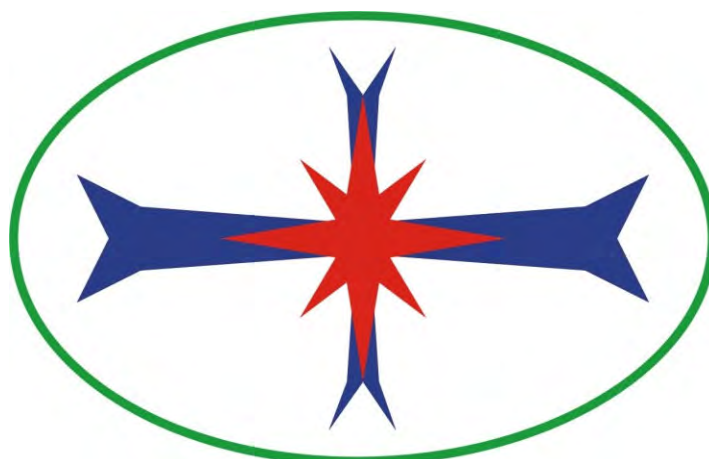
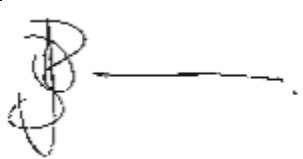


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Report: Blast Impact Assessment Twin Hills Gold Project		
Report Date:	15 August 2023	
BM&C Ref No:	ECC_Twin Hills Gold Project_EIAReport_230815V00	
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ii. Independence Declaration

A declaration that the specialist is independent in a form as may be specified by the competent authority

I, JD Zeeman, declare that -

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



Signature of the Specialist

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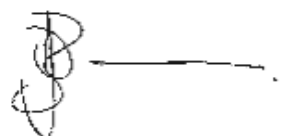
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Table of Contents

1	Executive Summary.....	9
2	Introduction.....	11
3	Objectives.....	12
4	Scope of blast impact study	12
5	Study area.....	13
6	Methodology	14
7	Season applicable to the investigation	14
8	Assumptions and Limitations	14
9	Legal Requirements	14
10	Sensitivity of Project	15
11	Consultation process.....	17
12	Influence from blasting operations	17
12.1	Ground vibration limitations on structures	17
12.2	Ground vibration limitations and human perceptions.....	19
12.3	Air blast limitations on structures	20
12.4	Air blast limitations and human perceptions.....	21
12.5	Fly rock	22
12.6	Noxious Fumes	23
12.7	Vibration impact on provincial and national roads.....	23
12.8	Vibration will upset adjacent communities	23
12.9	Cracking of houses and consequent devaluation	25
13	Baseline Structure Profile	27
14	Blasting Operations.....	30
14.1	Ground Vibration.....	31
14.2	Air blast	32
15	Construction Phase: Impact Assessment and Mitigation Measures.....	34
16	Operational Phase: Impact Assessment and Mitigation Measures	34
16.1	Review of expected ground vibration.....	35
16.1.1	Ground vibration minimum charge mass per delay – Opencast 1 - 90 kg	37
16.1.2	Ground vibration maximum charge mass per delay – Opencast 1 - 361 kg	41
16.1.3	Ground vibration minimum charge mass per delay – Opencast 2 - 90 kg	45
16.1.4	Ground vibration maximum charge mass per delay – Opencast 2 - 361 kg	49
16.1.5	Ground vibration minimum charge mass per delay – Opencast 3 - 90 kg	53
16.1.6	Ground vibration maximum charge mass per delay – Opencast 3 - 361 kg	57
16.2	Summary of ground vibration levels.....	60
16.3	Ground Vibration and human perception	62
16.4	Potential that vibration will upset adjacent communities.....	63
16.5	Cracking of houses and consequent devaluation	63

16.6	Review of expected air blast.....	64
16.6.1	Air blast minimum charge mass per delay – Opencast 1 - 90 kg.....	65
16.6.2	Air blast maximum charge mass per delay – Opencast 1 - 361 kg	68
16.6.3	Air blast minimum charge mass per delay – Opencast 2 - 90 kg.....	71
16.6.4	Air blast maximum charge mass per delay – Opencast 2 - 361 kg	74
16.6.5	Air blast minimum charge mass per delay – Opencast 3 - 90 kg.....	77
16.6.6	Air blast maximum charge mass per delay – Opencast 3 - 361 kg	80
16.7	Summary of findings for air blast.....	82
16.8	Fly-rock unsafe zone.....	83
16.9	Noxious fumes.....	86
16.10	Water Borehole Influence	86
17	Potential Environmental Impact Assessment: Operational Phase	89
17.1	Assessment Criteria	89
17.2	Limitations, Uncertainties and Assumptions	90
17.3	Assessment Methodology	90
17.4	Assessment.....	93
17.5	Mitigations	96
18	Closure Phase: Impact Assessment and Mitigation Measures	100
19	Alternatives (Comparison and Recommendation).....	100
20	Monitoring.....	100
21	Recommendations	103
21.1	Relocation	103
21.2	Blast Designs.....	103
21.3	Test Blasting	103
21.4	Stemming length	103
21.5	Safe blasting distance and evacuation.....	104
21.6	Road management	104
21.7	Photographic Inspections	104
21.8	Recommended ground vibration and air blast levels	106
21.9	Blasting times	107
21.10	Third party monitoring	107
21.11	Video monitoring of each blast	107
22	Knowledge Gaps	108
23	Project Result.....	108
24	Conclusion	108
25	Curriculum Vitae of Author	109
26	References	111

List of Acronyms used in this Report

a and b	Site Constant
APP	Air Pressure Pulse
B	Burden (m)
BH	Blast Hole
BMC	Blast Management & Consulting
D	Distance (m)
E	Explosive Mass (kg)
EIA	Environmental Impact Assessment
Freq.	Frequency
GRP	Gas Release Pulse
I&AP	Interested and Affected Parties
k	Factor value
L	Maximum Throw (m)
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 Mine
WGS 84	Coordinates (South African)

List of Units used in this Report

%	percentage
cm	centimetre
dB	decibel
dB _L	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

List of Figures

Figure 1: The Osino Twin Hills Gold Project site area	11
Figure 2: Locality Map	13
Figure 3: Identified sensitive areas – West UG2 and West Merensky	16
Figure 4: USBM Analysis Graph	18
Figure 5: Ground Vibration and Human Perception	20
Figure 6: Schematic of fly rock terminology	22
Figure 7: Example of blast induced damage.....	25
Figure 8: Proposed prediction equations	33
Figure 9: Ground vibration influence from minimum charge per delay – Opencast 1	37
Figure 10: Ground vibration influence from maximum charge per delay – Opencast 1.....	41
Figure 11: Ground vibration influence from minimum charge per delay – Opencast 2	45
Figure 12: Ground vibration influence from maximum charge per delay – Opencast 2.....	49
Figure 13: Ground vibration influence from minimum charge per delay – Opencast 3	53
Figure 14: Ground vibration influence from maximum charge per delay – Opencast 3.....	57
Figure 15: The effect of ground vibration with human perception and vibration limits.....	62
Figure 16: Air blast influence from minimum charge – Opencast 1	65
Figure 17: Air blast influence from maximum charge – Opencast 1.....	68
Figure 18: Air blast influence from minimum charge – Opencast 2	71
Figure 19: Air blast influence from maximum charge – Opencast 2.....	74
Figure 20: Air blast influence from minimum charge – Opencast 3	77
Figure 21: Air blast influence from maximum charge – Opencast 3.....	80
Figure 22: Fly rock prediction calculation.....	84
Figure 23: Predicted Fly Rock Exclusion Zone for the Opencast Pit areas	85
Figure 24: Location of the Boreholes	88
Figure 25: ECC ESIA methodology based on IFC standards	91
Figure 26: ECC ESIA methodology based on IFC standards	92
Figure 27: Mitigation POI's.....	97
Figure 28: Suggested monitoring positions	102
Figure 29: 1500 m area around Opencast pits identified for structure inspections.	105

List of Tables

Table 1: Damage Causing Levels for Air Blast	21
Table 2: Air Blast Limits	21
Table 3: Examples of typical non-blasting cracks	25
Table 4: POI Classification used	28
Table 5: List of points of interest identified (WGS84 – LO 15°)	28
Table 6: Blast design technical information	30
Table 7: Expected Ground Vibration at Various Distances from Charges Applied in this Study	32
Table 8: Air Blast Predicted Values.....	34
Table 9: Ground vibration evaluation for minimum charge – Opencast 1	38
Table 10: Ground vibration evaluation for maximum charge – Opencast 1.....	42
Table 11: Ground vibration evaluation for minimum charge – Opencast 2	46
Table 12: Ground vibration evaluation for maximum charge – Opencast 2.....	50
Table 13: Ground vibration evaluation for minimum charge – Opencast 3	54
Table 14: Ground vibration evaluation for maximum charge – Opencast 3.....	58
Table 15: Air blast evaluation for minimum charge – Opencast 1.....	66
Table 16: Air blast influence from maximum charge – Opencast 1.....	69
Table 17: Air blast evaluation for minimum charge – Opencast 2.....	72
Table 18: Air blast influence from maximum charge – Opencast 2.....	75
Table 19: Air blast evaluation for minimum charge – Opencast 3.....	78
Table 20: Air blast influence from maximum charge – Opencast 3.....	81
Table 21: Fly rock concern POI's.....	86
Table 22: Identified Water Boreholes	87
Table 23: Problematic Water Borehole	87
Table 24: Potential Impacts Without Mitigation Measures Mitigation	94
Table 25: Structures identified as problematic in and around the project area.....	96
Table 26: Mitigation measures: Maximum charge per delay for distance to POI.....	99
Table 27: Mitigation measures: Minimum distances required.....	100
Table 28: List of possible monitoring positions	103
Table 29: Combined list of structures identified for inspections.....	106
Table 30: Recommended ground vibration air blast limits.....	107

1 Executive Summary

Blast Management & Consulting (BMC) was contracted as part of Environmental Impact Assessment (EIA) to perform an initial review of possible impacts with regards to blasting operations in the proposed opencast mining 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 evaluated over an area as wide as 3500 m from the mining area considered. The range of structures observed is typical roads (tar and gravel), low cost houses, corrugated iron structures, industrial buildings, brick and mortar houses, power lines/pylons.

The location of structures around the Pit areas are such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Road (D1941), Hydrocensus Boreholes, Heritage Sites, Buildings/Structures and Cement Dam. The ground vibration levels predicted for these POI's ranged between 0.1 mm/s and 1801.4 mm/s for structures surrounding the open pit areas. The expected levels of ground vibration for some of these structures are high and will require specific mitigations in the way of adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Air blast predicted showed some concerns for opencast blasting. The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134dB. It is maintained that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located such that "free blasting" – meaning no controls on blast preparation – will not be possible.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 300 m and closer to pit boundary. Infrastructure at the pit areas such as roads and power lines/pylons, are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 356 m. The absolute minimum unsafe zone is then the 356 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices

should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Buildings/Structures, Heritage Sites, Hydrocensus Boreholes, Road (D1941) and River falls within the 500 m range from the pit areas.

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

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

2 Introduction

The Twin Hills Gold Project is located approximately 180 km inland from the Atlantic coastline in the southern area of a roughly triangular area bounded by the towns of Omaruru and Karibib and the small farming settlement of Wilhelmstal in the east. The Khan River defines the most northern part of the project area, and the B2 road between Windhoek and Swakopmund forms the southern border. The two sides are formed by the C36 running north-westwards to Omaruru from Wilhelmstal, and the C33 road from Karibib that runs north to Omaruru.

Omaruru is 45 km north of the project site. Karibib is the closest town approximately 15 km to the south-west.

The Twin Hills Gold Project will be an open pit mining and processing operation like other Namibian gold mines at B2Gold's Otjikoto and QKR's Navachab near Karibib. The development project will transition into a full-scale mining operation with open pits, waste rock dumps, processing plant, tailings storage facilities, internal power lines, water pipelines and road networks. Run of mine waste rock will be placed on site and ore will be sent to the plant for crushing, leaching, CIP processing, electrowinning and then smelting in an induction furnace to produce gold bars.

The proposed development is situated in a commercial agricultural region and land use is dominated by cattle, game, and small stock farming activities.

Figure 1 indicates the project site area layout plan of the proposed mining areas.

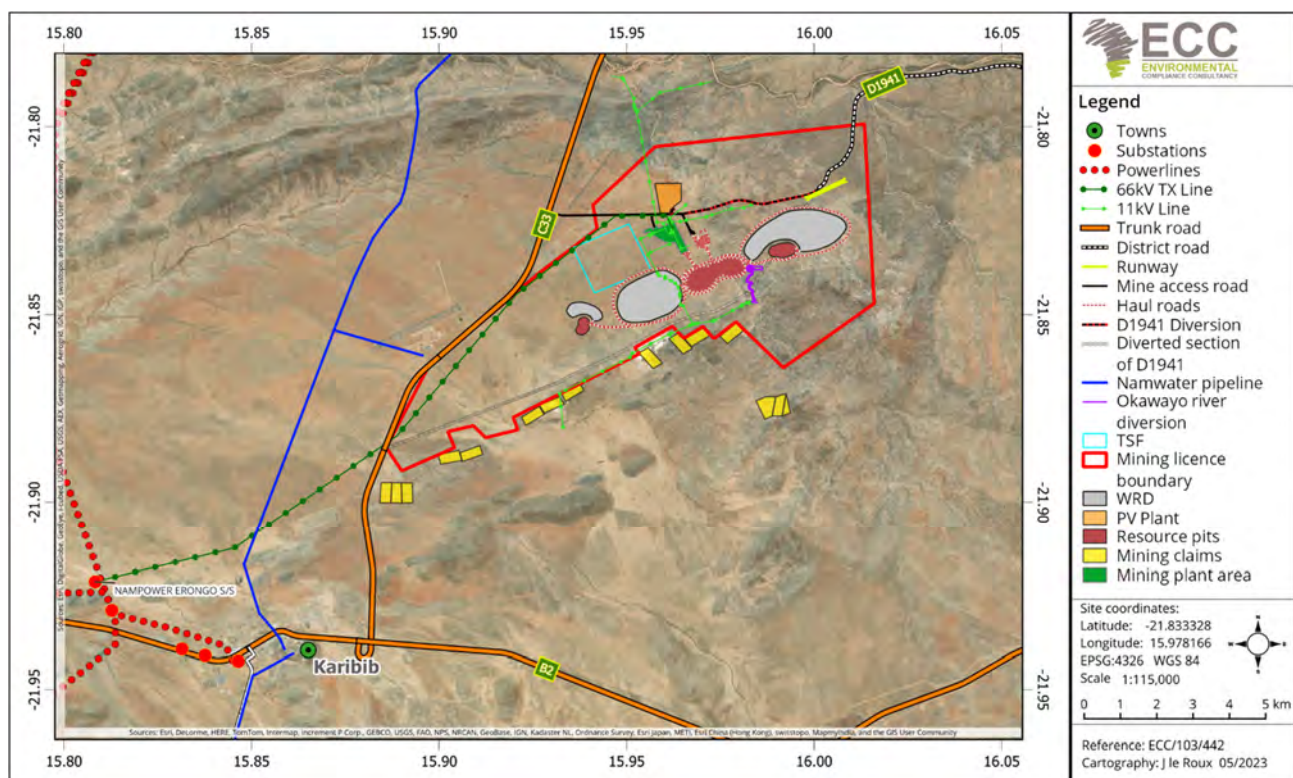


Figure 1: The Osino Twin Hills Gold Project site area

3 Objectives

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

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

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

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

4 Scope of blast impact study

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

- Background information of the proposed site.
- Blasting Operation Requirements.
- Site specific evaluation of blasting operations according to the following:
 - Evaluation of expected ground vibration levels from blasting operations at specific distances and on structures in surrounding areas;
 - Evaluation of expected ground vibration influence on neighbouring communities;
 - Evaluation of expected blasting influence on national and provincial roads surrounding the blasting operations if present;
 - Evaluation of expected ground vibration levels on water boreholes if present within 1500 m from blasting operations;

- Evaluation of expected air blast levels at specific distances from the operations and possible influence on structures;
 - Evaluation of fly rock unsafe zone;
 - Discussion on the occurrence of noxious fumes and dangers of fumes;
 - Evaluation the location of blasting operations in relation to surrounding areas according to the regulations from the applicable Acts.
- Impact Assessment.
 - Mitigations.
 - Recommendations.
 - Conclusion.

5 Study area

The Twin Hills Gold Project is located near the town of Karibib in the Erongo region of Namibia and is approximately 140 km directly north-west of Windhoek, the capital. Omaruru is 45 km north of the project site. Karibib is the closest town approximately 15 km to the south-west. The centre point of the site is 21°50'19.40"S and 15°58'25.39"E.

Figure 2 shows the Locality map of the proposed opencast mining areas.

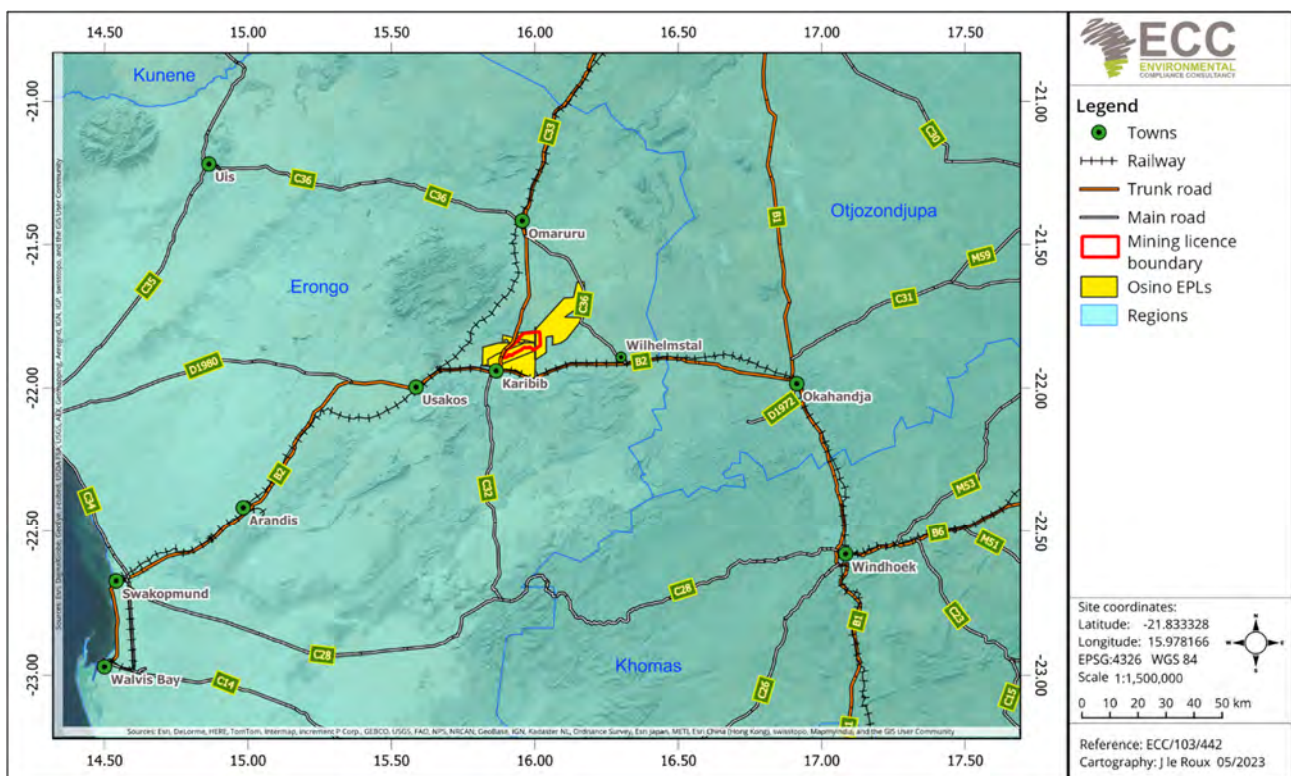


Figure 2: Locality Map

6 Methodology

The detailed plan of study consists of the following sections:

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

7 Season applicable to the investigation

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

8 Assumptions and Limitations

The following assumptions have been made:

- The anticipated levels of influence estimated in this report are calculated using standard accepted methodology according to international and local regulations.
- The assumption is made that the predictions are a good estimate with significant safety factors to ensure that expected levels are based on worst case scenarios. These will have to be confirmed with actual measurements once the operation is active.
- No confirmation of the predicted values could be made.
- Basic blast designs provided was applied.
- 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 be applicable to the study. There is currently uncertainty on the specific Namibian law requirements for blasting operations in relation to limits for ground vibration and air blast. The shortfall in direct legislation is supported by

international standards and other guidelines as well as relevant project experience of the consultants.

The following acts and supporting detail are considered:

- Mine Health and Safety Act of Namibia – to be considered,
- Ground vibration and air blast is also evaluated according to the USBM (United States Bureau of Mines) guidelines for safe blasting,
- Ground vibration and air blast is also evaluated according to guidelines as used by Blast Management & Consulting based on experience and knowledge.

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 normally associated where possible influences may occur and where influence is expected to be very low or none. Three different areas were identified in this regard:

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

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

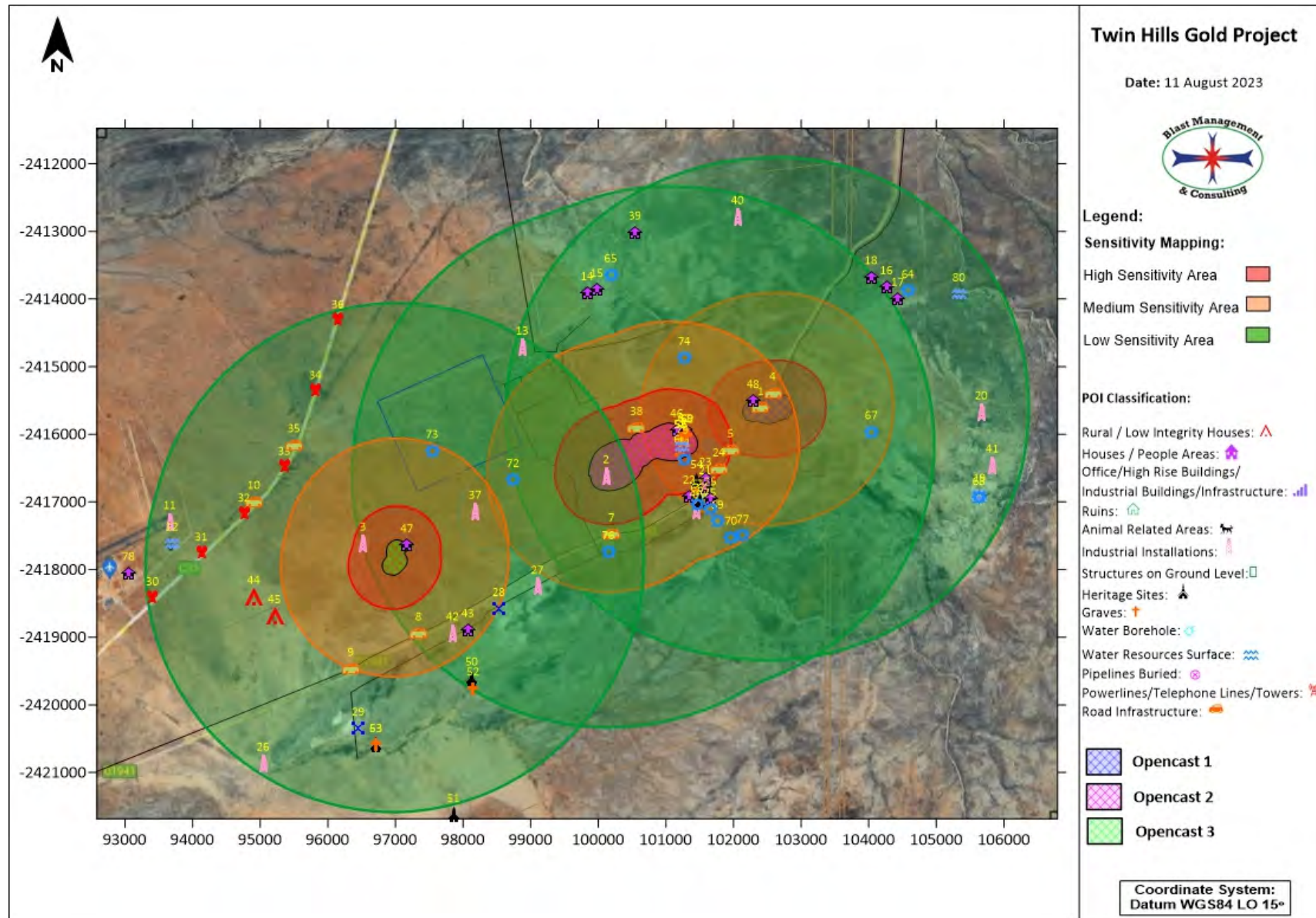


Figure 3: Identified sensitive areas – West UG2 and West Merensky

11 Consultation process

Consultation was only done with the client via the Environmental Practitioner. No other consultation with external parties was utilised. The work done is based on the author's knowledge, information provided by the client and information captured during site visit.

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 regulations of the different acts consulted and international accepted standards these effects are required to be within certain limits. The following sections provide guidelines on these limits. As indicated, there are no specific South African ground vibration and air blast limit standard.

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 limits are then applicable to the different types of structures. Limitations on ground vibration take the form of maximum allowable levels or intensity for different installations or structures. Ground vibration limits are also dependent on the frequency of the ground vibration. Frequency is the rate at which the vibration oscillates. Faster oscillation is synonymous with higher frequency and lower oscillation is synonymous with lower frequency. Lower frequencies are less acceptable than higher frequencies because structures have a low natural frequency. Significant ground vibration at low frequencies could cause increased structure vibrations due to the natural low frequency of the structure and this may lead to crack formation or damages.

Guidelines applied in this document consists of the United States Bureau of Mines (USBM) according to 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 is recorded and analysed. The data is then evaluated accordingly. The USBM graph is used for plotting of data and evaluating the data. Figure 4 below provides a graphic representation of the USBM analysis for safe ground vibration levels. The USBM graph is divided mainly into two parts. The red lines in the figure are the USBM criteria:

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

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

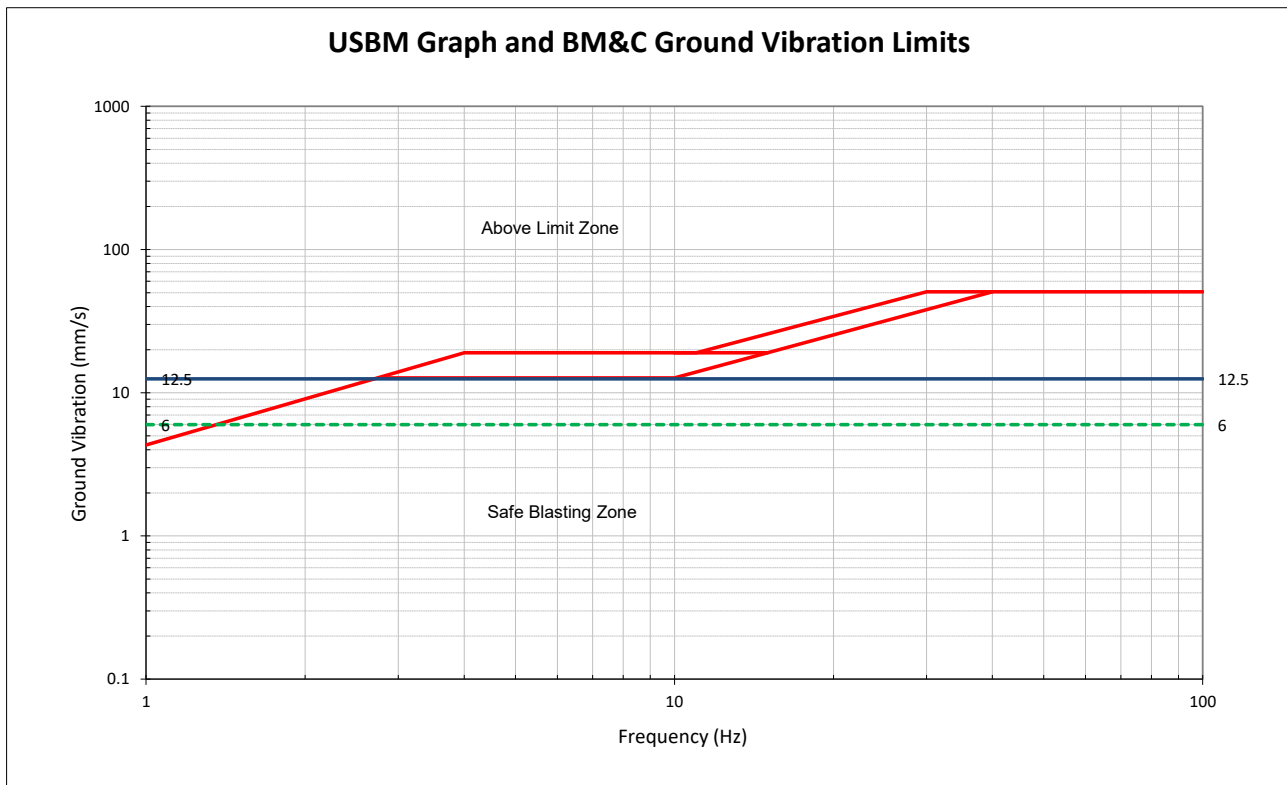


Figure 4: USBM Analysis Graph

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

- National roads/tar roads: 150 mm/s (BMC).
- Steel pipelines: 50 mm/s (Rand Water Board).
- Electrical lines: 75 mm/s (Eskom).
- Sasol Pipelines: 25 mms/s (Sasol).
- Railways: 150 mm/s (BMC).

- Concrete less than 3 days old: 5 mm/s².
- Concrete after 10 days: 200 mm/s³.
- 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/s⁴.

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

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

12.2 Ground vibration limitations and human perceptions

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

Ground vibration is experienced at different levels; BMC considers only the levels that are experienced as “Perceptible”, “Unpleasant” and “Intolerable”. This is indicative of the human being’s perceptions of ground vibration and clearly indicates that humans are sensitive to ground vibration and humans perceive ground vibration levels of 0.8 mm/s as perceptible (See Figure 5).

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

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

This guideline helps with managing ground vibration and the complaints that could be received due to blast induced ground vibration.

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

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

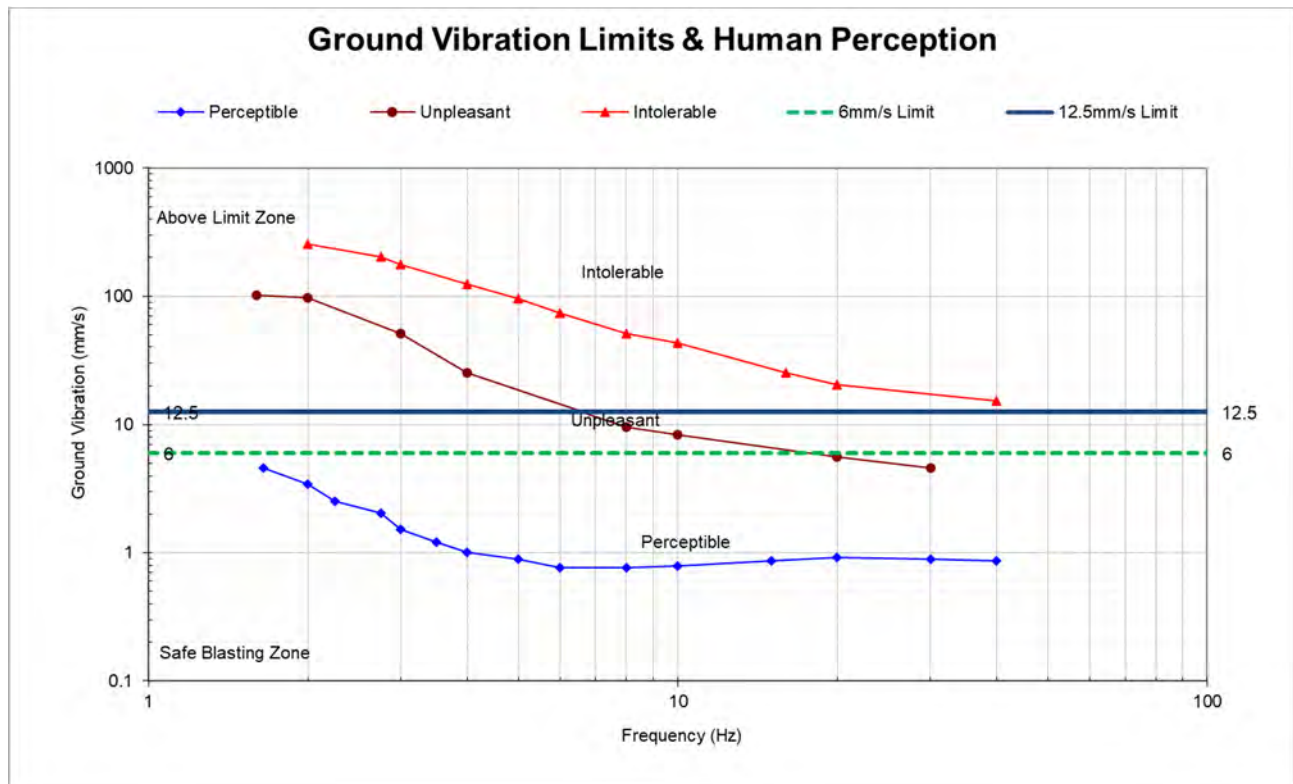


Figure 5: Ground Vibration and Human Perception

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

- Direct rock displacement at the blast; the air pressure pulse (APP).
- Vibrating ground some distance away from the blast; rock pressure pulse (RPP).

- Venting of blast holes or blowouts; the gas release pulse (GRP).

The general recommended limit for air blast currently applied in South Africa is 134dB. This is based on work done by the USBM. The USBM also indicates that the level is reduced to 128 dB in proximity of hospitals, schools and sensitive areas where people congregate. Based on work carried out by Siskind *et al.* (1980), monitored air blast amplitudes up to 135dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies. Persson *et al.* (1994) have published estimates of damage thresholds based on empirical data (Table 1). Levels given in Table 1 are at the point of measurement. The weakest points on a structure are the windows and ceilings.

Table 1: Damage Causing Levels for Air Blast

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

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

Table 2: Air Blast Limits

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

All attempts should be made to keep air blast levels from blasting operations well below 120dB 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 120dB. This will ensure fewer complaints regarding blasting operations. The effect of air blast on structures that startle people will also be reduced, which in turn reduces the reasons for complaints. It is the effect on structures (like rattling windows, doors or a large roof surface) that startles people. These effects are sometimes erroneously identified as ground vibration and considered to be damaging the structure.

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

12.5 Fly rock

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

Fly rock can be categorised as follows:

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

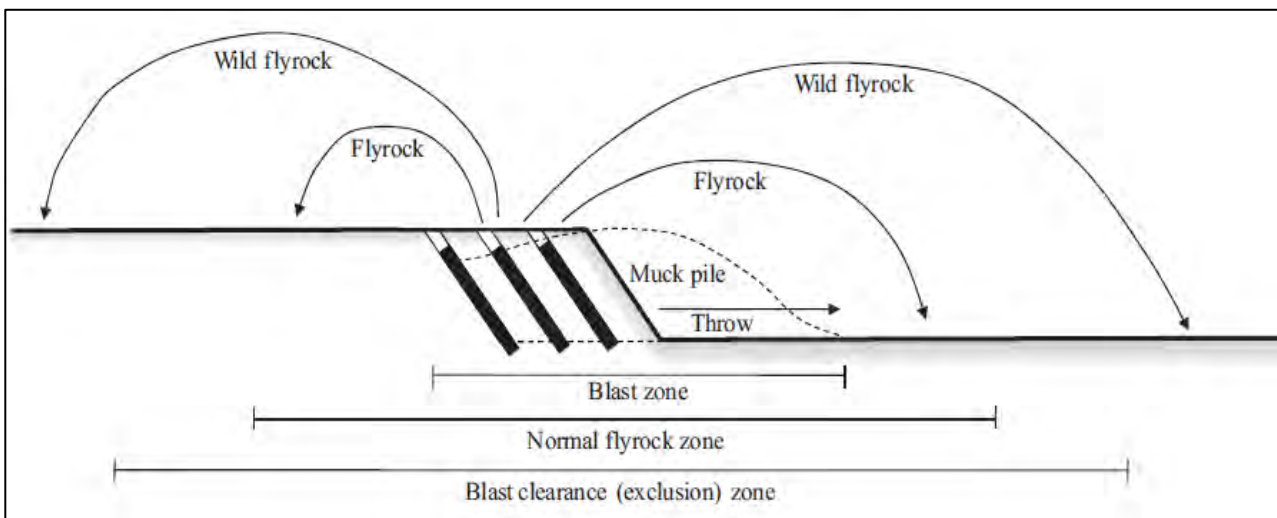


Figure 6: Schematic of fly rock terminology

Fly rock from blasting can result under the following conditions:

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

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

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

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

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 are particular undesirable. These fumes present themselves as red brown cloud after the blast has detonated. It has been reported that 10ppm to 20ppm can be mildly irritating. Exposure to 150 ppm or more (no time period given) has been reported to cause death from pulmonary oedema. It has been predicted that 50% lethality would occur following exposure to 174ppm for 1 hour. Anybody exposed must be taken to hospital for proper treatment.

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

12.7 Vibration impact on provincial and national roads

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

12.8 Vibration will upset adjacent communities

The effects of ground vibration and air blast will have influence on people. These effects tend to create noises on structures in various forms and people react to these occurrences even at low levels. As with human perception given above – people will experience ground vibration at very low levels. These levels are well below damage capability for most structures.

Much work has also been done in the field of public relations in the mining industry. Most probably one aspect that stands out is “Promote good neighbour ship”. This is achieved through communication and more communication with the neighbours. Consider their concerns and address in a proper manner.

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

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

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

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

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

premature ejection occurs, too long and there can be excessive confinement and poor fragmentation. The length of the stemming column will depend on the diameter of the hole and the type of material being used,

- Monitoring of blasting and re-optimising the blasting design in the light of results, changing conditions and experience should be carried out as standard.

12.9 Cracking of houses and consequent devaluation

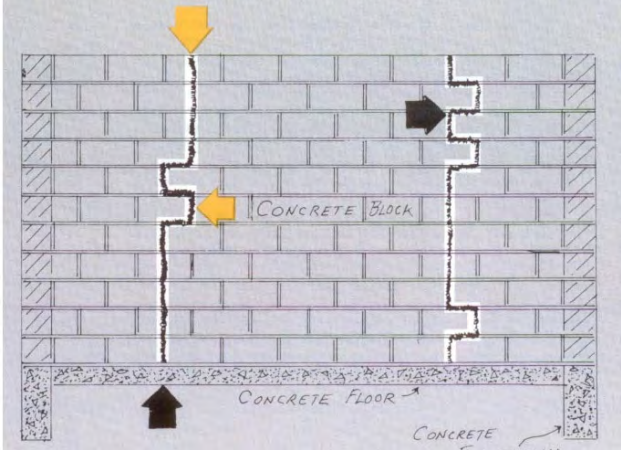
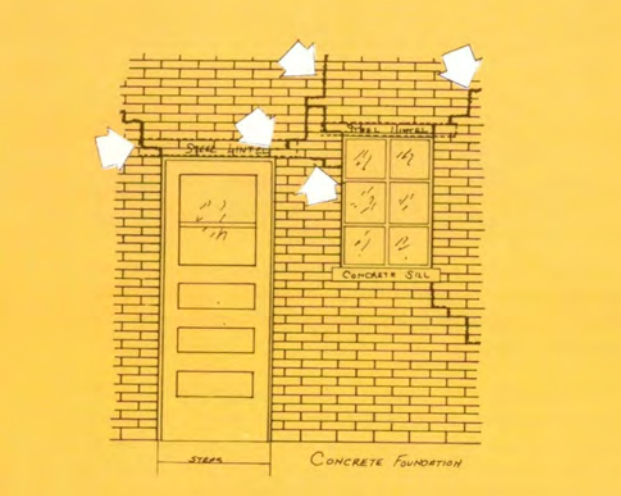
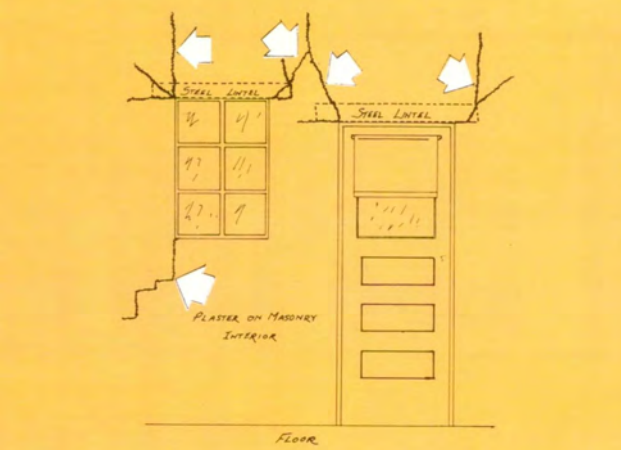
Houses in general have cracks. It is reported that a house could develop up to 15 non-blasting cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and at continued high levels. The influences of environmental forces such as temperature, water, wind etc.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

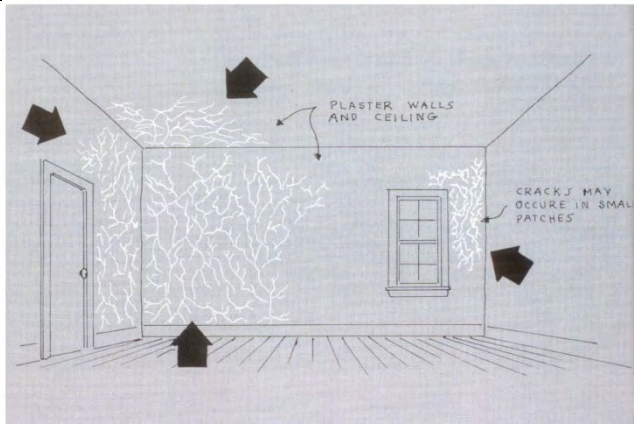
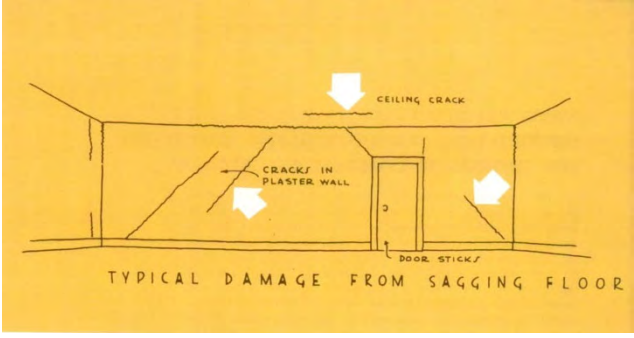
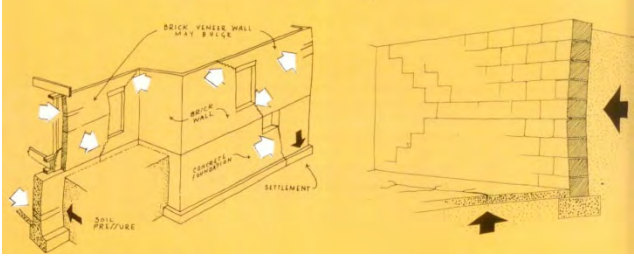


Figure 7: Example of blast induced damage.

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

Table 3: Examples of typical non-blasting cracks

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

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

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

13 Baseline Structure Profile

Work was done familiarising oneself with the surroundings. The site was reviewed using Google Earth imagery. All possible structures in a possible influence area are 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 Building and structures of poor construction
2	Private Houses and people sensitive areas
3	Office, High-rise buildings and Industrial buildings / Infrastructure
4	Ruins
5	Animal related installations and animal sensitive areas
6	Industrial Installations
7	Earth like structures – no surface structure
8	Heritage sites (buildings, infrastructure, activity)
9	Graves
10	Water Borehole
11	Water Resources Surface
12	Pipelines Buried
13	Powerlines / Telephone Lines / Towers
14	Road Infrastructure
15	Infrastructure Inside Pit

Table 5: List of points of interest identified (WGS84 – LO 15°)

Tag	Description	Classification	Y	X
1	Road (D1941) - Inside Pit 1 Area	14	-102404.42	2415611.95
2	Cement Dam - Inside Pit 2 Area	6	-100118.70	2416619.50
3	Cement Dam	6	-96523.84	2417617.63
4	Road (D1941)	14	-102583.08	2415393.85
5	Road (D1941)	14	-101960.09	2416234.07
6	Road (D1941)	14	-101550.22	2416898.78
7	Road (D1941)	14	-100195.83	2417481.64
8	Road (D1941)	14	-97345.46	2418947.35
9	Road (D1941)	14	-96342.90	2419468.57
10	Road (C33)	14	-94911.53	2417001.53
11	Landing Strip	6	-93666.02	2417297.78
12	Water Reservoir	11	-93700.32	2417616.39
13	Cement Dam	6	-98879.36	2414717.94
14	Buildings/Structures	2	-99837.52	2413910.82
15	Farmstead	2	-99983.74	2413864.91
16	Farmstead	2	-104263.34	2413823.69
17	Buildings/Structures	2	-104429.44	2413995.66
18	Structure	2	-104037.45	2413678.32

Tag	Description	Classification	Y	X
19	Dam/Dam Wall	11	-105638.70	2416896.62
20	Cement Dam	6	-105665.09	2415675.12
21	Buildings/Structures	2	-101581.01	2416782.55
22	Buildings/Structures	2	-101345.61	2416922.10
23	Buildings/Structures	2	-101590.11	2416653.33
24	Road (D1941)	14	-101786.98	2416519.52
25	Buildings/Structures	2	-101660.72	2416946.97
26	Cement Dam	6	-95047.21	2420869.54
27	Mine Activity	6	-99101.76	2418253.72
28	Mine Buildings/Structures	3	-98530.87	2418583.56
29	Mine Buildings/Structures	3	-96453.68	2420352.51
30	Power Lines/Pylons	13	-93411.81	2418396.61
31	Power Lines/Pylons	13	-94131.72	2417738.99
32	Power Lines/Pylons	13	-94763.58	2417162.32
33	Power Lines/Pylons	13	-95359.79	2416470.71
34	Power Lines/Pylons	13	-95820.03	2415345.98
35	Road (C33)	14	-95503.62	2416158.34
36	Power Lines/Pylons	13	-96151.41	2414298.93
37	Cement Dam	6	-98181.29	2417144.84
38	Gravel Road	14	-100567.93	2415907.12
39	Structure	2	-100544.73	2413016.47
40	Cement Dam	6	-102062.78	2412787.23
41	Cement Dam	6	-105830.75	2416463.10
42	Cement Dam	6	-97851.34	2418941.38
43	Structure	2	-98073.91	2418892.69
44	Rural Village/House	1	-94911.83	2418404.07
45	Rural Village/Houses	1	-95216.81	2418688.66
46	Structures - Inside Pit 2 Area	2	-101164.98	2415942.56
47	Structure	2	-97173.42	2417642.20
48	Structures - Inside Pit 1 Area	2	-102294.63	2415509.11
49	Cement Dam	6	-101446.92	2417134.17
50	Heritage Site (Anchor Stones - Okawayo 476)	8	-98131.11	2419608.88
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	8	-97861.27	2421629.40
52	Heritage Site (Graves - Okawayo 478)	9	-98153.96	2419759.63
53	Heritage Site (Marble quern stone - Okawayo 479)	8	-96717.21	2420593.58
54	Heritage Site (Farm Building - Okawayo 480)	8	-101460.69	2416693.94
55	Heritage Site (Historical Farmstead - Okawayo 481)	8	-101497.11	2416981.00
56	Heritage Site (Graves) - Inside Pit 2 area	9	-101229.44	2416098.01
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	9	-101215.31	2416097.31
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	9	-101218.22	2416100.46
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	9	-101319.56	2416017.13
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	9	-101215.08	2416323.04
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	9	-101276.52	2416010.02
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	9	-101320.74	2416021.01
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	9	-96717.09	2420593.82
64	Hydrocensus Borehole (Klein Oka 1)	10	-104581.83	2413881.56

Tag	Description	Classification	Y	X
65	Hydrocensus Borehole (Klein Oka 2)	10	-100189.09	2413643.47
66	Hydrocensus Borehole (Oka 7)	10	-101466.60	2417040.83
67	Hydrocensus Borehole (Oka12)	10	-104040.62	2415967.40
68	Hydrocensus Borehole (Twin 6)	10	-105630.25	2416941.79
69	Hydrocensus Borehole (BH3)	10	-101764.72	2417292.93
70	Hydrocensus Borehole (OKP040)	10	-101965.80	2417530.02
71	Hydrocensus Borehole (OKP045)	10	-101278.52	2416370.56
72	Hydrocensus Borehole (OKP008)	10	-98740.51	2416677.68
73	Hydrocensus Borehole (OKP015)	10	-97546.03	2416246.51
74	Hydrocensus Borehole (OKP004)	10	-101275.52	2414873.96
75	Hydrocensus Borehole (Deep Injection Well)	10	-101654.67	2417108.85
76	Hydrocensus Borehole (OKP013)	10	-100152.07	2417742.11
77	Hydrocensus Borehole (OKP056)	10	-102137.87	2417503.01
78	Buildings (Airport)	2	-93057.94	2418053.66
79	Okawayo River - Inside Pit 2 area	11	-101246.66	2416181.23
80	River	11	-105334.38	2413931.12

14 Blasting Operations

In order to evaluate the possible influence from blasting operations with regards to ground vibration, air blast and fly rock a planned blast design is required to determine possible influences. In the mining process blasting will definitely be required for the overburden material.

This report concentrates on the drilling and blasting of the overburden. Ore blasts requires significantly less explosives per unit than the overburden. The overburden blasts are then considered as a worst-case scenario and is used as indicator of possible influence.

Planned blast design technical information was provided and used for defining expected outcomes. Using this data provided JKSimblast blast design software was used to 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 summary technical information of the blast provided.

Table 6: Blast design technical information

Parameters	Units	Ore Blasts	Waste Blasts
Hole diameter	mm	102	102
Bench height	m	10	10
Explosive Type		Emulsion	Blend
Angle of the hole (90° is vertical)	°	90	90
Burden	m	2.9	2.9
Spacing	m	3.2	3.2
Stemming length	m	1.9	2
Sub-drill	m	0.7	0.7
Length of hole	m	10.7	10.7

Actual powder factor	kg/m ³	1	0.9
Mass of Explosive per hole	kg	90.82	83.23
Cubic metres blasted per hole	m ³	90.09	91.3
Mean fragmentation	cm	20	19

Evaluation of the blasting operations considered a minimum charge and a maximum charge. The minimum charge was derived from the 102 mm diameter single blast hole and the maximum charge was based on typical 4 blastholes detonating using shock tube initiation. The minimum charge relates to 90 kg and the maximum charge relates to 361 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 is as follows:

Factors:

a = 1143

b = -1.65

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

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

Based on the designs presented on expected drilling and charging design, the following Table 7 shows expected ground vibration levels (PPV) for various distances calculated at the two different charge masses. The charge masses are 90 kg and 361 kg for the Pit areas.

Table 7: Expected Ground Vibration at Various Distances from Charges Applied in this Study

No.	Distance (m)	Expected PPV (mm/s) for 90 kg Charge	Expected PPV (mm/s) for 361 kg Charge
1	50.0	73.6	231.6
2	100.0	37.7	118.6
3	150.0	12.0	37.8
4	200.0	7.5	23.5
5	250.0	5.2	16.3
6	300.0	3.8	12.0
7	400.0	2.4	7.5
8	500.0	1.6	5.2
9	600.0	1.2	3.8
10	700.0	0.9	3.0
11	800.0	0.8	2.4
12	900.0	0.6	2.0
13	1000.0	0.5	1.7
14	1250.0	0.4	1.1
15	1500.0	0.3	0.8
16	1750.0	0.2	0.7
17	2000.0	0.2	0.5
18	2500.0	0.1	0.4
19	3000.0	0.1	0.3
20	3500.0	0.1	0.2
21	4000.0	0.1	0.2
22	4500.0	0.0	0.1
23	5000.0	0.0	0.1
24	5500.0	0.0	0.1

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 influence on the outcome of air blast. Air blast is the direct result from the blast process, although influenced by meteorological conditions, wind strength and direction, the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result. Air blast is also an aspect that can be controlled to a great degree by applying basic rules.

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

Standard accepted prediction equations are applied for the prediction of air blast. A standard cube root scaling prediction formula is applied for air blast predictions. The following Equation 2 was used

to calculate possible air blast values in millibar. This equation does not take temperature or any weather conditions into account.

Equation 2:

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

Where:

P = Air blast level (mB)

D = Distance from source (m)

E = Maximum charge mass per delay (kg)

A = Constant - (14.3)

B = Constant – (-0.71)

The constants for A and B were then selected according to the information as provided in Figure 8 below. Various types of mining operations are expected to yield different results. The information provided in Figure 8 is based on detailed research that was conducted for each of the different types of mining environments. In this report, the data for “Metal Mine” was applied in the prediction of air blast.

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

Table 26.7 - Air overpressure prediction equations.

Figure 8: Proposed prediction equations

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

Equation 3:

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

Where:

p_s = Air blast level (dB)

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

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

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

As discussed earlier the prediction of air blast is very subjective. Following in Table 8 below is a summary of values predicted according to Equation 2.

Table 8: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) for 90 kg Charge	Air blast (dB) for 361 kg Charge
1	50.0	142.2	145.0
2	100.0	139.7	142.5
3	150.0	135.4	138.2
4	200.0	133.6	136.5
5	250.0	132.2	135.1
6	300.0	131.1	134.0
7	400.0	129.3	132.2
8	500.0	128.0	130.8
9	600.0	126.8	129.7
10	700.0	125.9	128.8
11	800.0	125.1	127.9
12	900.0	124.4	127.2
13	1000.0	123.7	126.6
14	1250.0	122.3	125.2
15	1500.0	121.2	124.1
16	1750.0	120.2	123.1
17	2000.0	119.4	122.3
18	2500.0	118.1	120.9
19	3000.0	116.9	119.8
20	3500.0	116.0	118.8
21	4000.0	115.1	118.0
22	4500.0	114.4	117.3
23	5000.0	113.8	116.7
24	5500.0	113.2	116.1

15 Construction Phase: Impact Assessment and Mitigation Measures

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

16 Operational Phase: Impact Assessment and Mitigation Measures

The area surrounding the proposed mining area was reviewed for structures, traffic, roads, human interface, animals' interface etc. Various installations and structures were observed. These are listed in Table 5. This section concentrates on the outcome of modelling the possible effects of ground

vibration, air blast and fly rock specifically to these points of interest or possible interfaces. In evaluation, the charge mass scenarios selected as indicated in section 14 is considered with regards to ground vibration and air blast.

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

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

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

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

16.1 Review of expected ground vibration

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

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

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

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

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

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

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

The whole project area is evaluated in the following order:

- Opencast 1
- Opencast 2
- Opencast 3

16.1.1 Ground vibration minimum charge mass per delay – Opencast 1 - 90 kg

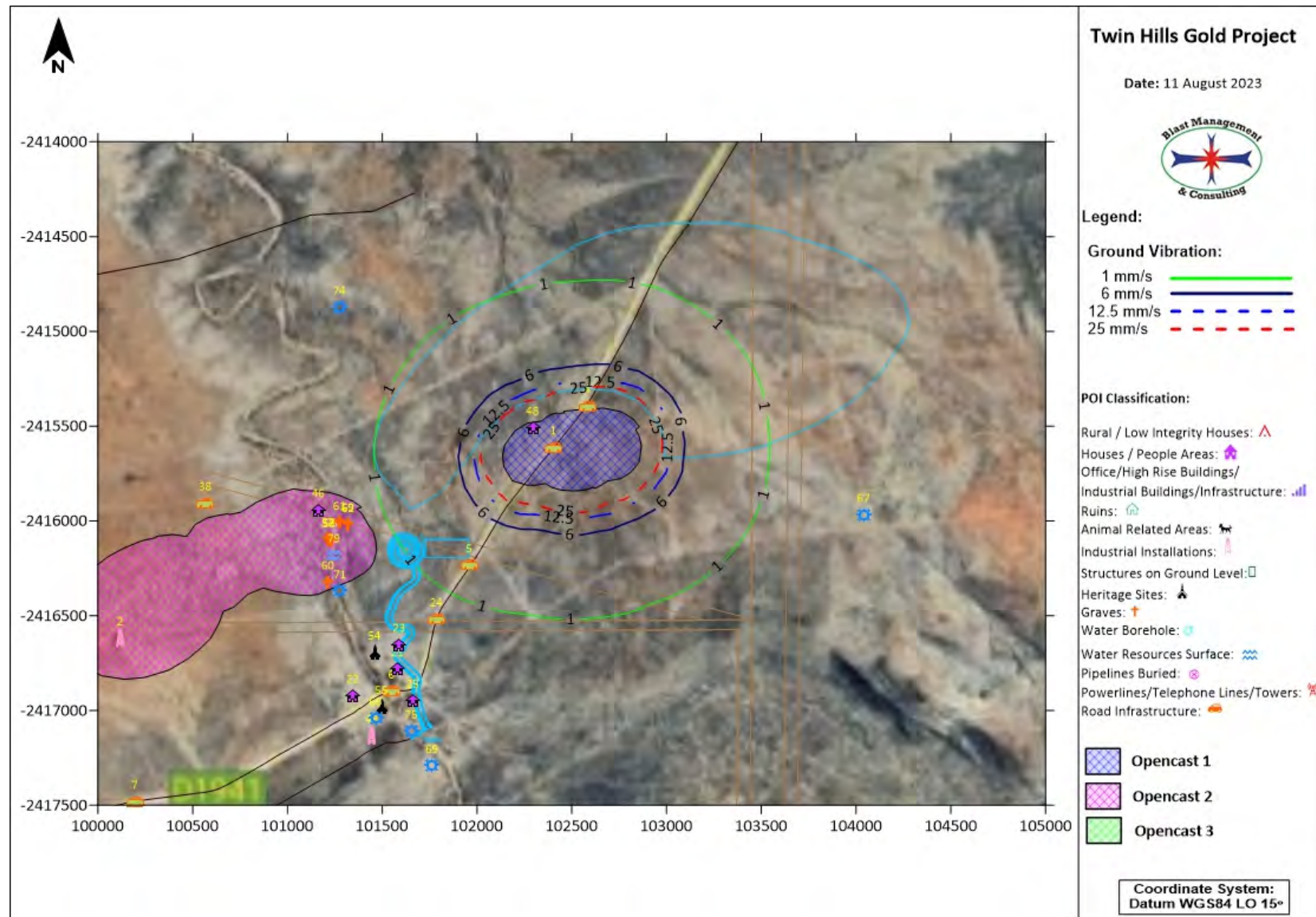


Figure 9: Ground vibration influence from minimum charge per delay – Opencast 1

Table 9: Ground vibration evaluation for minimum charge – Opencast 1

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Road (D1941) - Inside Pit 1 Area	150	-	90	-	-	-
2	Cement Dam - Inside Pit 2 Area	50	2217	90	0.1	Acceptable	N/A
3	Cement Dam	50	5932	90	0.0	Acceptable	N/A
4	Road (D1941)	150	17	90	458.4	Problematic	N/A
5	Road (D1941)	150	500	90	1.6	Acceptable	N/A
6	Road (D1941)	150	1280	90	0.3	Acceptable	N/A
7	Road (D1941)	150	2614	90	0.1	Acceptable	N/A
8	Road (D1941)	150	5780	90	0.0	Acceptable	N/A
9	Road (D1941)	150	6905	90	0.0	Acceptable	N/A
10	Road (C33)	150	7344	90	0.0	Acceptable	N/A
11	Landing Strip	150	8622	90	0.0	Acceptable	N/A
12	Water Reservoir	50	8654	90	0.0	Acceptable	N/A
13	Cement Dam	50	3384	90	0.1	Acceptable	N/A
14	Buildings/Structures	12.5	2859	90	0.1	Acceptable	Too Low
15	Farmstead	12.5	2769	90	0.1	Acceptable	Too Low
16	Farmstead	12.5	2182	90	0.1	Acceptable	Too Low
17	Buildings/Structures	12.5	2175	90	0.1	Acceptable	Too Low
18	Structure	12.5	2158	90	0.1	Acceptable	Too Low
19	Dam/Dam Wall	50	3034	90	0.1	Acceptable	N/A
20	Cement Dam	50	2799	90	0.1	Acceptable	N/A
21	Buildings/Structures	12.5	1165	90	0.4	Acceptable	Too Low
22	Buildings/Structures	12.5	1413	90	0.3	Acceptable	Too Low
23	Buildings/Structures	12.5	1052	90	0.5	Acceptable	Too Low
24	Road (D1941)	150	834	90	0.7	Acceptable	N/A
25	Buildings/Structures	12.5	1273	90	0.4	Acceptable	Too Low
26	Cement Dam	50	8763	90	0.0	Acceptable	N/A
27	Mine Activity	200	3949	90	0.1	Acceptable	N/A
28	Mine Buildings/Structures	25	4602	90	0.0	Acceptable	Too Low
29	Mine Buildings/Structures	25	7328	90	0.0	Acceptable	Too Low
30	Power Lines/Pylons	75	9133	90	0.0	Acceptable	N/A
31	Power Lines/Pylons	75	8262	90	0.0	Acceptable	N/A
32	Power Lines/Pylons	75	7519	90	0.0	Acceptable	N/A
33	Power Lines/Pylons	75	6823	90	0.0	Acceptable	N/A
34	Power Lines/Pylons	75	6322	90	0.0	Acceptable	N/A
35	Road (C33)	150	6650	90	0.0	Acceptable	N/A
36	Power Lines/Pylons	75	6134	90	0.0	Acceptable	N/A
37	Cement Dam	50	4211	90	0.0	Acceptable	N/A
38	Gravel Road	200	1585	90	0.2	Acceptable	N/A
39	Structure	12.5	3005	90	0.1	Acceptable	Too Low
40	Cement Dam	50	2664	90	0.1	Acceptable	N/A
41	Cement Dam	50	3073	90	0.1	Acceptable	N/A
42	Cement Dam	50	5360	90	0.0	Acceptable	N/A
43	Structure	12.5	5153	90	0.0	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
44	Rural Village/House	6	7714	90	0.0	Acceptable	Too Low
45	Rural Village/Houses	6	7537	90	0.0	Acceptable	Too Low
46	Structures - Inside Pit 2 Area	12.5	1004	90	0.5	Acceptable	Too Low
47	Structure	12.5	5330	90	0.0	Acceptable	Too Low
48	Structures - Inside Pit 1 Area	12.5	-	90	-	-	-
49	Cement Dam	50	1536	90	0.3	Acceptable	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	150	5572	90	0.0	Acceptable	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	150	7269	90	0.0	Acceptable	N/A
52	Heritage Site (Graves - Okawayo 478)	50	5660	90	0.0	Acceptable	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	150	7281	90	0.0	Acceptable	N/A
54	Heritage Site (Farm Building - Okawayo 480)	6	1162	90	0.4	Acceptable	Too Low
55	Heritage Site (Historical Farmstead - Okawayo 481)	6	1378	90	0.3	Acceptable	Too Low
56	Heritage Site (Graves) - Inside Pit 2 area	50	990	90	0.5	Acceptable	N/A
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	1003	90	0.5	Acceptable	N/A
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	1001	90	0.5	Acceptable	N/A
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	877	90	0.7	Acceptable	N/A
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	1108	90	0.4	Acceptable	N/A
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	915	90	0.6	Acceptable	N/A
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	877	90	0.7	Acceptable	N/A
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	7281	90	0.0	Acceptable	N/A
64	Hydrocensus Borehole (Klein Oka 1)	50	2365	90	0.1	Acceptable	N/A
65	Hydrocensus Borehole (Klein Oka 2)	50	2754	90	0.1	Acceptable	N/A
66	Hydrocensus Borehole (Oka 7)	50	1445	90	0.3	Acceptable	N/A
67	Hydrocensus Borehole (Oka12)	50	1216	90	0.4	Acceptable	N/A
68	Hydrocensus Borehole (Twin 6)	50	3045	90	0.1	Acceptable	N/A
69	Hydrocensus Borehole (BH3)	50	1562	90	0.3	Acceptable	N/A
70	Hydrocensus Borehole (OKP040)	50	1745	90	0.2	Acceptable	N/A
71	Hydrocensus Borehole (OKP045)	50	1078	90	0.5	Acceptable	N/A
72	Hydrocensus Borehole (OKP008)	50	3535	90	0.1	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
73	Hydrocensus Borehole (OKP015)	50	4626	90	0.0	Acceptable	N/A
74	Hydrocensus Borehole (OKP004)	50	1131	90	0.4	Acceptable	N/A
75	Hydrocensus Borehole (Deep Injection Well)	50	1424	90	0.3	Acceptable	N/A
76	Hydrocensus Borehole (OKP013)	50	2821	90	0.1	Acceptable	N/A
77	Hydrocensus Borehole (OKP056)	50	1694	90	0.2	Acceptable	N/A
78	Buildings (Airport)	12.5	9381	90	0.0	Acceptable	Too Low
79	Okawayo River - Inside Pit 2 area	200	1010	90	0.5	Acceptable	N/A
80	River	200	2935	90	0.1	Acceptable	N/A

16.1.2 Ground vibration maximum charge mass per delay – Opencast 1 - 361 kg

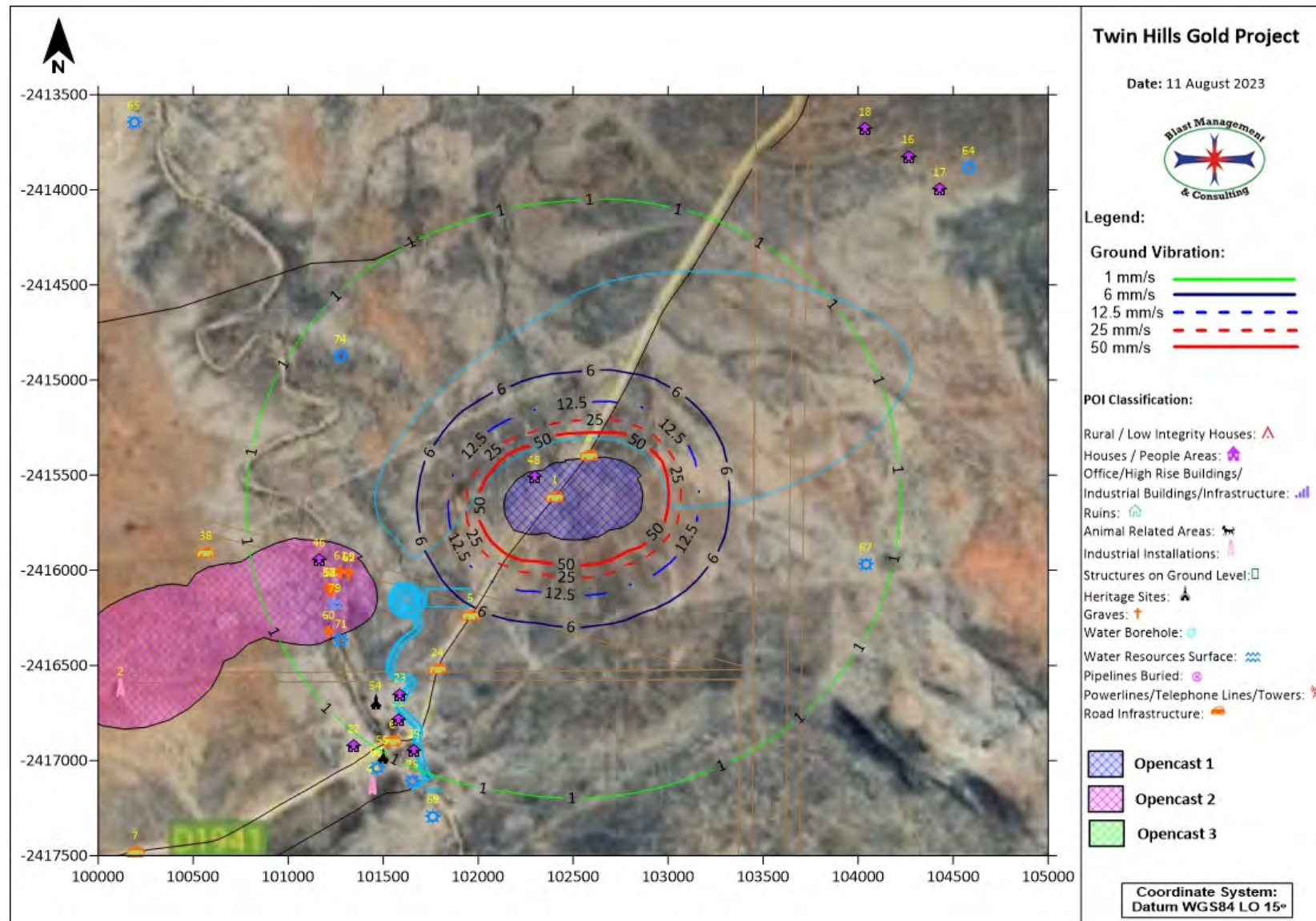


Figure 10: Ground vibration influence from maximum charge per delay – Opencast 1

Table 10: Ground vibration evaluation for maximum charge – Opencast 1

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Road (D1941) - Inside Pit 1 Area	150	-	361	-	-	-
2	Cement Dam - Inside Pit 2 Area	50	2217	361	0.4	Acceptable	N/A
3	Cement Dam	50	5932	361	0.1	Acceptable	N/A
4	Road (D1941)	150	17	361	1441.8	Problematic	N/A
5	Road (D1941)	150	500	361	5.2	Acceptable	N/A
6	Road (D1941)	150	1280	361	1.1	Acceptable	N/A
7	Road (D1941)	150	2614	361	0.3	Acceptable	N/A
8	Road (D1941)	150	5780	361	0.1	Acceptable	N/A
9	Road (D1941)	150	6905	361	0.1	Acceptable	N/A
10	Road (C33)	150	7344	361	0.1	Acceptable	N/A
11	Landing Strip	150	8622	361	0.0	Acceptable	N/A
12	Water Reservoir	50	8654	361	0.0	Acceptable	N/A
13	Cement Dam	50	3384	361	0.2	Acceptable	N/A
14	Buildings/Structures	12.5	2859	361	0.3	Acceptable	Too Low
15	Farmstead	12.5	2769	361	0.3	Acceptable	Too Low
16	Farmstead	12.5	2182	361	0.5	Acceptable	Too Low
17	Buildings/Structures	12.5	2175	361	0.5	Acceptable	Too Low
18	Structure	12.5	2158	361	0.5	Acceptable	Too Low
19	Dam/Dam Wall	50	3034	361	0.3	Acceptable	N/A
20	Cement Dam	50	2799	361	0.3	Acceptable	N/A
21	Buildings/Structures	12.5	1165	361	1.3	Acceptable	Perceptible
22	Buildings/Structures	12.5	1413	361	0.9	Acceptable	Perceptible
23	Buildings/Structures	12.5	1052	361	1.5	Acceptable	Perceptible
24	Road (D1941)	150	834	361	2.2	Acceptable	N/A
25	Buildings/Structures	12.5	1273	361	1.1	Acceptable	Perceptible
26	Cement Dam	50	8763	361	0.0	Acceptable	N/A
27	Mine Activity	200	3949	361	0.2	Acceptable	N/A
28	Mine Buildings/Structures	25	4602	361	0.1	Acceptable	Too Low
29	Mine Buildings/Structures	25	7328	361	0.1	Acceptable	Too Low
30	Power Lines/Pylons	75	9133	361	0.0	Acceptable	N/A
31	Power Lines/Pylons	75	8262	361	0.1	Acceptable	N/A
32	Power Lines/Pylons	75	7519	361	0.1	Acceptable	N/A
33	Power Lines/Pylons	75	6823	361	0.1	Acceptable	N/A
34	Power Lines/Pylons	75	6322	361	0.1	Acceptable	N/A
35	Road (C33)	150	6650	361	0.1	Acceptable	N/A
36	Power Lines/Pylons	75	6134	361	0.1	Acceptable	N/A
37	Cement Dam	50	4211	361	0.2	Acceptable	N/A
38	Gravel Road	200	1585	361	0.8	Acceptable	N/A
39	Structure	12.5	3005	361	0.3	Acceptable	Too Low
40	Cement Dam	50	2664	361	0.3	Acceptable	N/A
41	Cement Dam	50	3073	361	0.3	Acceptable	N/A
42	Cement Dam	50	5360	361	0.1	Acceptable	N/A
43	Structure	12.5	5153	361	0.1	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
44	Rural Village/House	6	7714	361	0.1	Acceptable	Too Low
45	Rural Village/Houses	6	7537	361	0.1	Acceptable	Too Low
46	Structures - Inside Pit 2 Area	12.5	1004	361	1.6	Acceptable	Perceptible
47	Structure	12.5	5330	361	0.1	Acceptable	Too Low
48	Structures - Inside Pit 1 Area	12.5	-	361	-	-	-
49	Cement Dam	50	1536	361	0.8	Acceptable	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	150	5572	361	0.1	Acceptable	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	150	7269	361	0.1	Acceptable	N/A
52	Heritage Site (Graves - Okawayo 478)	50	5660	361	0.1	Acceptable	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	150	7281	361	0.1	Acceptable	N/A
54	Heritage Site (Farm Building - Okawayo 480)	6	1162	361	1.3	Acceptable	Perceptible
55	Heritage Site (Historical Farmstead - Okawayo 481)	6	1378	361	1.0	Acceptable	Perceptible
56	Heritage Site (Graves) - Inside Pit 2 area	50	990	361	1.7	Acceptable	N/A
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	1003	361	1.6	Acceptable	N/A
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	1001	361	1.6	Acceptable	N/A
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	877	361	2.1	Acceptable	N/A
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	1108	361	1.4	Acceptable	N/A
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	915	361	1.9	Acceptable	N/A
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	877	361	2.1	Acceptable	N/A
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	7281	361	0.1	Acceptable	N/A
64	Hydrocensus Borehole (Klein Oka 1)	50	2365	361	0.4	Acceptable	N/A
65	Hydrocensus Borehole (Klein Oka 2)	50	2754	361	0.3	Acceptable	N/A
66	Hydrocensus Borehole (Oka 7)	50	1445	361	0.9	Acceptable	N/A
67	Hydrocensus Borehole (Oka12)	50	1216	361	1.2	Acceptable	N/A
68	Hydrocensus Borehole (Twin 6)	50	3045	361	0.3	Acceptable	N/A
69	Hydrocensus Borehole (BH3)	50	1562	361	0.8	Acceptable	N/A
70	Hydrocensus Borehole (OKP040)	50	1745	361	0.7	Acceptable	N/A
71	Hydrocensus Borehole (OKP045)	50	1078	361	1.5	Acceptable	N/A
72	Hydrocensus Borehole (OKP008)	50	3535	361	0.2	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
73	Hydrocensus Borehole (OKP015)	50	4626	361	0.1	Acceptable	N/A
74	Hydrocensus Borehole (OKP004)	50	1131	361	1.3	Acceptable	N/A
75	Hydrocensus Borehole (Deep Injection Well)	50	1424	361	0.9	Acceptable	N/A
76	Hydrocensus Borehole (OKP013)	50	2821	361	0.3	Acceptable	N/A
77	Hydrocensus Borehole (OKP056)	50	1694	361	0.7	Acceptable	N/A
78	Buildings (Airport)	12.5	9381	361	0.0	Acceptable	Too Low
79	Okawayo River - Inside Pit 2 area	200	1010	361	1.6	Acceptable	N/A
80	River	200	2935	361	0.3	Acceptable	N/A

16.1.3 Ground vibration minimum charge mass per delay – Opencast 2 - 90 kg

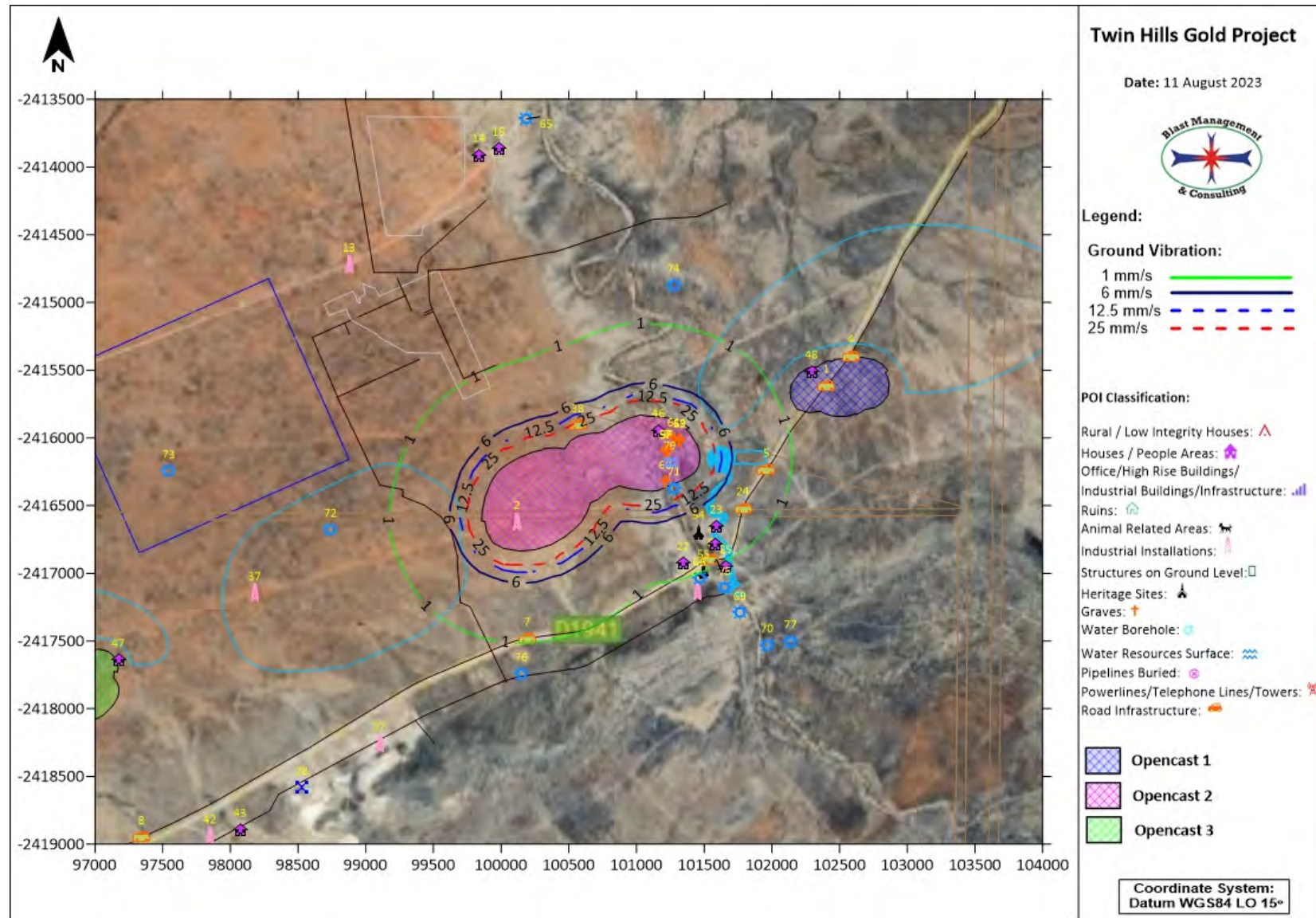


Figure 11: Ground vibration influence from minimum charge per delay – Opencast 2

Table 11: Ground vibration evaluation for minimum charge – Opencast 2

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Road (D1941) - Inside Pit 1 Area	150	1052	90	0.5	Acceptable	N/A
2	Cement Dam - Inside Pit 2 Area	50	-	90	-	-	-
3	Cement Dam	50	3481	90	0.1	Acceptable	N/A
4	Road (D1941)	150	1310	90	0.3	Acceptable	N/A
5	Road (D1941)	150	497	90	1.7	Acceptable	N/A
6	Road (D1941)	150	622	90	1.2	Acceptable	N/A
7	Road (D1941)	150	649	90	1.1	Acceptable	N/A
8	Road (D1941)	150	3387	90	0.1	Acceptable	N/A
9	Road (D1941)	150	4496	90	0.0	Acceptable	N/A
10	Road (C33)	150	4960	90	0.0	Acceptable	N/A
11	Landing Strip	150	6228	90	0.0	Acceptable	N/A
12	Water Reservoir	50	6237	90	0.0	Acceptable	N/A
13	Cement Dam	50	1881	90	0.2	Acceptable	N/A
14	Buildings/Structures	12.5	2201	90	0.1	Acceptable	Too Low
15	Farmstead	12.5	2200	90	0.1	Acceptable	Too Low
16	Farmstead	12.5	3564	90	0.1	Acceptable	Too Low
17	Buildings/Structures	12.5	3604	90	0.1	Acceptable	Too Low
18	Structure	12.5	3476	90	0.1	Acceptable	Too Low
19	Dam/Dam Wall	50	4234	90	0.0	Acceptable	N/A
20	Cement Dam	50	4222	90	0.0	Acceptable	N/A
21	Buildings/Structures	12.5	528	90	1.5	Acceptable	Perceptible
22	Buildings/Structures	12.5	566	90	1.3	Acceptable	Perceptible
23	Buildings/Structures	12.5	420	90	2.2	Acceptable	Perceptible
24	Road (D1941)	150	444	90	2.0	Acceptable	N/A
25	Buildings/Structures	12.5	711	90	0.9	Acceptable	Perceptible
26	Cement Dam	50	6383	90	0.0	Acceptable	N/A
27	Mine Activity	200	1700	90	0.2	Acceptable	N/A
28	Mine Buildings/Structures	25	2295	90	0.1	Acceptable	Too Low
29	Mine Buildings/Structures	25	4998	90	0.0	Acceptable	Too Low
30	Power Lines/Pylons	75	6687	90	0.0	Acceptable	N/A
31	Power Lines/Pylons	75	5834	90	0.0	Acceptable	N/A
32	Power Lines/Pylons	75	5122	90	0.0	Acceptable	N/A
33	Power Lines/Pylons	75	4499	90	0.0	Acceptable	N/A
34	Power Lines/Pylons	75	4206	90	0.0	Acceptable	N/A
35	Road (C33)	150	4373	90	0.0	Acceptable	N/A
36	Power Lines/Pylons	75	4284	90	0.0	Acceptable	N/A
37	Cement Dam	50	1757	90	0.2	Acceptable	N/A
38	Gravel Road	200	77	90	36.0	Acceptable	N/A
39	Structure	12.5	2857	90	0.1	Acceptable	Too Low
40	Cement Dam	50	3176	90	0.1	Acceptable	N/A
41	Cement Dam	50	4373	90	0.0	Acceptable	N/A
42	Cement Dam	50	3012	90	0.1	Acceptable	N/A
43	Structure	12.5	2825	90	0.1	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
44	Rural Village/House	6	5259	90	0.0	Acceptable	Too Low
45	Rural Village/Houses	6	5083	90	0.0	Acceptable	Too Low
46	Structures - Inside Pit 2 Area	12.5	-	90	-	-	-
47	Structure	12.5	2874	90	0.1	Acceptable	Too Low
48	Structures - Inside Pit 1 Area	12.5	999	90	0.5	Acceptable	Too Low
49	Cement Dam	50	800	90	0.8	Acceptable	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	150	3363	90	0.1	Acceptable	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	150	5274	90	0.0	Acceptable	N/A
52	Heritage Site (Graves - Okawayo 478)	50	3479	90	0.1	Acceptable	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	150	5000	90	0.0	Acceptable	N/A
54	Heritage Site (Farm Building - Okawayo 480)	6	398	90	2.4	Acceptable	Perceptible
55	Heritage Site (Historical Farmstead - Okawayo 481)	6	678	90	1.0	Acceptable	Perceptible
56	Heritage Site (Graves) - Inside Pit 2 area	50	-	90	-	-	-
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	90	-	-	-
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	90	-	-	-
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	90	-	-	-
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	90	-	-	-
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	90	-	-	-
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	90	-	-	-
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	90	-	-	-
64	Hydrocensus Borehole (Klein Oka 1)	50	3794	90	0.1	Acceptable	N/A
65	Hydrocensus Borehole (Klein Oka 2)	50	2337	90	0.1	Acceptable	N/A
66	Hydrocensus Borehole (Oka 7)	50	721	90	0.9	Acceptable	N/A
67	Hydrocensus Borehole (Oka12)	50	2578	90	0.1	Acceptable	N/A
68	Hydrocensus Borehole (Twin 6)	50	4234	90	0.0	Acceptable	N/A
69	Hydrocensus Borehole (BH3)	50	1068	90	0.5	Acceptable	N/A
70	Hydrocensus Borehole (OKP040)	50	1369	90	0.3	Acceptable	N/A
71	Hydrocensus Borehole (OKP045)	50	30	90	174.4	Problematic	N/A
72	Hydrocensus Borehole (OKP008)	50	1118	90	0.4	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
73	Hydrocensus Borehole (OKP015)	50	2332	90	0.1	Acceptable	N/A
74	Hydrocensus Borehole (OKP004)	50	975	90	0.5	Acceptable	N/A
75	Hydrocensus Borehole (Deep Injection Well)	50	856	90	0.7	Acceptable	N/A
76	Hydrocensus Borehole (OKP013)	50	907	90	0.6	Acceptable	N/A
77	Hydrocensus Borehole (OKP056)	50	1431	90	0.3	Acceptable	N/A
78	Buildings (Airport)	12.5	6949	90	0.0	Acceptable	Too Low
79	Okawayo River - Inside Pit 2 area	200	-	90	-	-	-
80	River	200	4423	90	0.0	Acceptable	N/A

16.1.4 Ground vibration maximum charge mass per delay – Opencast 2 - 361 kg

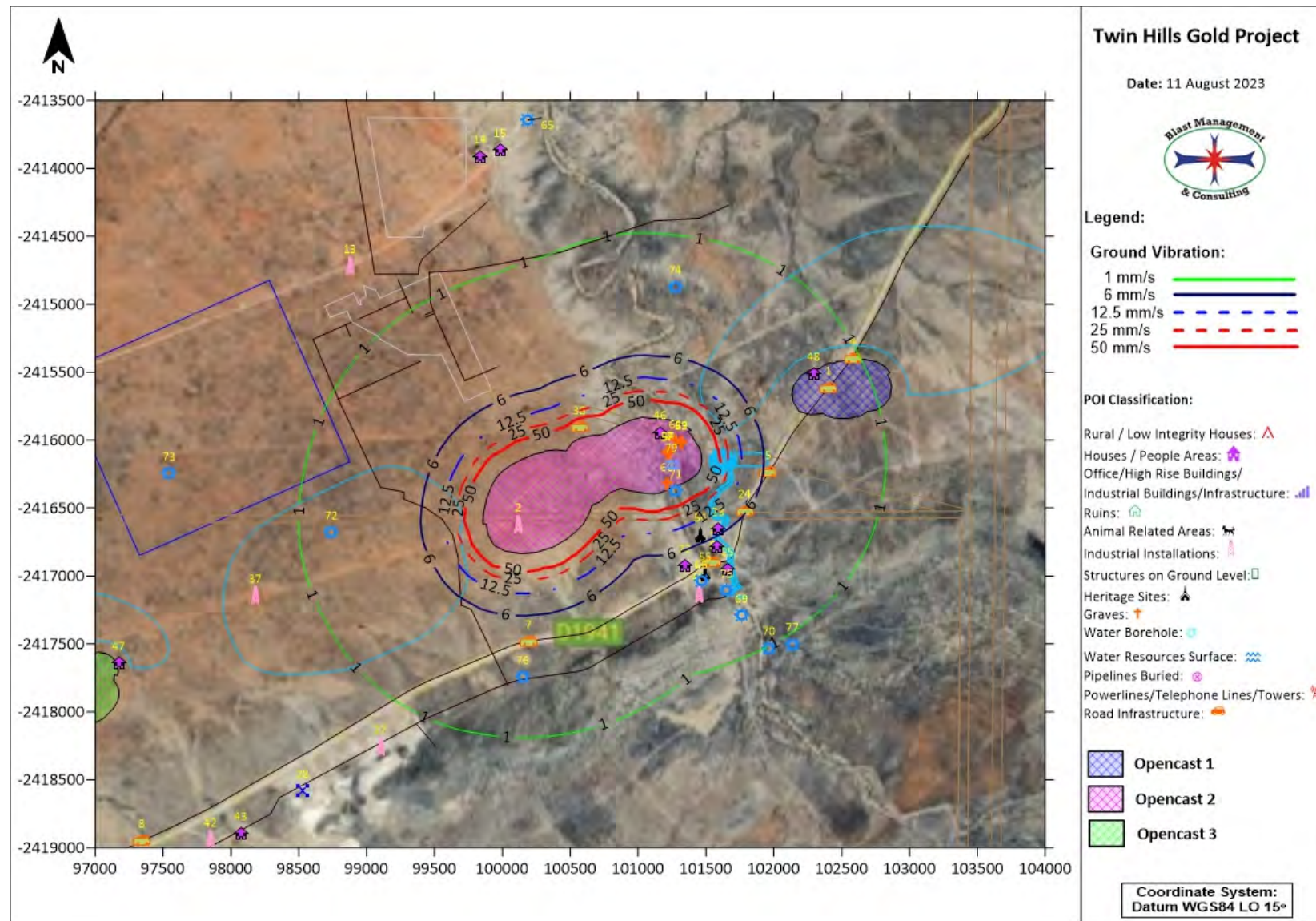


Figure 12: Ground vibration influence from maximum charge per delay – Opencast 2

Table 12: Ground vibration evaluation for maximum charge – Opencast 2

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Road (D1941) - Inside Pit 1 Area	150	1052	361	1.5	Acceptable	N/A
2	Cement Dam - Inside Pit 2 Area	50	-	361	-	-	-
3	Cement Dam	50	3481	361	0.2	Acceptable	N/A
4	Road (D1941)	150	1310	361	1.1	Acceptable	N/A
5	Road (D1941)	150	497	361	5.2	Acceptable	N/A
6	Road (D1941)	150	622	361	3.6	Acceptable	N/A
7	Road (D1941)	150	649	361	3.4	Acceptable	N/A
8	Road (D1941)	150	3387	361	0.2	Acceptable	N/A
9	Road (D1941)	150	4496	361	0.1	Acceptable	N/A
10	Road (C33)	150	4960	361	0.1	Acceptable	N/A
11	Landing Strip	150	6228	361	0.1	Acceptable	N/A
12	Water Reservoir	50	6237	361	0.1	Acceptable	N/A
13	Cement Dam	50	1881	361	0.6	Acceptable	N/A
14	Buildings/Structures	12.5	2201	361	0.4	Acceptable	Too Low
15	Farmstead	12.5	2200	361	0.4	Acceptable	Too Low
16	Farmstead	12.5	3564	361	0.2	Acceptable	Too Low
17	Buildings/Structures	12.5	3604	361	0.2	Acceptable	Too Low
18	Structure	12.5	3476	361	0.2	Acceptable	Too Low
19	Dam/Dam Wall	50	4234	361	0.2	Acceptable	N/A
20	Cement Dam	50	4222	361	0.2	Acceptable	N/A
21	Buildings/Structures	12.5	528	361	4.7	Acceptable	Perceptible
22	Buildings/Structures	12.5	566	361	4.2	Acceptable	Perceptible
23	Buildings/Structures	12.5	420	361	6.9	Acceptable	Unpleasant
24	Road (D1941)	150	444	361	6.3	Acceptable	N/A
25	Buildings/Structures	12.5	711	361	2.9	Acceptable	Perceptible
26	Cement Dam	50	6383	361	0.1	Acceptable	N/A
27	Mine Activity	200	1700	361	0.7	Acceptable	N/A
28	Mine Buildings/Structures	25	2295	361	0.4	Acceptable	Too Low
29	Mine Buildings/Structures	25	4998	361	0.1	Acceptable	Too Low
30	Power Lines/Pylons	75	6687	361	0.1	Acceptable	N/A
31	Power Lines/Pylons	75	5834	361	0.1	Acceptable	N/A
32	Power Lines/Pylons	75	5122	361	0.1	Acceptable	N/A
33	Power Lines/Pylons	75	4499	361	0.1	Acceptable	N/A
34	Power Lines/Pylons	75	4206	361	0.2	Acceptable	N/A
35	Road (C33)	150	4373	361	0.1	Acceptable	N/A
36	Power Lines/Pylons	75	4284	361	0.1	Acceptable	N/A
37	Cement Dam	50	1757	361	0.7	Acceptable	N/A
38	Gravel Road	200	77	361	113.3	Acceptable	N/A
39	Structure	12.5	2857	361	0.3	Acceptable	Too Low
40	Cement Dam	50	3176	361	0.2	Acceptable	N/A
41	Cement Dam	50	4373	361	0.1	Acceptable	N/A
42	Cement Dam	50	3012	361	0.3	Acceptable	N/A
43	Structure	12.5	2825	361	0.3	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
44	Rural Village/House	6	5259	361	0.1	Acceptable	Too Low
45	Rural Village/Houses	6	5083	361	0.1	Acceptable	Too Low
46	Structures - Inside Pit 2 Area	12.5	-	361	-	-	-
47	Structure	12.5	2874	361	0.3	Acceptable	Too Low
48	Structures - Inside Pit 1 Area	12.5	999	361	1.7	Acceptable	Perceptible
49	Cement Dam	50	800	361	2.4	Acceptable	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	150	3363	361	0.2	Acceptable	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	150	5274	361	0.1	Acceptable	N/A
52	Heritage Site (Graves - Okawayo 478)	50	3479	361	0.2	Acceptable	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	150	5000	361	0.1	Acceptable	N/A
54	Heritage Site (Farm Building - Okawayo 480)	6	398	361	7.5	Problematic	Unpleasant
55	Heritage Site (Historical Farmstead - Okawayo 481)	6	678	361	3.1	Acceptable	Perceptible
56	Heritage Site (Graves) - Inside Pit 2 area	50	-	361	-	-	-
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	361	-	-	-
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	361	-	-	-
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	361	-	-	-
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	361	-	-	-
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	361	-	-	-
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	361	-	-	-
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	-	361	-	-	-
64	Hydrocensus Borehole (Klein Oka 1)	50	3794	361	0.2	Acceptable	N/A
65	Hydrocensus Borehole (Klein Oka 2)	50	2337	361	0.4	Acceptable	N/A
66	Hydrocensus Borehole (Oka 7)	50	721	361	2.8	Acceptable	N/A
67	Hydrocensus Borehole (Oka12)	50	2578	361	0.3	Acceptable	N/A
68	Hydrocensus Borehole (Twin 6)	50	4234	361	0.2	Acceptable	N/A
69	Hydrocensus Borehole (BH3)	50	1068	361	1.5	Acceptable	N/A
70	Hydrocensus Borehole (OKP040)	50	1369	361	1.0	Acceptable	N/A
71	Hydrocensus Borehole (OKP045)	50	30	361	548.4	Problematic	N/A
72	Hydrocensus Borehole (OKP008)	50	1118	361	1.4	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
73	Hydrocensus Borehole (OKP015)	50	2332	361	0.4	Acceptable	N/A
74	Hydrocensus Borehole (OKP004)	50	975	361	1.7	Acceptable	N/A
75	Hydrocensus Borehole (Deep Injection Well)	50	856	361	2.1	Acceptable	N/A
76	Hydrocensus Borehole (OKP013)	50	907	361	1.9	Acceptable	N/A
77	Hydrocensus Borehole (OKP056)	50	1431	361	0.9	Acceptable	N/A
78	Buildings (Airport)	12.5	6949	361	0.1	Acceptable	Too Low
79	Okawayo River - Inside Pit 2 area	200	-	361	-	-	-
80	River	200	4423	361	0.1	Acceptable	N/A

16.1.5 Ground vibration minimum charge mass per delay – Opencast 3 - 90 kg

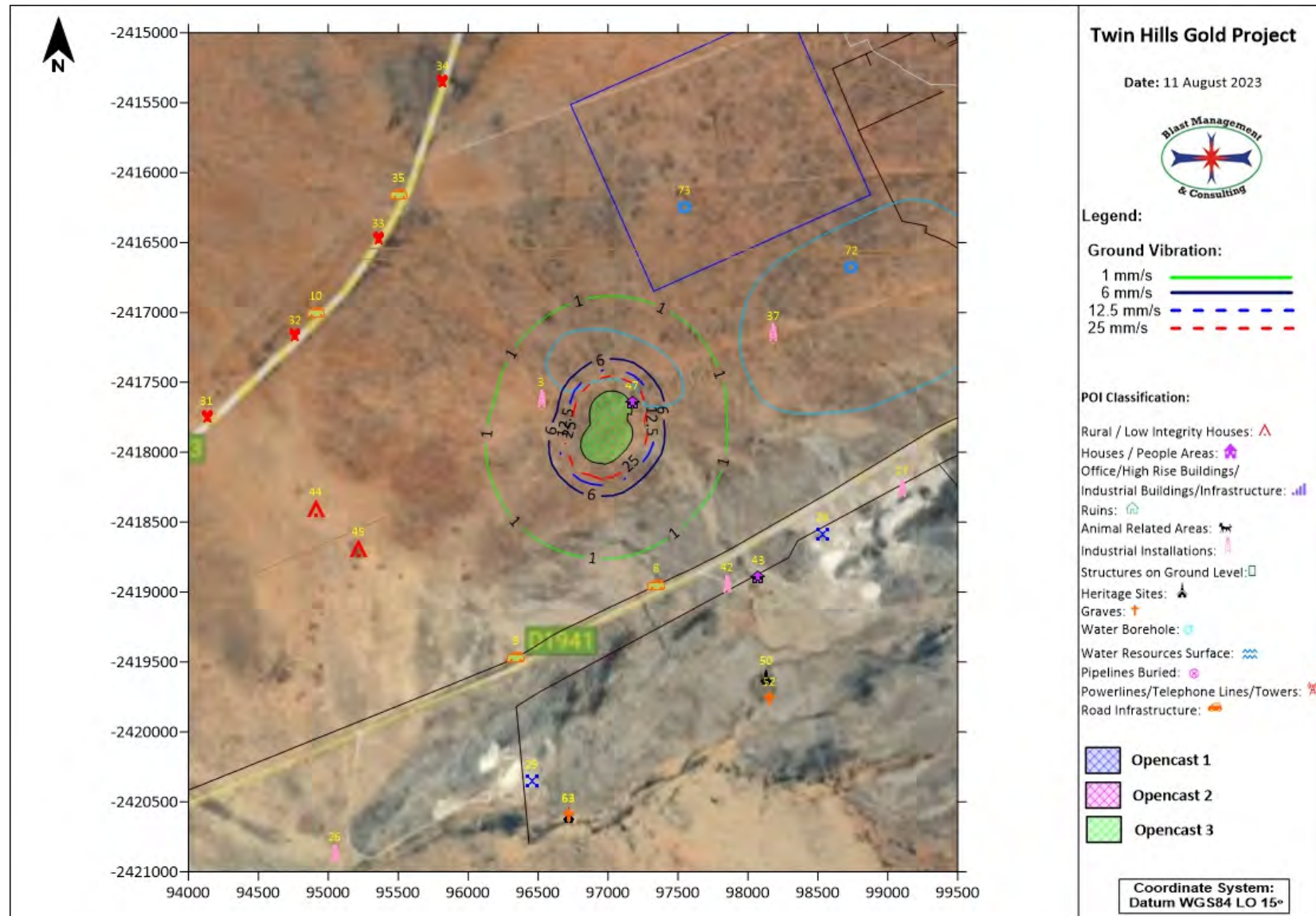


Figure 13: Ground vibration influence from minimum charge per delay – Opencast 3

Table 13: Ground vibration evaluation for minimum charge – Opencast 3

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Road (D1941) - Inside Pit 1 Area	150	5624	90	0.0	Acceptable	N/A
2	Cement Dam - Inside Pit 2 Area	50	3130	90	0.1	Acceptable	N/A
3	Cement Dam	50	355	90	2.9	Acceptable	N/A
4	Road (D1941)	150	5872	90	0.0	Acceptable	N/A
5	Road (D1941)	150	5001	90	0.0	Acceptable	N/A
6	Road (D1941)	150	4448	90	0.0	Acceptable	N/A
7	Road (D1941)	150	3033	90	0.1	Acceptable	N/A
8	Road (D1941)	150	935	90	0.6	Acceptable	N/A
9	Road (D1941)	150	1502	90	0.3	Acceptable	N/A
10	Road (C33)	150	2075	90	0.2	Acceptable	N/A
11	Landing Strip	150	3202	90	0.1	Acceptable	N/A
12	Water Reservoir	50	3121	90	0.1	Acceptable	N/A
13	Cement Dam	50	3370	90	0.1	Acceptable	N/A
14	Buildings/Structures	12.5	4578	90	0.0	Acceptable	Too Low
15	Farmstead	12.5	4702	90	0.0	Acceptable	Too Low
16	Farmstead	12.5	8067	90	0.0	Acceptable	Too Low
17	Buildings/Structures	12.5	8135	90	0.0	Acceptable	Too Low
18	Structure	12.5	7940	90	0.0	Acceptable	Too Low
19	Dam/Dam Wall	50	8505	90	0.0	Acceptable	N/A
20	Cement Dam	50	8727	90	0.0	Acceptable	N/A
21	Buildings/Structures	12.5	4500	90	0.0	Acceptable	Too Low
22	Buildings/Structures	12.5	4243	90	0.0	Acceptable	Too Low
23	Buildings/Structures	12.5	4536	90	0.0	Acceptable	Too Low
24	Road (D1941)	150	4759	90	0.0	Acceptable	N/A
25	Buildings/Structures	12.5	4549	90	0.0	Acceptable	Too Low
26	Cement Dam	50	3349	90	0.1	Acceptable	N/A
27	Mine Activity	200	1962	90	0.2	Acceptable	N/A
28	Mine Buildings/Structures	25	1519	90	0.3	Acceptable	Too Low
29	Mine Buildings/Structures	25	2323	90	0.1	Acceptable	Too Low
30	Power Lines/Pylons	75	3420	90	0.1	Acceptable	N/A
31	Power Lines/Pylons	75	2681	90	0.1	Acceptable	N/A
32	Power Lines/Pylons	75	2173	90	0.1	Acceptable	N/A
33	Power Lines/Pylons	75	1926	90	0.2	Acceptable	N/A
34	Power Lines/Pylons	75	2506	90	0.1	Acceptable	N/A
35	Road (C33)	150	2025	90	0.2	Acceptable	N/A
36	Power Lines/Pylons	75	3373	90	0.1	Acceptable	N/A
37	Cement Dam	50	1138	90	0.4	Acceptable	N/A
38	Gravel Road	200	3827	90	0.1	Acceptable	N/A
39	Structure	12.5	5717	90	0.0	Acceptable	Too Low
40	Cement Dam	50	6893	90	0.0	Acceptable	N/A
41	Cement Dam	50	8745	90	0.0	Acceptable	N/A
42	Cement Dam	50	1195	90	0.4	Acceptable	N/A
43	Structure	12.5	1315	90	0.3	Acceptable	Too Low

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
44	Rural Village/House	6	1943	90	0.2	Acceptable	Too Low
45	Rural Village/Houses	6	1741	90	0.2	Acceptable	Too Low
46	Structures - Inside Pit 2 Area	12.5	4352	90	0.0	Acceptable	Too Low
47	Structure	12.5	14	90	572.7	Problematic	Intolerable
48	Structures - Inside Pit 1 Area	12.5	5561	90	0.0	Acceptable	Too Low
49	Cement Dam	50	4311	90	0.0	Acceptable	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	150	1895	90	0.2	Acceptable	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	150	3654	90	0.1	Acceptable	N/A
52	Heritage Site (Graves - Okawayo 478)	50	2033	90	0.2	Acceptable	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	150	2521	90	0.1	Acceptable	N/A
54	Heritage Site (Farm Building - Okawayo 480)	6	4401	90	0.0	Acceptable	Too Low
55	Heritage Site (Historical Farmstead - Okawayo 481)	6	4382	90	0.0	Acceptable	Too Low
56	Heritage Site (Graves) - Inside Pit 2 area	50	4353	90	0.0	Acceptable	N/A
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4340	90	0.0	Acceptable	N/A
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4342	90	0.0	Acceptable	N/A
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4466	90	0.0	Acceptable	N/A
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4264	90	0.0	Acceptable	N/A
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4429	90	0.0	Acceptable	N/A
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4466	90	0.0	Acceptable	N/A
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	2521	90	0.1	Acceptable	N/A
64	Hydrocensus Borehole (Klein Oka 1)	50	8323	90	0.0	Acceptable	N/A
65	Hydrocensus Borehole (Klein Oka 2)	50	5003	90	0.0	Acceptable	N/A
66	Hydrocensus Borehole (Oka 7)	50	4343	90	0.0	Acceptable	N/A
67	Hydrocensus Borehole (Oka12)	50	7079	90	0.0	Acceptable	N/A
68	Hydrocensus Borehole (Twin 6)	50	8492	90	0.0	Acceptable	N/A
69	Hydrocensus Borehole (BH3)	50	4611	90	0.0	Acceptable	N/A
70	Hydrocensus Borehole (OKP040)	50	4798	90	0.0	Acceptable	N/A
71	Hydrocensus Borehole (OKP045)	50	4309	90	0.0	Acceptable	N/A
72	Hydrocensus Borehole (OKP008)	50	1853	90	0.2	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
73	Hydrocensus Borehole (OKP015)	50	1405	90	0.3	Acceptable	N/A
74	Hydrocensus Borehole (OKP004)	50	4961	90	0.0	Acceptable	N/A
75	Hydrocensus Borehole (Deep Injection Well)	50	4520	90	0.0	Acceptable	N/A
76	Hydrocensus Borehole (OKP013)	50	2979	90	0.1	Acceptable	N/A
77	Hydrocensus Borehole (OKP056)	50	4971	90	0.0	Acceptable	N/A
78	Buildings (Airport)	12.5	3747	90	0.1	Acceptable	Too Low
79	Okawayo River - Inside Pit 2 area	200	4340	90	0.0	Acceptable	N/A
80	River	200	8979	90	0.0	Acceptable	N/A

16.1.6 Ground vibration maximum charge mass per delay – Opencast 3 - 361 kg

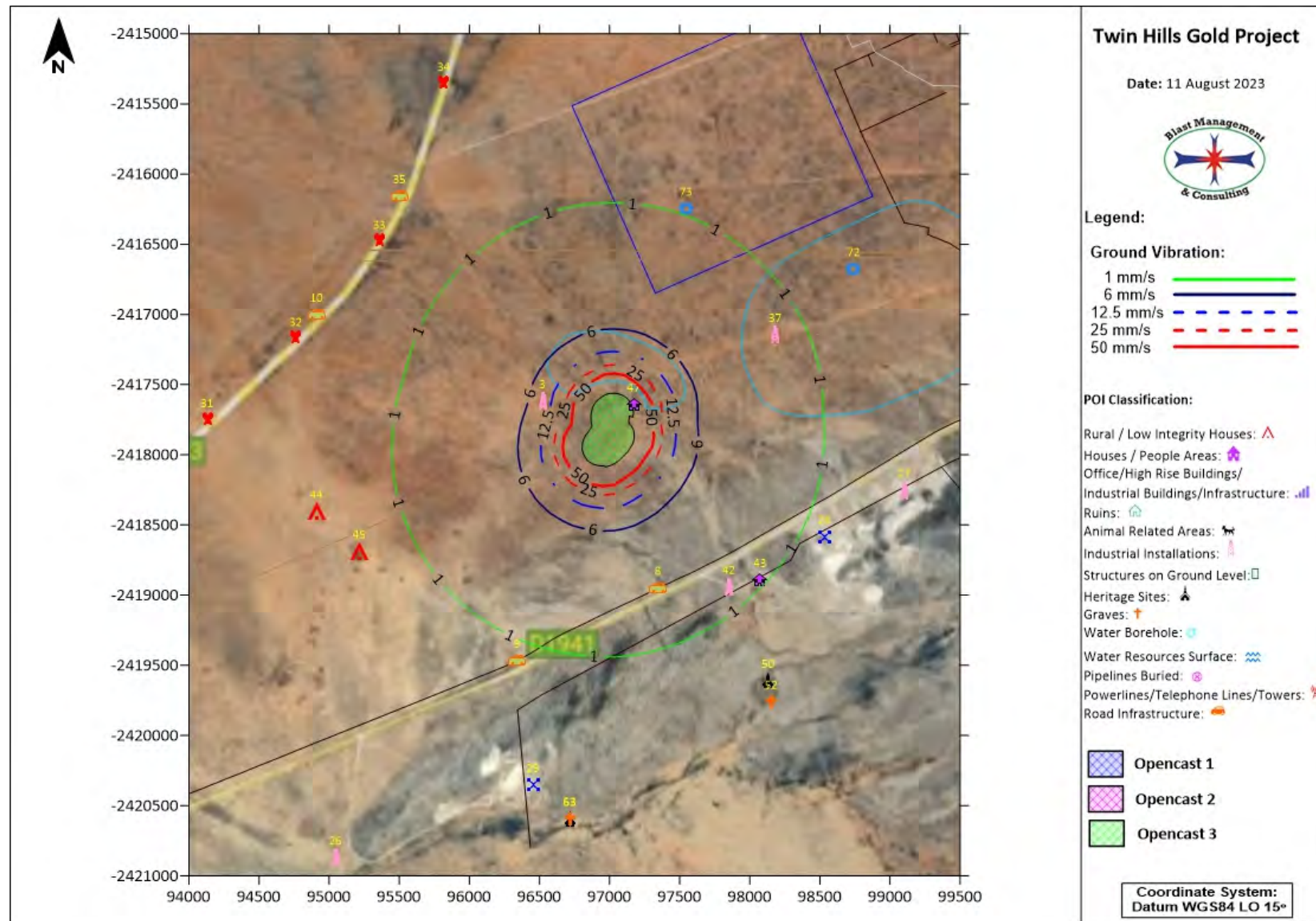


Figure 14: Ground vibration influence from maximum charge per delay – Opencast 3

Table 14: Ground vibration evaluation for maximum charge – Opencast 3

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
1	Road (D1941) - Inside Pit 1 Area	150	5624	361	0.1	Acceptable	N/A
2	Cement Dam - Inside Pit 2 Area	50	3130	361	0.3	Acceptable	N/A
3	Cement Dam	50	355	361	9.1	Acceptable	N/A
4	Road (D1941)	150	5872	361	0.1	Acceptable	N/A
5	Road (D1941)	150	5001	361	0.1	Acceptable	N/A
6	Road (D1941)	150	4448	361	0.1	Acceptable	N/A
7	Road (D1941)	150	3033	361	0.3	Acceptable	N/A
8	Road (D1941)	150	935	361	1.8	Acceptable	N/A
9	Road (D1941)	150	1502	361	0.8	Acceptable	N/A
10	Road (C33)	150	2075	361	0.5	Acceptable	N/A
11	Landing Strip	150	3202	361	0.2	Acceptable	N/A
12	Water Reservoir	50	3121	361	0.3	Acceptable	N/A
13	Cement Dam	50	3370	361	0.2	Acceptable	N/A
14	Buildings/Structures	12.5	4578	361	0.1	Acceptable	Too Low
15	Farmstead	12.5	4702	361	0.1	Acceptable	Too Low
16	Farmstead	12.5	8067	361	0.1	Acceptable	Too Low
17	Buildings/Structures	12.5	8135	361	0.1	Acceptable	Too Low
18	Structure	12.5	7940	361	0.1	Acceptable	Too Low
19	Dam/Dam Wall	50	8505	361	0.0	Acceptable	N/A
20	Cement Dam	50	8727	361	0.0	Acceptable	N/A
21	Buildings/Structures	12.5	4500	361	0.1	Acceptable	Too Low
22	Buildings/Structures	12.5	4243	361	0.2	Acceptable	Too Low
23	Buildings/Structures	12.5	4536	361	0.1	Acceptable	Too Low
24	Road (D1941)	150	4759	361	0.1	Acceptable	N/A
25	Buildings/Structures	12.5	4549	361	0.1	Acceptable	Too Low
26	Cement Dam	50	3349	361	0.2	Acceptable	N/A
27	Mine Activity	200	1962	361	0.5	Acceptable	N/A
28	Mine Buildings/Structures	25	1519	361	0.8	Acceptable	Perceptible
29	Mine Buildings/Structures	25	2323	361	0.4	Acceptable	Too Low
30	Power Lines/Pylons	75	3420	361	0.2	Acceptable	N/A
31	Power Lines/Pylons	75	2681	361	0.3	Acceptable	N/A
32	Power Lines/Pylons	75	2173	361	0.5	Acceptable	N/A
33	Power Lines/Pylons	75	1926	361	0.6	Acceptable	N/A
34	Power Lines/Pylons	75	2506	361	0.4	Acceptable	N/A
35	Road (C33)	150	2025	361	0.5	Acceptable	N/A
36	Power Lines/Pylons	75	3373	361	0.2	Acceptable	N/A
37	Cement Dam	50	1138	361	1.3	Acceptable	N/A
38	Gravel Road	200	3827	361	0.2	Acceptable	N/A
39	Structure	12.5	5717	361	0.1	Acceptable	Too Low
40	Cement Dam	50	6893	361	0.1	Acceptable	N/A
41	Cement Dam	50	8745	361	0.0	Acceptable	N/A
42	Cement Dam	50	1195	361	1.2	Acceptable	N/A
43	Structure	12.5	1315	361	1.1	Acceptable	Perceptible

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
44	Rural Village/House	6	1943	361	0.6	Acceptable	Too Low
45	Rural Village/Houses	6	1741	361	0.7	Acceptable	Too Low
46	Structures - Inside Pit 2 Area	12.5	4352	361	0.1	Acceptable	Too Low
47	Structure	12.5	14	361	1801.4	Problematic	Intolerable
48	Structures - Inside Pit 1 Area	12.5	5561	361	0.1	Acceptable	Too Low
49	Cement Dam	50	4311	361	0.1	Acceptable	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	150	1895	361	0.6	Acceptable	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	150	3654	361	0.2	Acceptable	N/A
52	Heritage Site (Graves - Okawayo 478)	50	2033	361	0.5	Acceptable	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	150	2521	361	0.4	Acceptable	N/A
54	Heritage Site (Farm Building - Okawayo 480)	6	4401	361	0.1	Acceptable	Too Low
55	Heritage Site (Historical Farmstead - Okawayo 481)	6	4382	361	0.1	Acceptable	Too Low
56	Heritage Site (Graves) - Inside Pit 2 area	50	4353	361	0.1	Acceptable	N/A
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4340	361	0.1	Acceptable	N/A
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4342	361	0.1	Acceptable	N/A
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4466	361	0.1	Acceptable	N/A
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4264	361	0.2	Acceptable	N/A
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4429	361	0.1	Acceptable	N/A
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	4466	361	0.1	Acceptable	N/A
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	50	2521	361	0.4	Acceptable	N/A
64	Hydrocensus Borehole (Klein Oka 1)	50	8323	361	0.1	Acceptable	N/A
65	Hydrocensus Borehole (Klein Oka 2)	50	5003	361	0.1	Acceptable	N/A
66	Hydrocensus Borehole (Oka 7)	50	4343	361	0.1	Acceptable	N/A
67	Hydrocensus Borehole (Oka12)	50	7079	361	0.1	Acceptable	N/A
68	Hydrocensus Borehole (Twin 6)	50	8492	361	0.0	Acceptable	N/A
69	Hydrocensus Borehole (BH3)	50	4611	361	0.1	Acceptable	N/A
70	Hydrocensus Borehole (OKP040)	50	4798	361	0.1	Acceptable	N/A
71	Hydrocensus Borehole (OKP045)	50	4309	361	0.1	Acceptable	N/A
72	Hydrocensus Borehole (OKP008)	50	1853	361	0.6	Acceptable	N/A

Tag	Description	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz	Human Tolerance @ 30Hz
73	Hydrocensus Borehole (OKP015)	50	1405	361	0.9	Acceptable	N/A
74	Hydrocensus Borehole (OKP004)	50	4961	361	0.1	Acceptable	N/A
75	Hydrocensus Borehole (Deep Injection Well)	50	4520	361	0.1	Acceptable	N/A
76	Hydrocensus Borehole (OKP013)	50	2979	361	0.3	Acceptable	N/A
77	Hydrocensus Borehole (OKP056)	50	4971	361	0.1	Acceptable	N/A
78	Buildings (Airport)	12.5	3747	361	0.2	Acceptable	Too Low
79	Okawayo River - Inside Pit 2 area	200	4340	361	0.1	Acceptable	N/A
80	River	200	8979	361	0.0	Acceptable	N/A

16.2 Summary of ground vibration levels

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

The distances between structures and the pit areas are a contributing factor to the levels of ground vibration expected and the subsequent possible influences. It is observed that for the different charge masses evaluated that levels of ground vibration will change as well. In view of the minimum and maximum charge specific attention will need to be given to specific areas.

Opencast 1: Expected ground vibration levels for minimum and maximum charge ranged between none and 1443 mm/s for the identified POI's. Minimum and maximum charge used indicated one POI that exceeds the permitted ground vibration levels and structural damage may be induced. On a human perception scale seven POI's were identified where vibration levels may be perceptible and lower for the maximum charge.

Opencast 2: Expected ground vibration levels for minimum and maximum charge ranged between none and 548 mm/s for the identified POI's. One POI was identified for minimum charge and two POI's for maximum charge exceeding the permitted ground vibration levels and structural damage may be induced. On a human perception scale six POI's were identified where vibration levels may be perceptible and lower for the minimum charge and five POI's for the maximum charge. Two POI's for maximum charge could lead to complaints.

Opencast 3: Expected ground vibration levels for minimum and maximum charge ranged between none and 1801 mm/s for the identified POI's. One POI might be of concern exceeding the permitted ground vibration levels and structural damage may be induced on minimum charge and maximum

charge. On a human perception scale two POI's were identified where vibration levels may be perceptible and lower for the maximum charge. The minimum charge showed one POI for minimum charge and maximum charge that could lead to complaints.

Perceptible levels of vibration that may be experienced up to 1431 m, unpleasant up to 500 m and intolerable up to 250 m for all Pit areas. Problematic levels of ground vibration – levels greater than the proposed limit – are expected up to 65 m from the pit edge for the maximum charge. Any blast operations further away from the boundary will have lesser influence on these points.

The evaluation mainly considered a distance up to 3500 m from the pit areas. The closest structures observed are the Road (D1941), Hydrocencus Boreholes, Heritage Sites, Buildings/Structures and Cement Dam. The planned maximum charge evaluated showed that it could be problematic in terms of potential structural damage and human perception. The ground vibration levels predicted for these POI's ranged between 0.1 mm/s and 1801.4 mm/s for structures surrounding all open pit areas.

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

- Opencast 1: 1004 m
- Opencast 2: 398 m
- Opencast 3: 14 m

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

- Opencast 1: 1.6 mm/s
- Opencast 2: 7.5 mm/s
- Opencast 3: 1801.4 mm/s

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

Structure conditions ranged from industrial construction to poor condition structures.

Various Heritage Sites which include Anchor Stones, Quartzite schist outcrop, Graves, Marble quern stone, Farm Building, Historical Farmstead and potential burial ground were identified by the Heritage Specialist. HIA recommended the following: The grave site (POI 56) on the Farm Okawayo need to be exhumed and reburied outside the footprint of the project area, due to the degree of imminent threat. It is recommended that further investigation of Site 478 (POI 52) is carried out if the project proceeds further, although this action will require a permit from the National Heritage Council; that the driller's camp at Site 480 (POI 54) is moved at least 100m away from the ruin; and that consideration is given to possible damage to Site 481 (POI 55) caused by blasting and vibration. It is still uncertain about the number of burial grounds (POI 57 – POI 63) in the project area, therefore, it may be useful to scan other suspected sites to determine possible additional burials.

Water boreholes identified are at proximity to all Pit areas. There are fourteen water boreholes identified within the mining rights area and it is uncertain what the long-term plan will be for these boreholes. A mitigation plan will be required to determine if these boreholes will be retained or replaced.

Mitigation of ground vibration was considered and discussed in Section 18.3. A detail inspection of the area and accurate identification of structures will also need to be done to ensure the levels of ground vibration allowable and limit to be applied.

16.3 Ground Vibration and human perception

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to an average of 30Hz frequency and plotted with expected human perceptions on the safe blasting criteria graph (see Figure 15 below). The frequency range selected is the expected average range for frequencies that will be measured for ground vibration when blasting is done. Based on the maximum charge and ground vibration predicted over distance it can be seen from Figure 15 that up to a distance of 1431 m people may experience levels of ground vibration as perceptible. At 500 m and closer the perception of ground vibration could be unpleasant. Closer than 250 m the levels will be intolerable and generally greater than limits applied for structures in the areas.

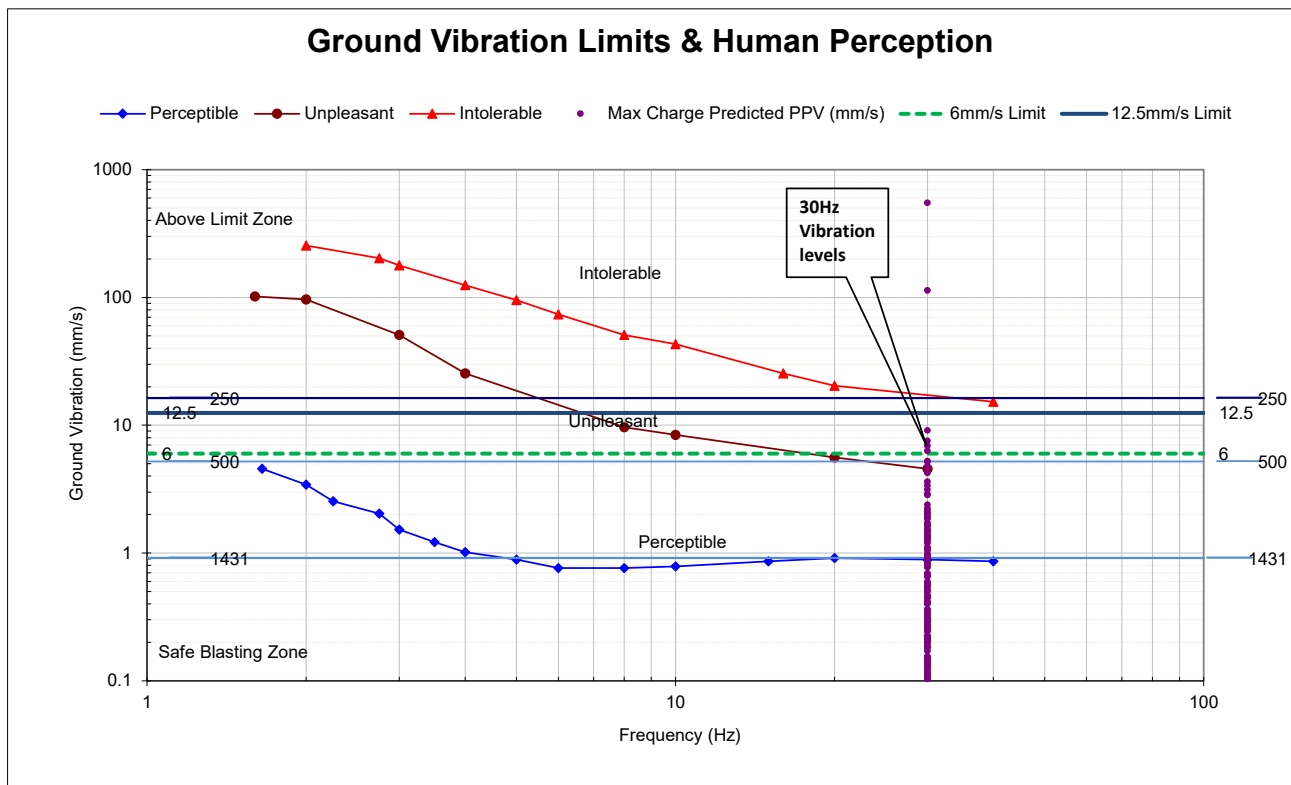


Figure 15: The effect of ground vibration with human perception and vibration limits

16.4 Potential that vibration will upset adjacent communities

Ground vibration and air blast generally upset people living in the vicinity of mining operations. The nearest building/structure is at Opencast 3 (POI 47) and are approximately 14 m from the planned operation. These buildings are located such that levels of ground vibration predicted from minimum charge may be intolerable and could lead to structural damage. Charge mass per delay greater than minimum charge will show increased levels of ground vibration and higher probability of damage.

Ground vibration levels expected from maximum charge has possibility to be perceptible up to 1431 m. It is certain that lesser charges will reduce this distance for instance at minimum charge this distance is expected to be 799 m. Within these distance ranges there are a significant number of houses. The anticipated ground vibration levels are certain to have possibility of upsetting the house holds within these ranges.

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

16.5 Cracking of houses and consequent devaluation

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

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

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

16.6 Review of expected air blast

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

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

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

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

The whole project area is evaluated in the following order:

- Opencast 1
- Opencast 2
- Opencast 3

16.6.1 Air blast minimum charge mass per delay – Opencast 1 - 90 kg

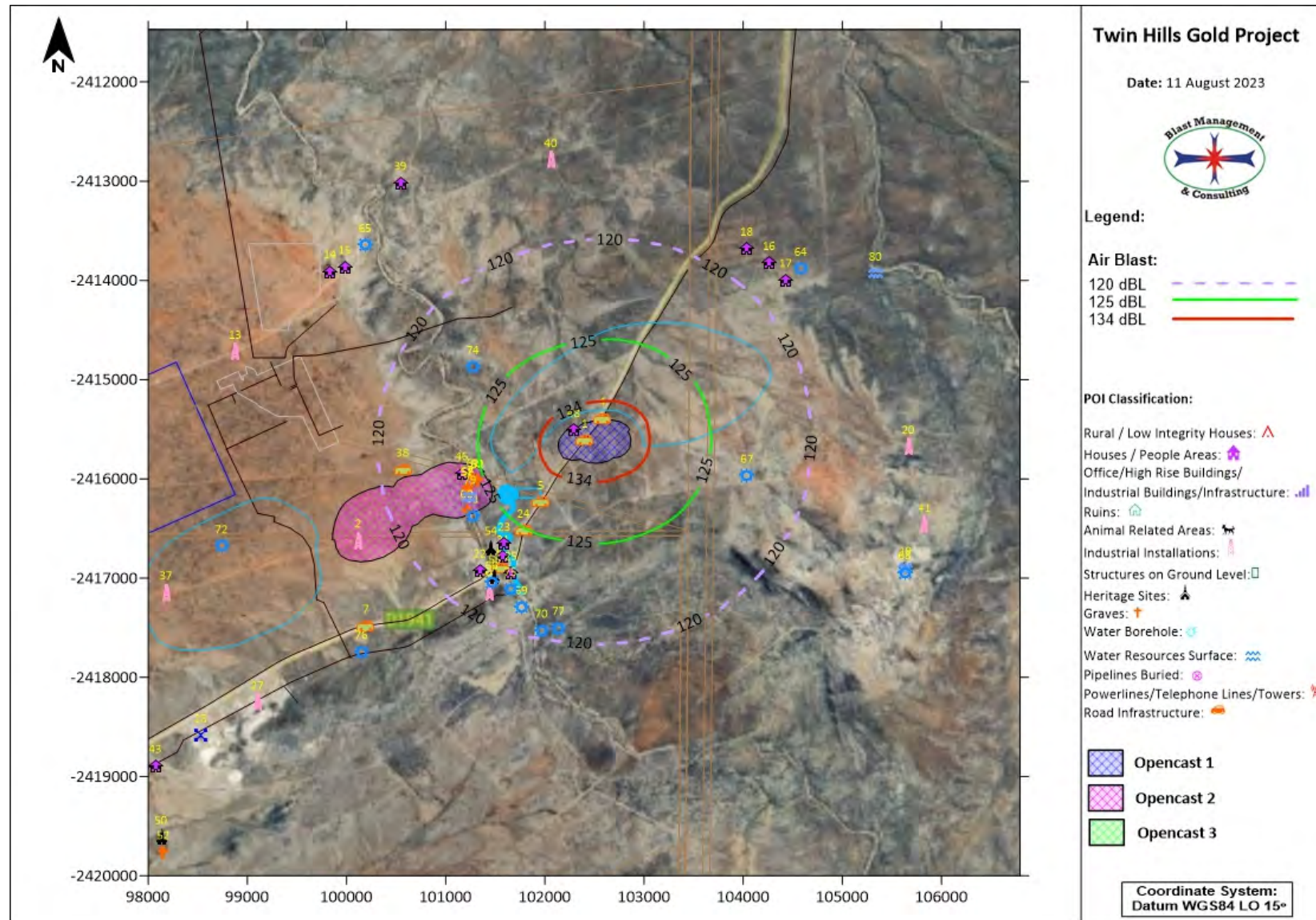


Figure 16: Air blast influence from minimum charge – Opencast 1

Table 15: Air blast evaluation for minimum charge – Opencast 1

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Road (D1941) - Inside Pit 1 Area	-	-	-
2	Cement Dam - Inside Pit 2 Area	2217	118.8	N/A
3	Cement Dam	5932	112.7	N/A
4	Road (D1941)	17	149.0	N/A
5	Road (D1941)	500	128.0	N/A
6	Road (D1941)	1280	122.2	N/A
7	Road (D1941)	2614	117.8	N/A
8	Road (D1941)	5780	112.9	N/A
9	Road (D1941)	6905	111.8	N/A
10	Road (C33)	7344	111.4	N/A
11	Landing Strip	8622	110.5	N/A
12	Water Reservoir	8654	110.5	N/A
13	Cement Dam	3384	116.2	N/A
14	Buildings/Structures	2859	117.2	Acceptable
15	Farmstead	2769	117.5	Acceptable
16	Farmstead	2182	118.9	Acceptable
17	Buildings/Structures	2175	118.9	Acceptable
18	Structure	2158	119.0	Acceptable
19	Dam/Dam Wall	3034	116.9	N/A
20	Cement Dam	2799	117.4	N/A
21	Buildings/Structures	1165	122.7	Complaint
22	Buildings/Structures	1413	121.6	Complaint
23	Buildings/Structures	1052	123.4	Complaint
24	Road (D1941)	834	124.8	N/A
25	Buildings/Structures	1273	122.2	Complaint
26	Cement Dam	8763	110.3	N/A
27	Mine Activity	3949	115.2	N/A
28	Mine Buildings/Structures	4602	114.4	Acceptable
29	Mine Buildings/Structures	7328	111.4	Acceptable
30	Power Lines/Pylons	9133	110.1	N/A
31	Power Lines/Pylons	8262	110.7	N/A
32	Power Lines/Pylons	7519	111.3	N/A
33	Power Lines/Pylons	6823	111.9	N/A
34	Power Lines/Pylons	6322	112.4	N/A
35	Road (C33)	6650	112.1	N/A
36	Power Lines/Pylons	6134	112.5	N/A
37	Cement Dam	4211	114.8	N/A
38	Gravel Road	1585	120.9	N/A
39	Structure	3005	116.9	Acceptable
40	Cement Dam	2664	117.7	N/A
41	Cement Dam	3073	116.8	N/A
42	Cement Dam	5360	113.4	N/A
43	Structure	5153	113.7	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Rural Village/House	7714	111.2	Acceptable
45	Rural Village/Houses	7537	111.3	Acceptable
46	Structures - Inside Pit 2 Area	1004	123.7	Complaint
47	Structure	5330	113.4	Acceptable
48	Structures - Inside Pit 1 Area	-	-	-
49	Cement Dam	1536	121.0	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	5572	113.1	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	7269	111.5	N/A
52	Heritage Site (Graves - Okawayo 478)	5660	113.0	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	7281	111.5	N/A
54	Heritage Site (Farm Building - Okawayo 480)	1162	122.8	Complaint
55	Heritage Site (Historical Farmstead - Okawayo 481)	1378	121.7	Complaint
56	Heritage Site (Graves) - Inside Pit 2 area	990	123.8	N/A
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	1003	123.7	N/A
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	1001	123.7	N/A
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	877	124.5	N/A
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	1108	123.1	N/A
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	915	124.2	N/A
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	877	124.5	N/A
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	7281	111.5	N/A
64	Hydrocensus Borehole (Klein Oka 1)	2365	118.4	N/A
65	Hydrocensus Borehole (Klein Oka 2)	2754	117.5	N/A
66	Hydrocensus Borehole (Oka 7)	1445	121.4	N/A
67	Hydrocensus Borehole (Oka12)	1216	122.5	N/A
68	Hydrocensus Borehole (Twin 6)	3045	116.9	N/A
69	Hydrocensus Borehole (BH3)	1562	121.0	N/A
70	Hydrocensus Borehole (OKP040)	1745	120.3	N/A
71	Hydrocensus Borehole (OKP045)	1078	123.2	N/A
72	Hydrocensus Borehole (OKP008)	3535	115.9	N/A
73	Hydrocensus Borehole (OKP015)	4626	114.3	N/A
74	Hydrocensus Borehole (OKP004)	1131	122.9	N/A
75	Hydrocensus Borehole (Deep Injection Well)	1424	121.5	N/A
76	Hydrocensus Borehole (OKP013)	2821	117.3	N/A
77	Hydrocensus Borehole (OKP056)	1694	120.5	N/A
78	Buildings (Airport)	9381	109.9	Acceptable
79	Okawayo River - Inside Pit 2 area	1010	123.6	N/A
80	River	2935	117.1	N/A

16.6.2 Air blast maximum charge mass per delay – Opencast 1 - 361 kg

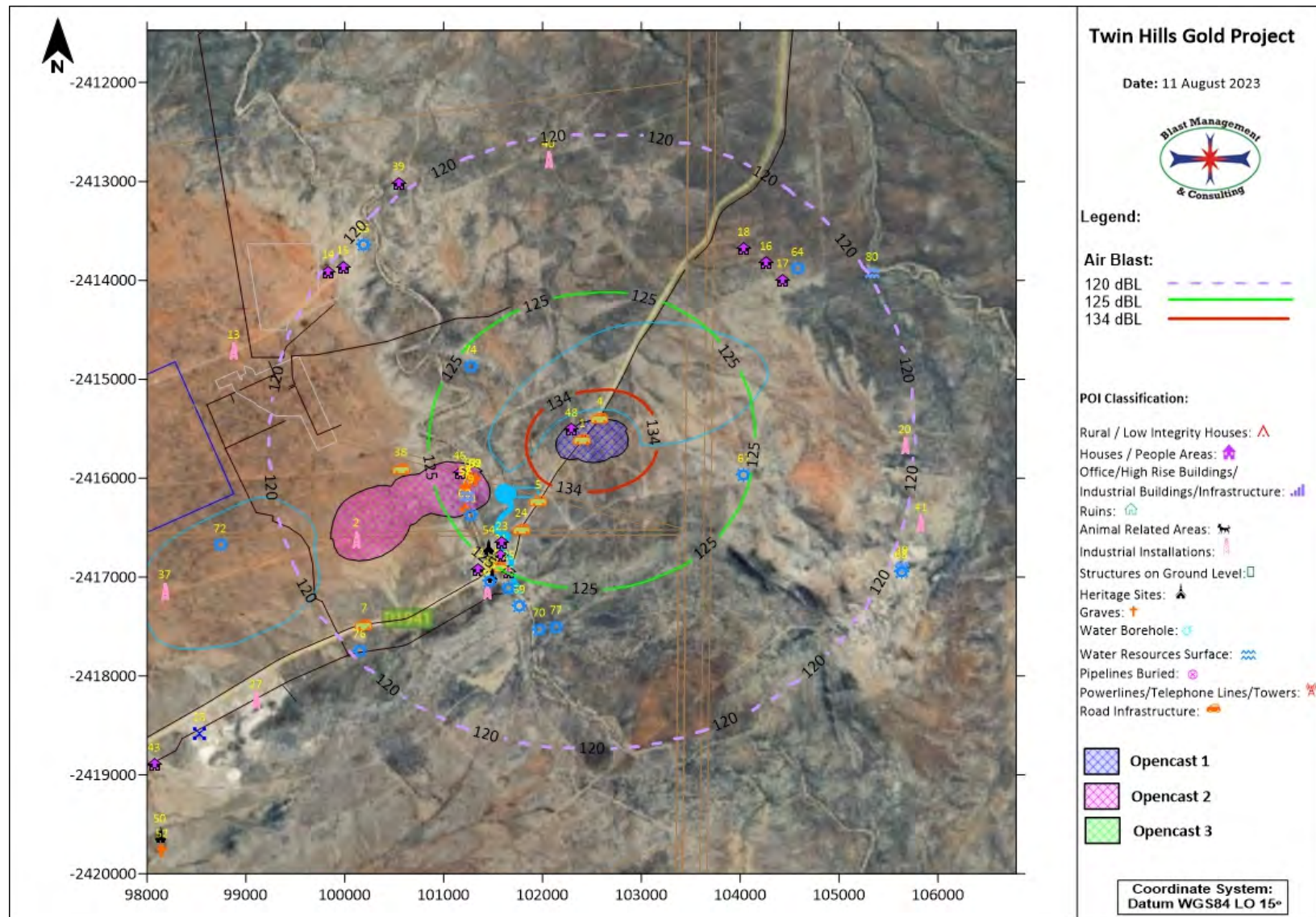


Figure 17: Air blast influence from maximum charge – Opencast 1

Table 16: Air blast influence from maximum charge – Opencast 1

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Road (D1941) - Inside Pit 1 Area	-	-	-
2	Cement Dam - Inside Pit 2 Area	2217	121.6	N/A
3	Cement Dam	5932	115.6	N/A
4	Road (D1941)	17	151.9	N/A
5	Road (D1941)	500	130.8	N/A
6	Road (D1941)	1280	125.0	N/A
7	Road (D1941)	2614	120.6	N/A
8	Road (D1941)	5780	115.7	N/A
9	Road (D1941)	6905	114.7	N/A
10	Road (C33)	7344	114.3	N/A
11	Landing Strip	8622	113.3	N/A
12	Water Reservoir	8654	113.3	N/A
13	Cement Dam	3384	119.0	N/A
14	Buildings/Structures	2859	120.1	Complaint
15	Farmstead	2769	120.3	Complaint
16	Farmstead	2182	121.7	Complaint
17	Buildings/Structures	2175	121.8	Complaint
18	Structure	2158	121.8	Complaint
19	Dam/Dam Wall	3034	119.7	N/A
20	Cement Dam	2799	120.2	N/A
21	Buildings/Structures	1165	125.6	Complaint
22	Buildings/Structures	1413	124.4	Complaint
23	Buildings/Structures	1052	126.2	Complaint
24	Road (D1941)	834	127.7	N/A
25	Buildings/Structures	1273	125.1	Complaint
26	Cement Dam	8763	113.2	N/A
27	Mine Activity	3949	118.1	N/A
28	Mine Buildings/Structures	4602	117.2	Acceptable
29	Mine Buildings/Structures	7328	114.3	Acceptable
30	Power Lines/Pylons	9133	112.9	N/A
31	Power Lines/Pylons	8262	113.6	N/A
32	Power Lines/Pylons	7519	114.1	N/A
33	Power Lines/Pylons	6823	114.8	N/A
34	Power Lines/Pylons	6322	115.2	N/A
35	Road (C33)	6650	114.9	N/A
36	Power Lines/Pylons	6134	115.4	N/A
37	Cement Dam	4211	117.7	N/A
38	Gravel Road	1585	123.7	N/A
39	Structure	3005	119.8	Acceptable
40	Cement Dam	2664	120.5	N/A
41	Cement Dam	3073	119.6	N/A
42	Cement Dam	5360	116.2	N/A
43	Structure	5153	116.5	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Rural Village/House	7714	114.0	Acceptable
45	Rural Village/Houses	7537	114.1	Acceptable
46	Structures - Inside Pit 2 Area	1004	126.5	Complaint
47	Structure	5330	116.3	Acceptable
48	Structures - Inside Pit 1 Area	-	-	-
49	Cement Dam	1536	123.9	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	5572	116.0	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	7269	114.4	N/A
52	Heritage Site (Graves - Okawayo 478)	5660	115.9	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	7281	114.4	N/A
54	Heritage Site (Farm Building - Okawayo 480)	1162	125.6	Complaint
55	Heritage Site (Historical Farmstead - Okawayo 481)	1378	124.6	Complaint
56	Heritage Site (Graves) - Inside Pit 2 area	990	126.6	N/A
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	1003	126.5	N/A
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	1001	126.5	N/A
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	877	127.4	N/A
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	1108	125.9	N/A
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	915	127.1	N/A
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	877	127.4	N/A
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	7281	114.4	N/A
64	Hydrocensus Borehole (Klein Oka 1)	2365	121.2	N/A
65	Hydrocensus Borehole (Klein Oka 2)	2754	120.3	N/A
66	Hydrocensus Borehole (Oka 7)	1445	124.3	N/A
67	Hydrocensus Borehole (Oka12)	1216	125.3	N/A
68	Hydrocensus Borehole (Twin 6)	3045	119.7	N/A
69	Hydrocensus Borehole (BH3)	1562	123.8	N/A
70	Hydrocensus Borehole (OKP040)	1745	123.1	N/A
71	Hydrocensus Borehole (OKP045)	1078	126.1	N/A
72	Hydrocensus Borehole (OKP008)	3535	118.8	N/A
73	Hydrocensus Borehole (OKP015)	4626	117.1	N/A
74	Hydrocensus Borehole (OKP004)	1131	125.8	N/A
75	Hydrocensus Borehole (Deep Injection Well)	1424	124.4	N/A
76	Hydrocensus Borehole (OKP013)	2821	120.2	N/A
77	Hydrocensus Borehole (OKP056)	1694	123.3	N/A
78	Buildings (Airport)	9381	112.8	Acceptable
79	Okawayo River - Inside Pit 2 area	1010	126.5	N/A
80	River	2935	119.9	N/A

16.6.3 Air blast minimum charge mass per delay – Opencast 2 - 90 kg

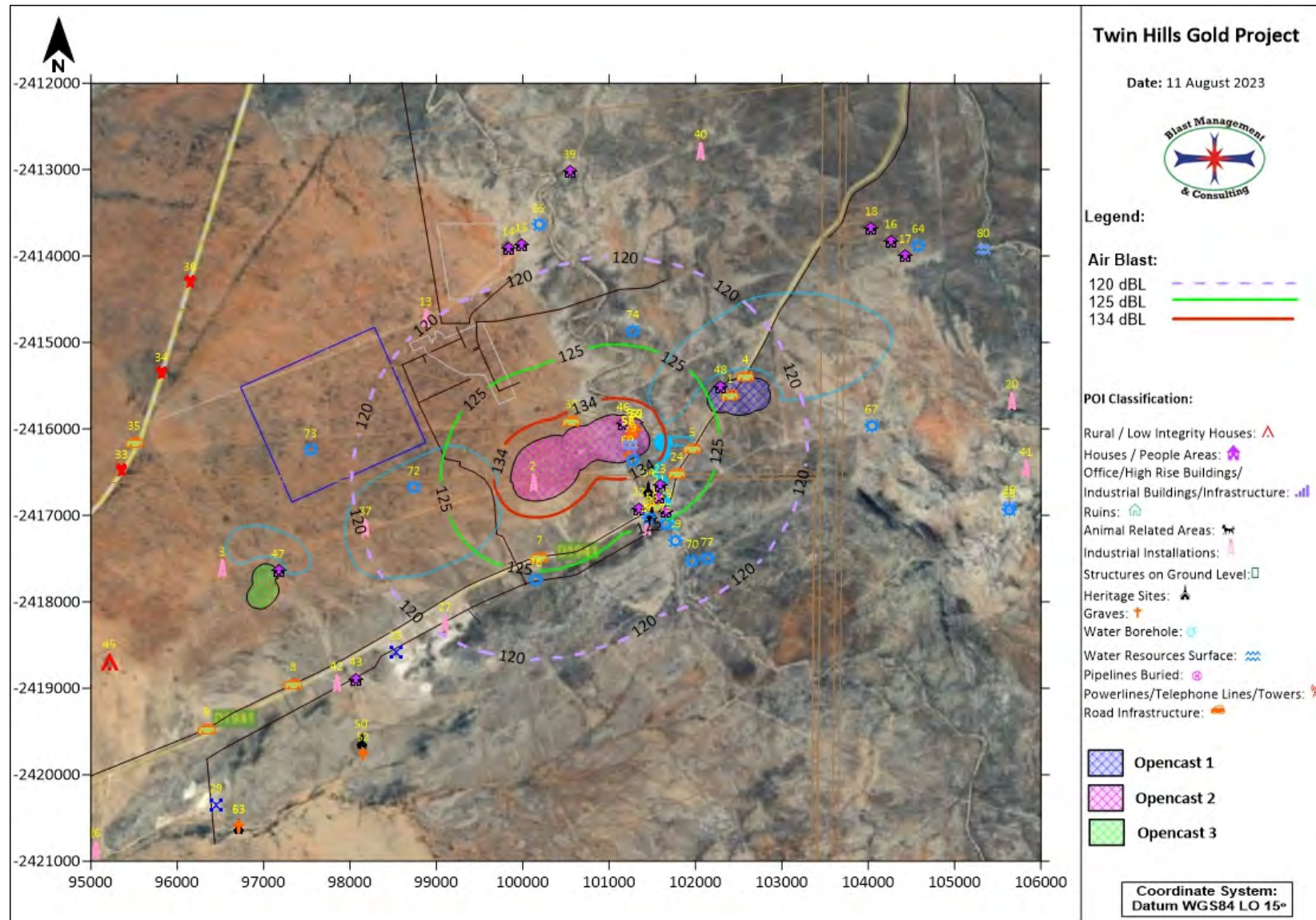


Figure 18: Air blast influence from minimum charge – Opencast 2

Table 17: Air blast evaluation for minimum charge – Opencast 2

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Road (D1941) - Inside Pit 1 Area	1052	123.4	N/A
2	Cement Dam - Inside Pit 2 Area	-	-	-
3	Cement Dam	3481	116.0	N/A
4	Road (D1941)	1310	122.0	N/A
5	Road (D1941)	497	128.0	N/A
6	Road (D1941)	622	126.6	N/A
7	Road (D1941)	649	126.4	N/A
8	Road (D1941)	3387	116.2	N/A
9	Road (D1941)	4496	114.4	N/A
10	Road (C33)	4960	113.8	N/A
11	Landing Strip	6228	112.4	N/A
12	Water Reservoir	6237	112.4	N/A
13	Cement Dam	1881	119.8	N/A
14	Buildings/Structures	2201	118.8	Acceptable
15	Farmstead	2200	118.8	Acceptable
16	Farmstead	3564	115.9	Acceptable
17	Buildings/Structures	3604	115.8	Acceptable
18	Structure	3476	116.0	Acceptable
19	Dam/Dam Wall	4234	114.8	N/A
20	Cement Dam	4222	114.8	N/A
21	Buildings/Structures	528	127.6	Complaint
22	Buildings/Structures	566	127.2	Complaint
23	Buildings/Structures	420	129.0	Complaint
24	Road (D1941)	444	128.7	N/A
25	Buildings/Structures	711	125.8	Complaint
26	Cement Dam	6383	112.3	N/A
27	Mine Activity	1700	120.4	N/A
28	Mine Buildings/Structures	2295	118.6	Acceptable
29	Mine Buildings/Structures	4998	113.8	Acceptable
30	Power Lines/Pylons	6687	112.0	N/A
31	Power Lines/Pylons	5834	112.8	N/A
32	Power Lines/Pylons	5122	113.7	N/A
33	Power Lines/Pylons	4499	114.4	N/A
34	Power Lines/Pylons	4206	114.8	N/A
35	Road (C33)	4373	114.6	N/A
36	Power Lines/Pylons	4284	114.8	N/A
37	Cement Dam	1757	120.2	N/A
38	Gravel Road	77	139.5	N/A
39	Structure	2857	117.2	Acceptable
40	Cement Dam	3176	116.6	N/A
41	Cement Dam	4373	114.6	N/A
42	Cement Dam	3012	116.9	N/A
43	Structure	2825	117.3	Acceptable

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Rural Village/House	5259	113.5	Acceptable
45	Rural Village/Houses	5083	113.7	Acceptable
46	Structures - Inside Pit 2 Area	-	-	-
47	Structure	2874	117.2	Acceptable
48	Structures - Inside Pit 1 Area	999	123.7	Complaint
49	Cement Dam	800	125.1	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	3363	116.2	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	5274	113.5	N/A
52	Heritage Site (Graves - Okawayo 478)	3479	116.0	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	5000	113.8	N/A
54	Heritage Site (Farm Building - Okawayo 480)	398	129.4	Complaint
55	Heritage Site (Historical Farmstead - Okawayo 481)	678	126.1	Complaint
56	Heritage Site (Graves) - Inside Pit 2 area	-	-	-
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
64	Hydrocensus Borehole (Klein Oka 1)	3794	115.5	N/A
65	Hydrocensus Borehole (Klein Oka 2)	2337	118.5	N/A
66	Hydrocensus Borehole (Oka 7)	721	125.7	N/A
67	Hydrocensus Borehole (Oka12)	2578	117.8	N/A
68	Hydrocensus Borehole (Twin 6)	4234	114.8	N/A
69	Hydrocensus Borehole (BH3)	1068	123.3	N/A
70	Hydrocensus Borehole (OKP040)	1369	121.8	N/A
71	Hydrocensus Borehole (OKP045)	30	145.4	N/A
72	Hydrocensus Borehole (OKP008)	1118	123.0	N/A
73	Hydrocensus Borehole (OKP015)	2332	118.5	N/A
74	Hydrocensus Borehole (OKP004)	975	123.9	N/A
75	Hydrocensus Borehole (Deep Injection Well)	856	124.7	N/A
76	Hydrocensus Borehole (OKP013)	907	124.3	N/A
77	Hydrocensus Borehole (OKP056)	1431	121.5	N/A
78	Buildings (Airport)	6949	111.8	Acceptable
79	Okawayo River - Inside Pit 2 area	-	-	-
80	River	4423	114.5	N/A

16.6.4 Air blast maximum charge mass per delay – Opencast 2 - 361 kg

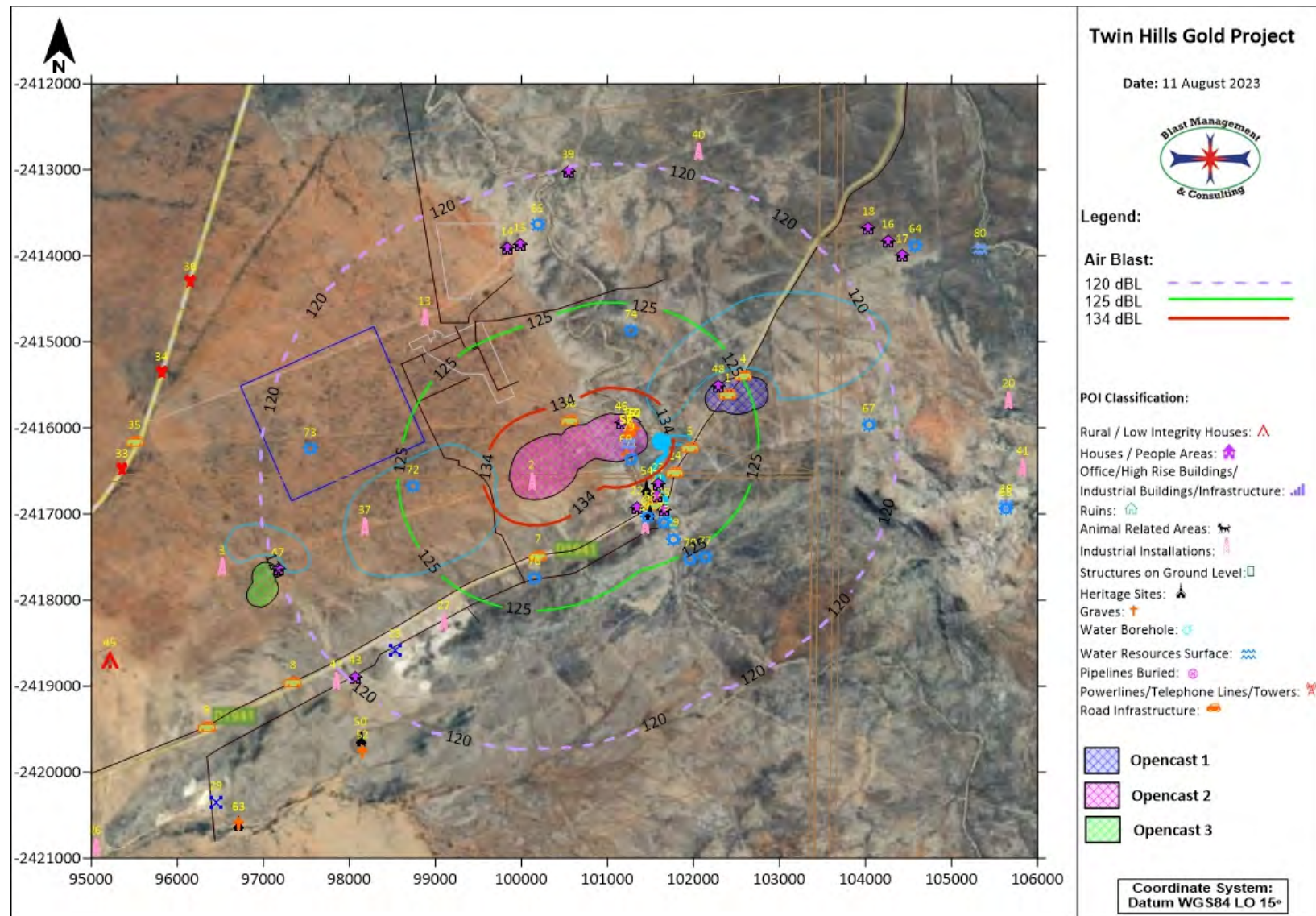


Figure 19: Air blast influence from maximum charge – Opencast 2

Table 18: Air blast influence from maximum charge – Opencast 2

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Road (D1941) - Inside Pit 1 Area	1052	126.2	N/A
2	Cement Dam - Inside Pit 2 Area	-	-	-
3	Cement Dam	3481	118.9	N/A
4	Road (D1941)	1310	124.9	N/A
5	Road (D1941)	497	130.9	N/A
6	Road (D1941)	622	129.5	N/A
7	Road (D1941)	649	129.2	N/A
8	Road (D1941)	3387	119.0	N/A
9	Road (D1941)	4496	117.3	N/A
10	Road (C33)	4960	116.7	N/A
11	Landing Strip	6228	115.3	N/A
12	Water Reservoir	6237	115.3	N/A
13	Cement Dam	1881	122.7	N/A
14	Buildings/Structures	2201	121.7	Complaint
15	Farmstead	2200	121.7	Complaint
16	Farmstead	3564	118.7	Acceptable
17	Buildings/Structures	3604	118.6	Acceptable
18	Structure	3476	118.9	Acceptable
19	Dam/Dam Wall	4234	117.7	N/A
20	Cement Dam	4222	117.7	N/A
21	Buildings/Structures	528	130.5	Complaint
22	Buildings/Structures	566	130.1	Complaint
23	Buildings/Structures	420	131.9	Complaint
24	Road (D1941)	444	131.6	N/A
25	Buildings/Structures	711	128.7	Complaint
26	Cement Dam	6383	115.1	N/A
27	Mine Activity	1700	123.3	N/A
28	Mine Buildings/Structures	2295	121.4	Complaint
29	Mine Buildings/Structures	4998	116.7	Acceptable
30	Power Lines/Pylons	6687	114.8	N/A
31	Power Lines/Pylons	5834	115.7	N/A
32	Power Lines/Pylons	5122	116.5	N/A
33	Power Lines/Pylons	4499	117.3	N/A
34	Power Lines/Pylons	4206	117.7	N/A
35	Road (C33)	4373	117.5	N/A
36	Power Lines/Pylons	4284	117.6	N/A
37	Cement Dam	1757	123.1	N/A
38	Gravel Road	77	142.3	N/A
39	Structure	2857	120.1	Complaint
40	Cement Dam	3176	119.5	N/A
41	Cement Dam	4373	117.5	N/A
42	Cement Dam	3012	119.8	N/A
43	Structure	2825	120.2	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Rural Village/House	5259	116.3	Acceptable
45	Rural Village/Houses	5083	116.5	Acceptable
46	Structures - Inside Pit 2 Area	-	-	-
47	Structure	2874	120.0	Acceptable
48	Structures - Inside Pit 1 Area	999	126.6	Complaint
49	Cement Dam	800	127.9	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	3363	119.1	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	5274	116.3	N/A
52	Heritage Site (Graves - Okawayo 478)	3479	118.9	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	5000	116.7	N/A
54	Heritage Site (Farm Building - Okawayo 480)	398	132.2	Complaint
55	Heritage Site (Historical Farmstead - Okawayo 481)	678	129.0	Complaint
56	Heritage Site (Graves) - Inside Pit 2 area	-	-	-
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	-	-	-
64	Hydrocensus Borehole (Klein Oka 1)	3794	118.3	N/A
65	Hydrocensus Borehole (Klein Oka 2)	2337	121.3	N/A
66	Hydrocensus Borehole (Oka 7)	721	128.6	N/A
67	Hydrocensus Borehole (Oka12)	2578	120.7	N/A
68	Hydrocensus Borehole (Twin 6)	4234	117.7	N/A
69	Hydrocensus Borehole (BH3)	1068	126.1	N/A
70	Hydrocensus Borehole (OKP040)	1369	124.6	N/A
71	Hydrocensus Borehole (OKP045)	30	148.2	N/A
72	Hydrocensus Borehole (OKP008)	1118	125.9	N/A
73	Hydrocensus Borehole (OKP015)	2332	121.4	N/A
74	Hydrocensus Borehole (OKP004)	975	126.7	N/A
75	Hydrocensus Borehole (Deep Injection Well)	856	127.5	N/A
76	Hydrocensus Borehole (OKP013)	907	127.1	N/A
77	Hydrocensus Borehole (OKP056)	1431	124.4	N/A
78	Buildings (Airport)	6949	114.6	Acceptable
79	Okawayo River - Inside Pit 2 area	-	-	-
80	River	4423	117.4	N/A

16.6.5 Air blast minimum charge mass per delay – Opencast 3 - 90 kg

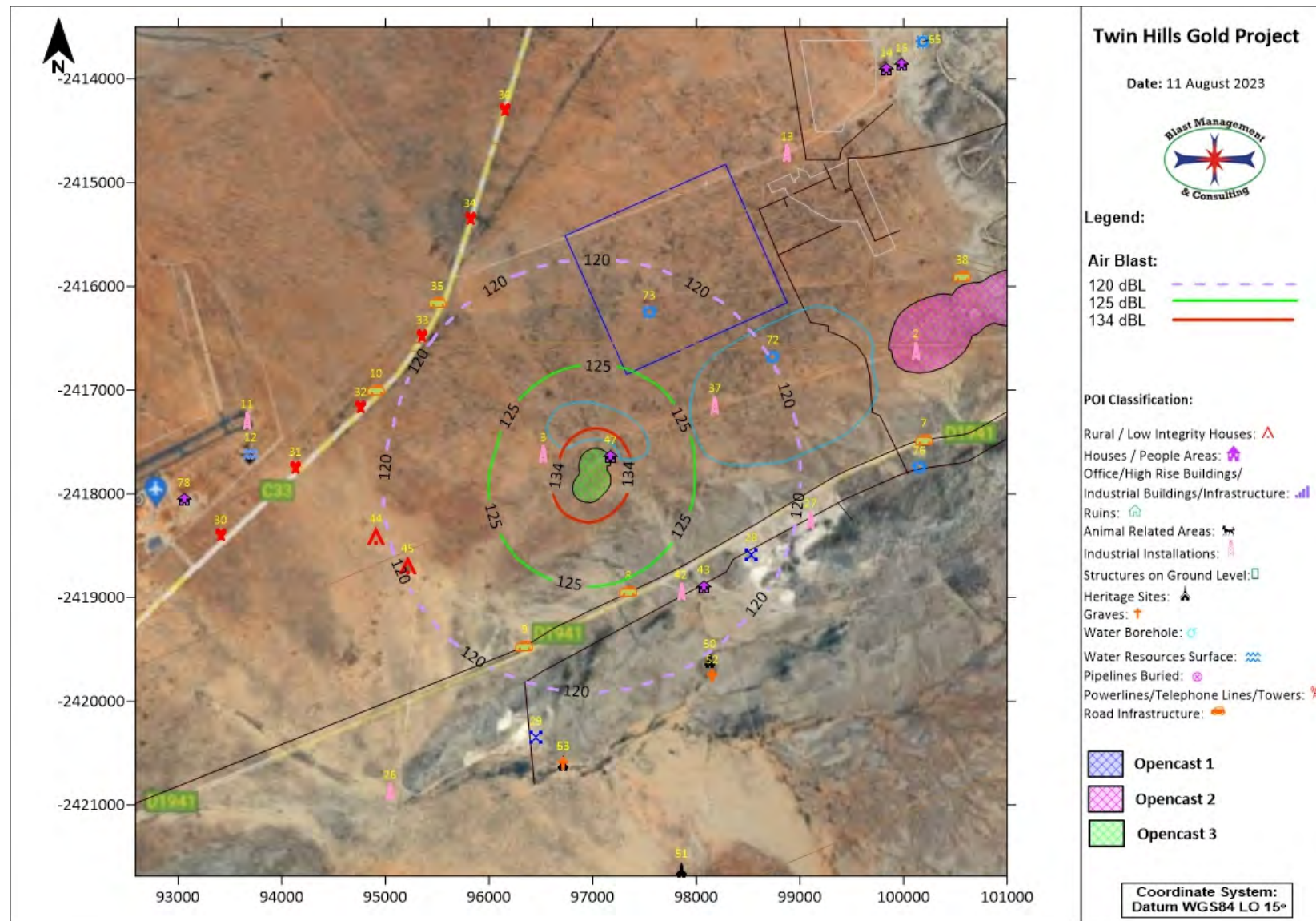


Figure 20: Air blast influence from minimum charge – Opencast 3

Table 19: Air blast evaluation for minimum charge – Opencast 3

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Road (D1941) - Inside Pit 1 Area	5624	113.1	N/A
2	Cement Dam - Inside Pit 2 Area	3130	116.7	N/A
3	Cement Dam	355	130.1	N/A
4	Road (D1941)	5872	112.8	N/A
5	Road (D1941)	5001	113.8	N/A
6	Road (D1941)	4448	114.5	N/A
7	Road (D1941)	3033	116.9	N/A
8	Road (D1941)	935	124.1	N/A
9	Road (D1941)	1502	121.2	N/A
10	Road (C33)	2075	119.2	N/A
11	Landing Strip	3202	116.5	N/A
12	Water Reservoir	3121	116.7	N/A
13	Cement Dam	3370	116.2	N/A
14	Buildings/Structures	4578	114.4	Acceptable
15	Farmstead	4702	114.2	Acceptable
16	Farmstead	8067	110.8	Acceptable
17	Buildings/Structures	8135	110.8	Acceptable
18	Structure	7940	111.0	Acceptable
19	Dam/Dam Wall	8505	110.6	N/A
20	Cement Dam	8727	110.5	N/A
21	Buildings/Structures	4500	114.4	Acceptable
22	Buildings/Structures	4243	114.8	Acceptable
23	Buildings/Structures	4536	114.4	Acceptable
24	Road (D1941)	4759	114.1	N/A
25	Buildings/Structures	4549	114.4	Acceptable
26	Cement Dam	3349	116.3	N/A
27	Mine Activity	1962	119.6	N/A
28	Mine Buildings/Structures	1519	121.1	Complaint
29	Mine Buildings/Structures	2323	118.5	Acceptable
30	Power Lines/Pylons	3420	116.1	N/A
31	Power Lines/Pylons	2681	117.6	N/A
32	Power Lines/Pylons	2173	118.9	N/A
33	Power Lines/Pylons	1926	119.7	N/A
34	Power Lines/Pylons	2506	118.1	N/A
35	Road (C33)	2025	119.4	N/A
36	Power Lines/Pylons	3373	116.2	N/A
37	Cement Dam	1138	122.9	N/A
38	Gravel Road	3827	115.4	N/A
39	Structure	5717	113.0	Acceptable
40	Cement Dam	6893	111.9	N/A
41	Cement Dam	8745	110.3	N/A
42	Cement Dam	1195	122.6	N/A
43	Structure	1315	122.0	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Rural Village/House	1943	119.6	Acceptable
45	Rural Village/Houses	1741	120.3	Complaint
46	Structures - Inside Pit 2 Area	4352	114.7	Acceptable
47	Structure	14	149.8	Problematic
48	Structures - Inside Pit 1 Area	5561	113.1	Acceptable
49	Cement Dam	4311	114.7	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	1895	119.8	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	3654	115.7	N/A
52	Heritage Site (Graves - Okawayo 478)	2033	119.3	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	2521	118.0	N/A
54	Heritage Site (Farm Building - Okawayo 480)	4401	114.6	Acceptable
55	Heritage Site (Historical Farmstead - Okawayo 481)	4382	114.6	Acceptable
56	Heritage Site (Graves) - Inside Pit 2 area	4353	114.7	N/A
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	4340	114.7	N/A
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	4342	114.7	N/A
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	4466	114.5	N/A
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	4264	114.8	N/A
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	4429	114.5	N/A
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	4466	114.5	N/A
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	2521	118.0	N/A
64	Hydrocensus Borehole (Klein Oka 1)	8323	110.7	N/A
65	Hydrocensus Borehole (Klein Oka 2)	5003	113.8	N/A
66	Hydrocensus Borehole (Oka 7)	4343	114.7	N/A
67	Hydrocensus Borehole (Oka12)	7079	111.7	N/A
68	Hydrocensus Borehole (Twin 6)	8492	110.6	N/A
69	Hydrocensus Borehole (BH3)	4611	114.3	N/A
70	Hydrocensus Borehole (OKP040)	4798	114.0	N/A
71	Hydrocensus Borehole (OKP045)	4309	114.7	N/A
72	Hydrocensus Borehole (OKP008)	1853	119.9	N/A
73	Hydrocensus Borehole (OKP015)	1405	121.6	N/A
74	Hydrocensus Borehole (OKP004)	4961	113.8	N/A
75	Hydrocensus Borehole (Deep Injection Well)	4520	114.4	N/A
76	Hydrocensus Borehole (OKP013)	2979	117.0	N/A
77	Hydrocensus Borehole (OKP056)	4971	113.8	N/A
78	Buildings (Airport)	3747	115.6	Acceptable
79	Okawayo River - Inside Pit 2 area	4340	114.7	N/A
80	River	8979	110.2	N/A

16.6.6 Air blast maximum charge mass per delay – Opencast 3 - 361 kg

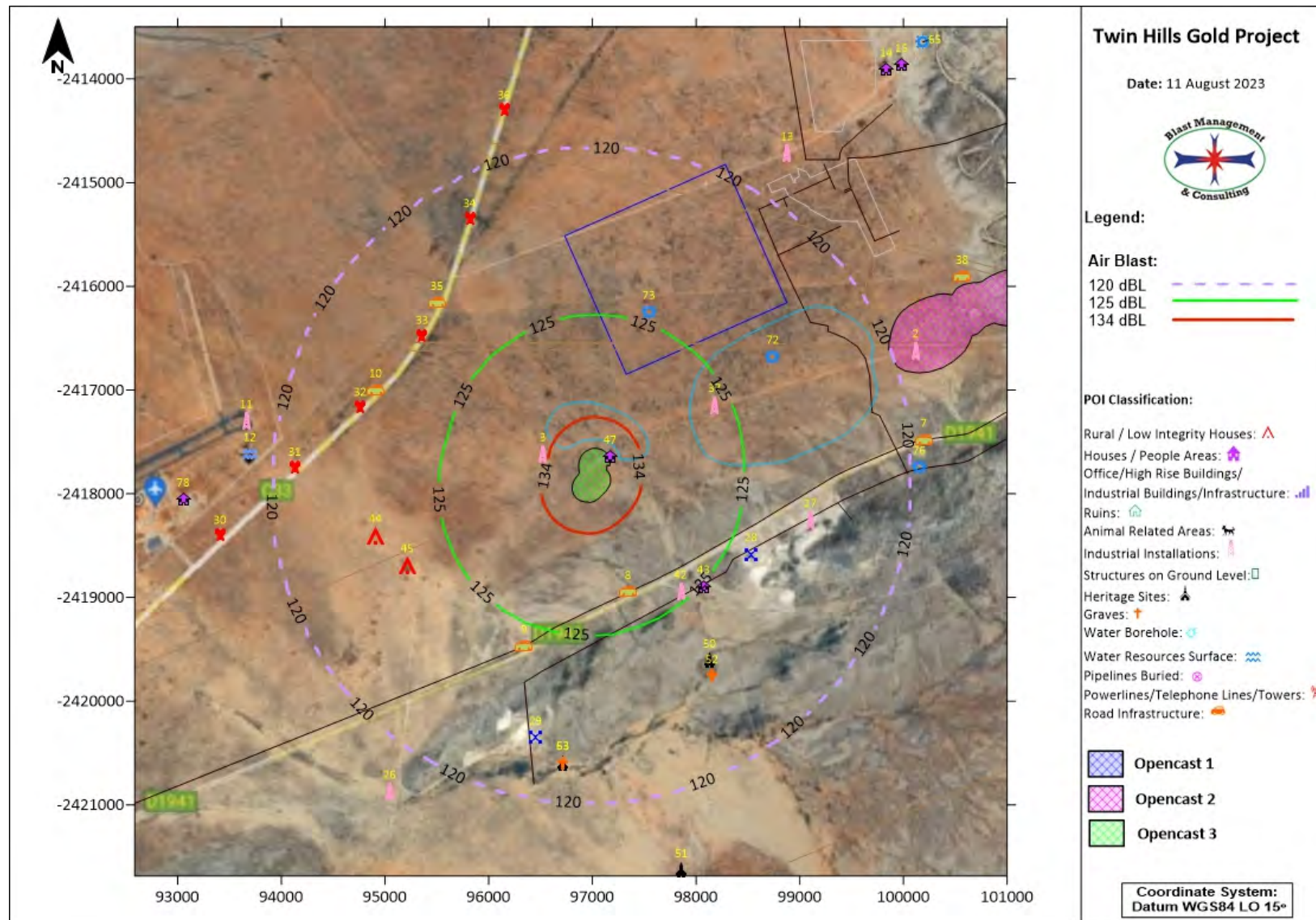


Figure 21: Air blast influence from maximum charge – Opencast 3

Table 20: Air blast influence from maximum charge – Opencast 3

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Road (D1941) - Inside Pit 1 Area	5624	115.9	N/A
2	Cement Dam - Inside Pit 2 Area	3130	119.5	N/A
3	Cement Dam	355	132.9	N/A
4	Road (D1941)	5872	115.7	N/A
5	Road (D1941)	5001	116.7	N/A
6	Road (D1941)	4448	117.4	N/A
7	Road (D1941)	3033	119.7	N/A
8	Road (D1941)	935	127.0	N/A
9	Road (D1941)	1502	124.1	N/A
10	Road (C33)	2075	122.1	N/A
11	Landing Strip	3202	119.4	N/A
12	Water Reservoir	3121	119.6	N/A
13	Cement Dam	3370	119.1	N/A
14	Buildings/Structures	4578	117.2	Acceptable
15	Farmstead	4702	117.0	Acceptable
16	Farmstead	8067	113.8	Acceptable
17	Buildings/Structures	8135	113.7	Acceptable
18	Structure	7940	113.8	Acceptable
19	Dam/Dam Wall	8505	113.4	N/A
20	Cement Dam	8727	113.2	N/A
21	Buildings/Structures	4500	117.3	Acceptable
22	Buildings/Structures	4243	117.7	Acceptable
23	Buildings/Structures	4536	117.3	Acceptable
24	Road (D1941)	4759	117.0	N/A
25	Buildings/Structures	4549	117.2	Acceptable
26	Cement Dam	3349	119.1	N/A
27	Mine Activity	1962	122.4	N/A
28	Mine Buildings/Structures	1519	124.0	Complaint
29	Mine Buildings/Structures	2323	121.4	Complaint
30	Power Lines/Pylons	3420	119.0	N/A
31	Power Lines/Pylons	2681	120.5	N/A
32	Power Lines/Pylons	2173	121.8	N/A
33	Power Lines/Pylons	1926	122.5	N/A
34	Power Lines/Pylons	2506	120.9	N/A
35	Road (C33)	2025	122.2	N/A
36	Power Lines/Pylons	3373	119.1	N/A
37	Cement Dam	1138	125.8	N/A
38	Gravel Road	3827	118.3	N/A
39	Structure	5717	115.8	Acceptable
40	Cement Dam	6893	114.7	N/A
41	Cement Dam	8745	113.2	N/A
42	Cement Dam	1195	125.5	N/A
43	Structure	1315	124.9	Complaint

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
44	Rural Village/House	1943	122.5	Complaint
45	Rural Village/Houses	1741	123.1	Complaint
46	Structures - Inside Pit 2 Area	4352	117.5	Acceptable
47	Structure	14	152.7	Problematic
48	Structures - Inside Pit 1 Area	5561	116.0	Acceptable
49	Cement Dam	4311	117.6	N/A
50	Heritage Site (Anchor Stones - Okawayo 476)	1895	122.6	N/A
51	Heritage Site (Quartzite schist outcrop - Okawayo 477)	3654	118.6	N/A
52	Heritage Site (Graves - Okawayo 478)	2033	122.2	N/A
53	Heritage Site (Marble quern stone - Okawayo 479)	2521	120.9	N/A
54	Heritage Site (Farm Building - Okawayo 480)	4401	117.5	Acceptable
55	Heritage Site (Historical Farmstead - Okawayo 481)	4382	117.5	Acceptable
56	Heritage Site (Graves) - Inside Pit 2 area	4353	117.5	N/A
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	4340	117.5	N/A
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	4342	117.5	N/A
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	4466	117.3	N/A
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	4264	117.6	N/A
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	4429	117.4	N/A
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	4466	117.3	N/A
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	2521	120.9	N/A
64	Hydrocensus Borehole (Klein Oka 1)	8323	113.5	N/A
65	Hydrocensus Borehole (Klein Oka 2)	5003	116.7	N/A
66	Hydrocensus Borehole (Oka 7)	4343	117.5	N/A
67	Hydrocensus Borehole (Oka12)	7079	114.5	N/A
68	Hydrocensus Borehole (Twin 6)	8492	113.4	N/A
69	Hydrocensus Borehole (BH3)	4611	117.2	N/A
70	Hydrocensus Borehole (OKP040)	4798	116.9	N/A
71	Hydrocensus Borehole (OKP045)	4309	117.6	N/A
72	Hydrocensus Borehole (OKP008)	1853	122.7	N/A
73	Hydrocensus Borehole (OKP015)	1405	124.5	N/A
74	Hydrocensus Borehole (OKP004)	4961	116.7	N/A
75	Hydrocensus Borehole (Deep Injection Well)	4520	117.3	N/A
76	Hydrocensus Borehole (OKP013)	2979	119.8	N/A
77	Hydrocensus Borehole (OKP056)	4971	116.7	N/A
78	Buildings (Airport)	3747	118.4	Acceptable
79	Okawayo River - Inside Pit 2 area	4340	117.5	N/A
80	River	8979	113.0	N/A

16.7 Summary of findings for air blast

Review of the air blast levels indicate some concerns. Air blast predicted for the maximum charge ranges between 112.8 and 152.7 dB for all the POI's considered. This includes the nearest points such as the Buildings/Structures, Heritage Site (Farm Building), Heritage Site (Historical Farmstead)

and Structures. These levels may contribute to effects such as rattling of roofs or door or windows with limited points that are expected to be damaging and others could lead to complaints.

Expected levels for air blast at Opencast 1 for minimum and maximum charges ranged between 110 dBL and 152 dBL at the identified POI's.

Expected levels for air blast at Opencast 2 for minimum and maximum charges ranged between 112 dBL and 148 dBL at the identified POI's.

Expected levels for air blast at Opencast 3 for minimum and maximum charges ranged between 110 dBL and 153 dBL at the identified POI's.

Minimum charge predictions identified that seven POI's (Opencast 1); seven POI's (Opencast 2) and three POI's (Opencast 3) at pit areas could experience levels of air blast that could lead to complaints. Maximum charge predictions indicate twelve POI's (Opencast 1); twelve POI's (Opencast 2) and five POI's (Opencast 3) at pit areas could experience air blast that could lead to complaints. One POI (Opencast 3) was identified where damage may be induced.

The current limit applied on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 300 m and closer to pit boundary. Infrastructure at the pit areas such as roads, graves, power lines/pylons are present, but air blast does not have any influence on these installations.

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

16.8 Fly-rock unsafe zone

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

Calculations are also used to help and assist determining safe distances. A safe distance from blasting is calculated following rules and guidelines from the International Society of Explosives Engineers (ISEE) Blasters Handbook. Using this calculation, the minimum safe distances can be determined that should be cleared of people, animals and equipment. Figure 22 shows the results from the ISEE calculations for fly rock range based on a 102 mm diameter blast hole and 1.9 m stemming length. Based on these values a possible fly rock range with a safety factor of 2 was calculated to be 356 m. The absolute minimum unsafe zone is then the 356 m. This calculation is a

guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated. Figure 23 shows the area around the Pit areas that incorporates the 356 m unsafe zone.

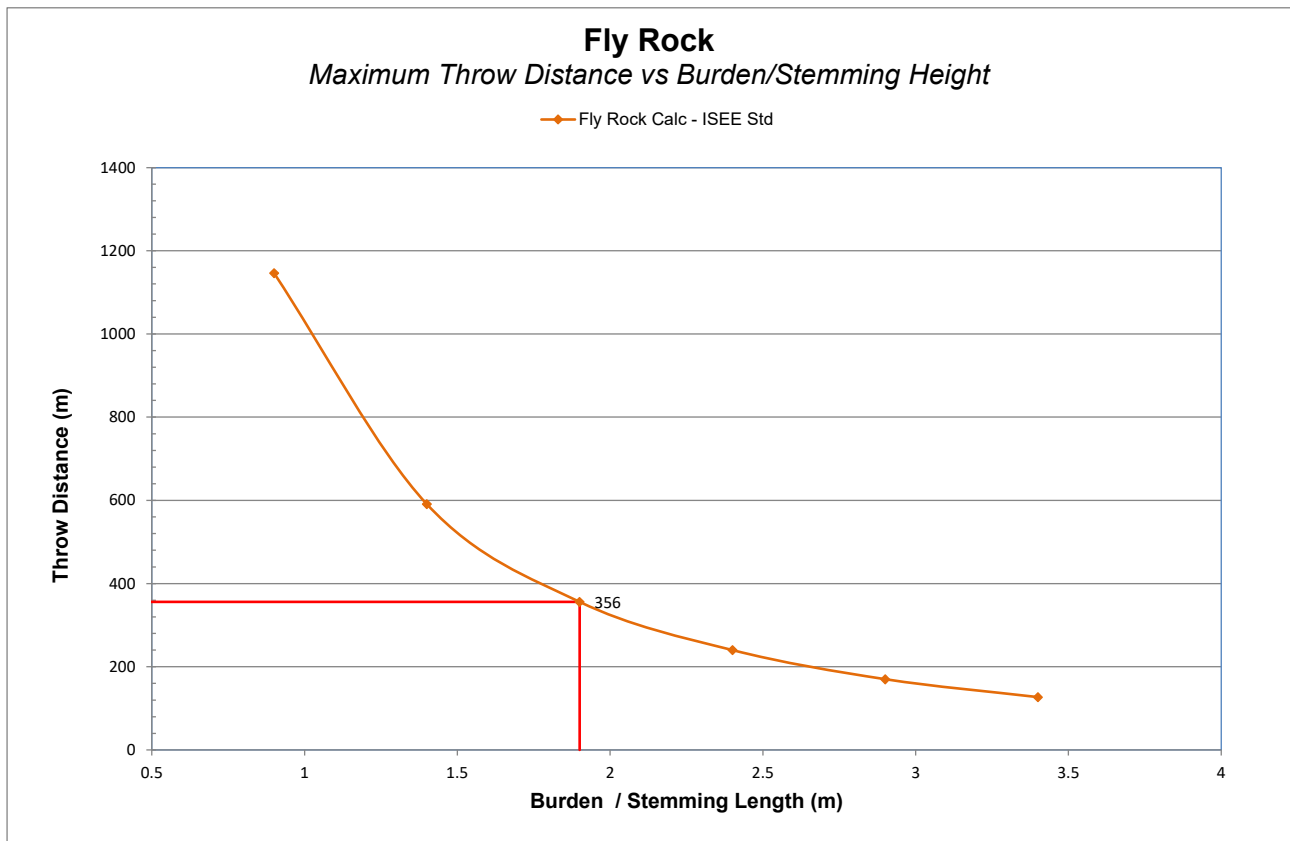


Figure 22: Fly rock prediction calculation

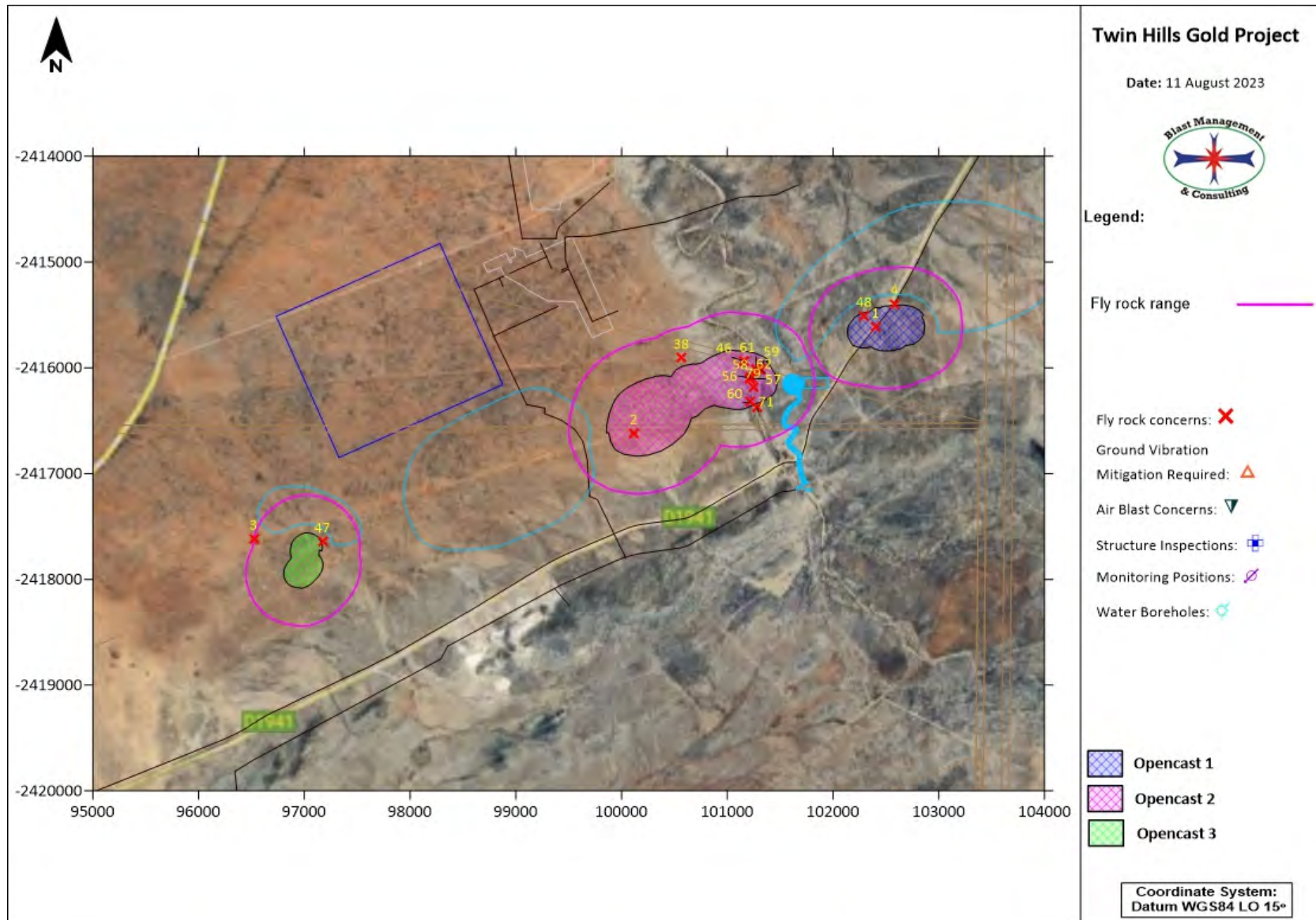


Figure 23: Predicted Fly Rock Exclusion Zone for the Opencast Pit areas

Review of the calculated unsafe zone showed POI's for the Pit areas (including POI's inside the pit areas at this stage), are within the unsafe zone. Table 21 below shows the POI's of concern and coordinates.

Table 21: Fly rock concern POI's

Tag	Description	Y	X
Opencast 1			
1	Road (D1941) - Inside Pit 1 Area	-102404.42	2415611.95
4	Road (D1941)	-102583.08	2415393.85
48	Structures - Inside Pit 1 Area	-102294.63	2415509.11
Opencast 2			
2	Cement Dam - Inside Pit 2 Area	-100118.70	2416619.50
38	Gravel Road	-100567.93	2415907.12
46	Structures - Inside Pit 2 Area	-101164.98	2415942.56
56	Heritage Site (Graves) - Inside Pit 2 area	-101229.44	2416098.01
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101215.31	2416097.31
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101218.22	2416100.46
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101319.56	2416017.13
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101215.08	2416323.04
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101276.52	2416010.02
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101320.74	2416021.01
71	Hydrocensus Borehole (OKP045)	-101278.52	2416370.56
79	Okawayo River - Inside Pit 2 area	-101246.66	2416181.23
Opencast 3			
3	Cement Dam	-96523.84	2417617.63
47	Structure	-97173.42	2417642.20

16.9 Noxious fumes

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

16.10 Water Borehole Influence

Location of boreholes for water was evaluated for possible influence from blasting. Hydrocensus boreholes were identified within the influence area at the Pit areas. There is one borehole that is in close proximity of the blasting areas and off ground vibration concern. Table 22 shows all the identified boreholes and Table 23 shows the possible problematic borehole. Figure 24 shows the location of the boreholes in relation to the pit areas.

Table 22: Identified Water Boreholes

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m) to nearest Pit	Predicted PPV (mm/s)
64	Hydrocensus Borehole (Klein Oka 1)	-104581.83	2413881.56	50	2365	0.4
65	Hydrocensus Borehole (Klein Oka 2)	-100189.09	2413643.47	50	2337	0.4
66	Hydrocensus Borehole (Oka 7)	-101466.60	2417040.83	50	721	2.8
67	Hydrocensus Borehole (Oka12)	-104040.62	2415967.40	50	1216	1.2
68	Hydrocensus Borehole (Twin 6)	-105630.25	2416941.79	50	3045	0.3
69	Hydrocensus Borehole (BH3)	-101764.72	2417292.93	50	1068	1.5
70	Hydrocensus Borehole (OKP040)	-101965.80	2417530.02	50	1369	1.0
71	Hydrocensus Borehole (OKP045)	-101278.52	2416370.56	50	30	537.9
72	Hydrocensus Borehole (OKP008)	-98740.51	2416677.68	50	1118	1.4
73	Hydrocensus Borehole (OKP015)	-97546.03	2416246.51	50	1405	0.9
74	Hydrocensus Borehole (OKP004)	-101275.52	2414873.96	50	975	1.7
75	Hydrocensus Borehole (Deep Injection Well)	-101654.67	2417108.85	50	856	2.1
76	Hydrocensus Borehole (OKP013)	-100152.07	2417742.11	50	907	1.9
77	Hydrocensus Borehole (OKP056)	-102137.87	2417503.01	50	1431	0.9

Table 23: Problematic Water Borehole

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m) to Pit	Predicted PPV (mm/s)
71	Hydrocensus Borehole (OKP045)	-101278.52	2416370.56	50	30	537.9

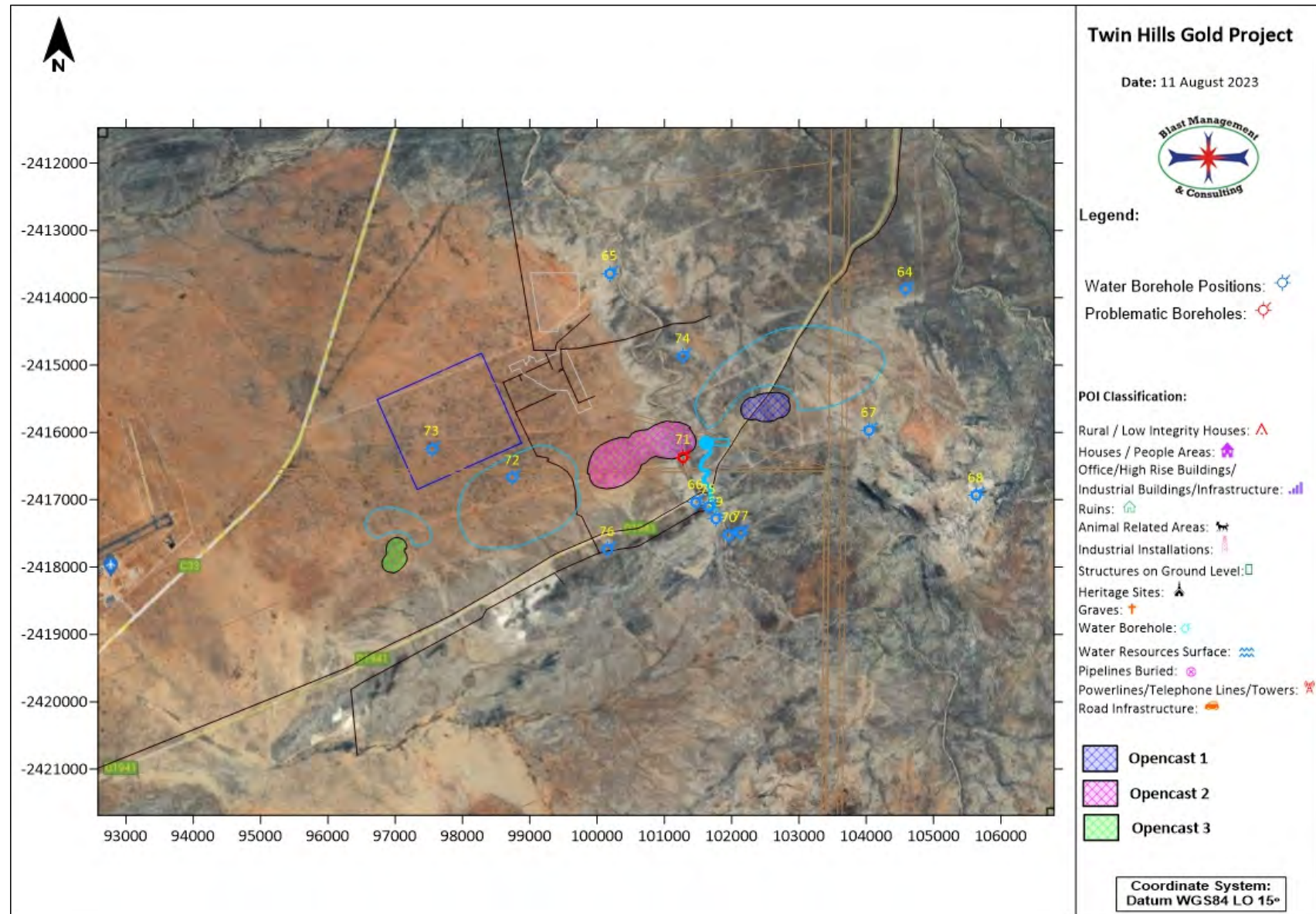


Figure 24: Location of the Boreholes

17 Potential Environmental Impact Assessment: Operational Phase

The following is the impact assessment of the various concerns covered by this report. The impact assessment and evaluation below were used for analysis and evaluation of aspects discussed in this report. The outcome of the analysis is provided in Table 24 with before mitigation and after mitigation. This risk assessment is a one-sided analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation.

Chapter 2 provides an overview of the approach used in this ESIA process, and details each of the steps undertaken to date. Predication and evaluation of impacts is a key step in the ESIA process. This chapter outlines the methods followed, to identify and evaluate the impacts arising from the proposed Project. The findings of the assessment are presented in chapter 7.

This chapter provides comprehensive details of the following:

- The assessment guidance used to assess impacts;
- The limitations, uncertainties, and assumptions with regards to the assessment methodology;
- How impacts are identified and evaluated, and how the level of significance derived;
- How mitigation is applied in the assessment, and how additional mitigation will be identified; and
- The cumulative impact assessment (CIA) method used.

The aims of this assessment are to determine which impacts are likely to be significant; to scope the available data and identify any gaps that need to be filled; to determine the spatial and temporal scope; and to identify the assessment methodology.

The scope of the assessment was determined through undertaking a preliminary assessment of the proposed Project against the receiving environment, and was obtained through a desktop review, available site-specific literature, monitoring data, and site reports, as set out in the existing 2021 scoping report and 2022 ESIA report.

17.1 Assessment Criteria

The following principal documents were used to inform the assessment method:

- International Finance Corporation standards and models, in particular performance standard 1: 'Assessment and management of environmental and social risks and impacts' (International Finance Corporation, 2012 and 2017);
- International Finance Corporation Cumulative Impact Assessment (CIA) and Management Good Practice Handbook (International Finance Corporation, 2013);
- Namibian Draft Procedures and Guidance for EIA and EMP (Republic of Namibia, 2008); and

- Requirements encapsulated in IFC Performance Standard 3 (PS 3)
- Equator Principles 4 (ep 4) - Guidance on environmental and social impact assessment

17.2 Limitations, Uncertainties and Assumptions

The following limitations and uncertainties associated with the assessment methodology were considered in the assessment phase:

- Topic specific assessment guidance has not been developed in Namibia. A generic assessment methodology will be applied to all topics using IFC guidance and professional judgement;
- Guidance for CIA has not been developed in Namibia, but a single accepted state of global practice has been established. The IFC's guidance document (International Finance Corporation, 2013) will be used for the CIA; and
- The climate change methodology was determined by an external specialist in this field in order to comply with international, national and lender reporting requirements.

17.3 Assessment Methodology

The ESIA methodology applied to this assessment has been developed by ECC using the International Finance Corporation (IFC) standards and models, in particular performance standard 1: 'Assessment and management of environmental and social risks and impacts' (International Finance Corporation, 2017); Namibian Draft Procedures and Guidance for EIA and EMP (Republic of Namibia, 2008); international and national best practice; and over 25 years of combined ESIA experience. The methodology is set out in Figure 25 and Figure 26.

The methodology utilised for the climate change assessment was developed by the specialist conducting this assessment to adhere to the requirements of IFC Performance Standard 3 (PS 3) and Equator Principles 4 (ep 4). ECC will not amend this methodology used, however impact significance will be scored.

The evaluation and identification of the environmental and social impacts require the assessment of the Project characteristics against the baseline characteristics, ensuring that all potentially significant impacts are identified and assessed. The significance of an impact is determined by taking into consideration the combination of the sensitivity and importance/value of environmental and social receptors that may be affected by the proposed Project, the nature and characteristics of the impact, and the magnitude of any potential change. The magnitude of change (the impact) is the identifiable changes to the existing environment that may be negligible, low, minor, moderate, high, or very high; temporary/short-term, long-term or permanent; and either beneficial or adverse.

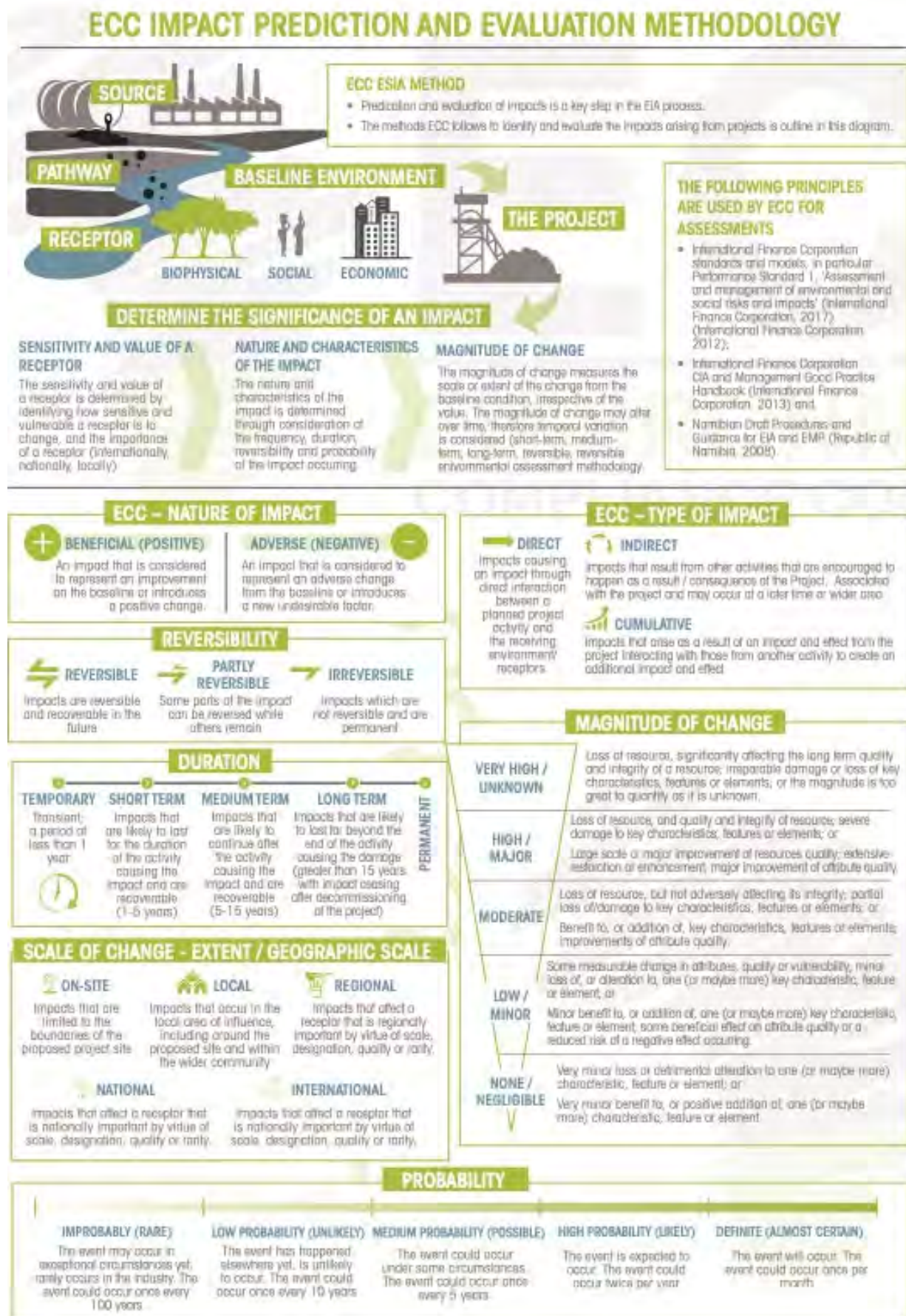
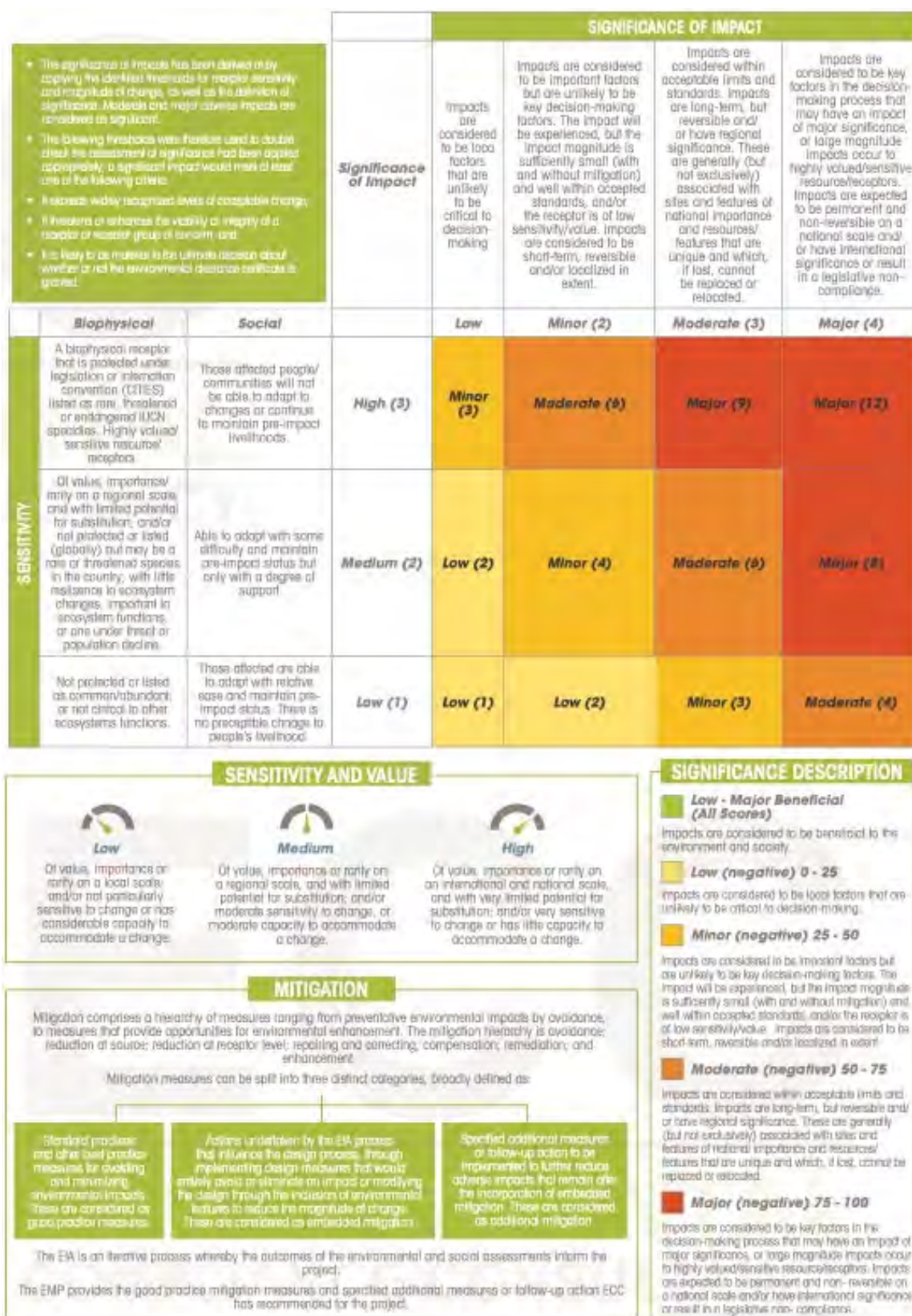


Figure 25: ECC ESIA methodology based on IFC standards



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Figure 26: ECC ESIA methodology based on IFC standards

17.4 Assessment

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

Table 24: Potential Impacts Without Mitigation Measures Mitigation

	Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
1	Blasting	Buildings (Airport)	Ground Vibration	Regional, Life of Mine	Low	Low	Low
2	Blasting	Cement Dam	Ground Vibration	Regional, Life of Mine	Low	Low	Low
3	Blasting	Dam/Dam Wall	Ground Vibration	Regional, Life of Mine	Low	Low	Low
4	Blasting	Farmstead	Ground Vibration	Regional, Life of Mine	Low	Low	Low
5	Blasting	Gravel Road	Ground Vibration	Regional, Life of Mine	Low	Low	Low
6	Blasting	Heritage Site	Ground Vibration	Regional, Life of Mine	Low	Low	Low
7	Blasting	Hydrocensus Borehole	Ground Vibration	Regional, Life of Mine	High	Major	Major
8	Blasting	Landing Strip	Ground Vibration	Regional, Life of Mine	Low	Low	Low
9	Blasting	Mine Activity	Ground Vibration	Regional, Life of Mine	Low	Low	Low
10	Blasting	Mine Buildings/Structures	Ground Vibration	Regional, Life of Mine	Low	Low	Low
11	Blasting	Power Lines/Pylons	Ground Vibration	Regional, Life of Mine	Low	Low	Low
12	Blasting	River	Ground Vibration	Regional, Life of Mine	Low	Low	Low
13	Blasting	Road	Ground Vibration	Regional, Life of Mine	High	Major	Major
14	Blasting	Rural Village/Houses	Ground Vibration	Regional, Life of Mine	Low	Low	Low
15	Blasting	Structure	Ground Vibration	Regional, Life of Mine	High	Major	Major
16	Blasting	Water Reservoir	Ground Vibration	Regional, Life of Mine	Low	Low	Low
17	Blasting	Buildings (Airport)	Air Blast	Regional, Life of Mine	Low	Low	Low
18	Blasting	Cement Dam	Air Blast	Regional, Life of Mine	Low	Low	Low
19	Blasting	Dam/Dam Wall	Air Blast	Regional, Life of Mine	Low	Low	Low
20	Blasting	Farmstead	Air Blast	Regional, Life of Mine	Medium	Moderate	Moderate
21	Blasting	Gravel Road	Air Blast	Regional, Life of Mine	Low	Low	Low
22	Blasting	Heritage Site	Air Blast	Regional, Life of Mine	Medium	Moderate	Moderate
23	Blasting	Hydrocensus Borehole	Air Blast	Regional, Life of Mine	Low	Low	Low
24	Blasting	Landing Strip	Air Blast	Regional, Life of Mine	Low	Low	Low
25	Blasting	Mine Activity	Air Blast	Regional, Life of Mine	Low	Low	Low
26	Blasting	Mine Buildings/Structures	Air Blast	Regional, Life of Mine	Low	Low	Low
27	Blasting	Power Lines/Pylons	Air Blast	Regional, Life of Mine	Low	Low	Low

	Activity	Receptor	Impact	Nature of impact	Value & Sensitivity	Magnitude of change	Significance of impact
28	Blasting	River	Air Blast	Regional, Life of Mine	Low	Low	Low
29	Blasting	Road	Air Blast	Regional, Life of Mine	Low	Low	Low
30	Blasting	Rural Village/Houses	Air Blast	Regional, Life of Mine	High	Moderate	Moderate
31	Blasting	Structure	Air Blast	Regional, Life of Mine	High	Major	Major
32	Blasting	Water Reservoir	Air Blast	Regional, Life of Mine	Low	Low	Low
33	Blasting	Buildings (Airport)	Fly Rock	Site, Life of Mine	Low	Low	Low
34	Blasting	Cement Dam	Fly Rock	Site, Life of Mine	High	Major	Major
35	Blasting	Dam/Dam Wall	Fly Rock	Site, Life of Mine	Low	Low	Low
36	Blasting	Farmstead	Fly Rock	Site, Life of Mine	Low	Low	Low
37	Blasting	Gravel Road	Fly Rock	Site, Life of Mine	High	Major	Major
38	Blasting	Heritage Site	Fly Rock	Site, Life of Mine	Low	Low	Low
39	Blasting	Hydrocensus Borehole	Fly Rock	Site, Life of Mine	Low	Low	Low
40	Blasting	Landing Strip	Fly Rock	Site, Life of Mine	Low	Low	Low
41	Blasting	Mine Activity	Fly Rock	Site, Life of Mine	Low	Low	Low
42	Blasting	Mine Buildings/Structures	Fly Rock	Site, Life of Mine	Low	Low	Low
43	Blasting	Power Lines/Pylons	Fly Rock	Site, Life of Mine	Low	Low	Low
44	Blasting	River	Fly Rock	Site, Life of Mine	Low	Low	Low
45	Blasting	Road	Fly Rock	Site, Life of Mine	Low	Low	Low
46	Blasting	Rural Village/Houses	Fly Rock	Site, Life of Mine	Low	Low	Low
47	Blasting	Structure	Fly Rock	Site, Life of Mine	High	Major	Major
48	Blasting	Water Reservoir	Fly Rock	Site, Life of Mine	Low	Low	Low

17.5 Mitigations

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

Specific impacts are expected at the following POI's identified. Table 25 shows list of POI's that will need to be considered. Figure 27 shows the location of these POI's in relation to the pit areas.

Table 25: Structures identified as problematic in and around the project area

Tag	Description	Classification	Y	X
Opencast 1				
1	Road (D1941) - Inside Pit 1 Area	15	-102404.42	2415611.95
4	Road (D1941)	14	-102583.08	2415393.85
48	Structures - Inside Pit 1 Area	15	-102294.63	2415509.11
Opencast 2				
2	Cement Dam - Inside Pit 2 Area	15	-100118.70	2416619.50
46	Structures - Inside Pit 2 Area	15	-101164.98	2415942.56
54	Heritage Site (Farm Building - Okawayo 480)	8	-101460.69	2416693.94
56	Heritage Site (Graves) - Inside Pit 2 area	15	-101229.44	2416098.01
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	15	-101215.31	2416097.31
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	15	-101218.22	2416100.46
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	15	-101319.56	2416017.13
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	15	-101215.08	2416323.04
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	15	-101276.52	2416010.02
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	15	-101320.74	2416021.01
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	15	-96717.09	2420593.82
71	Hydrocensus Borehole (OKP045)	10	-101278.52	2416370.56
79	Okawayo River - Inside Pit 2 area	15	-101246.66	2416181.23
Opencast 3				
47	Structure	2	-97173.42	2417642.20

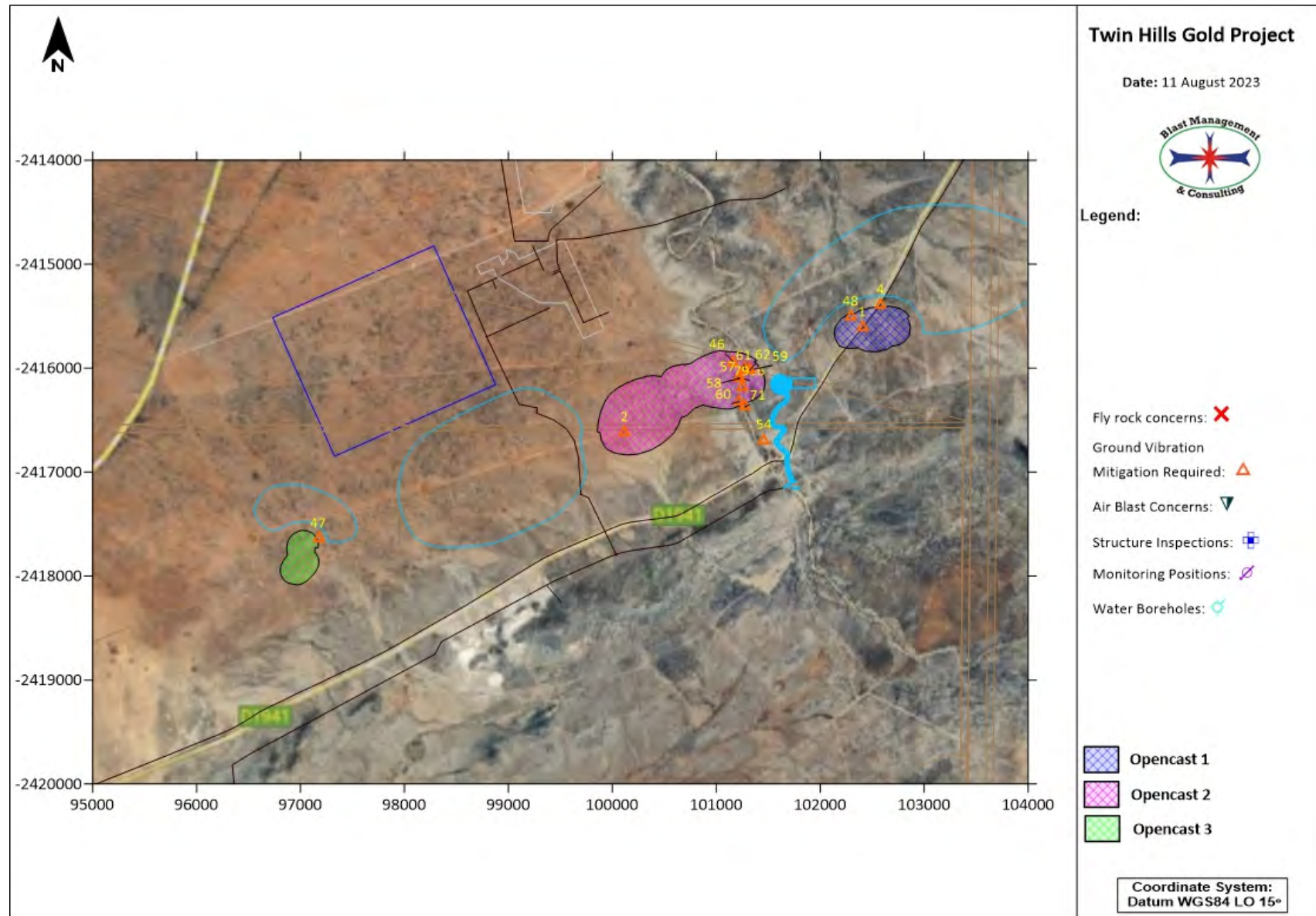


Figure 27: Mitigation POI's

Based on the modelling done, high levels of influence are specifically observed up to 400 m from the pit boundary. There are influences further but to lesser extent. The following specific mitigations may be considered.:

1. Relocation of households within the 400 m boundary from the mine
2. Changes to drill and blast design to mitigate ground vibration
3. Changes to charging designs to mitigate air blast and fly rock.

Relocation:

Relocation of households closer than 400 m from the pit boundary is recommended as an option as part of the mitigation of ground vibration, air blast and fly rock.

Air blast and Fly rock:

Air blast and 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.

Ground Vibration:

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

- Do blast design that considers the actual blasting, and the ground vibration levels to be adhered too.
- Change to bench heights with smaller diameter blastholes can be considered.
- Multiple charge decks in a blastholes initiated separately to reduce the charge mass per delay can be considered.
- Only apply electronic initiation systems to facilitate single hole firing.
- Do design for smaller diameter blast holes that will use fewer explosives per blast hole.

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

Table 26 do show mitigation in the form of maximum charge mass that will be allowed to maintain safe levels of ground vibration. Table 27 shows minimum distance between blast and POI to maintain ground vibration limits for minimum and maximum charge per delay.

Table 26: Mitigation measures: Maximum charge per delay for distance to POI

Tag	Description	Y	X	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)	Predicted PPV (mm/s)	Structure Response @ 10Hz
	Opencast 1							
1	Road (D1941) - Inside Pit 1 Area	-102404.42	2415611.95	Reroute of road				
4	Road (D1941)	-102583.08	2415393.85	150	17	23	150	Acceptable
48	Structures - Inside Pit 1 Area	-102294.63	2415509.11	Relocate				
	Opencast 2							
2	Cement Dam - Inside Pit 2 Area	-100118.70	2416619.50	Relocate				
46	Structures - Inside Pit 2 Area	-101164.98	2415942.56	Relocate				
54	Heritage Site (Farm Building - Okawayo 480)	-101460.69	2416693.94	6	398	273	6	Acceptable
56	Heritage Site (Graves) - Inside Pit 2 area	-101229.44	2416098.01	A plan of action to be done with the heritage specialist.				
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101215.31	2416097.31					
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101218.22	2416100.46					
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101319.56	2416017.13					
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101215.08	2416323.04					
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101276.52	2416010.02					
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101320.74	2416021.01					
63	Heritage Site (Potential burial ground) - Inside Pit 2 area	-96717.09	2420593.82					
71	Hydrocensus Borehole (OKP045)	-101278.52	2416370.56	50	30	20	50	Acceptable
79	Okawayo River - Inside Pit 2 area	-101246.66	2416181.23	Possible diversion				
	Opencast 3							
47	Structure	-97173.42	2417642.20	12.5	14	1	12.5	Acceptable

These POI's vary in distance and it will be required that each be evaluated in relation to a blast to be done. The distance should be checked, the charge mass allowed be calculated and then a design of charging or timing applied to ensure that the limits are not exceed. In most cases basic planned design does not need to change but timing can be adjusted as well electronic timing can used to reduce the charge mass per delay. This must be confirmed with monitoring of ground vibration at the POI.

The following Table 27 shows the minimum distance required between blast and POI for the minimum and maximum charge per delay to maintain the ground vibration limits applied.

Table 27: Mitigation measures: Minimum distances required

Tag	Example POI	Specific Limit (mm/s)	Distance (m)	Total Mass/Delay (kg)
Minimum charge per delay				
	Heritage Site (Farm Building - Okawayo 480)	6	228	90
	Structure	12.5	146	90
	Hydrocensus Borehole	50	63	90
	Road (D1941)	150	32	90
	River	200	27	90
Maximum charge per delay				
	Heritage Site (Farm Building - Okawayo 480)	6	458	361
	Structure	12.5	293	361
	Hydrocensus Borehole	50	127	361
	Road (D1941)	150	65	361
	River	200	55	361

Data provided in tables above clearly indicate that distance between blast and POI will have influence on the allowed charge mass per delay with regards to the different ground vibration limits.

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 time of the blast;
- Video Recording of the blast;
- Fly rock observations.

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

Five monitoring points were identified as possible locations that will need to be considered for all the pit areas. Not all the identified points will be required simultaneously. The identified points are guidelines to consider for each pit area. Monitoring positions (for all pits) are indicated in Figure 28 and Table 28 lists the positions with coordinates. These points will need to be re-defined after the first blasts done and the monitoring programme defined.

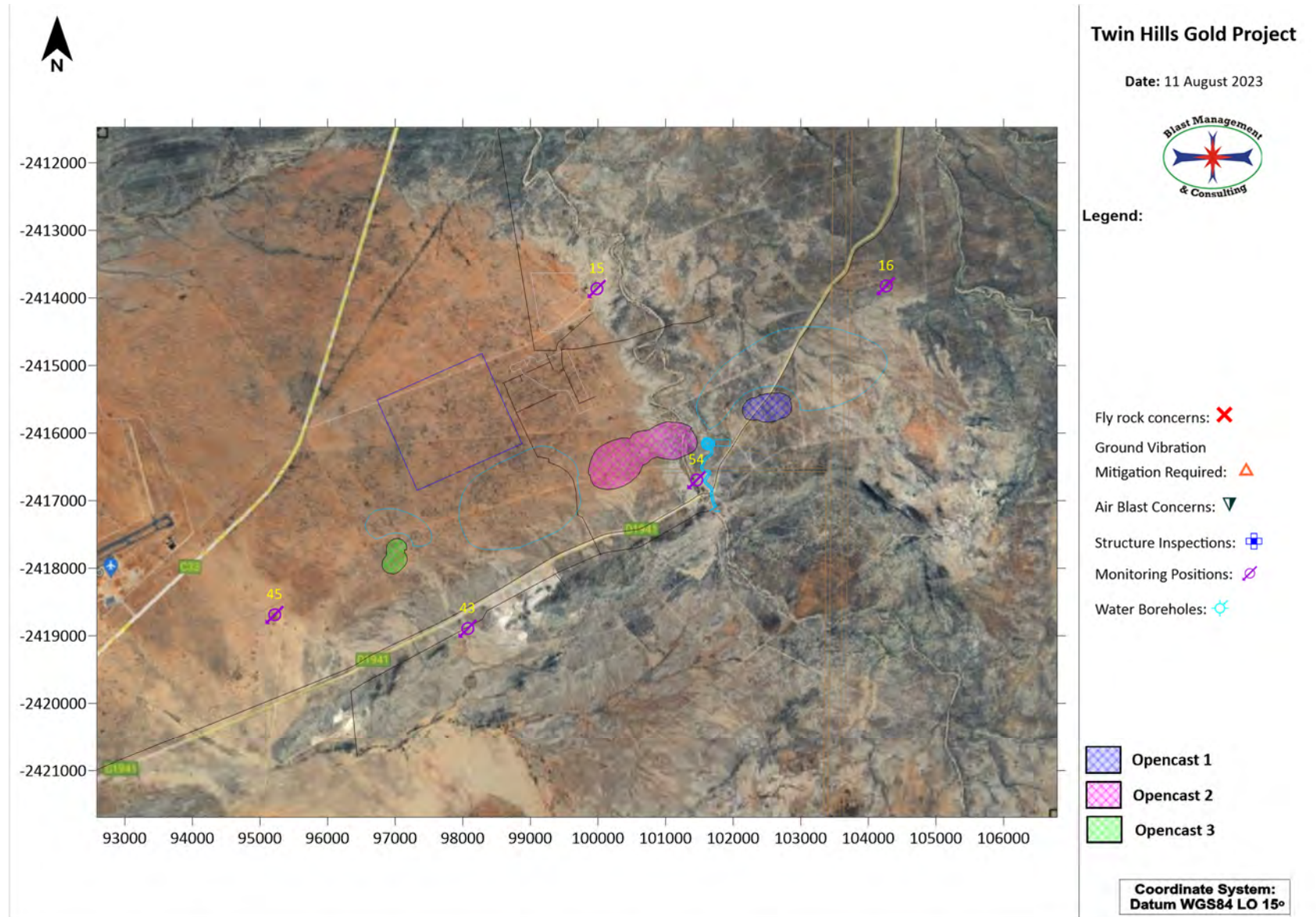


Figure 28: Suggested monitoring positions

Table 28: List of possible monitoring positions

Tag	Description	Y	X
15	Farmstead	-99983.74	2413864.91
16	Farmstead	-104263.34	2413823.69
43	Structure	-98073.91	2418892.69
45	Rural Village/Houses	-95216.81	2418688.66
54	Heritage Site (Farm Building - Okawayo 480)	-101460.69	2416693.94

21 Recommendations

The following recommendations are proposed.

21.1 Relocation

Review of possible impacts it is recommended that households within 400 m at least should be relocated. Expected levels of ground vibration and air blast is greatest up to 400 m.

21.2 Blast Designs

Blast designs can be reviewed prior to first blast planned and done. Specific attention can be given to the possible use of electronic initiation rather than conventional timing systems. This will allow for single blast hole firing instead of multiple blast holes. Single blast hole firing will provide single hole firing – thus less charge mass per delay and less influence. Please refer to section 17.5 for detail regarding mitigations required.

21.3 Test Blasting

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

21.4 Stemming length

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

21.5 Safe blasting distance and evacuation

Calculated minimum safe distance is 356 m. The final blast designs that may be used will determine the final decision on safe distance to evacuate people and animals. This distance may be greater pending the final code of practice of the mine and responsible blaster's decision on safe distance. The blaster has a legal obligation concerning the safe distance and he needs to determine this distance.

21.6 Road management

The D1941 road is at closest distance to the Opencast 1 area at approximately 17 m; 497 m to the Opencast 2 area and 935 m to the Opencast 3 area. The D1941 road is located such that when blasting is done within 500 m from this road travel management will be required. Stop and Go procedures during blasting will be required.

There are gravel roads that traverse through the existing approved mining area. There is no specific ground vibration concern for these roads. There are also other smaller gravel roads in the area. These roads are specifically of concern when blasting is done in regards with 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 to maintain safe blasting radius. It will be required that clearance distances be set, and road travel managed during blasting operations.

21.7 Photographic Inspections

The option of photographic survey of all structures up to 1500 m from the pit areas is recommended. The mine will be operating for a significant number of years. This will give advantage on any negotiations with regards to complaints from neighbours on structural issues due to blasting. This process can however only succeed if done in conjunction with a proper monitoring program. It is expected that ground vibration levels will be significantly less than proposed limits at 1500 m, but this process will ensure record of the pre-blasting status of the nearest structures to the pit area. At 1500 m the expected level of ground vibration will be perceptible. Figure 29 shows extent of the range of 1500 m around the pit areas with POI's identified. It must be noted that a point may represent a group of structures found in the vicinity of the point identified.

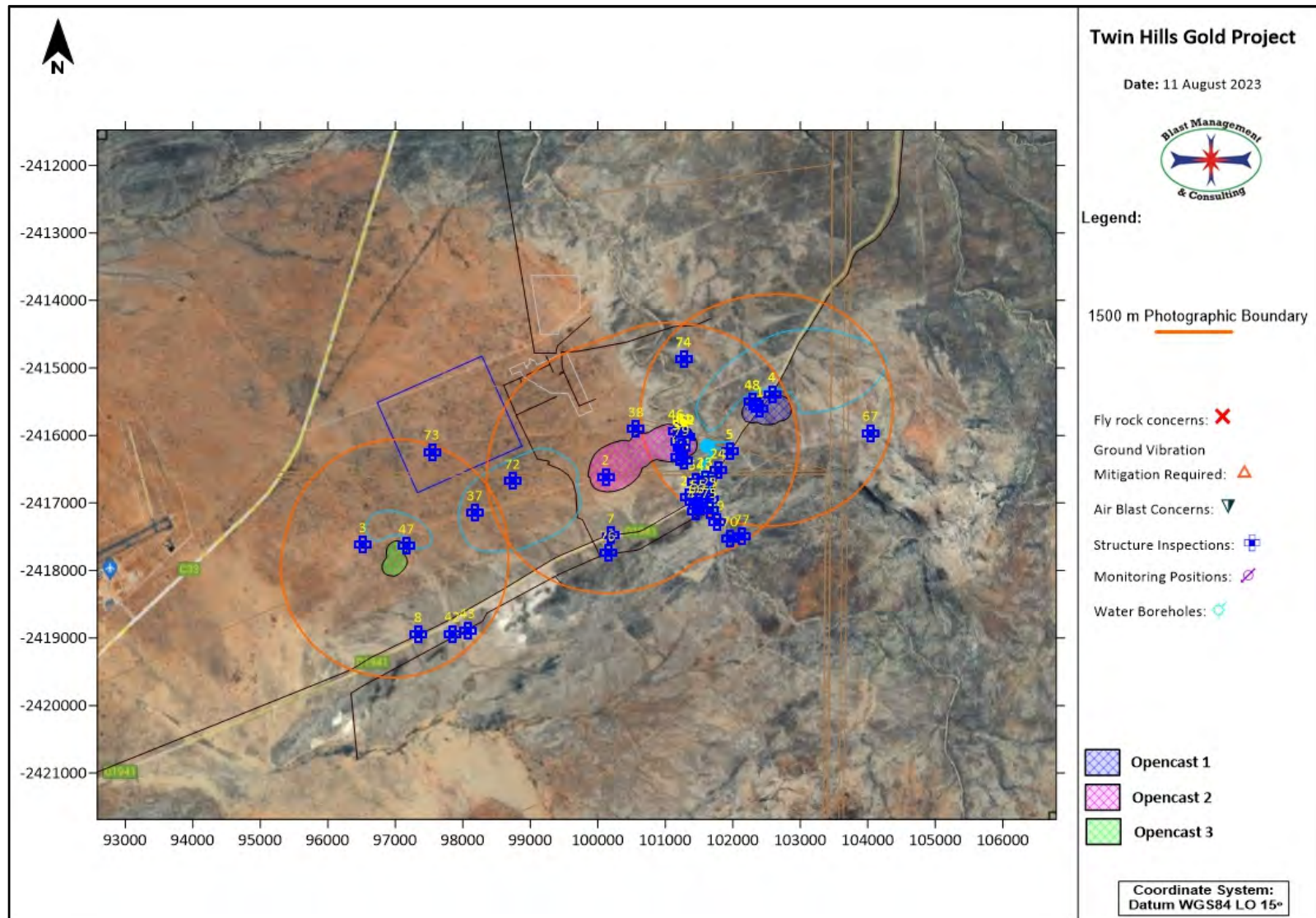


Figure 29: 1500 m area around Opencast pits identified for structure inspections.

Table 29: Combined list of structures identified for inspections

Tag	Description	Y	X
1	Road (D1941) - Inside Pit 1 Area	-102404.42	2415611.95
3	Cement Dam	-96523.84	2417617.63
4	Road (D1941)	-102583.08	2415393.85
5	Road (D1941)	-101960.09	2416234.07
6	Road (D1941)	-101550.22	2416898.78
8	Road (D1941)	-97345.46	2418947.35
21	Buildings/Structures	-101581.01	2416782.55
22	Buildings/Structures	-101345.61	2416922.10
23	Buildings/Structures	-101590.11	2416653.33
24	Road (D1941)	-101786.98	2416519.52
25	Buildings/Structures	-101660.72	2416946.97
37	Cement Dam	-98181.29	2417144.84
42	Cement Dam	-97851.34	2418941.38
43	Structure	-98073.91	2418892.69
46	Structures - Inside Pit 2 Area	-101164.98	2415942.56
47	Structure	-97173.42	2417642.20
48	Structures - Inside Pit 1 Area	-102294.63	2415509.11
54	Heritage Site (Farm Building - Okawayo 480)	-101460.69	2416693.94
55	Heritage Site (Historical Farmstead - Okawayo 481)	-101497.11	2416981.00
56	Heritage Site (Graves) - Inside Pit 2 area	-101229.44	2416098.01
57	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101215.31	2416097.31
58	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101218.22	2416100.46
59	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101319.56	2416017.13
60	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101215.08	2416323.04
61	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101276.52	2416010.02
62	Heritage Site (Potential burial ground) - Inside Pit 2 area	-101320.74	2416021.01
66	Hydrocensus Borehole (Oka 7)	-101466.60	2417040.83
67	Hydrocensus Borehole (Oka12)	-104040.62	2415967.40
69	Hydrocensus Borehole (BH3)	-101764.72	2417292.93
70	Hydrocensus Borehole (OKP040)	-101965.80	2417530.02
71	Hydrocensus Borehole (OKP045)	-101278.52	2416370.56
72	Hydrocensus Borehole (OKP008)	-98740.51	2416677.68
73	Hydrocensus Borehole (OKP015)	-97546.03	2416246.51
74	Hydrocensus Borehole (OKP004)	-101275.52	2414873.96
75	Hydrocensus Borehole (Deep Injection Well)	-101654.67	2417108.85
76	Hydrocensus Borehole (OKP013)	-100152.07	2417742.11
77	Hydrocensus Borehole (OKP056)	-102137.87	2417503.01
79	Okawayo River - Inside Pit 2 area	-101246.66	2416181.23

21.8 Recommended ground vibration and air blast levels

The ground vibration and air blast levels limits recommended for blasting operations in this area are provided in Table 30.

Table 30: Recommended ground vibration air blast limits

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

21.9 Blasting times

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

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

21.10 Third party monitoring

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

21.11 Video monitoring of each blast

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

22 Knowledge Gaps

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

23 Project Result

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

24 Conclusion

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

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

The location of structures around the Pit areas are such that the charge evaluated showed possible influences due to ground vibration. The closest structures observed are the Road (D1941), Hydrocencus Boreholes, Heritage Sites, Buildings/Structures and Cement Dam. The ground vibration levels predicted for these POI's ranged between 0.1 mm/s and 1801.4 mm/s for structures surrounding the open pit areas. The expected levels of ground vibration for some of these structures are high and will require specific mitigations in the way of adjusting charge mass per delay to reduce the levels of ground vibration. Ground vibration at structures and installations other than the identified problematic structures is well below any specific concern for inducing damage.

Air blast predicted showed some concerns for opencast blasting. The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134dB. It is maintained

that if stemming control is not exercised this effect could be greater with greater range of complaints or damage. The pits are located such that “free blasting” – meaning no controls on blast preparation – will not be possible.

The current accepted limit on air blast is 134 dBL. Damages are only expected to occur at levels greater than 134 dBL. Prediction shows that air blast will be greater than 134 dB at distance of 300 m and closer to pit boundary. Infrastructure at the pit areas such as roads and power lines/pylons, are present, but air blast does not have any influence on these installations.

Fly rock remains a concern for blasting operations. Based on the drilling and blasting parameters values for a possible fly rock range with a safety factor of 2 was calculated to be 356 m. The absolute minimum unsafe zone is then the 356 m. This calculation is a guideline and any distance cleared should not be less. The occurrence of fly rock can however never be 100% excluded. Best practices should be implemented at all times. The occurrence of fly rock can be mitigated but the possibility of the occurrence thereof can never be eliminated.

Specific actions will be required for the pit area such as Mine Health and Safety Act requirements when blasting is done within 500 m from structures and mining with 100 m for structures. The Buildings/Structures, Heritage Sites, Hydrocensus Boreholes, Road (D1941) and River falls within the 500 m range from the pit areas.

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

This concludes this investigation for the proposed Twin Hills Gold 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 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 AECl Explosives Ltd. Initial work involved testing science on small scale laboratory work and large-scale field work. Later, work entailed managing various testing facilities and testing projects. Due to restructuring of the Technical Department, Mr Zeeman was retrenched but fortunately was able to take up an appointment with AECl Explosives Ltd.'s Pumpable Emulsion Explosives Group for underground applications.

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

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

Mr Zeeman holds the following qualifications:

1985 - 1987 Diploma: Explosives Technology, Technikon Pretoria

1990 - 1992 BA Degree, University of Pretoria

1994 National Higher Diploma: Explosives Technology, Technikon Pretoria

1997 Project Management Certificate: Damelin College

2000 Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

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

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

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

26 References

1. BME Training Module – Vibration, air blast and fly rock, Module V, Dated 5 August 2001.
2. Chiapetta F., Van Vreden A., 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.
3. Dowding C.H., Construction Vibrations, 1996, Prentice Hall, Upper Saddle River, NJ 07458.
4. ISEE The Blasters' Handbook, 18th Edition, Cleveland, Ohio: International Society of Explosives Engineers; 2011.
5. Mechanical vibration and shock – Vibration of buildings – Guidelines for the measurement and evaluation of their effects on buildings, SABS ISO 4886:1990.
6. Oriard, L.L., 1999, The Effects of Vibration and Environmental Forces: A guide for Investigation of Structures, International Society of Explosives Engineers, Cleveland, Ohio, USA.
7. Persson P.A., Holmberg R. and Lee J., 1994, Rock Blasting and Explosives Engineering, Boca Raton, Florida: CRC Press.
8. Richards A. B., Moore A.J., Terrock Consulting Engineers Pty Ltd., 2002, Fly rock Control – By Chance or Design, Paper Presented at ISEE Conference – New Orleans.
9. Rowland, J.H.(III), Mainiero R., and Hurd D.A.(Jr.), Factors Affecting Fumes Production of an Emulsion and Anfo/Emulsion Blends.
10. Sapko M., Rowland J., Mainiero R., Zlochower I., Chemical and Physical Factors that Influence no Production during Blasting – Exploratory Study.
11. Scott A., Open Pit Blast Design, 1996, Julius Kruttschnitt Mineral Research Centre, The University of Queensland.
12. Siskind D.E., Stachura V.J., Stagg M.S. and Kopp J.W., 1980. Structure Response and Damage Produced by Air Blast from Surface Mining. US Bureau of Mines RI 8485.
13. 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.