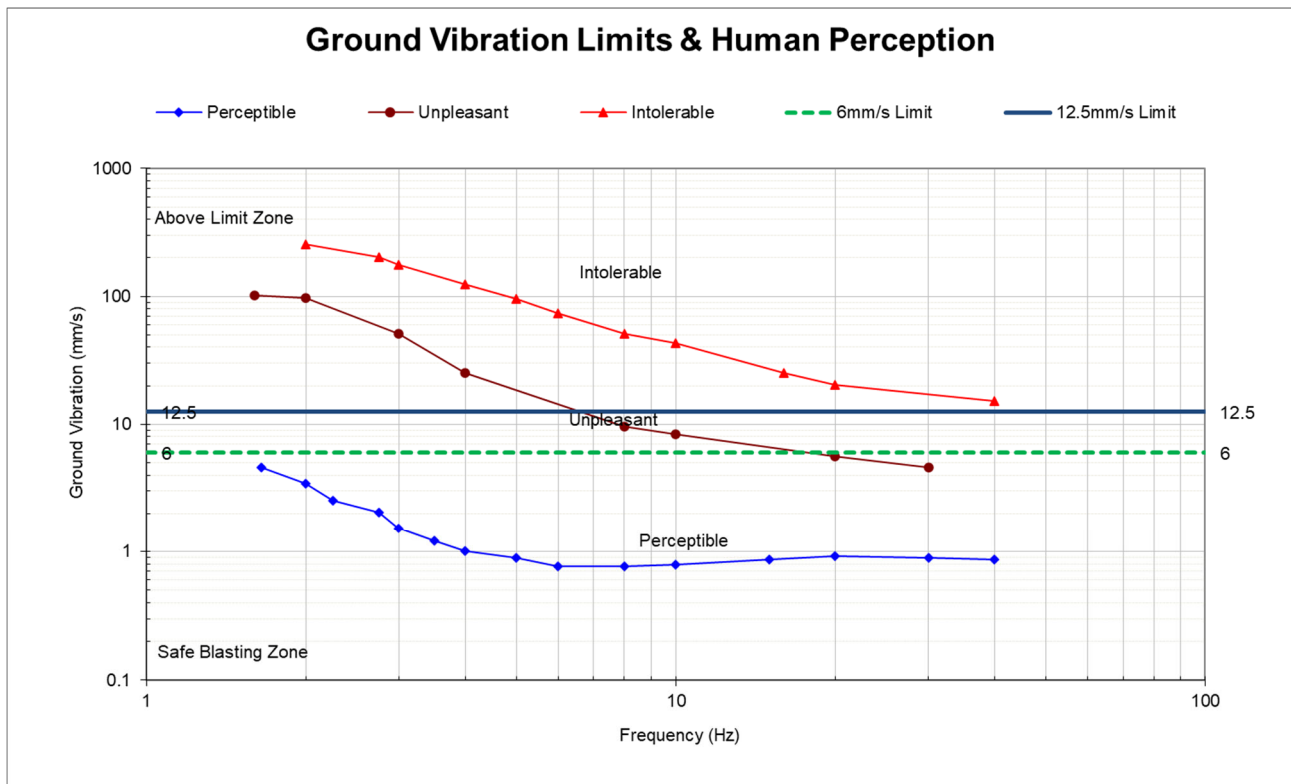


Figure 6: Ground Vibration and Human Perception

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 to hospitals, schools, and other 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**). The levels given in **Table 1** are at the point of measurement. The weakest points on a structure are typically the windows and ceilings. **Table 2** Provides air blast limits applied.

Table 1: Damage Causing Levels for Air Blast

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

Table 2 shows a summary of air blast limits applicable in this report:

Table 2: Air Blast Limits

Level (dBL)	Description
100	Barely noticeable
110	Readily noticeable
120	Currently accepted by the South African authorities as being a reasonable level for public concern (not more than 10% of the measurement should exceed this value)
134	Currently accepted by the South African authorities that damage will not occur below this level (no measurement should exceed this value outside of the mine boundaries) and the USBM Limit
164	Window break
176	Plaster cracks
180	Structural damage

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.

This report uses initial evaluation limits of <120 dB(L), 120-134 dB(L), and >134 dB(L), with the latter being the USBM's nuisance limit.

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 as a fly rock. **Figure 7** 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.

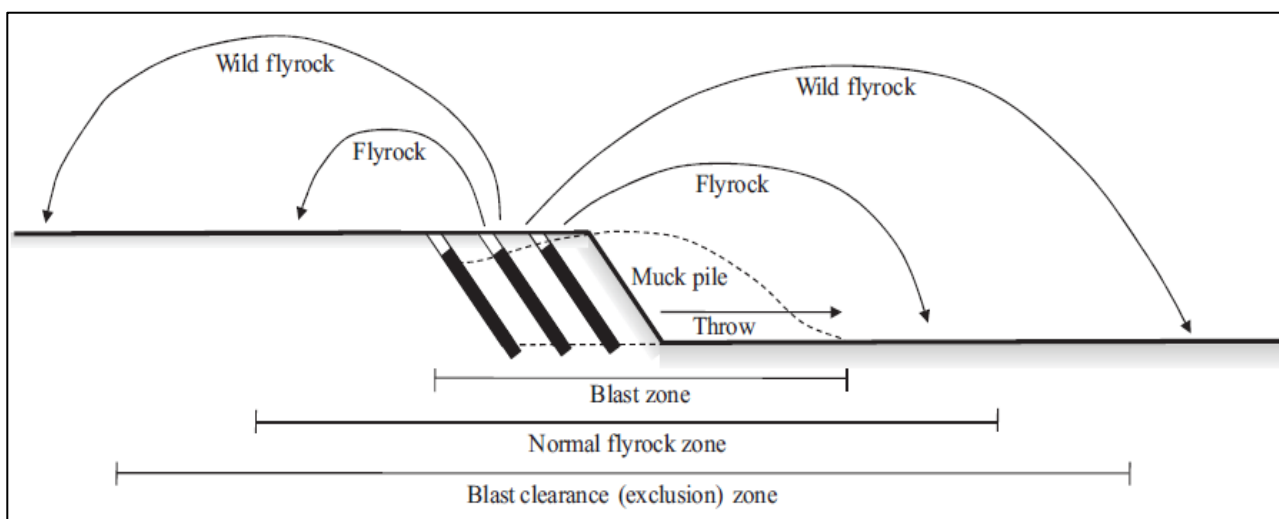


Figure 7: Schematic of fly rock terminology

Fly rock from blasting can result under the following conditions:

- When burdens are too small, rock elements can be propelled out of the free face area of the blast.
- When burdens are too large and 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 fly rock will cause damage to the road, vehicles, or even death to people or animals. This safe boundary is determined by the appointed blaster or as per 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 the ground when blasting is done too close to the road, or subsidence is caused due to blasting operations. Normally, 100 blast hole diameters is the minimum distance between the structure and blast hole to prevent any cracks from forming in the surroundings of a blast hole. Crack formation 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 be controlled in the vicinity of roads. Air blast from blasting does not influence 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 noise 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 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 in 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

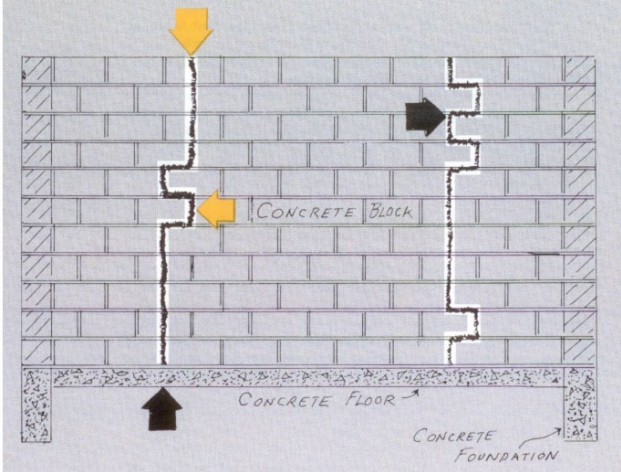
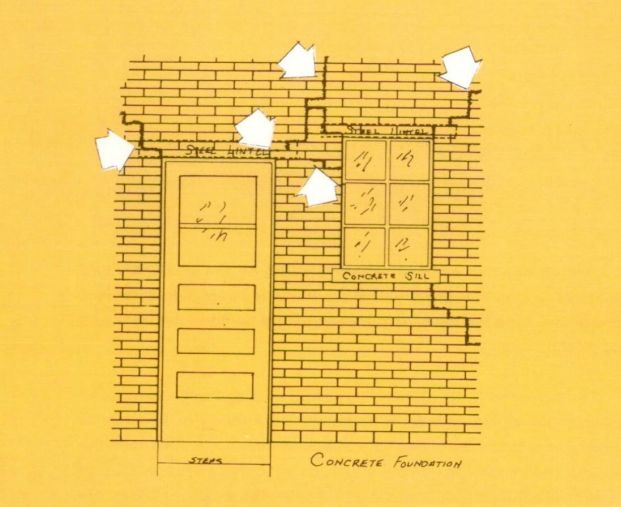
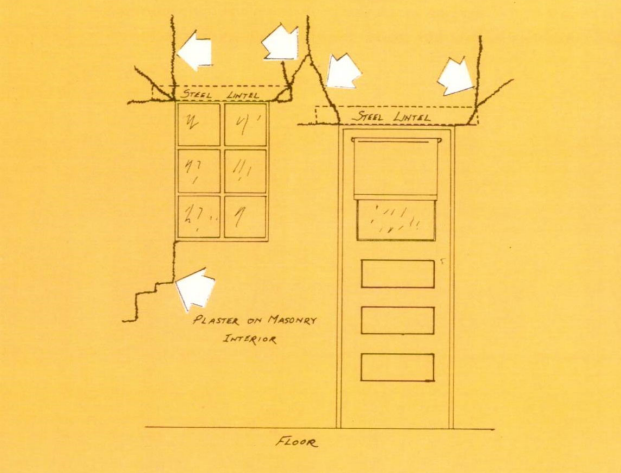
Houses, in general, have cracks. It is reported by Oriard that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, and wind also contribute to the cracks that have developed. Visual results of actual damage due to blasting operations are limited. There are cases where it did occur, and the result is shown in **Figure 8** below. A typical X crack formation is observed.

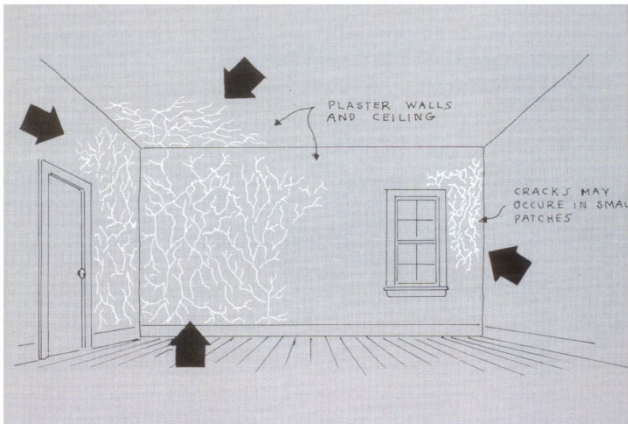
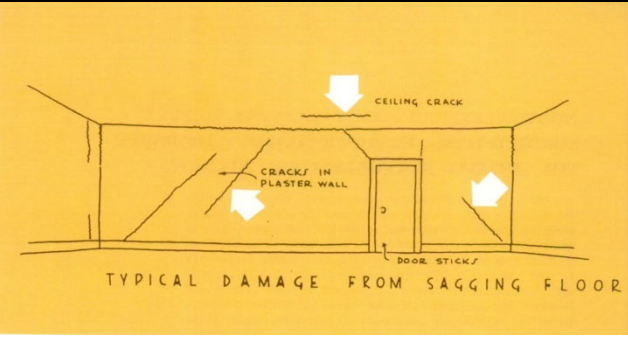
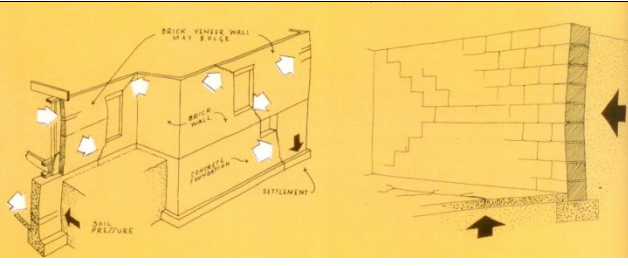


Figure 8: Example of blast-induced damage.

The table below with figures shows 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 8** on a structure will certainly influence the value, as structural damage has occurred. The presence of general vertical cracks or horizontal cracks that are found in all structures does not need to indicate devaluation due to blasting operations, but rather devaluation due to construction, building material, age, 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. The property value could 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	Hydrocensus Borehole (Borehole 6) - Inside Pit Area	15	6823080.99	780506.01
2	Structures - Inside Pit Area	15	6822594.99	782103.01
3	Structures - Inside Pit Area	15	6822605.99	782191.01
4	Conveyor (Planned)	6	6822470.99	782759.01
5	Conveyor (Planned)	6	6822802.99	782707.01
6	Conveyor (Planned)	6	6823031.99	782667.01
7	Pipeline (Planned)	12	6822868.99	784260.01
8	Pipeline (Planned)	12	6822424.99	784023.01
9	Power line (Proposed)	13	6823239.99	784182.01
10	Power line (Proposed)	13	6821561.99	785302.01
11	Power line (Proposed)	13	6824754.99	780430.01
12	Farm Buildings/Structures (Windmill)	2	6831944.99	774466.01
13	Heap Leach Option 1	6	6825696.99	774421.01
14	Heap Leach Option 2	6	6824865.99	780407.01
15	Tailings Storage Facilities (TSF)	6	6825281.99	779845.01
16	Tailings Storage Facilities (TSF)	6	6824489.99	786610.01
17	Mine Refuelling Area (Planned)	3	6822484.99	783123.01
18	Storm Water Attenuation Dams (Planned)	6	6822456.99	780049.01

Tag	Description	Classification	Y	X
19	Storm Water Attenuation Dams (Planned)	6	6823017.99	779841.01
20	Explosives Magazine (Planned)	3	6823770.99	779800.01
21	Terminal Reservoir (Planned)	6	6824322.99	778966.01
22	Central Access Road (Planned)	14	6822632.99	783953.01
23	Plant Footprint	3	6822912.99	783746.01
24	Future Structures (Planned)	2	6823089.99	783788.01
25	Plant Workshop (Planned)	3	6822936.99	784355.01
26	Switchyard (Planned)	3	6823134.99	784179.01
27	Water Storage Dam (Planned)	6	6820978.99	783765.01
28	Borehole (B1)	10	6822252.99	786034.01
29	Borehole (B2)	10	6821926.99	785827.01
30	Borehole (B3)	10	6821926.99	785884.01
31	Borehole (B4)	10	6824580.99	786089.01
32	Borehole (B5)	10	6824577.99	786123.01
33	Borehole (B6)	10	6826033.99	783912.01
34	Borehole (B7)	10	6826592.99	784667.01
35	Farm Buildings/Structures	2	6822755.99	784950.01
36	Orange River	11	6814449.99	781834.01
37	Vioolsdrif	2	6814646.99	756350.01
38	Solor Plant Footprint (Planned)	3	6832408.99	777157.01
39	Haib Township Mine Housing (Option 2 - Planned)	2	6831782.99	776931.01
40	Proposed Mini-Sub	3	6830546.99	779439.01
41	Haib River	11	6824183.99	784164.01
42	Heritage Site (Possible grave)	9	6822839.99	786012.01
43	Heritage Site (Suspected burial cairn)	9	6831661.99	776427.01
44	Heritage Site (19 Graves)	9	6814879.99	783929.01
45	Heritage Site (Four burial cairns near stock-post homestead)	9	6815072.99	779741.01
46	Heritage Site (Semi-circular stone enclosure)	8	6815130.99	777936.01
47	Heritage Site (Suspected burial cairn)	9	6815483.99	776008.01
48	Heritage Site (Three German military graves)	9	6815860.99	771119.01
49	Heritage Site (7 burial sites)	9	6817565.99	769459.01
50	Heritage Site (two substantial rectangular drystone structures)	8	6827495.99	764574.01
51	Heritage Site (Stone circle)	8	6826471.99	775497.01
52	Heritage Site (possible burial cairn)	9	6821569.99	776165.01
53	Power line (Proposed)	13	6826921.99	775764.01
54	Power line (existing)	13	6831128.99	778146.01
55	Road (B1)	14	6831652.16	770114.85

14 Blasting Operations

In order to evaluate the possible influence of blasting operations regarding ground vibration, air blast, and fly rock, a planned blast design is required to determine possible influences.

Blasting is planned as part of the Haib Copper 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 9** below shows the blast layout with blast holes, simulation, and maximum charge mass per delay. **Figure 10** shows a simulation with maximum charge per delay from the typical timing applied. **Figure 11** shows a simulation with the number of blast holes per delay from the typical timing applied.

Table 6: Planned Blast Design Parameters

Parameter	Unit	Mineralised material blasts	Waste blasts
Hole diameter	mm	165	165
Bench height	m	15	15
Explosive type		Emulsion	Blend
The angle of the hole (90° is vertical)	°	90	90
Burden	m	4.9	4.8
Spacing	m	5.3	5.3
Stemming length	m	3.1	3.2
Sub-drill	m	1.2	1.2
Length of hole	m	16.2	16.2
Actual powder factor	kg/m ³	0.9	0.85
Mass of explosive per hole	kg	357.69	327.12
Cubic metres blasted per hole	m ³	388.49	378.65
Mean fragmentation	cm	27	25
Cost of explosives	USD/t	665	679
Cost of explosives per hole	USD	238.01	222.09
Surface shock tube unit	USD/unit	2.51	2.51
Pentolite booster	USD/unit	5.14	5.14
Cost of accessories per hole	USD	7.65	7.65
Total cost per hole	USD	245.66	229.73
Total unit cost	USD/m ³	0.63	0.61
Density	t/m ³	2.78	2.78
Total unit cost	USD/t	0.23	0.22

Table 7: Blast Design Technical Parameters after Simulation

Blast Reference:	Haib_15_4.9x5.3
Rock Type:	Bulk
AS DESIGNED PARAMETERS:	

Avg. Burden (m):	4.9
Avg. Spacing (m):	5.3
Drill Pattern:	Staggered
BLAST HOLES	
Diameter (mm)	165
Number of Holes	209
Total Length (m)	3135.0
Av. Length (m)	15.0
CHARGE DECKS	
Material Name	BME INNOVEX 204
Total Number Charge Holes	209
Total Length (m)	2487.1
Mean Length (m)	11.9
Total Mass (kg)	63816
Mean Mass (kg)	305
STEMMING DECKS	
Material Name	Stemming
Total Number	209
Mean Length (m)	3.1
Type of Stemming:	Crushed Aggregate
Accessories Type:	Shock-tube
Surface Timing - Inter hole (ms):	17 ms
Surface Timing - Inter row (ms):	42/500 ms
Booster / Primer (gr.):	400
Delay Pattern:	Full Chevron
Max Charge per delay (kg):	1221
Max No of BH per delay:	4
Powder Factor (kg/m3):	0.78
Blast Volume / Size (m3):	81416
Free Face:	Yes

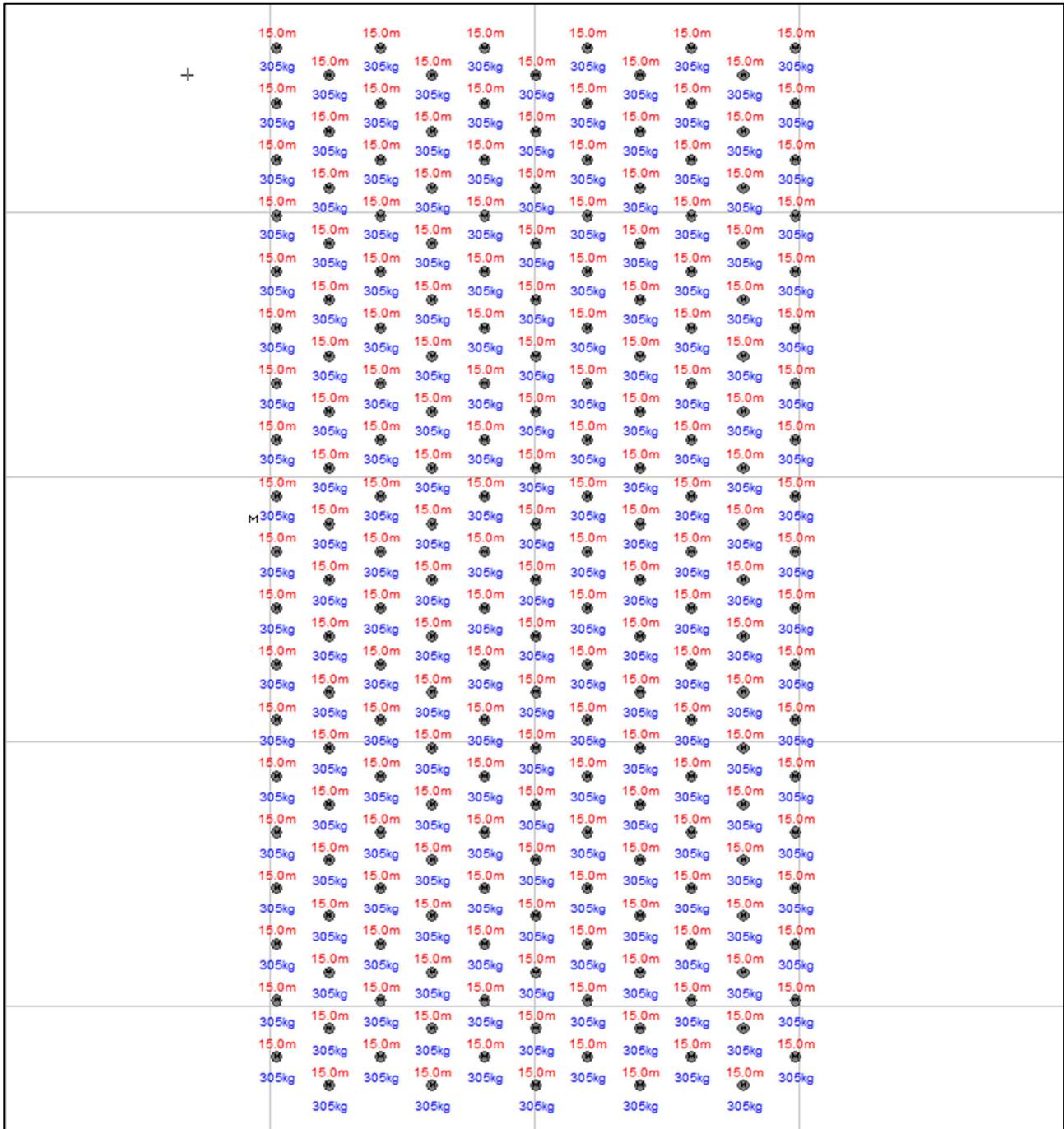


Figure 9: Blast holes layout with charge mass per blast hole

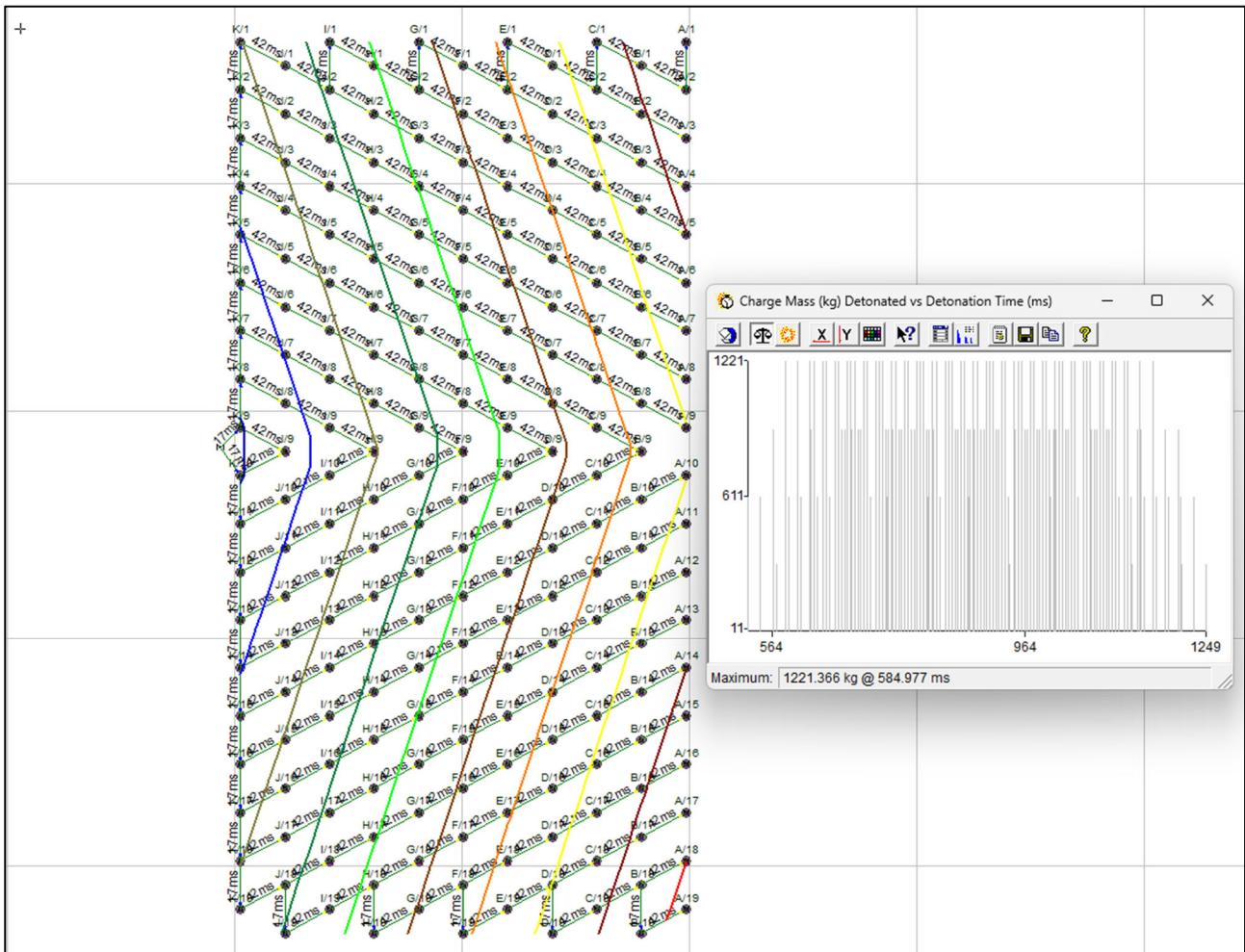


Figure 10: Simulation and charge mass per delay graph

The simulation work done provided information that is applied for predicting ground vibration and air blast. Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 165 mm diameter single blast hole, and the maximum charge was extracted from the blast simulation in JKSimblast. The maximum charge relates to the total number of blast holes that 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 1221 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 1221 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 1221 kg Charge
1	50.0	632.8
2	100.0	324.1
3	150.0	103.3
4	200.0	64.3

No.	Distance (m)	Expected PPV (mm/s) for 1221 kg Charge
5	250.0	44.5
6	300.0	32.9
7	400.0	20.5
8	500.0	14.2
9	600.0	10.5
10	700.0	8.1
11	800.0	6.5
12	900.0	5.4
13	1000.0	4.5
14	1250.0	3.1
15	1500.0	2.3
16	1750.0	1.8
17	2000.0	1.4
18	2500.0	1.0
19	3000.0	0.7
20	3500.0	0.6

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.

Standards do exist, and predictions can be made, but it must be considered that predictions of air blast are most effective only when measured and calibrated according to the circumstances where blasting is taking place.

The following equation is associated with predictions of air blast but is considered by the author as subjective. This equation does not take temperature or any weather conditions into account. Values were calculated using a cube root scaled distance relationship from expected charge masses and distance. Equation 2 is normally used where no actual data exists.

Equation 2:

$$dB(L) = 165 - 24 \log 10 \frac{D}{E^{1/3}}$$

Where:

$dB(L)$ = Air blast level [dB(L)]

D = Distance from source (m)

E = Maximum charge mass per delay (kg)

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

At the time of this report, no specific information was available to indicate any blasting requirements for establishing infrastructure. If blasting will be required to establish platforms or bases, it will typically be civil blasting. Civil blasting will have no impact on areas outside of the immediate area of the specific blast. Impacts will be negligible in comparison with the planned mining to be done. In the event of civil blasting to be done, it should be treated as a civil blast, and possible impacts must be evaluated for the specific blast to be done. Thus, no detailed impact evaluation was done for the construction phase regarding blasting operations.

16 Operational Phase: Impact Assessment and Mitigation Measures

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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 Section 14, is considers 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 roads
- 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 for possible structural concerns and human perception. Tables are provided for each of the different charge models concerning:

- "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 masses applied are according to the blast designs discussed in Section 15. These levels are then plotted and overlaid with current mining plans to observe possible influences on 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 for possible structural concerns. Tables are provided for each of the different charge models concerning:

- “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 – 1221 kg

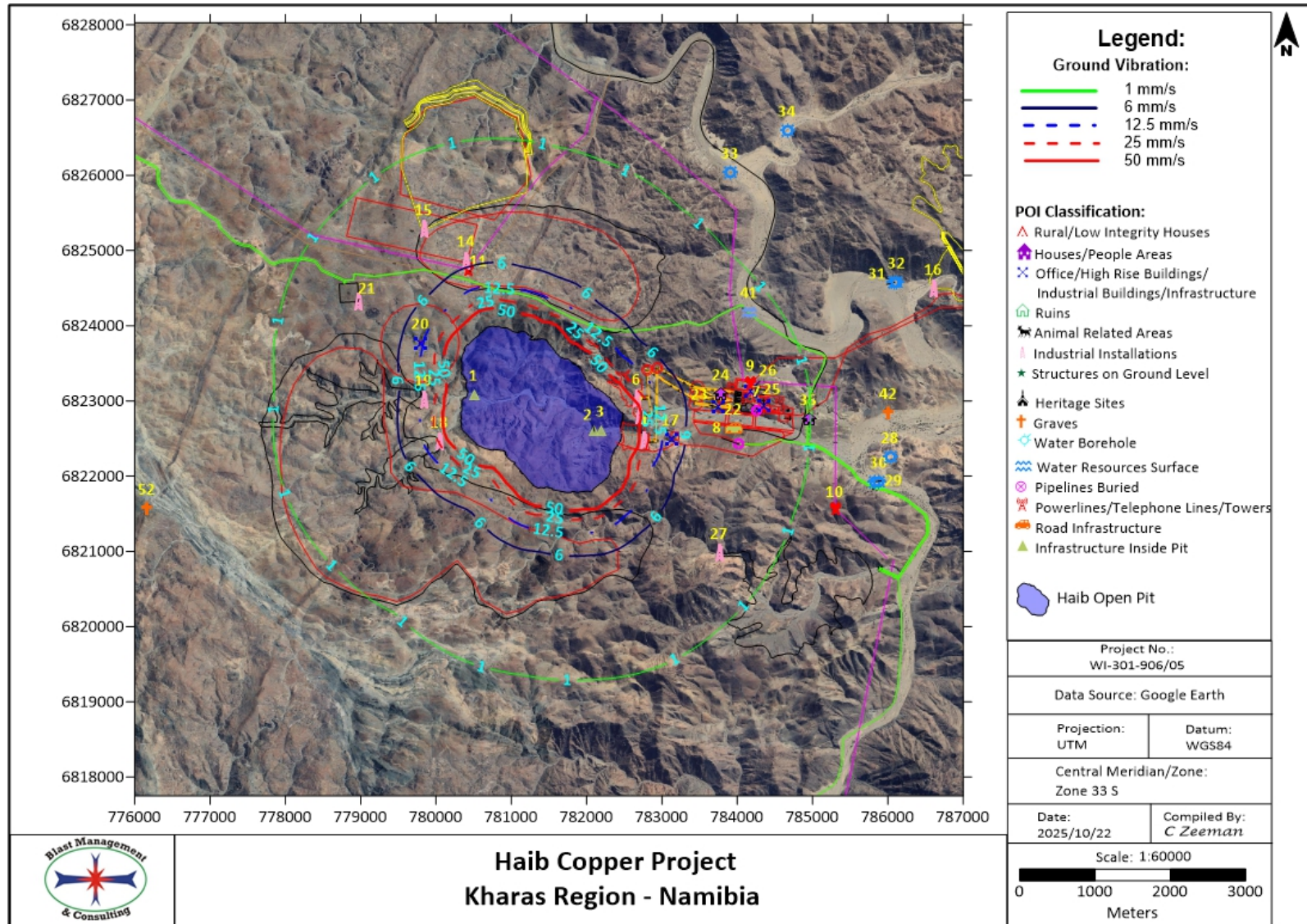


Figure 12: Ground vibration influence from the maximum charge per delay

16.2.2 Air blast from charge mass per delay – 1221 kg

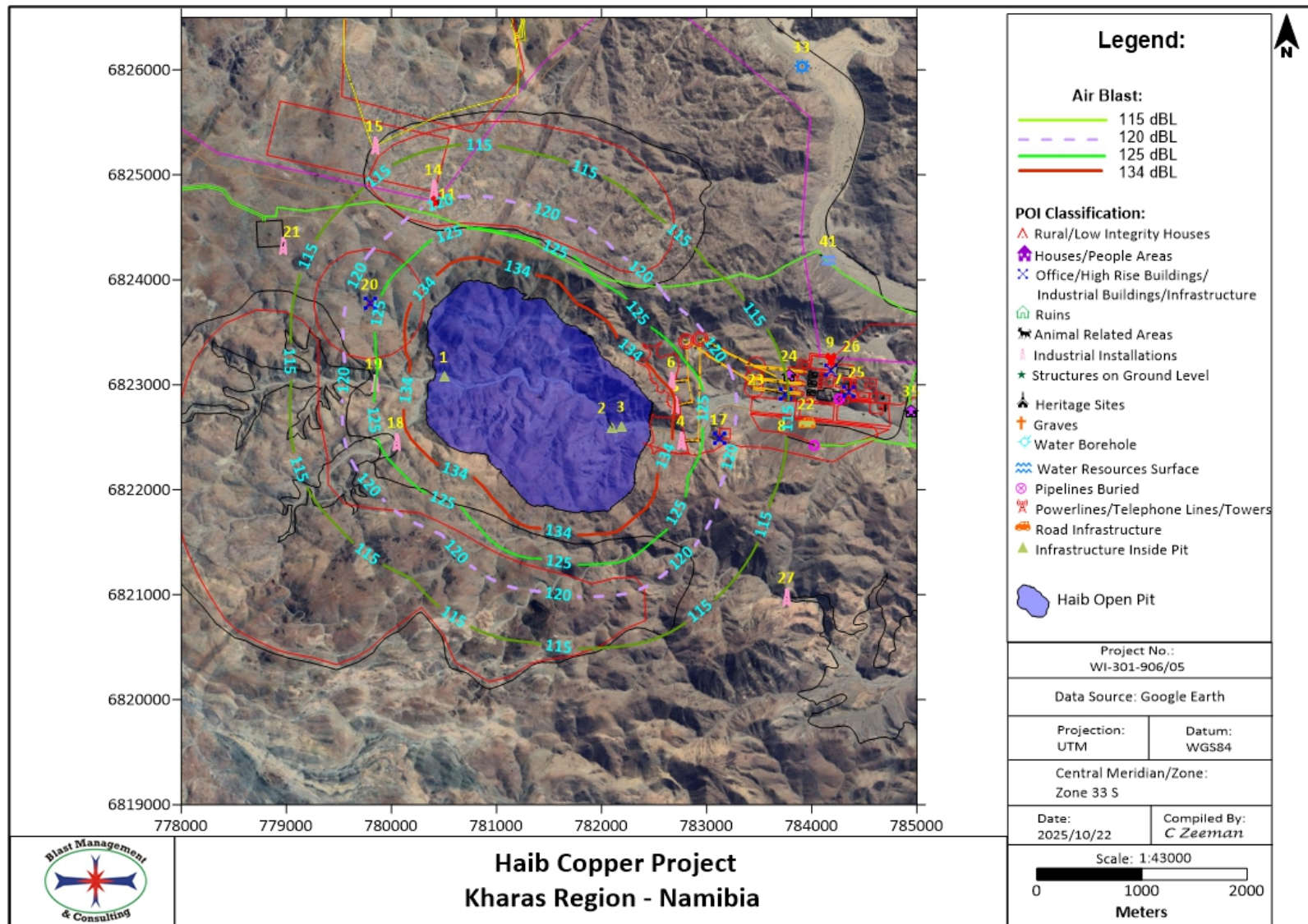


Figure 13: Air blast influence from the maximum charge

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	Hydrocensus Borehole (Borehole 6) - Inside Pit Area	50	-	1221	-	-	-	-	-	-
2	Structures - Inside Pit Area	12.5	-	1221	-	-	-	-	-	-
3	Structures - Inside Pit Area	12.5	-	1221	-	-	-	-	-	-
4	Conveyor (Planned)	150	299	1221	33.1	Acceptable	N/A	N/A	N/A	N/A
5	Conveyor (Planned)	150	222	1221	54.0	Acceptable	N/A	N/A	N/A	N/A
6	Conveyor (Planned)	150	271	1221	38.9	Acceptable	N/A	N/A	N/A	N/A
7	Pipeline (Planned)	50	1774	1221	1.8	Acceptable	N/A	N/A	N/A	N/A
8	Pipeline (Planned)	50	1560	1221	2.2	Acceptable	N/A	N/A	N/A	N/A
9	Power line (Proposed)	75	1747	1221	1.8	Acceptable	N/A	N/A	N/A	N/A
10	Power line (Proposed)	75	2991	1221	0.7	Acceptable	N/A	N/A	N/A	N/A
11	Power line (Proposed)	75	815	1221	6.3	Acceptable	N/A	N/A	N/A	N/A
12	Farm Buildings/Structures (Windmill)	12.5	10098	1221	0.1	Acceptable	Too Low	134	93.5	Acceptable
13	Heap Leach Option 1	25	6281	1221	0.2	Acceptable	N/A	N/A	N/A	N/A
14	Heap Leach Option 2	25	928	1221	5.1	Acceptable	N/A	N/A	N/A	N/A
15	Tailings Storage Facilities (TSF)	25	1544	1221	2.2	Acceptable	N/A	134	113.1	N/A
16	Tailings Storage Facilities (TSF)	25	4446	1221	0.4	Acceptable	N/A	134	102.1	N/A
17	Mine Refuelling Area (Planned)	12.5	657	1221	9.0	Acceptable	Unpleasant	134	122.0	Complaint
18	Storm Water Attenuation Dams (Planned)	50	339	1221	27.0	Acceptable	N/A	N/A	N/A	N/A
19	Storm Water Attenuation Dams (Planned)	50	505	1221	13.9	Acceptable	N/A	N/A	N/A	N/A
20	Explosives Magazine (Planned)	25	573	1221	11.3	Acceptable	Unpleasant	134	123.4	Complaint
21	Terminal Reservoir (Planned)	25	1546	1221	2.2	Acceptable	N/A	134	113.1	N/A
22	Central Access Road (Planned)	150	1479	1221	2.4	Acceptable	N/A	N/A	N/A	N/A
23	Plant Footprint	50	1263	1221	3.1	Acceptable	Perceptible	134	115.2	Acceptable
24	Future Structures (Planned)	12.5	1329	1221	2.8	Acceptable	Perceptible	134	114.7	Acceptable

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
25	Plant Workshop (Planned)	12.5	1871	1221	1.6	Acceptable	Perceptible	134	111.1	Acceptable
26	Switchyard (Planned)	25	1720	1221	1.8	Acceptable	Perceptible	134	112.0	Acceptable
27	Water Storage Dam (Planned)	25	1800	1221	1.7	Acceptable	N/A	N/A	N/A	N/A
28	Borehole (B1)	50	3579	1221	0.6	Acceptable	N/A	N/A	N/A	N/A
29	Borehole (B2)	50	3416	1221	0.6	Acceptable	N/A	N/A	N/A	N/A
30	Borehole (B3)	50	3472	1221	0.6	Acceptable	N/A	N/A	N/A	N/A
31	Borehole (B4)	50	4008	1221	0.5	Acceptable	N/A	N/A	N/A	N/A
32	Borehole (B5)	50	4037	1221	0.5	Acceptable	N/A	N/A	N/A	N/A
33	Borehole (B6)	50	3268	1221	0.6	Acceptable	N/A	N/A	N/A	N/A
34	Borehole (B7)	50	4180	1221	0.4	Acceptable	N/A	N/A	N/A	N/A
35	Farm Buildings/Structures	12.5	2466	1221	1.0	Acceptable	Perceptible	134	108.2	Acceptable
36	Orange River	200	7342	1221	0.2	Acceptable	N/A	N/A	N/A	N/A
37	Violsdrif	12.5	25286	1221	0.0	Acceptable	Too Low	134	84.0	Acceptable
38	Solor Plant Footprint (Planned)	25	9136	1221	0.1	Acceptable	Too Low	134	94.6	Acceptable
39	Haib Township Mine Housing (Option 2 - Planned)	12.5	8657	1221	0.1	Acceptable	Too Low	134	95.1	Acceptable
40	Proposed Mini-Sub	25	6683	1221	0.2	Acceptable	Too Low	134	97.8	Acceptable
41	Haib River	200	2156	1221	1.3	Acceptable	N/A	N/A	N/A	N/A
42	Heritage Site (Possible grave)	50	3526	1221	0.6	Acceptable	N/A	N/A	N/A	N/A
43	Heritage Site (Suspected burial cairn)	50	8780	1221	0.1	Acceptable	N/A	N/A	N/A	N/A
44	Heritage Site (19 Graves)	50	7171	1221	0.2	Acceptable	N/A	N/A	N/A	N/A
45	Heritage Site (Four burial cairns near stock-post homestead)	50	6972	1221	0.2	Acceptable	N/A	N/A	N/A	N/A
46	Heritage Site (Semi-circular stone enclosure)	6	7542	1221	0.2	Acceptable	Too Low	134	96.6	Acceptable
47	Heritage Site (Suspected burial cairn)	50	8292	1221	0.1	Acceptable	N/A	N/A	N/A	N/A
48	Heritage Site (Three German military graves)	50	11442	1221	0.1	Acceptable	N/A	N/A	N/A	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
49	Heritage Site (7 burial sites)	50	12006	1221	0.1	Acceptable	N/A	N/A	N/A	N/A
50	Heritage Site (two substantial rectangular drystone structures)	6	16247	1221	0.0	Acceptable	Too Low	134	88.6	Acceptable
51	Heritage Site (Stone circle)	6	5614	1221	0.3	Acceptable	Too Low	134	99.7	Acceptable
52	Heritage Site (possible burial cairn)	50	4307	1221	0.4	Acceptable	N/A	N/A	N/A	N/A
53	Power line (Proposed)	75	5627	1221	0.3	Acceptable	N/A	N/A	N/A	N/A
54	Power line (existing)	75	7586	1221	0.2	Acceptable	N/A	N/A	N/A	N/A
55	Road (B1)	150	12981	1221	0.1	Acceptable	N/A	N/A		

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 mostly acceptable levels ranging from none to levels as high as 54 mm/s over the range 222 m to 25.3 km from the pit boundary. Normally, blast impact evaluation is mainly considered for a distance up to 3500 m from the pit area. There are, however, a few POIs located further than the 3500 m - up to 25.3 km that were considered important to consider as well. The POIs beyond the 3500 m boundary are mainly heritage sites, boreholes, existing and planned power lines, and Vioolsdrif town. It will be imperative to ensure ongoing monitoring is undertaken to confirm levels of ground vibration to ensure that 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 planned mining infrastructure. Ground vibration levels expected at the Haib river are 1.3 mm/s, which is well within the limits of 200 mm/s. The Farm Buildings/Structures are within limits of 12.5 mm/s at a prediction of 1 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.

In view of the maximum charge, no specific points of concern were identified.

Maximum charge on a human perception scale indicated five POIs where ground vibration may be experienced as perceptible. These are mainly the planned mine infrastructure and the existing farm buildings/structures. Two POIs, POI17 Mine Refuelling Area (Planned) and POI20 Explosives Magazine (Planned), which are planned, were identified where vibration levels may be unpleasant on a human perception scale.

Perceptible levels of vibration may be experienced up to 2677 m and unpleasant up to 992 m, and intolerable up to 448 m. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 119 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 - POI35 Farm Buildings/Structures are located at 2466 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 eight water boreholes identified for the project. One borehole - POI1 Hydrocensus Borehole 6 is located within the pit area. It is expected that this borehole will eventually be lost due to mining operations. No impact is expected at the boreholes identified outside of the pit area.

No concerns were noted that will require specific mitigations for ground vibration.

16.4 Summary of findings for air blast

Review of the air blast levels predicted for the maximum charge ranges between 84 and 123.4 dB(L) for all the POIs considered. This includes the nearest points, such as the planned Explosives Magazine and planned Mine Refuelling Area. These levels may contribute to effects such as rattling of roofs or doors, or windows, not expecting any damaging effects. Air blast levels expected at the houses identified ranged between 84 dB(L) and 114.7 dB(L), with no reason for damage concern.

Maximum charge predictions identified that two POIs could experience levels of air blast that could lead to complaints. Both POIs are planned for Mining Infrastructure. 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 208 m and closer to the pit boundary. Infrastructure at the pit area, such as planned conveyor, planned power lines, and planned Storm Water Attenuation Dams, 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. No significant impact is expected. 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.

16.5 Ground Vibration and Human Perception

Considering the effect of ground vibration regarding 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 2677 m, people may experience levels of ground vibration as perceptible. At 992 m and closer, the perception of ground vibration could be unpleasant. Closer than 448 m, the levels will be intolerable and generally greater than the limits applied for structures in the area.

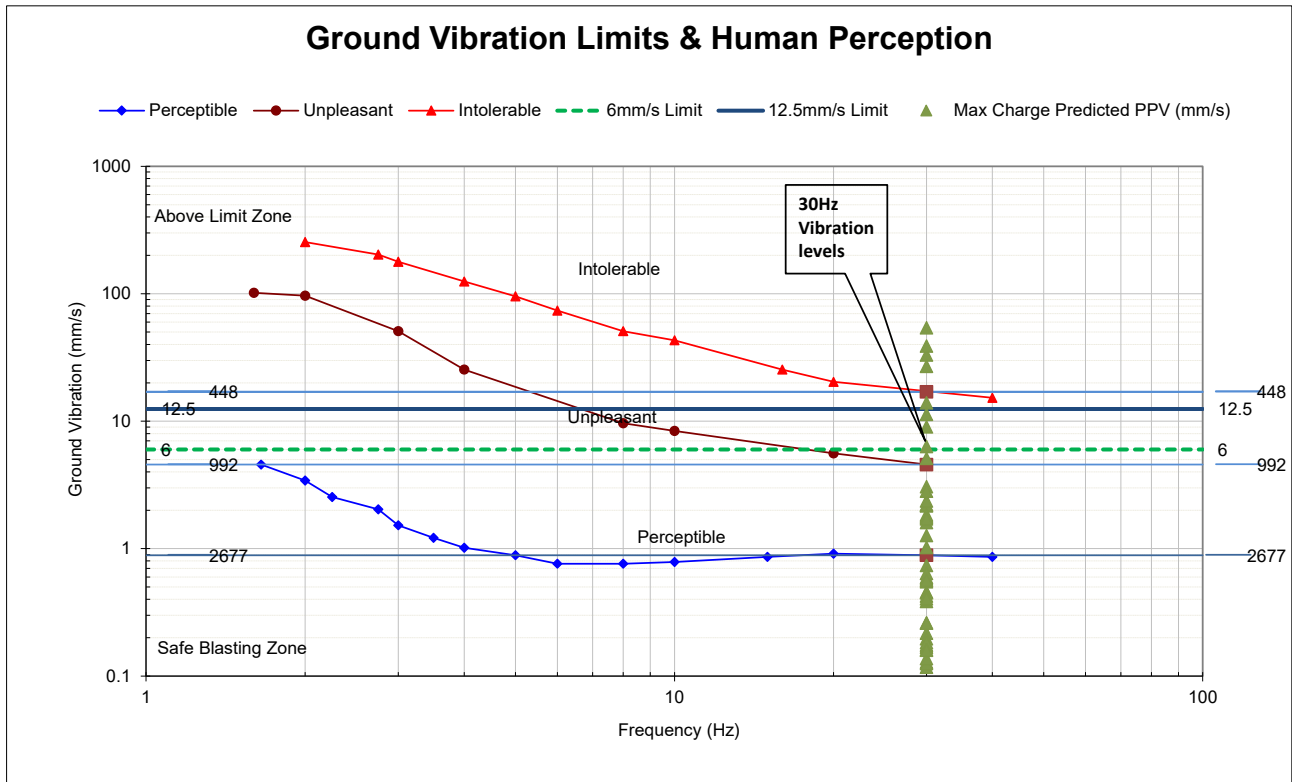


Figure 14: The effect of ground vibration on human perception and vibration limits

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 35 and is approximately 2466 m from the planned operation. These buildings are located such that levels of ground vibration predicted from maximum charge may be perceptible, 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 2677 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 1472 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 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 3.1 m stemming length. Based on these values, a possible fly rock range with a safety factor of 2 was calculated to be 490 m. The absolute minimum unsafe zone is then 490 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 always implemented. 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 490 m unsafe zone.

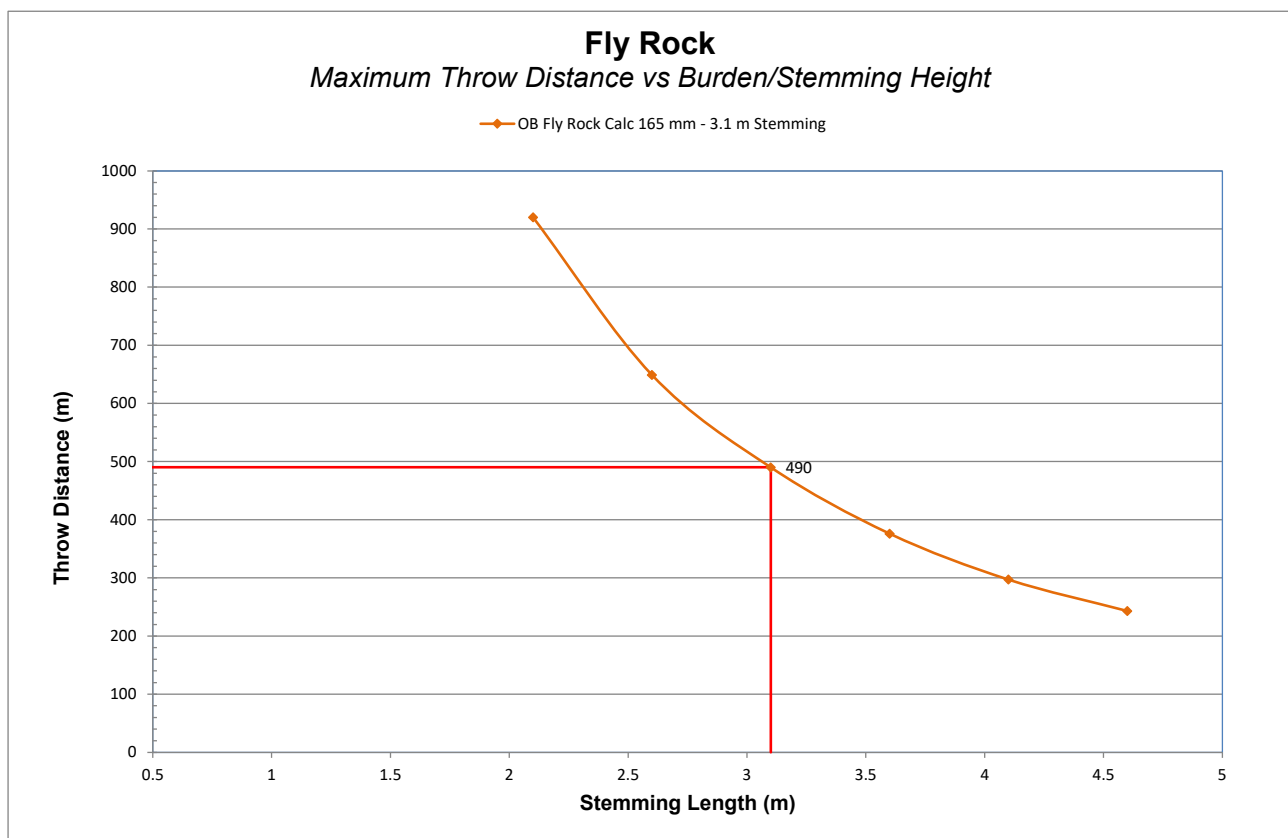


Figure 15: Fly rock prediction calculation

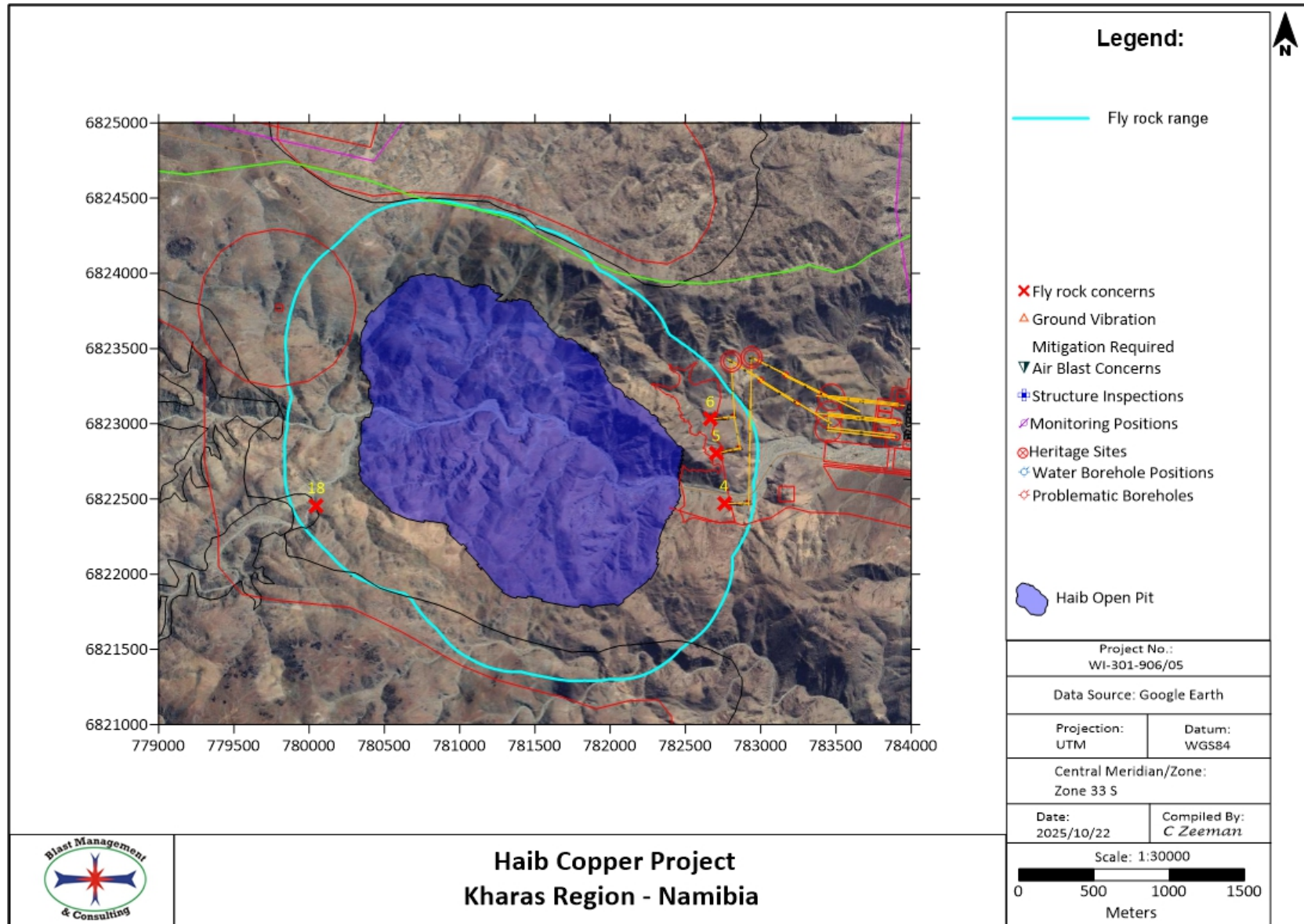


Figure 16: Predicted Fly Rock Exclusion Zone for the Opencast Pit area

Review of the calculated unsafe zone showed four POIs that are within the unsafe zone. These POIs are mainly mine-owned infrastructure. The mine will need to consider these POIs when blasting within 500 m of this infrastructure. **Table 11** below shows the POIs of concern and coordinates.

Table 11: Fly rock concern POIs

Tag	Description	Y	X
4	Conveyor (Planned)	6822470.99	782759.01
5	Conveyor (Planned)	6822802.99	782707.01
6	Conveyor (Planned)	6823031.99	782667.01
18	Storm Water Attenuation Dams (Planned)	6822456.99	780049.01

16.8 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.

16.9 Water Borehole Influence

A hydro-census was undertaken to identify boreholes within the exclusive prospecting licence area. The 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)
1	Hydrocensus Borehole (Borehole 6) - Inside Pit Area	6823080.99	780506.01	50	-	N/A
28	Borehole (B1)	6822252.99	786034.01	50	3579	0.6
29	Borehole (B2)	6821926.99	785827.01	50	3416	0.6
30	Borehole (B3)	6821926.99	785884.01	50	3472	0.6
31	Borehole (B4)	6824580.99	786089.01	50	4008	0.5
32	Borehole (B5)	6824577.99	786123.01	50	4037	0.5
33	Borehole (B6)	6826033.99	783912.01	50	3268	0.6
34	Borehole (B7)	6826592.99	784667.01	50	4180	0.4

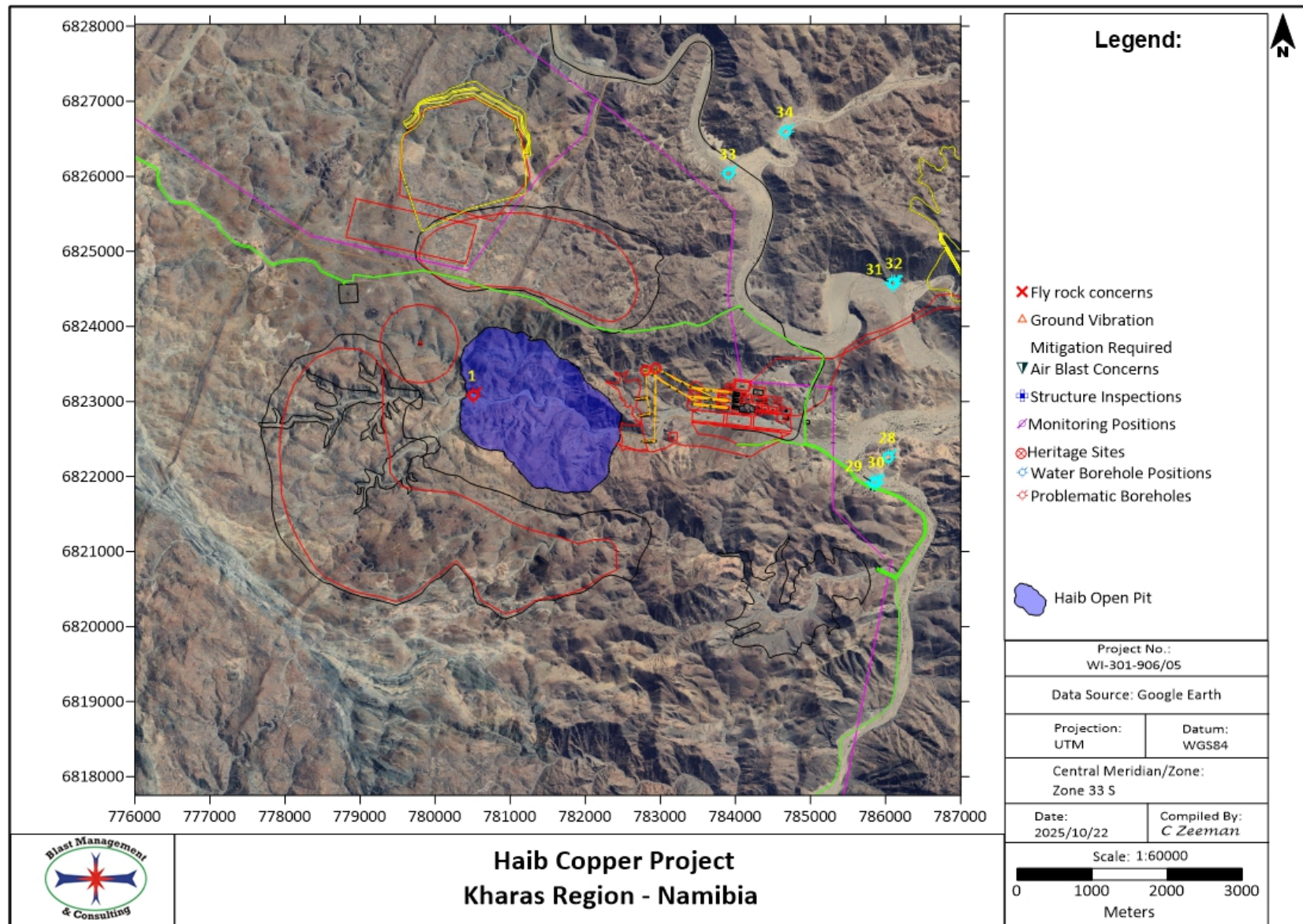


Figure 17: Location of the Boreholes

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 16 Before mitigation and after mitigation.

The adequate assessment and evaluation of the potential impacts and benefits that will be associated with a proposed project necessitates the development of a scientific method that will reduce the subjectivity involved in making such evaluations. Knight Piésold uses a simple, clearly defined method to accurately determine the significance of the predicted impact on, or benefit to, the surrounding natural and/or social environment.

Nonetheless, an impact assessment will always contain a degree of subjectivity, as it is based on the value judgment of various specialists and Environmental Assessment Practitioners. The evaluation of significance is thus contingent upon values, professional judgement, and dependent upon the environmental and community context. Ultimately, impact significance involves a process of determining the acceptability of a predicted impact to society.

The purpose of impact assessment is to identify and evaluate the likely significance of the potential impacts on identified receptors and resources according to defined assessment criteria, to develop and describe measures that will be taken to avoid, minimise, reduce or compensate for any potential adverse environmental effects, and to report the significance of the residual impacts that remain following mitigation.

17.1 Assessment Criteria

The following assessment methodology was applied as defined in the following sections. The outcome of the analysis is provided in **Table 16**, before mitigation and after mitigation.

17.1.1 Defining the nature of the impact

An impact is essentially any change to a resource or receptor brought about by the presence of the proposed project component or by the execution of a proposed project related activity. The terminology used to define the nature of an impact is detailed in **Table 13** below.

Table 13: Impact Nature

Term	Definition
Positive (+)	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Negative (-)	An impact that is considered to represent an adverse change from the baseline or introduces a new undesirable factor.
Direct impact (D)	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (e.g. between occupation of a site and the pre-existing habitats or between an effluent discharge and receiving water quality).
Indirect impact (I)	Impacts that result from other activities that are encouraged to happen as a consequence of the Project (e.g. in-migration for employment placing a demand on resources).
Cumulative impact (C)	Impacts that act together with other impacts (including those from concurrent or planned future third-party activities) to affect the same resources and/or receptors as the Project.

17.1.2 Assessing Significance

The Knight Piésold impact significance rating system is based on the following equation:

$$\text{Significance of Environmental / Social Impact} = \text{Consequence} \times \text{Probability}$$

The consequence of an impact can be derived from the following factors:

Severity / Magnitude – the degree of change brought about in the environment

Reversibility - the ability of the receptor to recover after an impact has occurred

Duration - how long the impact may be prevalent

Spatial Extent - the physical area which could be affected by an impact.

The **severity, reversibility, duration, and spatial extent** are ranked using the criteria indicated in **Table 14** and then the overall consequence is determined by adding up the individual scores and multiplying it by the **overall probability** (the likelihood of such an impact occurring). Once a score has been determined, this is checked against the **significance** descriptions indicated in **Table 15**.

Table 14: Ranking Criteria

Severity / magnitude (M)	Reversibility (R)	Duration (D)	Spatial extent (S)	Probability (P)
5 – Very high – The impact causes the characteristics of the receiving environment/ social receptor to be altered by a factor of 80 – 100 %	5 – Irreversible – <u>Environmental</u> - where natural functions or ecological processes are altered to the extent that it will permanently cease. <u>Social</u> - Those affected will not be able to adapt to changes and continue to maintain-pre impact livelihoods.	5 – Permanent - Impacts that cause a permanent change in the affected receptor or resource (e.g. removal or destruction of ecological habitat) that endures substantially beyond the Project lifetime.	5 – International - Impacts that affect internationally important resources such as areas protected by international conventions, international waters etc.	5 – Definite - The impact will occur.
4 – High – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 60 – 80 %		4 – Long term - impacts that will continue for the life of the Project, but ceases when the Project stops operating.	4 – National - Impacts that affect nationally important environmental resources or affect an area that is nationally important/ or have macro-economic consequences.	4 – High probability – 80% likelihood that the impact will occur
3 – Moderate – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 40 – 60 %	3 – Recoverable <u>Environmental</u> - where the affected environment is altered but natural functions and ecological processes may continue or recover with human input. <u>Social</u> - Able to adapt with some difficulty and maintain pre-impact livelihoods but only with a degree of support or intervention.	3 – Medium term - Impacts are predicted to be of medium duration (5 – 15 years)	3 – Regional - Impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystem.	3 – Medium probability – 60% likelihood that the impact will occur u

Severity / magnitude (M)	Reversibility (R)	Duration (D)	Spatial extent (S)	Probability (P)
2 – Low – The impact alters the characteristics of the receiving environment/ social receptor by a factor of 20 – 40 %		2 – Short term - Impacts are predicted to be of short duration (0 – 5 years)	2 – Local - Impacts that affect an area in a radius of 2 km around the site.	2 – Low probability - 40% likelihood that the impact will occur
1 – Minor – The impact causes very little change to the characteristics of the receiving environment/ social receptor and the alteration is less than 20 %	1 – Reversible <u>Environmental</u> - The impact affects the environment in such a way that natural functions and ecological processes are able to regenerate naturally. <u>Social</u> - People/ communities are able to adapt with relative ease and maintain pre-impact livelihoods.	1 – Temporary - Impacts are predicted to intermittent/ occasional over a short period.	1 – Site only - Impacts that are limited to the site boundaries.	1 – Improbable - 20% likelihood that the impact will occur

Table 15: Significance Definitions

Score According to Impact Assessment Matrix	Significance Definitions	Colour Scale Ratings	
		Negative Ratings	Positive Ratings
Between 0 and 29 significance points indicate Low Significance	An impact of low significance is one where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value.	Low	Low
Between 30 and 59 significance points indicate Moderate Significance	An impact of moderate significance is one within accepted limits and standards. The impact on the receptor will be noticeable and the normal functioning is altered, but the baseline condition prevail, albeit in a modified state. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is As Low As Reasonably Practicable (ALARP). This does not necessarily mean that “moderate” impacts have to be reduced to “low” impacts, but that moderate impacts are being managed effectively and efficiently to not exceed accepted standards.	Moderate	Moderate
60 to 100 significance points indicate High Significance	An impact of high significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An impact with high significance will completely modify the baseline conditions. A goal of the ESIA process is to get to a position where the Project does not have any high negative residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be high residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). It is then the function of regulators and stakeholders to weigh such negative factors against the positive factors, such as employment, in coming to a decision on the Project.	High	High

17.1.3 Mitigation and Residual Impacts

It is expected that for the identified significant impacts, the project team will work with the client in identifying suitable and practical mitigation measures that are implementable. Mitigation that can be incorporated into the Project design to avoid or reduce the negative impacts or enhance the positive impacts will be developed. A description of these mitigation measures will also be included within the Environmental and Social Management Plan (ESMP).

Residual impacts are those impacts which remain once the mitigation measures have been designed and applied. Once the mitigation is applied, each impact is re-evaluated (assuming that the mitigation measure is effectively applied) and any remaining impact is rated once again using the process outlined above. The result is a significance rating for the residual 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 of impacts in the Operational Phase 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.

No Assessment was done for Pre-Construction, Construction, or Decommissioning of the Mine. It is accepted that no drilling and blasting will be required in these phases.

Table 16: Potential Impacts Without and With Mitigation Measures

Project activity or issue	Potential impact	Nature of impact		Significance before mitigation							Significance after mitigation as per EMP						
		+ / -	D/I/C	M	R	D	S	P	TOTAL		SP	M	R	D	S	P	
Blasting																	
Ground Vibration from Blasting	Damage to Public Structures	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Boreholes	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Heritage Site	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Mine infrastructure	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Powerlines	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
Air Blast from Blasting	Damage to Public Structures	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Boreholes	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Heritage Site	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Mine infrastructure	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Powerlines	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
Fly Rock from Blasting	Damage to Public Structures	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Boreholes	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Heritage Site	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L
	Damage to Mine infrastructure	-	D	5	3	4	2	4	56	M	3	3	4	2	2	24	L
	Damage to Powerlines	-	D	1	1	4	2	1	8	L	1	1	4	2	1	8	L

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 POIs identified. **Table 17** shows a list of POIs that will need to be considered. **Figure 18** shows the location of these POIs in relation to the pit area.

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

Tag	Description	Classification	Y	X
4	Conveyor (Planned)	6	6822470.99	782759.01
5	Conveyor (Planned)	6	6822802.99	782707.01
6	Conveyor (Planned)	6	6823031.99	782667.01
18	Storm Water Attenuation Dams (Planned)	6	6822456.99	780049.01
1	Hydrocensus Borehole (Borehole 6) - Inside Pit Area	15	6823080.99	780506.01
2	Structures - Inside Pit Area	15	6822594.99	782103.01
3	Structures - Inside Pit Area	15	6822605.99	782191.01

Mitigation for POIs Inside the Pit Area

POIs 1, 2, and 3 are located within the pit area. These structures and the borehole are expected to be demolished due to mining. The value of the structures should be considered if currently privately owned, and relocation should be considered accordingly.

Fly rock:

Impact from the fly rock is expected at four mine infrastructure POIs. These POIs are within the calculated fly rock range. Blasting at the closest location, these POIs should consider the following mitigation. Blasting outside of range – further away does not require any specific mitigation.

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.
3. Possible consideration of smaller diameter blastholes to maintain the same powder factors with a reduced stemming length in areas closest to the POIs of concern.

Ground Vibration: No specific mitigation required.

Air Blast: No specific mitigation required.

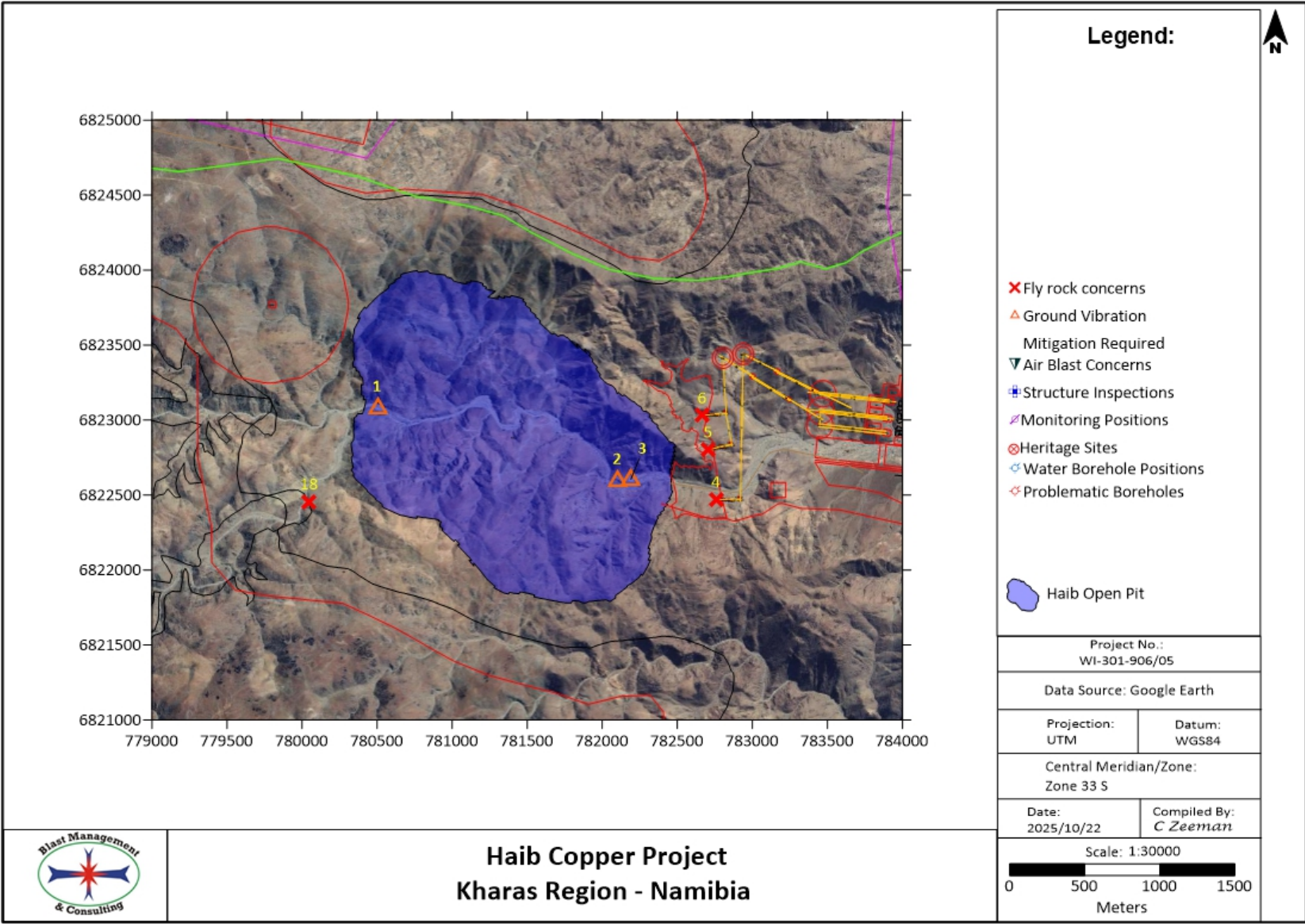


Figure 18: Mitigation POIs

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.

Four 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 19 and Table 18 lists the positions with coordinates. These points will need to be redefined after the first blasts are done and the monitoring programme is defined.

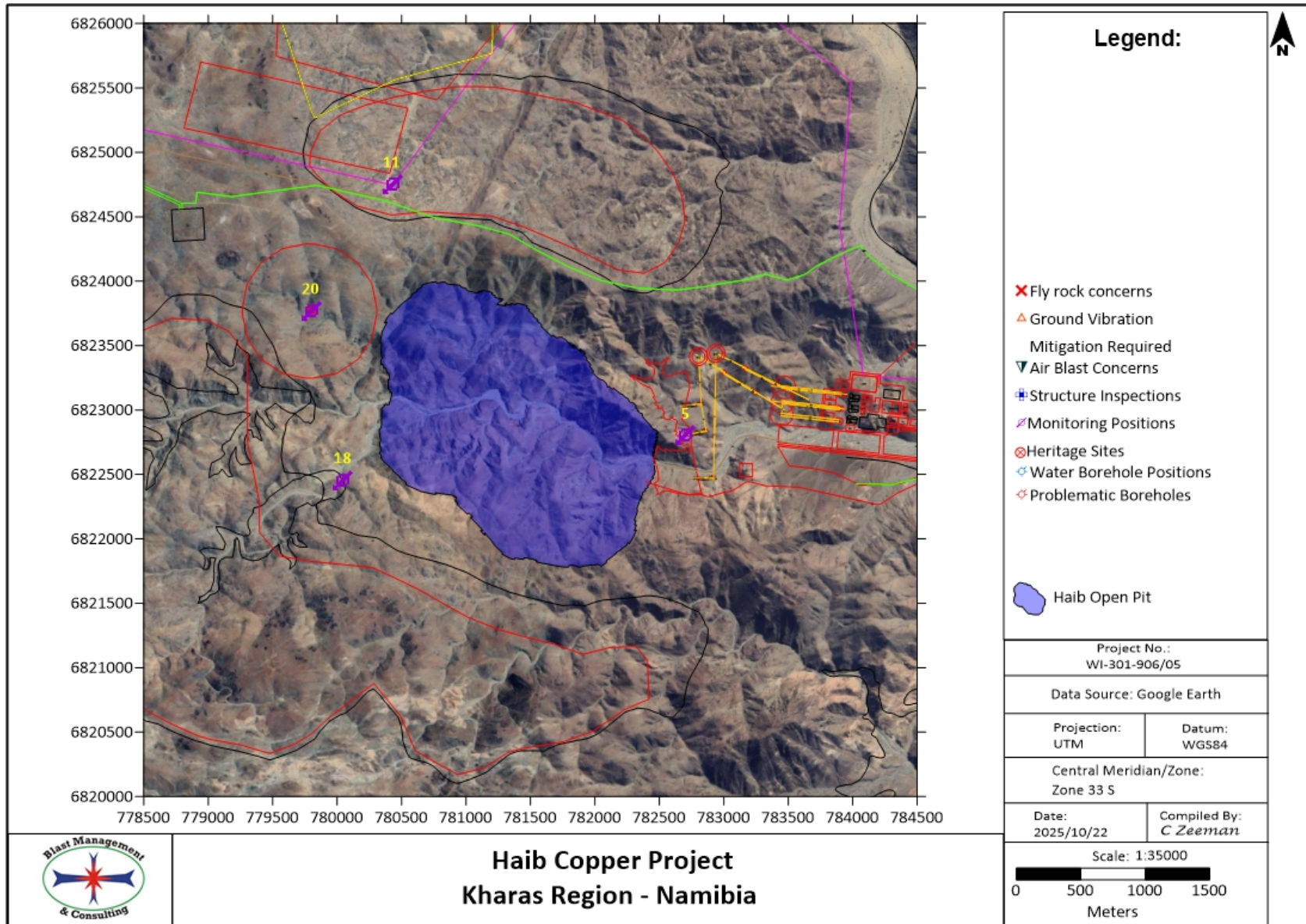


Figure 19: Suggested monitoring positions

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Table 18: List of possible monitoring positions

Tag	Description	Y	X
5	Conveyor (Planned)	6822802.99	782707.01
11	Power line (Proposed)	6824754.99	780430.01
18	Storm Water Attenuation Dams (Planned)	6822456.99	780049.01
20	Explosives Magazine (Planned)	6823770.99	779800.01

21 Recommendations

The following recommendations are proposed.

21.1 Unsafe Blasting Range

Four planned mining-related POIs are within a 490 m unsafe blasting zone from the pit that needs consideration. Up to 500 m is generally accepted as an unsafe area from blasting operations. Table 19 lists these installations. Figure 20 below shows the 500 m boundary around the opencast pit area. The location of planned mining installations is clearly observed.

Table 19: List of possible installations within the regulatory 500 m

Tag	Description	Y	X
4	Conveyor (Planned)	6822470.99	782759.01
5	Conveyor (Planned)	6822802.99	782707.01
6	Conveyor (Planned)	6823031.99	782667.01
18	Storm Water Attenuation Dams (Planned)	6822456.99	780049.01

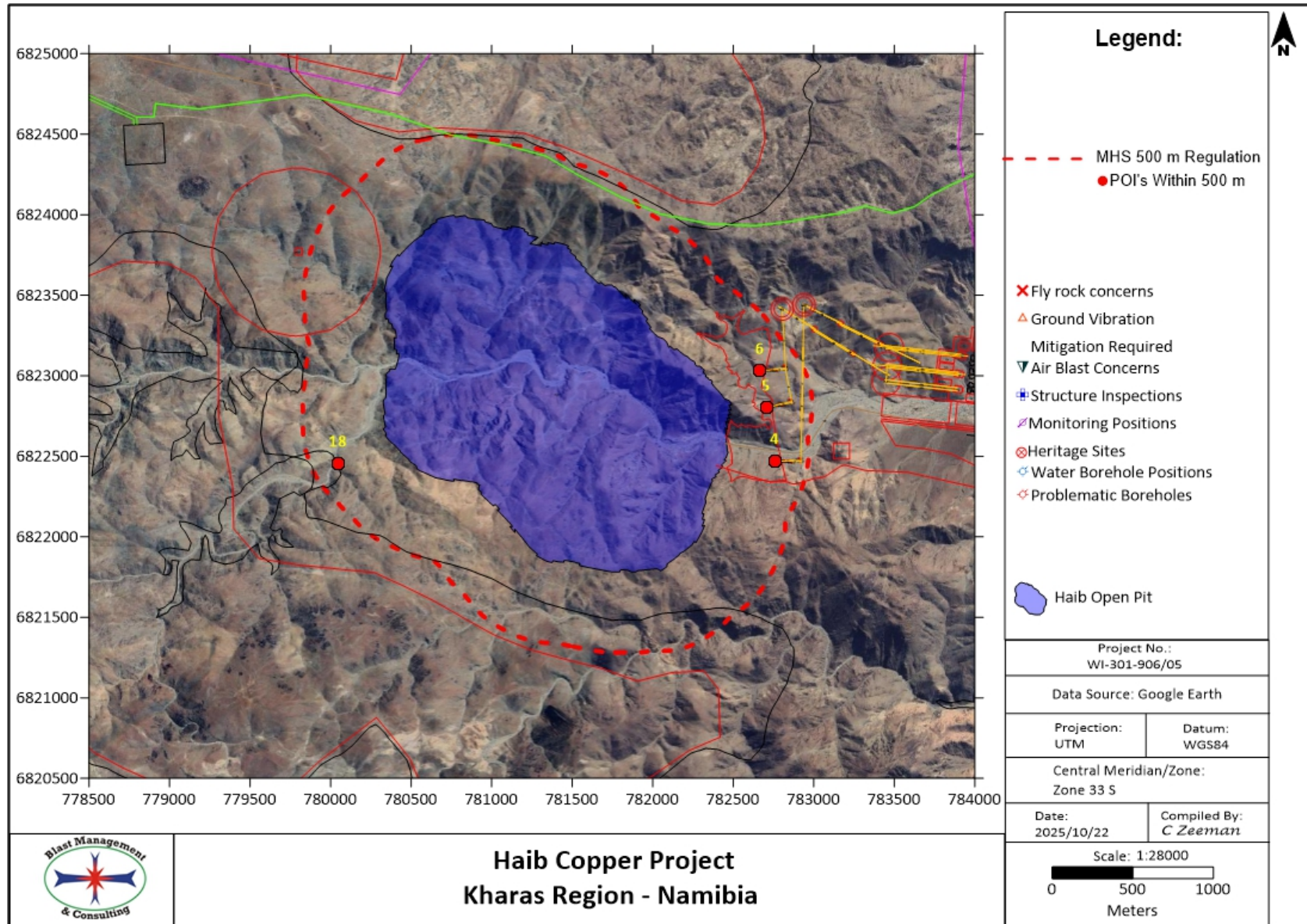


Figure 20: Regulatory 500 M Range For The Opencast Area

21.2 Relocation

The following POIs should be considered for relocation.

Table 20: List of Relocations to be Considered

Tag	Description	Classification	Y	X
2	Structures - Inside Pit Area	15	6822594.99	782103.01
3	Structures - Inside Pit Area	15	6822605.99	782191.01

21.3 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.

21.4 Stemming length

The current proposed stemming lengths used provide for some control on fly rock. 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 where a high level of fly rock control is required, the stemming ratio can be increased and could range between 30 and 34 times the blast hole's diameter.

21.5 Safe blasting distance and evacuation

Calculated minimum safe distance is 490m. 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.

21.6 Road management

The closest main road is the B1, which borders the EPL at approximate distance of 13km. There is no specific ground vibration concern for this road. 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.

21.7 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 20**.

Table 21: 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	

21.8 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.

21.9 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.

21.10 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 minor problems were identified, and recommendations made. The successful consideration of the concerns noted and the blast design adjusted for these concerns will provide for proper mitigation. There is no reason observed that this project cannot be executed successfully.

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 25.3 km. The range of structures observed is typical of Roads, Farm Buildings/Structures, Heritage sites, and the Haib River.

The model used for evaluation does indicate mostly acceptable levels ranging from none to levels as high as 54 mm/s over the range 222 m to 25.3 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 25.3 km that were considered important to consider as well. The POIs beyond the 3500 m boundary are mainly heritage sites, boreholes, existing and planned power lines, and Vioolsdrif town.

Ground vibration levels expected at the Haib river are 1.3 mm/s, which is well within the limits of 200 mm/s. The Farm Buildings/Structures are within limits of 12.5 mm/s at a prediction of 1 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.

Review of the air blast levels predicted for the maximum charge ranges between 84 and 123.4 dB(L) for all the POIs considered. This includes the nearest points, such as the planned Explosives Magazine and planned Mine Refuelling Area. Air blast levels expected at the houses identified ranged between 84 dB(L) and 114.7 dB(L).

Maximum charge predictions identified that two POIs could experience levels of air blast that could lead to complaints. Both of these POI's are planned Mining Infrastructure. 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 208 m and closer to the pit boundary. Infrastructure at the pit area, such as planned conveyor, planned power lines, and planned Storm Water Attenuation Dams, is present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range, with a safety factor of 2, was calculated to be 490 m. The absolute minimum unsafe zone is then 490 m. This calculation is a guideline, and any distance cleared should not be less than. Four POIs are 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 490 m, therefore, this should be used as the clearance distance. Specific actions will be required when blasting is done within 490 m of structures.

The planned mine accommodation houses are located 6.6 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 Haib Copper 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 Goedehoop Colliery; Photographic Surveys for Aquarius Kroondal Platinum – Klipfontein Village; Photographic Surveys for Aquarius – Everest South Project; Photographic Surveys for Kromdraai Opencast Mine; Photographic inspections for various other companies, including Landau Colliery, Platinum Joint Venture – three mini-pit areas; Continuous ground vibration and air blast monitoring for various coal mines; Full auditing and control with consultation on blast preparation, blasting and resultant effects for clients, e.g. Anglo Platinum Ltd, Kroondal Platinum Mine, Lonmin Platinum, Blast Monitoring Platinum Joint Venture – New Rustenburg N4 road; Monitoring of ground vibration induced on surface in underground mining environment; Monitoring and management of blasting in close relation to water pipelines in opencast mining environment; Specialized testing of explosives characteristics; Supply and service

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

BMC 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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