Universal Coal
NBC Colliery

ANNEXURE D2

PREVIOUS SPECIALIST ASSESSMENTS

cigroup
DO IT RIGHT

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Report: Environmental Impact Assessment: Ground Vibration and Air Blast Study
EIMS Pty Ltd. Exxaro Paardeplaats

EIMS Assignment Number: 0888

BM&C Ref. No.: EIMS~Paardeplaats~EIAReport121016V00.docx

Date: 16 October 2012

Signed:
Name: JD Zeeman

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1 LIST OF ACRONYMS USED IN THIS REPORT

Air Pressure Pulse	APP
Blast Management & Consulting	BM&C
Blasted Tonnage	T
Diameter	Dia.
Distance	D
East	E
Environmental Impact Assessment	EIA
Explosive Mass	E
Explosives (Trinitrotoluene)	TNT
Frequency	Freq.
Frequency	Freq.
Gas Release Pulse	GRP
Hectare	ha
Longitudinal	L
Million Ton per Annum	mtpa
National Highway 4	N4
North	N
North East	NE
North West	NW
Noxious Fumes	NOx’s
Number	No.
Peak Particle Velocity	PPV
Point of Interest	POI
Resultant Peak Particle Velocity	RPPV

Rock Pressure Pulse	RPP
Run of Mine	ROM
Site Constant	a
Site Constant	b
South	S
South East	SE
South West	SW
Transverse	T
United States Bureau of Mine	USBM
Vertical	V
West	W

2 LIST OF UNITS USED IN THIS REPORT

Air Blast	dB
Charge Height	m
Cup Density	Gr/cm^3
Ground Vibration	mm/s
Kilometre	km
Frequency	Hz
Mass	kg
Meter	m
Milliseconds	ms
Peak Acceleration	mm/s^2
Peak Displacement	mm
Peak Particle Velocity	mm/s
Powder Factor	kg/m^3
Vector Sum Peak Particle Velocity	mm/s
Coordinates (South African)	WGS84

3 LIST OF FIGURES

4 LIST OF TABLES

EXECUTIVE SUMMARY

Blast Management & Consulting (BM&C) 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 new opencast mining operation. Ground vibration, air blast, fly rock and fumes are some of the aspects as a result from blasting operations. The report concentrates on the ground vibration and air blast intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

The evaluation of effects yielded by blasting operations was evaluated over an area as wide as 3500m at least and in some cases further from the mining area considered. The range of structures expected is typical town and farming community with structures that range from well build to informal building style. These include rural type mud house buildings to brick and mortar structures, cement brick structures, and industrial structures. The project area consists mainly of one opencast pit area with option to mine only portion 30.

The project area has possibility of presence of people and farm animals at very close distances to the operations. There are a significant quantity structures in areas around the different pit areas within a 1000m. The N4 national highway is one concern that will need specific attention if the full project will be mined. The N4 is closer than 500m from the project area on the southern side. All animals and people should not be present within 500m from the blasting operations.

Three different charge masses were evaluated. The location of structures around the pit areas are such that even with minimum charge possible influences may be expected. Ground vibration yielded from blasting is expected to be lesser of concern. Air blast did show levels of concern and over distances further than that of ground vibration. There are significant quantities of houses in range where complaints may be expected. Complaints from air blast are normally based on the actual effects that are experienced due to rattling of roof, windows, doors etc. These effects could startle people and raise concern of possible damage.

The main project area or portion 30 is located such that “free blasting” – meaning without specific controls on blast preparation – will not be possible.

Specific mitigations were recommended in order to be able to conduct drilling and blasting operations. Specifically will limited charging be required with additional aspects for control of

air blast and fly rock with management of blasting operations. The concerns raised are in relation to promote good neighbour ship.

This concludes this investigation for Paardeplaats Project. It will be possible to operate this mine in a safe and effective manner provided attention is given to the areas of concern and recommendations as indicated.

5 INTRODUCTION

Blast Management & Consulting (BM&C) was contracted as part of Environmental Impact Assessment (EIA) to perform review of possible impacts with regards to blasting operations in the proposed new opencast mining operation. Ground vibration, air blast, fly rock and fumes are some of the aspects that results from blasting operations. This study will review possible influences that blasting may have on the surrounding area in respect of these aspects. The report concentrates on the ground vibration and air blast and intends to provide information, calculations, predictions, possible influences and mitigations of blasting operations for this project.

6 BACKGROUND INFORMATION

6.1 PROTOCOLS AND OBJECTIVES

The protocols applied in this document are based on the author's experience, guidelines from literature research, client requirements and general indicators from the various acts of South Africa. There is no direct reference in the following acts with regards to requirements and limits on the effect of ground vibration and air blast specifically and some of the aspects addressed in this report. The acts consulted are: National Environmental Management Act No. 107 of 1998, Mine Health and Safety Act No. 29 of 1996, Mineral and Petroleum Resources Development Act No. 28 of 2002.

The guidelines and safe blasting criteria are according international accepted standards and specific applied in this document is the United States Bureau of Mines (USBM) criteria for safe blasting for ground vibration and recommendations on air blast. There are no specific South African standard and the USBM is well accepted as standard for South Africa.

However it is sure that the protocols and objectives will fall within the broader spectrum as required by the various acts.

The objective of this document is to outline the expected environmental effects that blasting operations could have on the surrounding environment and proposal of specific mitigation measures that will be required. This study investigates the related influences of expected ground vibration, air blast, fly rock, and noxious fumes. These effects are investigated in relation to the surroundings of the blast site and possible influence on the neighbouring houses and owners or occupants.

Objectives can be summarized according to the following steps taken as part of the EIA study with regards specifically to ground vibration and air blast due to blasting operations.

- Background information of the proposed site
- Structure Profile
- Mining operations and Blasting Operation Requirements
- Effects of blasting operations:
- Ground vibration
- Air blast
- Fly rock
- Noxious fumes
- Site specific evaluation blasting effects for each area in relation to the points of interest identified
- Risk Assessment
- Mitigations
- Recommendations
- Conclusion

6.2 VISUALISATION OF THE PROPOSED SITE

The Paardeplaats project is located on Portions 28, 29, 30 and 40 of the farm Paardeplaats 380 JT; Remaining Extent (RE) of Portion 2 of the farm Paardeplaats 425 JS; and Portion 13 of Paardeplaats 380JT. The Paardeplaats project covers an area of approximately 1 415 ha and falls within the jurisdiction of the Nkangala District Municipality and Emakhazeni Local Municipality (ELM).

The Paardeplaats project will supply coal (ROM) to the Glisa mine beneficiation plant at a rate of 4.2 – 4.4 mtpa and supply to Eskom at a rate of 2.4 mtpa. The mining method will be a hybrid between roll-over mining as well as bench mining. The roll-over mining will be used where only one seam is present as well as where the overburden has a thickness less than 20m. The bench mining will be used where two or more seams are present and where the overburden has a thickness of more than 20m. The stripping operation removes the topsoil and exposes the overburden of the next cut. The continuity of this process is essential in order to ensure that sufficient workroom is maintained. The initial topsoil will be hauled to a designated area and be used for rehabilitation later on. When steady state is reached, topsoil is replaced in a continuous operation. The overburden will be drilled and blasted. The operation will be done in two phases. The top portion will be loaded and hauled; the lower portion will be done via a dozing process. This will ensure that the rehabilitation is adequately addressed by means of a backfilling process. Once the overburden has been removed, the coal (ROM) is transferred to the plant by means of a load and hauls operation. The mineral deposit consists of the No 2 seam of the Springs-Witbank Coalfield in Mpumalanga.

Figure 1 shows geographical locality plan of the proposed project area. Figure 2 shows project layout plan and figure 3 shows aerial view of the mining area and surroundings with points of interest.

The site was reviewed and presented hereafter. Site was reviewed with site visit and using Google Earth imagery. Information sought from review was typically what surface structures are present in a 3500m radius from the proposed mine boundary that will require consideration during modelling of blasting operations. This could consists of houses, general structures, power lines, pipe lines, reservoirs, mining activities, roads, shops, schools, gathering places, possible historical sites etc. A list was prepared as best possible for each structure in the vicinity of the pit areas. The list prepared covers structures and points of interest (POI) in the 3500m boundary. A list of structure locations was required for determining the allowable ground vibration limits and air blast limits possible. The list compiled is provided in Table 1 below.

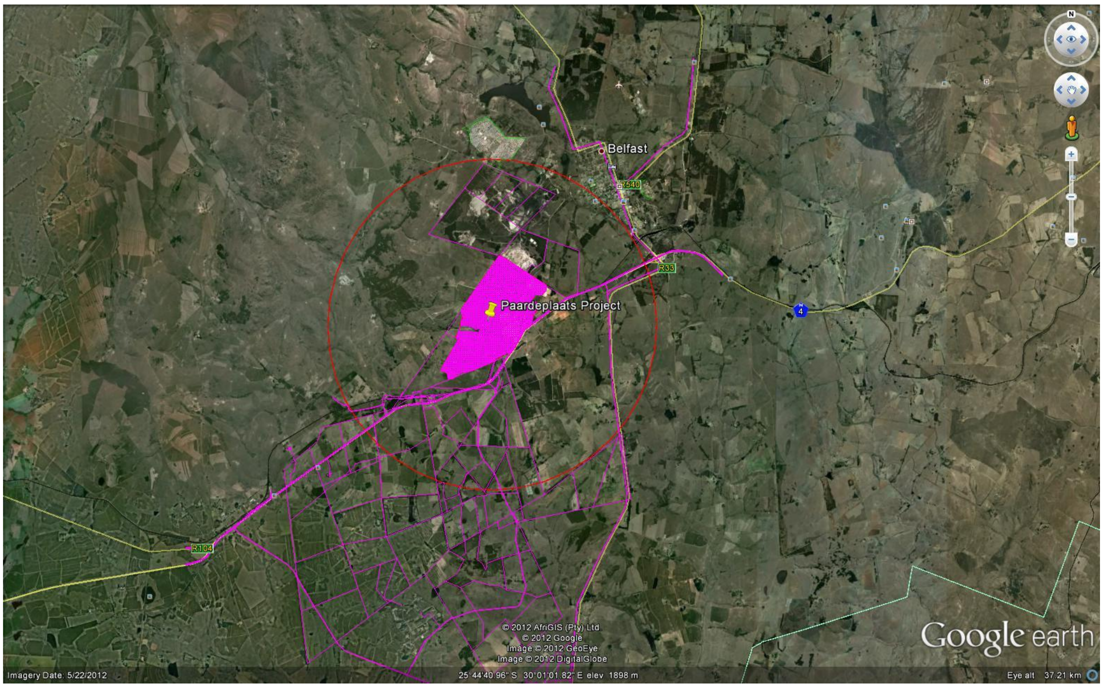

Figure 1: Locality of the project area

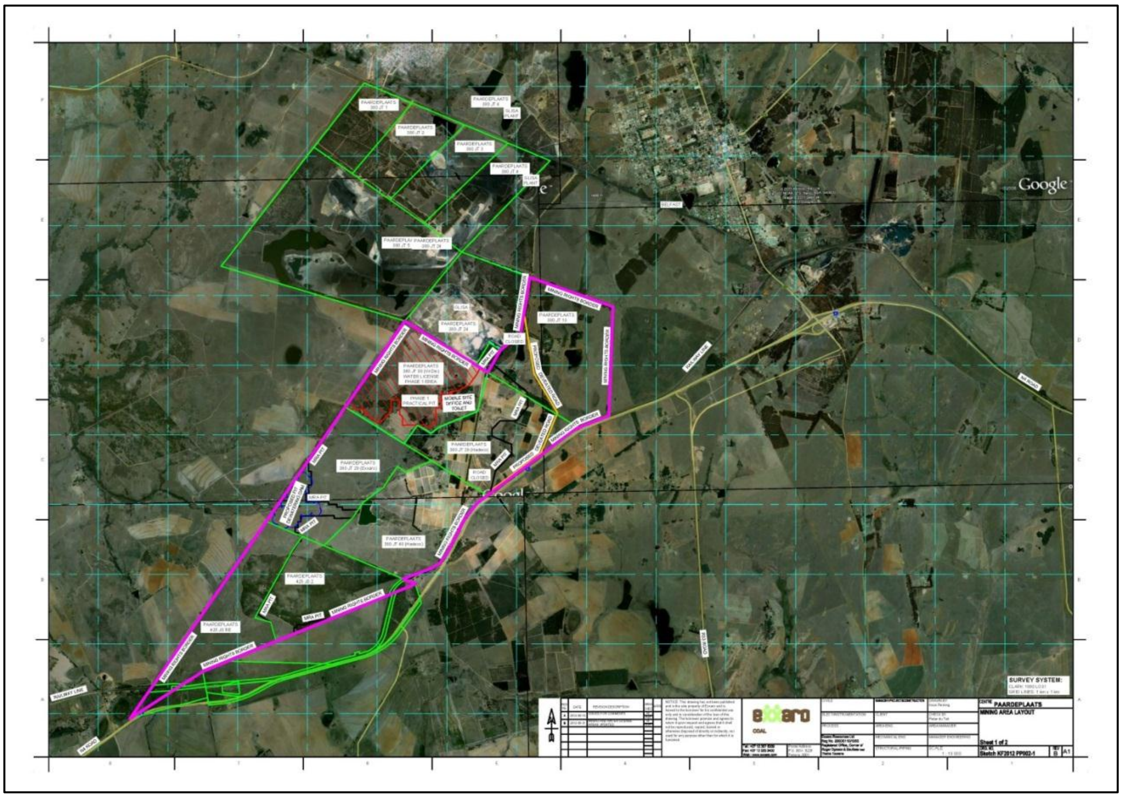

Figure 2: Proposed project area layout.

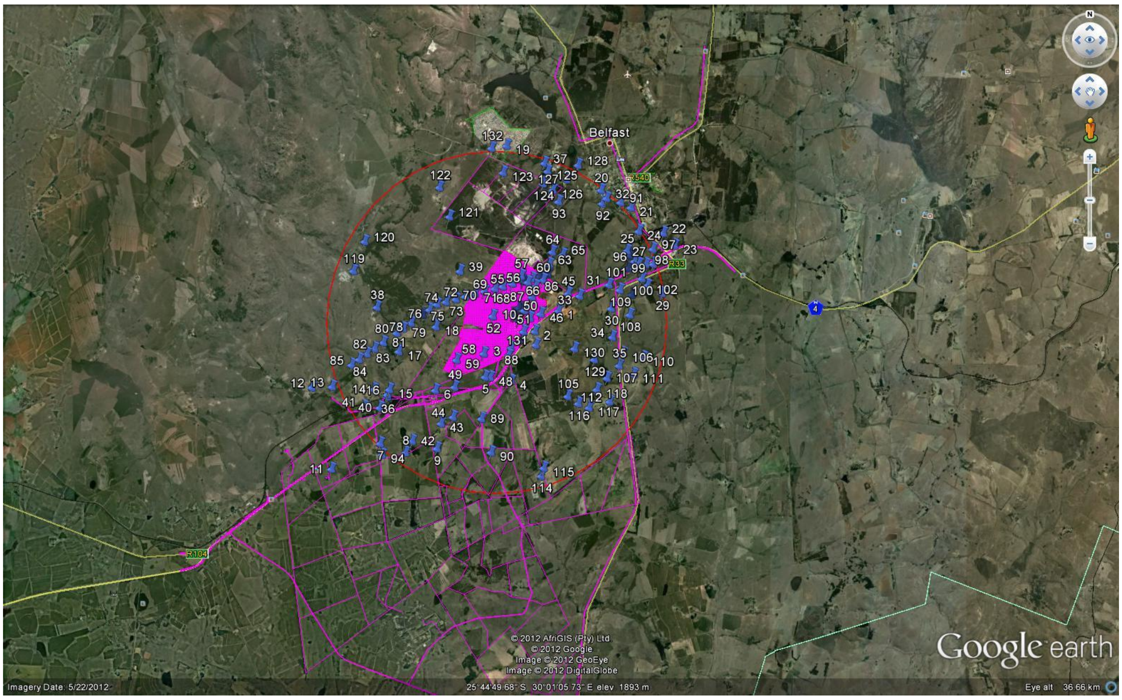

Figure 3: Aerial view and surface plan of the proposed mining area with points of interest identified.

Note: Blue Place marks = POI indicators

Table 1: List of points of interest used

Owner	Tag	Description	Y	X
Private	1	Shed	-101956	2848085
Private	2	Informal Housing	-101108	2848809
Private	3	Farm House	-100149	2849664
Private	4	Farmstead	-100240	2850579
Private	5	Railway Substation	-99302	2850426
Private	6	Buildings/Structures	-97509.3	2850890
Private	7	Farmstead	-95504.4	2852779
Private	8	Grain Storage	-96410.9	2853122
Private	9	Dams	-97544.5	2852981
Private	10	Telecom Tower	-100734	2848060
Private	11	Farm House/Hot Houses	-93737	2853689
Private	12	Farmstead	-93060.5	2850757
Private	13	Farmstead	-93793.4	2850736
Private	14	Farmstead	-95294.8	2850839
Private	15	Shed	-95858.4	2850852
Private	16	Informal Housing	-95780.1	2851032
Private	17	Dam	-96198.3	2849492
Private	18	Dam	-97538.4	2848612
Private	19	Siyathuthuka Village Houses	-100138	2842159
Private	20	Houses	-103525	2843774
Private	21	Houses	-104591	2844410
Private	22	Cattle Sales Yard	-105747	2845333
Private	23	Filling Station	-106145	2845780
Private	24	Farmstead	-104862	2845263
Private	25	Sub Station	-104439	2845959
Private	26	Farmstead	-104484	2846580
Private	27	Sheds	-104852	2846433
Private	28	Farmstead	-104605	2847524
Private	29	Shed	-105689	2847487
Private	30	Farmstead	-103860	2848011
Private	31	Farmstead	-103782	2847161
Private	32	Road	-103724	2844070
Private	33	Farmstead	-102727	2847555
Private	34	Informal Housing	-103889	2849035
Private	35	Farmstead	-104128	2850056
Private	36	School	-95785	2851110
Private	37	Dam	-101499	2842794
Private	38	Farmstead	-95413.1	2847898
Private	39	Farmstead	-98429.2	2846635
Private	40	Informal Housing	-95506.3	2851499
Private	41	Farm House	-94935	2851455
Private	42	Building/Structure	-96656.4	2852705
Private	43	Farm House	-97702.7	2852078
Private	44	Informal Housing	-98137	2851853
Private	45	N4 Road	-102308	2847467
Private	46	N4 Road	-101324	2848180
Private	47	N4 Road	-100627	2849126
Private	48	N4 Road	-99484.5	2850443
Private	49	N4 Road	-98205	2850779
Private	50	Houses	-100929	2848334
Private	51	Packing Sheds	-100699	2848816
Private	52	Dam	-99597.4	2848253
Private	53	Cement Dams	-100673	2848057
Private	54	Farm House	-100545	2847965
Private	55	Dam	-100311	2847091
Private	56	Informal Housing	-100866	2847051
Private	57	Farm House	-100630	2846824
Private	58	Farmstead	-99261.7	2849586
Private	59	Dam	-98277.1	2849811
Private	60	Cement Dam	-101416	2846974
Private	61	Power lines/Pylon	-101296	2846847
Private	62	Power lines/Pylon	-101592	2846775
Private	63	Dam	-101642	2846417
Private	64	Dam	-101754	2845976
Private	65	Farmstead	-102127	2846075
Private	66	Power lines/Pylon	-101028	2846926
Private	67	Power lines/Pylon	-100704	2847010

Private	68	Power lines/Pylon	-99968.2	2847193
Private	69	Power lines/Pylon	-99679.8	2847271
Private	70	Power lines/Pylon	-99306.4	2847360
Private	71	Power lines/Pylon	-98960.6	2847443
Private	72	Power lines/Pylon	-98614.2	2847541
Private	73	Power lines/Pylon	-98273.2	2847637
Private	74	Power lines/Pylon	-97915.1	2847728
Private	75	Power lines/Pylon	-97587.4	2847811
Private	76	Power lines/Pylon	-97316.5	2848000
Private	77	Power lines/Pylon	-97061.1	2848182
Private	78	Power lines/Pylon	-96639.7	2848469
Private	79	Power lines/Pylon	-96353	2848673
Private	80	Power lines/Pylon	-96126.6	2848829
Private	81	Power lines/Pylon	-95642.5	2849169
Private	82	Power lines/Pylon	-95331.3	2849381
Private	83	Power lines/Pylon	-95061.2	2849571
Private	84	Power lines/Pylon	-94780.4	2849766
Private	85	Power lines/Pylon	-94505.6	2849960
Private	86	Informal Housing	-101145	2847204
Private	87	Road	-101009	2847575
Private	88	Informal Housing	-100239	2849394
Private	89	Farm House	-99160.6	2851923
Private	90	Farmstead	-99496.4	2853132
Private	91	Houses	-104225	2844222
Private	92	Informal Housing	-103563	2844253
Private	93	Labour Housing	-101993	2844177
Private	94	Informal Housing	-95566.1	2853183
Private	95	Power lines/Pylons	-104576	2846131
Private	96	Power lines/Pylons	-104709	2846329
Private	97	Informal Housing	-105367	2845902
Private	98	Sheds	-105107	2846450
Private	99	Shed	-105379	2846441
Private	100	Informal Housing	-104966	2846955
Private	101	Housing	-104724	2846580
Private	102	Informal Housing	-105157	2847203
Private	103	Farm House	-100394	2848217
Private	104	Cement Dam	-100322	2848189
Private	105	Informal Housing	-102269	2851141
Private	106	R33 Road	-104271	2849622
Private	107	Dam	-103689	2850502
Private	108	Shed	-104521	2848244
Private	109	R33 Road	-104172	2847353
Private	110	Farm House	-105002	2849775
Private	111	Farmstead	-104646	2850376
Private	112	Farmstead	-103775	2851346
Private	113	Orchards	-100527	2848400
Private	114	Hot Houses	-101291	2853994
Private	115	Farmstead	-101388	2853709
Private	116	Informal Housing	-102649	2851406
Private	117	Informal Housing	-103032	2851556
Private	118	Dam	-103323	2850908
Private	119	Farmstead	-94558.9	2846584
Private	120	Informal Housing	-94978.1	2845530
Private	121	Dam	-98063.3	2844678
Private	122	Farmstead	-97714.1	2843633
Private	123	Farm House	-100007	2843123
Private	124	Sheds	-101442	2843526
Private	125	Sewer Works	-101607	2843085
Mine	126	Mine Activity	-101789	2843760
Private	127	Graveyard	-102290	2843378
Private	128	Graveyard	-102706	2842870
Private	129	Dam	-103235	2849833
Private	130	Dam	-102527	2849435
Private	131	Structure	-101138	2849291
Private	132	Graveyard	-99596.8	2842242

6.3 STRUCTURAL PROFILE

Essential in the evaluation of the effect from blasting operations is also the profile of typical structures found in the area surrounding the mining area. On a site visit the typical structures were identified and presented in Table 2 below. This is not a photographic inspection but rather a profile of typical installations surrounding the proposed mining area. Different structures or installations have different limitations with regards to ground vibration, air blast and fly rock.

Table 2: Structure Profile

	Old House at guesthouse
	Stone cladded wall structure at guesthouse
	Old structure at guesthouse

	Closest Belfast town houses
	Old ruins
	Communication tower
	Old guesthouse structure

	Farm house
	Water tower on rock pillar building
	Electrical substation
	Power lines

	Farm house
	School buildings
	Old stone structure
	Farmhouse

	Dam wall
	Brick and mortar buildings
	Brick and mortar buildings
	Traditional mud houses

	School
	Traditional mud houses
	Railway Line
	Old structure

The structure profile indicates that the area contains structures in the area evaluated range between industrial and traditional build mud houses. Houses range between reasonably well build houses to old structures and in different conditions. The structure types were identified as best possible and for each an allowable limit assigned that is used in the final evaluations and mitigations were applicable. Table 1 above gives a list of structures identified as points of interest and with each ground vibration and air blast evaluation is a set of limits applicable for the different points of interest.

6.4 MINING AND BLASTING OPERATIONS

The Paardeplaats project is situated next to the existing Glisa opencast operations. Data from the Glisa operation was applied for evaluation of the Paardeplaats project. The following description is applicable as it is expected to be the same as the Glisa operation.

The mining method will be conventional opencast truck and shovel roll over method. Roll over mining or strip mining is undertaken by creating an initial cut or strip which is mined out. As the mining moves forward to the second strip, a portion of the overburden from this second strip is backfilled into the initial cut. A portion of the overburden removed from the initial cut is then stockpiled and used to backfill the final cut.

In order to define expected ground vibration, air blast and fly rock influences site visit with monitoring of current blasting operations were done. Information gathered from this monitoring process was then applied for prediction and determining possible influences for the expansion of current mining operations. Additionally to the specific blast monitoring done, fixed monitors were also stationed at three different areas. These monitors were situated in three different directions from the mine on private property outside mine boundary. Data from these monitors were also used in the predictions of possible influences. Blast designs current applied by the contractor used for drilling and blasting is summarised in Table 3. Three basic configurations are used: coal, interburden and overburden blasts.

Table 3: Information on blast designs used

Technical Aspect	Bench Coal	Interburden	Overburden
B/H Diameter (mm)	141	127	171
Explosive Density (g/cm^3)	1.15	1.15	1.15
Burden (m)	5	5	5
Spacing (m)	5	5	7
Bench Height (m)	3.3	3.42	22.6
Min Depth (m)	3.3	3.42	22.6
Average Depth (m)	3.3	3.42	22.6
Linear Charge Mass (kg)	17.96	14.57	26.41
P/F Blasthole (kg/m^3)	0.26	0.28	0.64
Stemming Length (m)(30BHDia)	2.12	1.79	3.33
Column Length (incl. Subdrill.)	1.2	1.63	19.3
Explosives Per B/H (incl. Subdrill+airgap) (kg)	21	24	509
Include SubDrill (Yes/No)	No	No	No

Specific blasts were monitored in order to determine the attenuation and influence of ground vibration and air blast from current blasting operations. The data recorded from the fixed monitors and specific monitors assist in making more accurate estimates and calculations of possible influences.

Data recorded from specific monitoring and that of the fixed monitoring stations are presented in Table 4 below. Figure 4 and Figure 4: Fixed monitor results

shows the graphs of the recorded data for the fixed monitoring and specific blasts monitored. Figure 6 shows the positions used for the fixed monitoring positions.

Table 4: Recorded ground vibration and air blast results

Date	**Time**	**Seis. Location**	**L-PPV**	**T-PPV**	**V-PPV**	**L-Freq.**	**T-Freq.**	**V-Freq.**	**RPPV (mm/s)**	**Air Blast (dB)**
2010/11/08	12:13:52	FixedPoint 01	0.21	0.21	0.22	***	***	***	0.33	122
2010/11/08	16:34:06	FixedPoint 01	0.29	0.22	0.35	***	***	3.68	0.39	126
2010/11/10	13:56:44	FixedPoint 01	0.22	0.29	0.27	***	***	***	0.35	121
2010/11/10	16:19:53	FixedPoint 01	0.30	0.27	0.44	9.66	***	***	0.48	128
2010/11/15	14:07:55	Point 01	161.00	93.60	71.20	18.30	11.90	21.30	180.00	165
2010/11/15	14:07:52	Point 02	45.00	47.40	27.90	23.30	15.10	30.10	49.90	148
2010/11/15	14:07:52	Point 03	10.70	13.60	7.87	24.40	23.30	25.60	14.60	146
2010/11/15	14:07:53	Point 04	3.94	4.06	3.30	15.50	17.70	21.30	5.25	141
2010/11/16	17:59:42	Point 1	119.00	165.00	86.60	16.50	17.70	19.70	169.00	162
2010/11/16	17:59:44	Point 2	90.40	110.00	56.00	11.10	12.50	28.40	110.00	147
2010/11/16	17:59:41	Point 3	63.10	28.60	26.20	11.60	18.30	26.90	67.70	140
2010/11/16	17:59:42	Point 4	38.10	26.90	13.80	8.53	11.60	18.30	40.70	132
2010/11/16	18:00:07	FixedPoint 01	0.35	0.30	0.54	4.57	***	10.00	0.57	129
2010/11/16	17:22:10	Point 2	0.25	0.13	0.25	>100	>100	>100	0.31	121
2010/11/16	17:22:07	Point 3	0.25	0.13	0.13	>100	>100	>100	0.31	121
2010/11/16	17:22:07	Point 4	0.25	0.13	0.25	56.90	>100	>100	0.31	123
2010/11/16	18:03:52	Point 1	0.89	1.14	0.51	18.30	23.30	36.60	1.21	**
2010/11/16	18:03:54	Point 2	0.51	0.64	0.38	14.60	9.48	25.60	0.75	123
2010/11/16	18:00:07	FixedPoint 01	0.35	0.30	0.54	4.57	***	10.00	0.57	129
2010/11/25	16:28:23	FixedPoint 01	0.27	0.30	0.43	***	***	13.50	0.47	122
2010/11/29	14:23:56	FixedPoint 01	0.24	0.22	0.22	***	***	***	0.32	127

Explanation of row headings:

Date:	Date event recorded
Time:	Time event recorded
Seis Location:	Seismograph position where placed
L, T & V-PPV:	Longitudinal, Transverse & Vertical peak particle velocities (mm/s)
L, T & V-PD:	Longitudinal, Transverse & Vertical peak Displacement (mm)
L, T & V-PPA:	Longitudinal, Transverse & Vertical peak particle acceleration (g)
L, T & V-Freq.:	Longitudinal, Transverse & Vertical dominate frequencies (Hz)
RPPV:	Resultant Peak Particle velocity (mm/s)
dB:	Peak Air blast Recorded (dB)
***:	Sensor limit exceeded / No Calculation Possible
**:	Microphone Disabled

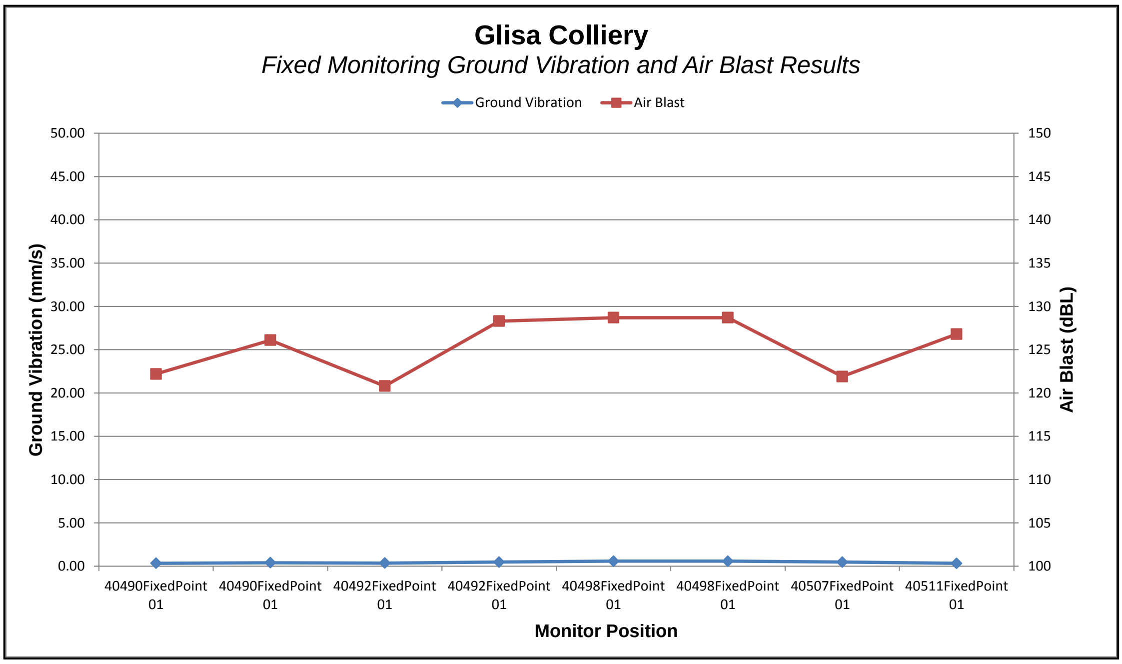

Figure 4: Fixed monitor results

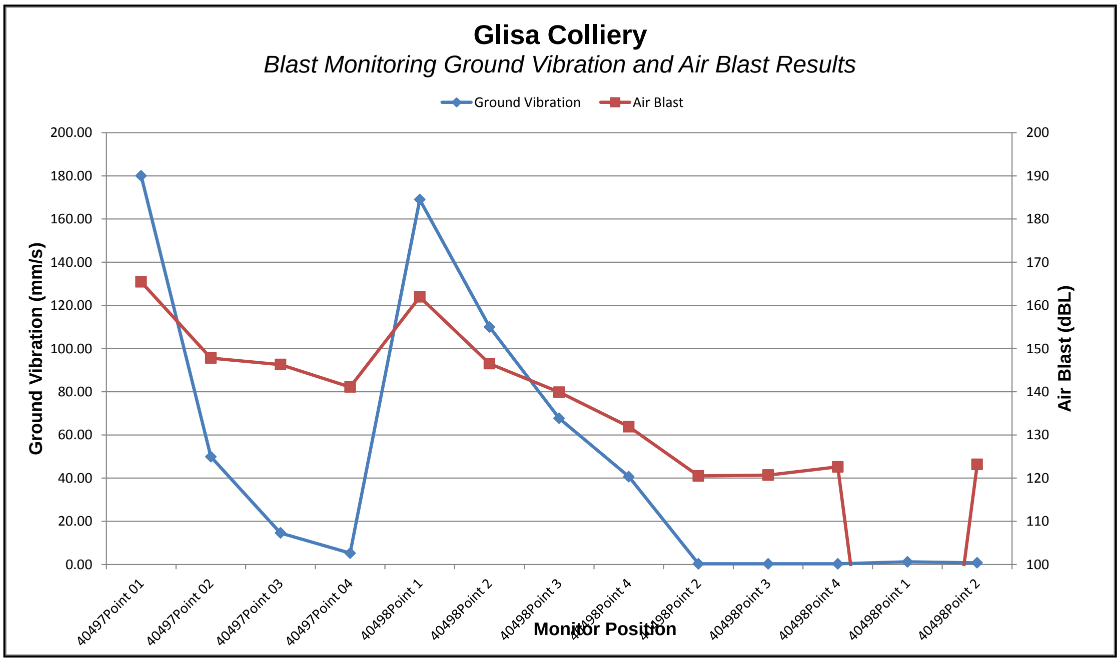

Figure 5: Blast monitor results

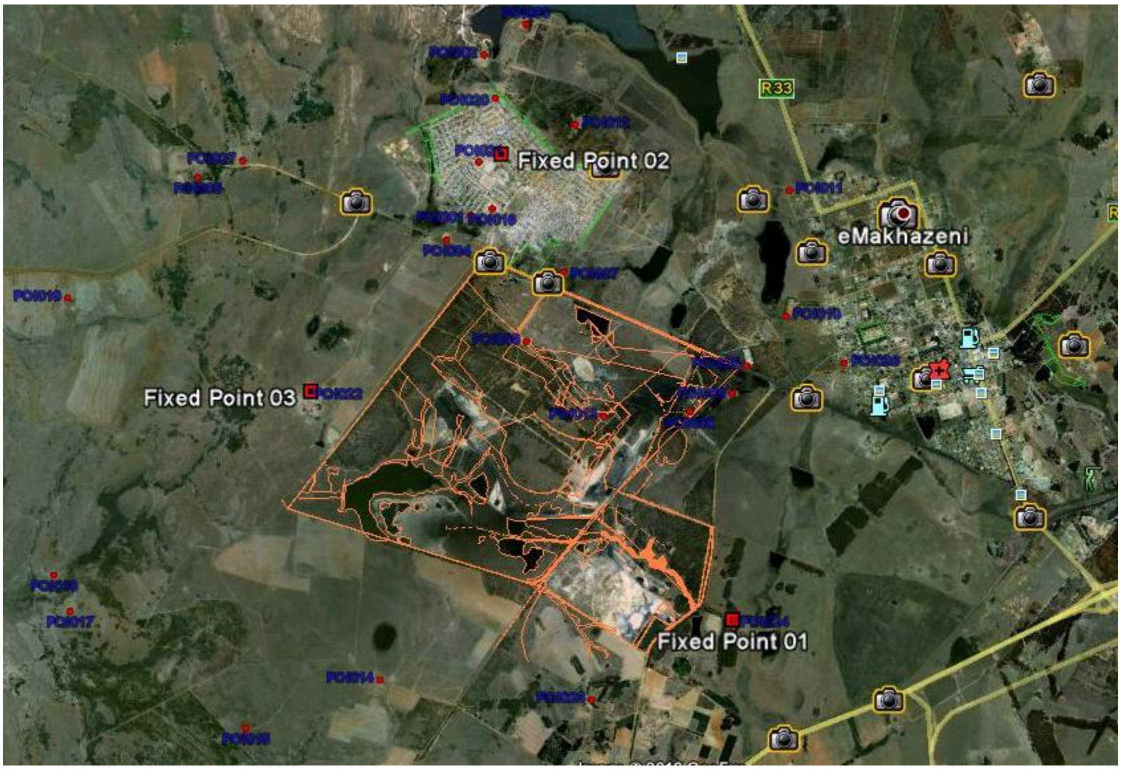

Figure 6: Fixed Monitoring Positions

Data recorded with blast designs and layouts are then applied in the prediction process used in this document. Re-simulation of the blasts are required to determine what is the charge mass per delay according to the specific blast drilling, charging and timing design. These factors have influence on the level of ground vibration and air blast yielded. Re-simulation of a current blasting is shown in Figure 7 below.

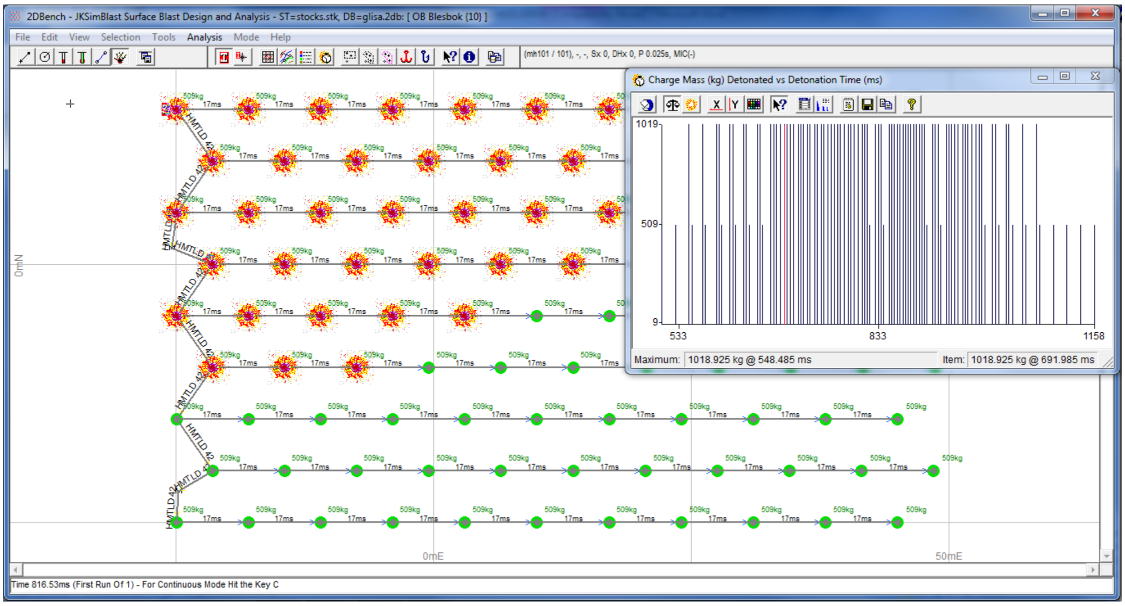

Figure 7: Basic Blast Layout and timing of Blesbok Pit blast

The typical charging applied in the blast is presented in Figure 8 below. The figures will shows the charge mass loaded on the blast hole and the stemming applied. (These values are averaged values from the blasting company).

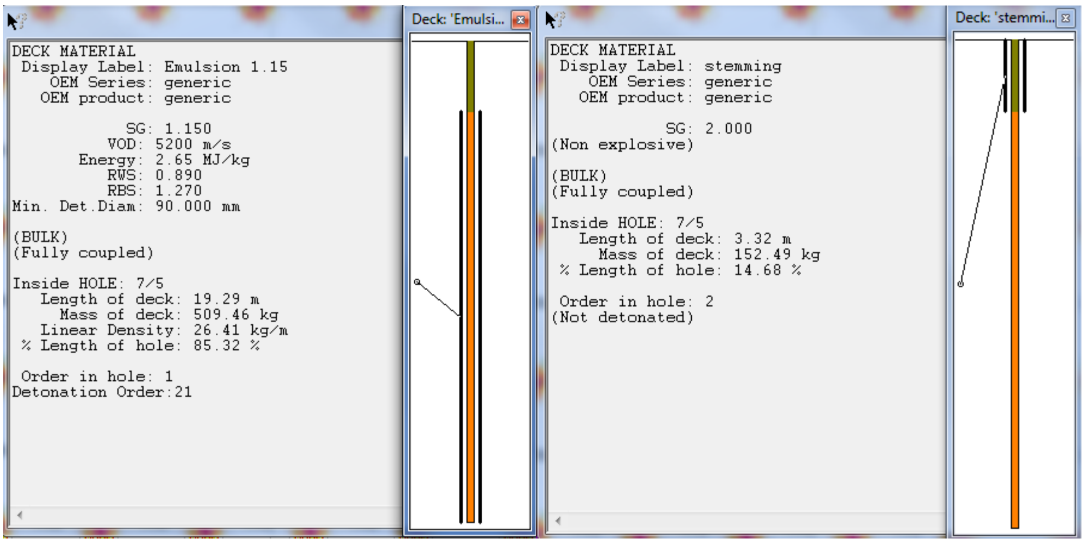

Figure 8: Graph with Blasthole Information

Table 5 shows that expected charge masses for each design with different quantity of blastholes detonating pending on the timing layout used. Indicated in the table is outcome of simulation of overburden blasts for the Blesbok pit and Block B. The coal blast values were calculated from values provided and a 6x blasthole per delay applied. Data from this table is used for all further calculations with regards to ground vibration and air blast etc.

Table 5: Charge mass information

Blast Type	Qty Blastholes	Charge / Delay (kg)
Coal	6x	127
OB Block B	2x	1019
OB Blesbok	4x	2035

6.5 EFFECTS OF BLASTING OPERATIONS:

Blasting operations have effect to its surroundings. These effects can manifest in the form of ground vibration, air blast, fumes, fly rock etc. The application of explosives breaking rock will always have a positive and negative manifestation of different energies. It is the effects that have negative outcome that we concentrate on and that will need to be managed. The following sections address the reason, prediction, modelling and control on aspects like ground vibration, air blast, fly rock and fumes.

6.5.1 Ground Vibration

Explosives are used to break rock through the shock waves and gasses yielded from the explosion. Ground vibration is a natural result from blasting activities. The far field vibrations are inevitable, but un-desirable by products of blasting operations. The shock wave energy that travels beyond the zone of rock breakage is wasted and could cause damage and annoyance. The level or intensity of these far field vibration is however dependant on various factors. Some of these factors can be controlled to yield desired levels of ground vibration and still produce enough rock breakage energy.

Factors influencing ground vibration are the charge mass per delay, distance from the blast, the delay period and the geometry of the blast. These factors are controlled by planned design and proper blast preparation.

The larger the charge mass per delay - not the total mass of the blast, the greater the vibration energy yielded. Blasts are timed to produce effective relief and rock movement for successful breakage of the rock. A certain quantity of holes will detonate within the same time frame or delay and it is the maximum total explosive mass per such delay that will have the greatest influence. All calculations are based on the maximum charge detonating on a specific delay.

Secondly is the distance between the blast and the point of interest / concern. Ground vibrations attenuate over distance at a rate determined by the mass per delay, timing and geology. Each geological interface a shock wave encounters will reduce the vibration energy due to reflections of the shock wave. Closer to the blast will yield high levels and further from the blast will yield lower levels.

Thirdly the geology of the blast medium and surroundings has influences as well. High density materials have high shock wave transferability where low density materials have low transferability of the shock waves. Solid rock i.e. norite will yield higher levels of ground vibration than sand for the same distance and charge mass. The precise geology in the path of a shock wave cannot be observed easily, but can be tested for if necessary in typical signature trace studies - which are discussed shortly below.

6.5.2 Ground Vibration Prediction

When 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. Site constants as determined for the Glisa operation was used and applied. The utilization of the scaled distance prediction formula is standard practice.

Equation 1:

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

Where:
PPV = Predicted ground vibration (mm/s)
a = Site constant
b = Site constant
D = Distance (m)
E = Explosive Mass (kg)
Applicable factors a & b used:
a = 783
b = -1.52

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 may be 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 observed surrounding the site. Structures types and qualities vary greatly and this calls for limits to be considered as follows: 6mm/s, 12.5mm/s levels, 25mm/s and for some structures and installations up to maximum of 150mm/s.

Blast designs done are shown in Table 3 above. An overburden blasthole of 509kg will be loaded in a 22.6 m deep overburden blasthole. 21kg will be loaded in a 3.3m deep coal blasthole. Considering general timing systems to be used it is expected that as much as 4 blastholes could detonated simultaneously. In extreme cases this can be up to 6 to 10 blastholes. In order to evaluate the possible influence the author selected three charge masses that will span the range of possible charge mass per delay. Review of the charge per blasthole and the possible timing of a blast the following charge masses were selected to ensure proper range of energy source. Therefore six coal blastholes yielding 127kg charge, 2 times overburden blastholes detonating simultaneously will yield 1019kg and 4 overburden blastholes detonating simultaneously will yield 2035kg. The charges selected are expected to provide a range of possible charging configurations in actual mining of this area. These charge masses are used for modelling aspects in this report. Considering the parameters, ground vibration and charge mass, the following calculations were done for consideration in this report. Attention will be given to levels of 6mm/s, 12.5 mm/s and 25 mm/s.

Firstly the distance required from specific charge masses to maintain different vibration limits (6mm/s, 12.5 mm/s and 25 mm/s) was calculated and presented in
Table 6 below. The charge masses used are representative of minimum and maximum charges that can be expected from a typical blast. Figure 9 shows the graphic representation of data provided in
Table 6.

Table 6: Distances Required for Maintaining Specific Vibration Levels at Specific Charge Masses

No.	Charge Mass (kg)	Distance (m) 6mm/s PPV Limit	Distance (m) 12.5mm/s PPV Limit	Distance (m) 25mm/s PPV Limit
1	100.0	237	146	93
2	200.0	336	207	131
3	300.0	411	254	161
4	400.0	475	293	186
5	500.0	531	327	208
6	600.0	581	359	227
7	700.0	628	387	246
8	800.0	671	414	262

9	900.0	712	439	278
10	1000.0	750	463	293
11	1100.0	787	486	308
12	1200.0	822	507	321
13	1300.0	856	528	335
14	1400.0	888	548	347
15	1500.0	919	567	359
16	1600.0	949	586	371
17	1700.0	978	604	383
18	1800.0	1007	621	394
19	1900.0	1034	638	405
20	2000.0	1061	655	415

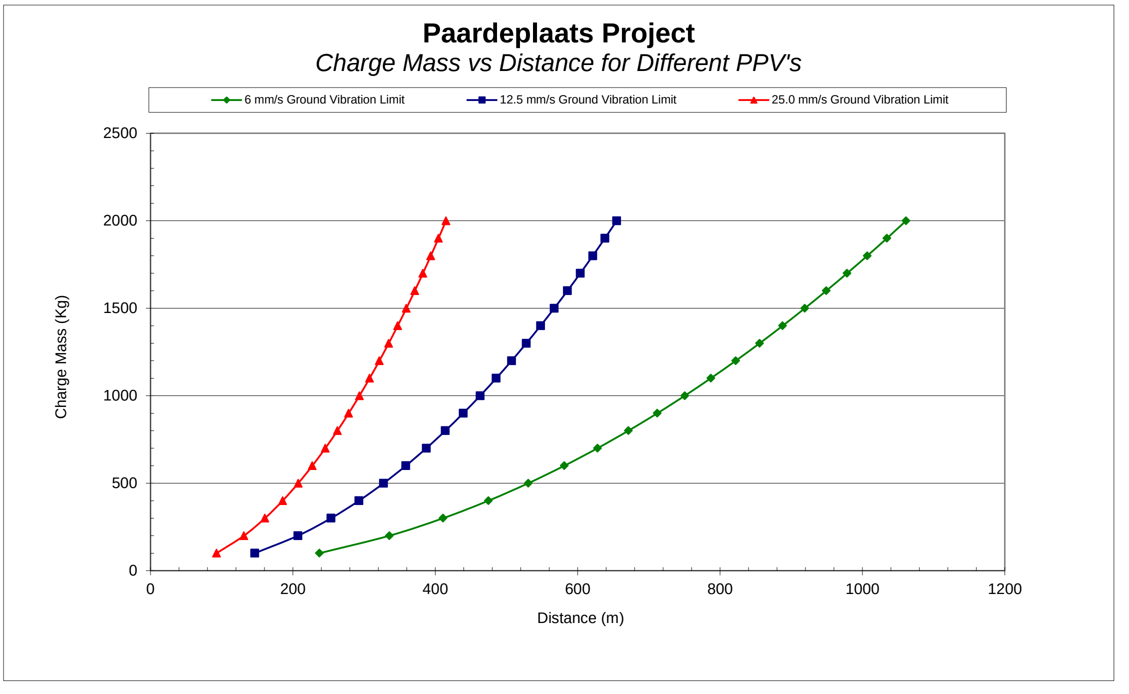

Figure 9: Distance versus Charge Mass for Limiting Vibration Levels

Secondly the required charge masses to yield different vibration levels (6mm/s, 12.5 mm/s and 25 mm/s) at various distances was calculated and presented in Table 7 below. This is used to consider what maximum charge mass can be allowed for specific distance of interest.

Table 7: Limiting Charge Masses at Specific Distances for Maintaining Specific Ground Vibration Levels

No.	**Distance (m)**	**Charge Mass (kg) 6mm/s PPV Limit**	**Charge Mass (kg) 12.5mm/s PPV Limit**	**Charge Mass (kg) 25mm/s PPV Limit**
1	50.0	4	12	29
2	100.0	10	26	65
3	150.0	40	105	261
4	200.0	71	187	464
5	250.0	111	292	726
6	300.0	160	420	1045
7	400.0	284	746	1858
8	500.0	444	1166	2903
9	600.0	639	1679	4180
10	700.0	870	2285	5689
11	800.0	1136	2985	7431
12	900.0	1438	3778	9405

13	1000.0	1776	4664	11611
14	1250.0	2774	7288	18142
15	1500.0	3995	10494	26124
16	1750.0	5438	14284	35558
17	2000.0	7102	18657	46443
18	2500.0	11098	29151	72568
19	3000.0	15981	41977	104497
20	3500.0	21751	57136	142232

Based on the design presented on expected drilling and charging design, the following Table 8 shows expected ground vibration levels for various distances calculated at three different charge masses. A low charge mass (127kg), the expected medium charge (1019kg) mass per delay and a maximum charge (2035kg) mass as worst case scenario.

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

No.	Distance (m)	Expected PPV (mm/s) for 127kg Charge	Expected PPV (mm/s) for 1019kg Charge	Expected PPV (mm/s) for 2035kg Charge
1	50.0	76.8	373.6	632.0
2	100.0	41.4	201.7	341.2
3	150.0	14.5	70.3	119.0
4	200.0	9.3	45.4	76.8
5	250.0	6.6	32.4	54.7
6	300.0	5.0	24.5	41.5
7	400.0	3.3	15.8	26.8
8	500.0	2.3	11.3	19.1
9	600.0	1.8	8.6	14.5
10	700.0	1.4	6.8	11.4
11	800.0	1.1	5.5	9.3
12	900.0	0.9	4.6	7.8
13	1000.0	0.8	3.9	6.7
14	1250.0	0.6	2.8	4.7
15	1500.0	0.4	2.1	3.6
16	1750.0	0.3	1.7	2.8
17	2000.0	0.3	1.4	2.3
18	2500.0	0.2	1.0	1.7
19	3000.0	0.2	0.7	1.3
20	3500.0	0.1	0.6	1.0

Figure 10 below shows the relationship of ground vibration over distance for the three charges considered as given in Table 8 above. The attenuation of ground vibration over distance is clearly observed. Ground vibration attenuation follows a logarithmic trend and the graph indicates this trend. Indicated on the graph as well are the limits that should be applicable due to the various structures and types of installations in this area as given above. The graph can be used to scale expected ground vibration at specific distances for the same maximum charges as used in this report. The expected vibration level at specific distance can be read from the graph, provided the same maximum charges are applicable, or by rough estimate if the charge per delay should be between the charge masses applied for this case.

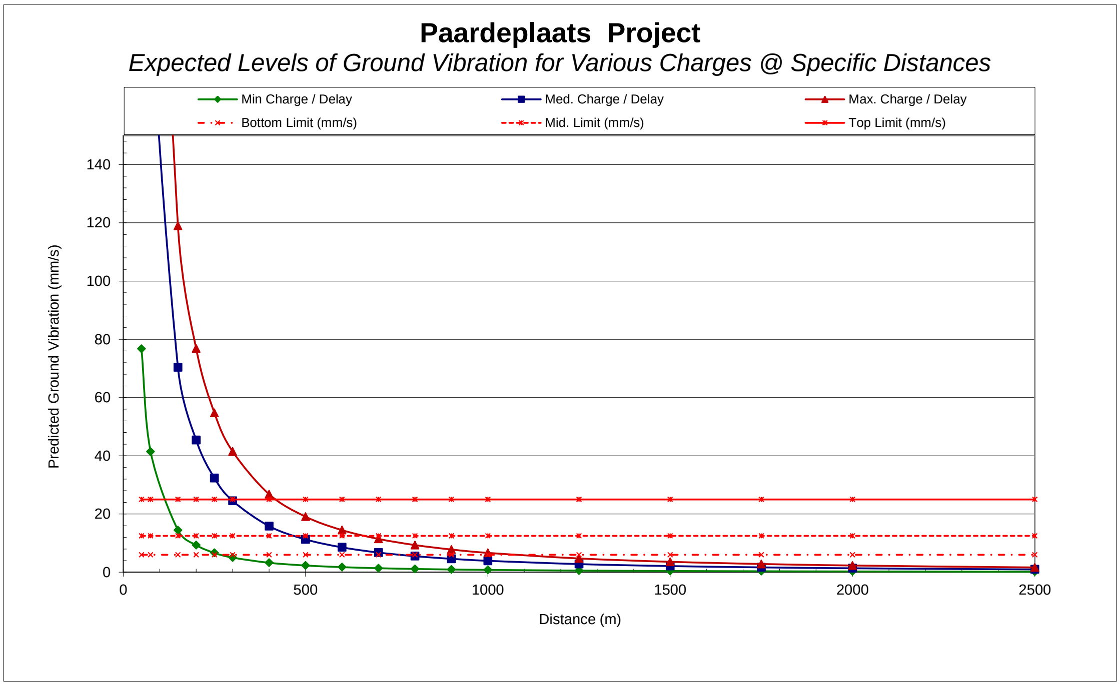

Figure 10: Ground vibration over distance for the three charge masses used in modelling

6.5.3 Ground Vibration Limitations on Structures

Limitations on ground vibration are in the form of maximum allowable levels for different installations and structures. These levels are normally quoted in peak particle velocity or as ground vibration in millimetres per second (mm/s). There are unfortunately no exact South African standard. Thus currently the United States Bureau of Mines (USBM) criterion for safe blasting is applied where private structures are of concern. This is a process of evaluating the vibration amplitudes and frequency of the vibrations according to set rules for preventing damage. The vibration amplitudes and frequency is then plotted on a graph. The graph indicates two main areas:

- The Safe Blasting Criteria Area
- The Unsafe Blasting Criteria Area

When ground vibration is recorded and the amplitude in velocity (mm/s) is analysed for frequency it plots this relationship on the USBM graph. If data falls in the lower part of the graph then the blast was done safely. If the data falls in the upper part of the graph then the probability of inducing damage to mortar and brick structures increases significantly. There is a relationship between amplitude and frequency due to the natural frequencies of structures. This is normally low - below 10 Hz - and thus the lower the frequency, the lower the allowable amplitude. Higher frequencies allows for higher amplitudes. The extra lines on the graph are more detailed for specific type walls and structure configurations. Locally we are only concerned with the lowest line on the USBM graph. Due to poor state structures in the area additionally a 6mm/s and 12.5mm/s limits were added.

This is a pre blast analysis but predictions help us determine expected amplitudes and experience has taught us what frequencies could be expected. The USBM graph for safe blasting was developed by the United States Bureau of Mines through research and data accumulated from sources other than their own research. Figure 6 shows an example of a USBM analysis graph with 6mm/s and 12.5mm/s guidelines added.

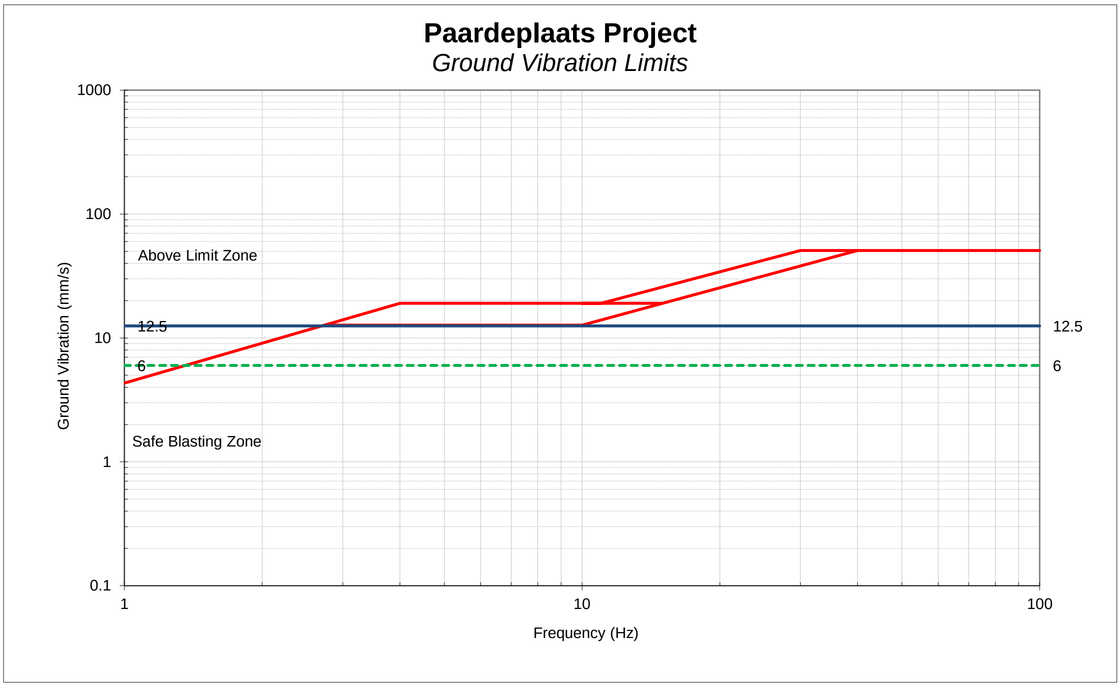

Figure 11: USBM Analysis Graph

Additional limitations that should be considered are as follows, these were determined through research and various institutions:

- National Roads/Tar Roads: 150 mm/s
- Steel pipelines: 50 mm/s
- Electrical Lines: 75 mm/s
- Railway: 150 mm/s
- Concrete aged less than 3 days: 5mm/s
- Concrete after 10 days: 200 mm/s
- Sensitive Plant equipment: 12 or 25 mm/s depending on type – some switches could trip at levels less than 25 mm/s.

Considering the above limitations, BM&C work is based on the following:

- USBM criteria for safe blasting

- The additional limitations provided
- Consideration of private structures
- Should these structures be in poor condition is the basic limit of 25 mm/s reduced to 12.5 mm/s or even when structures are in very poor condition limits will be restricted to 6 mm/s
- We also consider the input from other consultants in the field locally and internationally.

6.5.4 Ground Vibration Limitations with Regards to Human Perceptions

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

Ground vibration is experienced as "Perceptible", "Unpleasant" and "Intolerable" (only to name three of the five levels tested) at different vibration levels for different frequencies. This is indicative of the human's perceptions on ground vibration and clearly indicates that humans are sensitive to ground vibration. This "tool" is only a guideline and helps with managing ground vibration and the respective complaints that people could have due to blast induced ground vibrations. Humans already perceive ground vibration levels of 4.5 mm/s as unpleasant.

Generally people also assume that any vibrations of the structure - windows or roofs rattling - will cause damage to the structure. Air blast also induces vibration of the structure and is the cause of nine out of ten complaints. (See Figure 12)

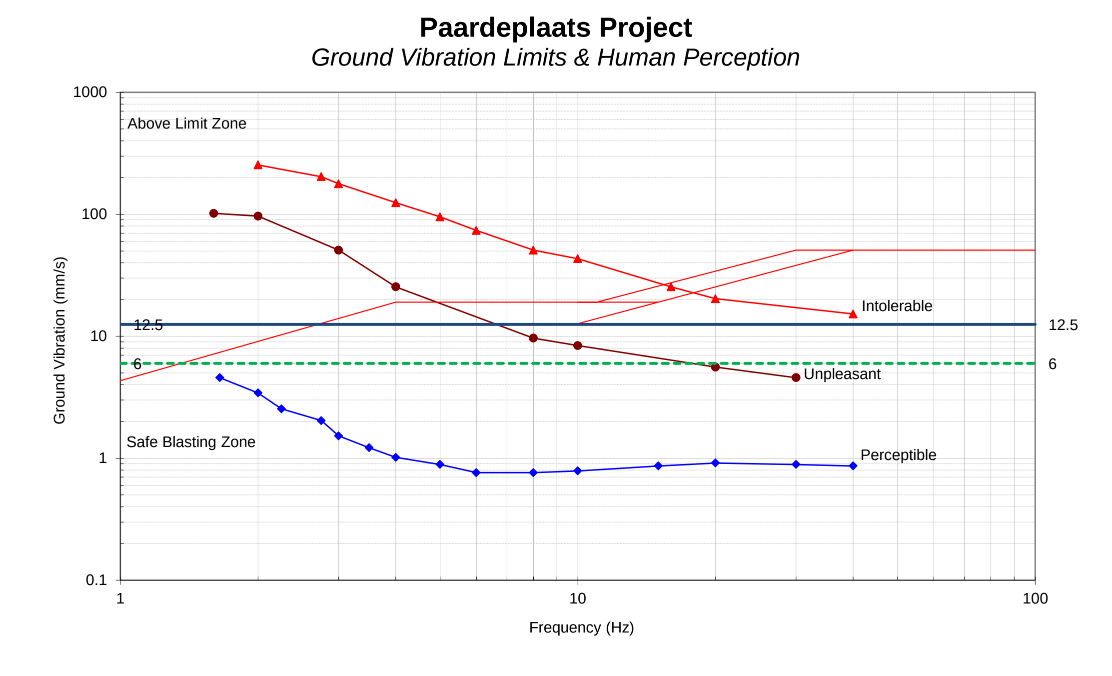

Figure 12: USBM Analysis with Human Perception

6.5.5 Air blast

Air blast or air-overpressure is pressure acting and should not be confused with sound that is within audible range (detected by the human ear). Sound is also a build up from pressure but is at a completely different frequency to air blast. Air blast is normally associated with frequency levels less than 20 Hz, which is the threshold for hearing. Air blast is the direct result from the blast process although influenced by meteorological conditions the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result.

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)

6.5.6 Air Blast limitations on structures

The recommended limit for air blast currently applied in South Africa is 134 dB. This is specifically pertaining to air blast or otherwise known as air-overpressure. This takes into consideration where public is of concern. Air-overpressure is pressure acting and should not be confused with sound that is within audible range (detected by the human ear). However, all attempts should be made to keep air blast levels generated from blasting operations below 120 dB or greater magnitude toward critical areas where public is of concern. This will ensure that the minimum amount of disturbance is generated towards the critical areas surrounding the mining area.

Based on work carried out by Siskind et.al. (1980)[1], monitored air blast amplitudes up to 135 dB are safe for structures, provided the monitoring instrument is sensitive to low frequencies (down to 1 Hz). Persson et.al. (1994)[2] have published the following estimates of damage thresholds based on empirical data (Table 8). Levels given in Table 9 are at the point of measurement. The weakest point on a structure is the windows and ceilings.

Table 9: Damage Limits for Air Blast

Level	Description
120 dB	Threshold of pain for continuous sound
>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

All attempts should be made to keep air blast levels generated from blasting operations well below 120 dB where public is of concern. This will ensure that the minimum amount of disturbance is generated towards the critical areas surrounding the mining area and limit the possibility of complaints due to the secondary effects from air blast.

6.5.7 Air Blast limitations with regards to human perceptions

Considering the human perception and misunderstanding that could occur between ground vibration and air blast BM&C generally recommends that blasting be done in such a way that air blast levels is kept below 120dB. In this way it is certain that fewer complaints will be received for blasting operations. The effects on structures that startled people are significantly less – thus no reason for complaining. It is the actual influence on structures like rattling of windows or doors or large roof surface’s that startle people. These effects are sometimes misjudged as ground vibration and considered as damaging to the structure.

Initial limits for evaluation conditions have been set at 120dB, 134dB and less than 134dB. USBM limits are 134 dB for nuisance, at this level 5% of residents would be expected to complain, because they are startled and frightened; even 120dB could sometimes lead to rattling windows, feelings of annoyance and fright.

6.5.8 Air Blast Prediction

An aspect that is not normally considered as pre-operation definable is the effect of air blast. This is mainly due to the fact that air blast is an aspect that can be controlled to a great degree by applying basic rules. Air blast is the direct result from the blast process, although influenced by meteorological conditions, the final blast layout, timing, stemming, accessories used, covered or not covered etc. all has an influence on the outcome of the result.

In this report the author have used the data recorded from the Glisa operation to calculate predicted values. These values were calculated using a cube root scaled distance relationship from known charge masses, distance and the actual levels recorded.

Equation 2:

$$dB(L) = a\left(\frac{D}{\sqrt[3]{E}}\right)^{-b}$$

Where:

dB(L) = Predicted Air blast

a = Site constant

b = Site constant

D = Distance

E = Explosive Mass

The tests done indicated the following values for factors a and b as follows:

Factors:

a = 182

b = -0.0686

Although the above equation was applied for prediction of air blast levels, additional measures are also recommended in order to ensure that air blast and associated fly-rock possibilities are minimized completely. As discussed earlier the prediction of air blast is very subjective. Following in Table 10 below is a summary of values predicted according to Equation 2. Figure 13 shows the graphical relationship for air blast as set out in Table 10.

Table 10: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) for 127kg Charge	Air blast (dB) for 1019kg Charge	Air blast (dB) for 2035kg Charge
1	50.0	155	163	166
2	100.0	151	159	161
3	150.0	144	151	154
4	200.0	141	148	151
5	250.0	139	146	148
6	300.0	137	144	146
7	400.0	135	141	144
8	500.0	133	139	141

9	600.0	131	137	140
10	700.0	130	136	138
11	800.0	129	135	137
12	900.0	127	134	136
13	1000.0	127	133	135
14	1250.0	125	131	133
15	1500.0	123	129	131
16	1750.0	122	128	130
17	2000.0	121	127	129
18	2500.0	119	125	127
19	3000.0	117	123	125
20	3500.0	116	122	124

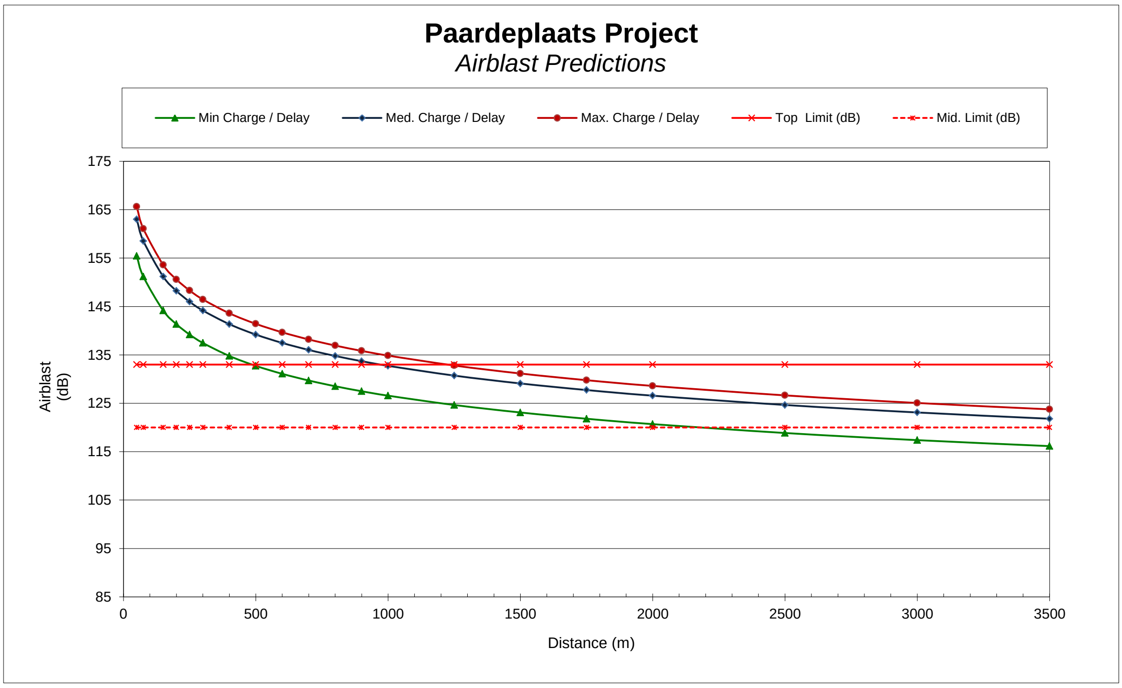

Figure 13: Predicted air blast levels

6.5.9 Fly Rock and Causes

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 within large coal mines are designed to cast the blasted material much greater distances than practices in a quarrying or hard rock operations. This movement should be in the direction of the free face, and therefore the orientation of the blasting is important. Material or elements travelling outside of this expected range may be considered to be fly rock.

Fly rock from blasting can result from three mechanisms due to the lack of confinement of the energy in the explosive column. The main mechanisms are:

- Face burst - burden conditions usually control fly rock distances in front of the face

- Cratering - If the stemming height to hole diameter ratio is too small or the collar rock is weak
- Rifling - If the stemming material is ejected with insufficient stemming height or inappropriate stemming material is used

In short the following list is typical causes of fly rock:

- Burden to small,
- Burden to large,
- Stemming length to short,
- Out of sequence initiation of blastholes,
- Drilling inaccuracies,
- Incorrect blasthole angles,
- Over charged blastholes.

It is possible to blast without any fly rock with proper confinement of the explosive charges within blast holes using proper stemming procedures and materials. Stemming is further required to ensure that explosive energy is efficiently used to its maximum. Free blasting with no control on stemming cannot be allowed as this will result in poor blast results and possible damage to any nearby structures.

6.5.10 Fly Rock Predictions

The use of prediction calculations for fly rock is in my opinion secondary to the basics of blast preparation. Question is why should there be fly rock? Blasts can be shot without fly rock occurring by using basic guidelines on blast preparation and specifically stemming control. Quality of preparation will certainly have influence on the final blast result. Predictions on the possibility of fly rock are useful for operations that are hampered by the past incidents of fly rock and situations where back tracking needs to be done where fly rock did occur and fault analysis needs to be done. Predictions may also be used to consider what minimum confinement that may be allowed in certain circumstances. Work done in this field did show various considerations of the process of fly rock generation. Considering fly rock predictions will also require that specific “calibration” must be done at the specific site. The blast layout, geology, explosives, stemming material etc. will all play a specific role in the prediction of fly rock and needs to be tested for.

Prediction considered is based on the areas where fly rock may originate from in the blasting process: Face Burst, Cratering and Stemming ejection.

Research as done by Richards, Moore has shown the following equations. The following equations will be applied:

Equation 3: Face Burst

$$L = \frac{k^2}{g} \times \left(\frac{\sqrt{m}}{B}\right)^{2.6}$$

Equation 4: Cratering

$$L = \frac{k^2}{g} \times \left(\frac{\sqrt{m}}{SH}\right)^{2.6}$$

Equation 5: Stemming Ejection

$$L = \frac{k^2}{g} \times \left(\frac{\sqrt{m}}{SH}\right)^{2.6} \times \sin 2\theta$$

Where:

θ	= Drill hole angle
L	= Maximum Throw (m)
m	= Charge mass / m (kg/m)
B	= Burden (m)
SH	= Stemming height (m)
g	= Gravitational constant
k	= Factor value

The Richards & Moore research has shown that a factor applicable for the above equation ranges between 13.5 for a coal environment and 27 for a hard rock environment. Figure 14 below shows the relationship burden or stemming length towards expected throw distance. Throw distance considered here on the same level as the free face. Landing level of elements lower than free face could see longer distances. Optimal throw distance is also observed at 45 degree angles of departure.

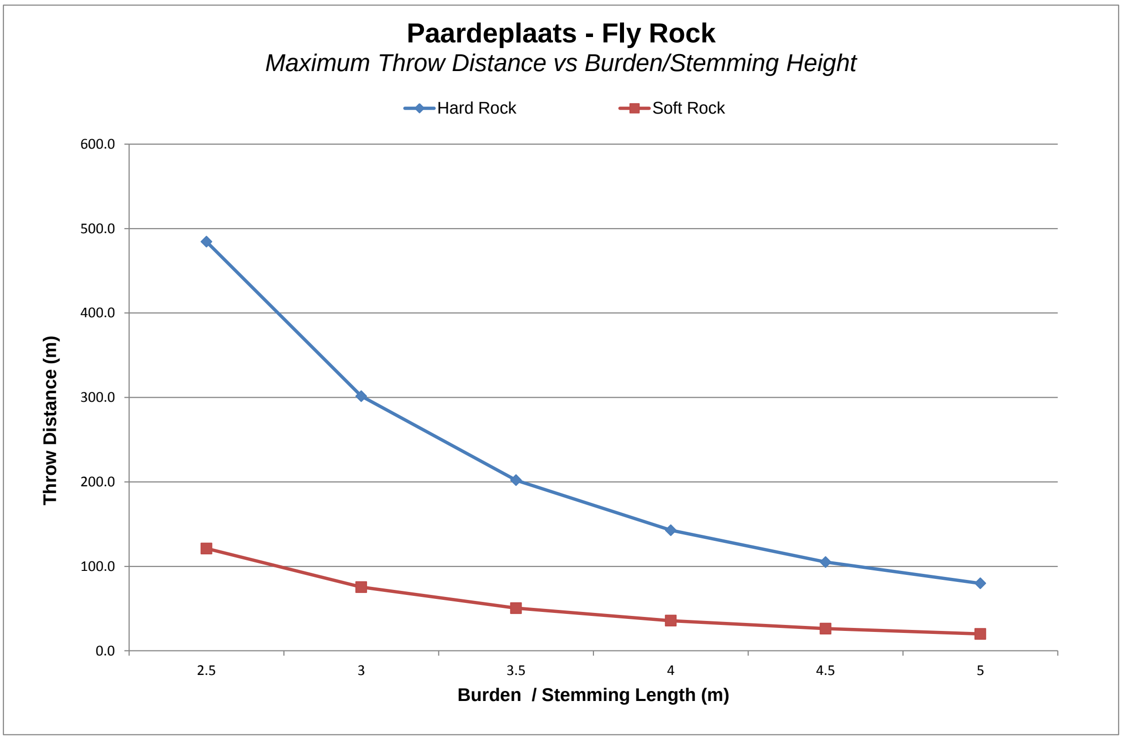

Figure 14: Predicted Fly rock

Face burdens are as important to prevent fly rock as proper stemming controls. There is direct relationship between blast free face burden and probability of fly rock from the face. A further equation can be used for ensuring the face burden is not insufficient. Applying equation 6 and the scaled burden is not less than 0.71m3/2kg-1/2 it is not expected to have fly rock from the face.

Equation 6: Scaled burden

$$Bs = \left(\frac{B}{\sqrt{Mc}}\right)$$

Where:

Bs	= Scaled Burden (m3/2kg-1/2)
Mc	= Charge mass / m (kg/m)
B	= Burden (m)

Table 11 below shows the relationship of face burdens on the scaled burden and gives indication of which scaled burdens are problematic for the typical designs used in this report.

Table 11: Relationship between face burden and scaled burden.

Scaled Burden ($m^{3/2}kg^{-1/2}$)	0.49	0.58	0.68	0.78	0.88	0.97
Min. Face Burden (m)	2.5	3	3.5	4	4.5	5

Red: Problematic areas

6.5.11 Impact of fly rock

The occurrence of fly rock in any form will have impact if found to travel outside the safe boundary. This safe boundary may be anything between 10 m, 500m or even greater. If a road or structure or people or animals are closer than the safe distance from 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. Fact is fly rock will cause damage to the road, vehicles or even death to people or animals.

6.5.12 Noxious Fumes

Explosives currently used 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 detonated. It has been reported that 10 to 20 ppm has been 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 174 ppm for 1 hour. Anybody exposed must be taken to hospital for proper treatment.

6.5.13 Noxious Fumes Causes

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, and specific types of ground can also contribute to fumes.

Poor quality control on explosives will yield improper balance of the explosive product. This is typically in the form of too little or too much fuel oil or incorrect quantities of additives to the mixture. Improper quality will cause break down on the explosives product that may result in poor performance. A “burning” may occur that increases the probability of fumes in the form of NO and NO2.

Damage to explosives occur when deep blasthole are charged from the top of the hole and literally fall into the hole and get damage at the bottom. The bottom is normally the point of initiation and damaged explosives will not initiate properly. A slow reaction to detonation is forced and again contributes negatively to the explosives performance and fume creating capability.

Studies showed that inadvertent emulsion mixture with drill cuttings can also be a significant contributing factor to NOx production. The NO production from the detonation of emulsion equally mixed (by mass) with drill cuttings increased by a factor of 2.7 over that of emulsion alone. The corresponding NO2 production increased by factor of 9 while detonation propagated at a steady Velocity of Detonation.

Water also has visible effect on the generation of fumes from emulsion explosives. Tests have shown that the detonation velocity may not be influenced as much but the volumes of fumes generated were significantly higher.

Further is also known that for certain ground types, especially the oxidized type materials could have an advert effect on explosives as well. These ground materials types tends to react with the explosives and causes more than expected fumes.

Drill diameter is also contributing factor to explosive performance and the subsequent generation of fumes. Explosives are diameter dependant for optimal performance. If diameter is too small for a specific product improper detonation will occur and may result in a burning of the product rather than detonation. This will have an adverse effect of more fumes created. Each explosive product has a critical diameter. It is the smallest diameter where failure to detonate properly occurs. ANFO blends are normally not good for small diameter blastholes and emulsion explosives can be sued in the smaller diameter blastholes.

6.5.14 Noxious Fumes Control

Control actions on fumes will include the use the proper quality explosives and proper loading conditions. Quality assurance will need to be achieved from the supplier with quality checks on explosives from time to time. Further action is to prevail from loading blastholes at long periods prior to blasting. Excessive sleeping of charged blastholes will add to fumes generation and should be prevented. Additional measures could include placing stemming plugs at the bottom of the hole and loading emulsion from the bottom up will excluded mixing of drill chippings with the explosives in initiation area. The checking of blastholes for water will ensure that charging crew charges blasthole from the bottom (which should be a standard practise) and displaces the water. This will also ensure proper initiation of the blasthole.

6.5.15 Vibration impact on 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 to close to the road or subsidence is caused due to blasting operations. Normally 100 blasthole diameters are a minimum distance between structure and blasthole to prevent any cracks being formed into the surrounds of a blasthole. 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 does not have influence on air blast by virtue of the type of structure. 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.

6.5.16 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.

6.5.17 Cracking of houses and consequent devaluation

Houses in general have cracks. It is reported that a house could develop up to 15 cracks a year. Ground vibration will be mostly responsible for cracks in structures if high enough and 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 15 below. A typical X crack formations is observed.

Figure 15: Example of blast induced damage.

Observing cracks of this form 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 or else stated was not always applied in the country side when houses were built. 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.

6.5.18 Water well Influence from Blasting Activities

Water monitoring holes are present on and around the proposed two site sites: the main project area and the portion 30 area. The author has not had much experience on the effect of blasting on water wells but specific research was done and results from this research work are presented.

Case 1 looked at 36 case histories. Vibration levels up 50mm/s were measured. The well yield and aquifer storage improved as the mining neared the wells, because of the opening of the fractures from loss of lateral confinement, not blasting. This is similar to how stress-relief fractures form. At one site the process was reversed after the mine was backfilled. It was more likely the fractures were recompressed. It was stated that blasting may cause some temporary (transient) turbidity similar to those events that cause turbidity without blasting.

Such as:

1. Natural sloughing off inside of the well bore due to inherent rock instability. This can be accelerated by frequent over pumping. This is common to wells completed through considerable thickness of poorly consolidated and/or highly fractured clay stones and shale's.

2. Significant rainfall events. The apertures of the shallow fractures that are intersected by a domestic well are commonly highly transmissive, thus will transmit substantial amounts of shallow flowing and rapidly recharging water. This water will commonly be turbid and can enter the well in high volumes. The lack of grouting of the near surface casing commonly allows this to happen. Also, if the top of the well is not grouted properly surface water can enter along the side of the casing and flow down the annulus.

The Berger Study observed ground-water impacts from manmade stress-release caused the rock mass removal during mining, but nothing from the blasting. The water quality and water levels were unaffected by the blasting. The "opening up" of the fractures lowered the ground-water levels by increasing the storage or porosity.

A study tested wells 50m from a blast. Wells exhibited no quality or quantity impacts. Blast pressure surges ranged from 3 to 10cm. Blasting caused no noticeable water table fluctuations and the hydraulic conductivity was unchanged. The pumping of the pit and encroachment of the high wall toward the wells dewatered the water table aquifer.

It may then be concluded from the studies researched as follows: Depending on the well construction, litho logic units encountered, and proximity to the blasting, it is believed that large shots could act as a catalyst for some well sloughing or collapse. However, the well would have to be inherently weak to begin with. The small to moderate shots will not show to impact wells. The minor water fluctuations attributed to blasting may cause a short term turbidity problem, but do not pose any long term problems. This fluctuation would not cause well collapse, as fluctuations from recharge and pumping occurs frequently. Long term changes to the well yield are more likely due to the opening of fractures from loss of lateral confinement. Short term dewatering of wells is caused by the opening of the fractures creating additional storage. A longer term dewatering is caused by encroachment of the high wall and pumping of the pit water. The pit acts like a large pumping well. It is not believed that long term water quality problems will be caused by blasting alone. The possible exception is the introduction of residual nitrates, from the blasting materials, into the ground water system. This is only possible through wells that are hydro logically connected to a blasting site. Most of the long term impacts on water quality are due to the mining (the breakup of the rocks). The influence will also be dependant if wells are beneath the excavation. Stress relief effects occur at shorter distances in this instance.

The results observed and levels recorded during research done showed that levels up to 50mm/s or even higher in certain cases did not have any noticeable effect. It seems that safe conditions will be in the order of the 50mm/s. In addition to this there are certain aspects that will need to be addressed prior to blasting operations.

7 SITE SENSITIVENESS AND SPECIFIC REVIEW, MODELLING OF THE VARIOUS ASPECTS FROM BLASTING OPERATIONS:

The area surrounding the proposed mining areas was reviewed for structures, traffic, roads, human interface, animals interface etc. Various installations and structures were observed. These are listed in Table 1. Table 2 shows typical structures from area. 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 three charge mass scenarios are considered with regards to ground vibration and air blast. Review of the charge per blasthole and the possible timing of a blast the following charge masses were selected to ensure proper source coverage. Review of the blast designs considered the possible charges per delay expected range between 127 and 2035kg. Therefore six coal blastholes yielding 127kg charge, 2 times overburden blastholes detonating simultaneously will yield 1019kg and 4 overburden blastholes detonating simultaneously will yield 2035kg.

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.

Two models are presented in this report. Firstly the model using the three charges for the original full size project area. The second model considers only mining of portion 30. Only the maximum charge mass was evaluated for portion 30.

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.

7.1 REVIEW OF EXPECTED GROUND VIBRATION

Ground vibration is calculated and modelled for minimum, medium and maximum charge mass at specific distances from the opencast mining area. The charge masses applied are according blast designs in section 6.4. 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 to 3500m around the opencast mining area.

Presented herewith are the expected ground vibration level contours. Discussion of level of ground vibration and relevant influences is also given. Expected ground vibration levels were calculated for each of the structure locations or POI's considered surrounding the mining area. Evaluation is given for each POI with regards to human perception and structure concern. Evaluation is done in form of the criteria what humans experience and where by structures could be damaged. This is according to accepted criteria for prevention of damage to structures and when levels are low enough to have no significant influence. Tables are provided for each of the different charge modelling done with regards to No., Structure, Shortest Distance (m), Max Charge, Predicted PPV (mm/s), and Possible Concern. The No." is only number order. "Structure" is description of the structure. The "Shortest Distance" is the distance between the structure and edge of the pit area. The "Max Charge" is the charge size in kg used for the specific modelling or calculations. The "Predicted PPV (mm/s)" is the calculated ground vibration for the structure and the "possible concern" indicates if there is any concern for structure damage or not or human perception. Indicators used are such as "perceptible", "unpleasant", "intolerable" which stems from the humans perception information given and indicators such as "high" or "low" is given whereby there is possibility of damage to a structure or no significant influence is expected and concern is low. Levels below 0.76 mm/s could be considered as to be low or negligible possibility of influence.

Provided as well with each simulation are indicators of the ground vibration limits used: 6, 12.5 and 25mm/s. 6 mm/s is indicated as a “Solid Blue” line, 12.5mm/s “Intermittent Blue” line and 25mm/s as a “Intermittent Red” line. This enables immediate review of possible concerns that may be applicable to any of the privately owned structures, social gathering areas or installations. Consideration can also then be given to influence on sensitive installations within the mine boundary.

Data is provided as follows: Vibration contours followed by table with predicted ground vibration values and evaluation.

7.2 CALCULATED GROUND VIBRATION LEVELS

Presented are simulations for expected ground vibration levels from three different charge masses.

7.2.1 Minimum Charge per Delay – 127kg

The outcome of the simulation from minimum charge is presented in

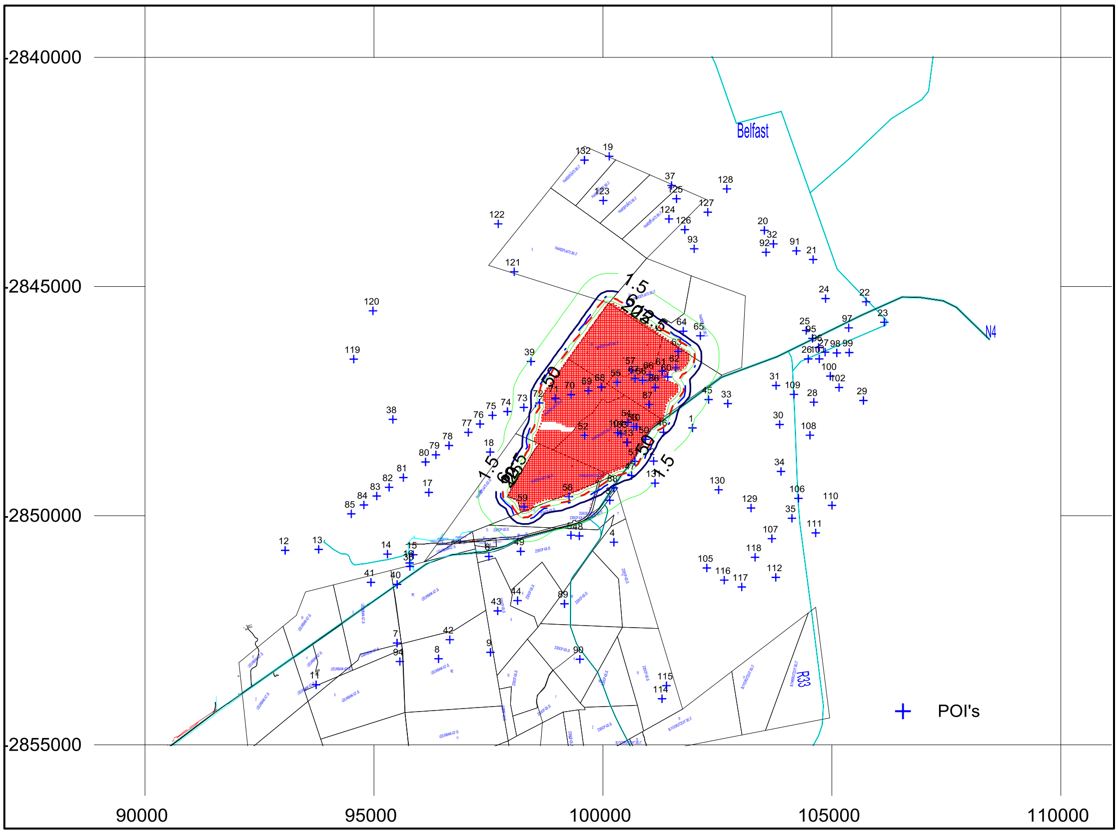

Figure 16; Figure 17 shows zoomed area of

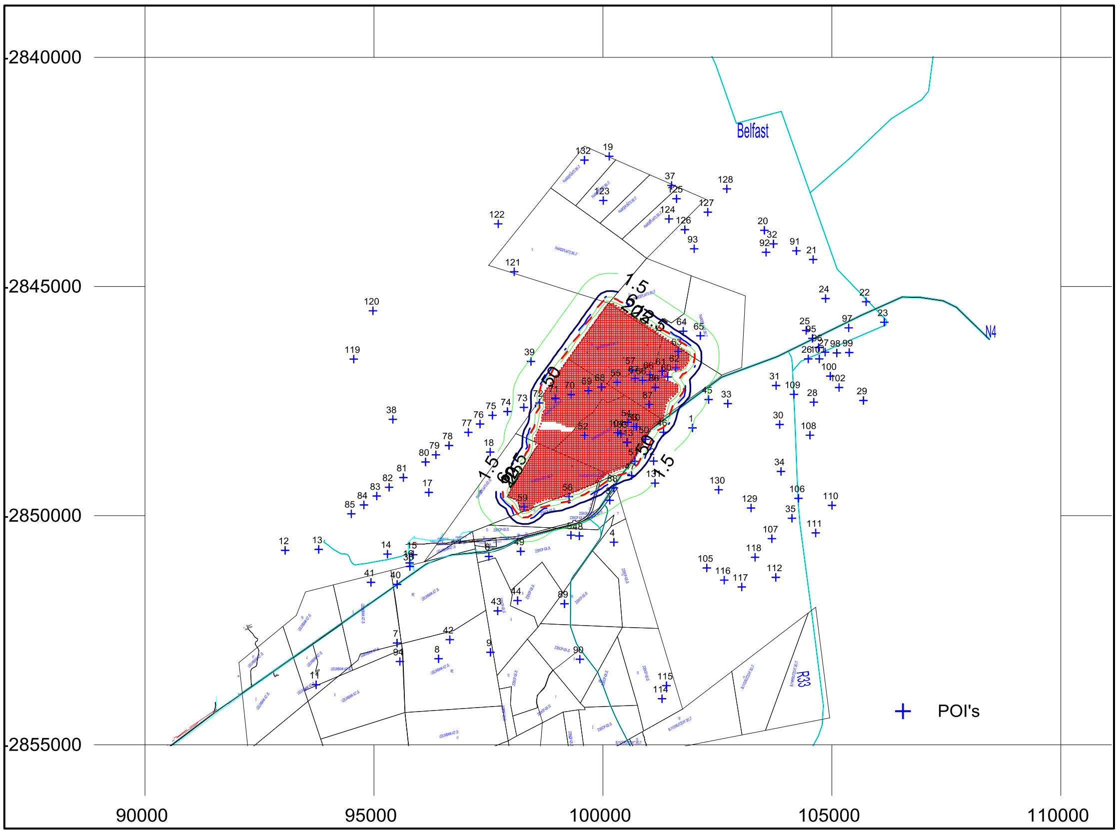

Figure 16, medium charge in Figure 18, Figure 14 shows zoomed area of Figure 13 and maximum charge in Figure 15

The expected level for each of the identified structures, possible influence and concern is also considered and presented directly after each vibration contour is the following tables Table 12, Table 13 and Table 13 below.

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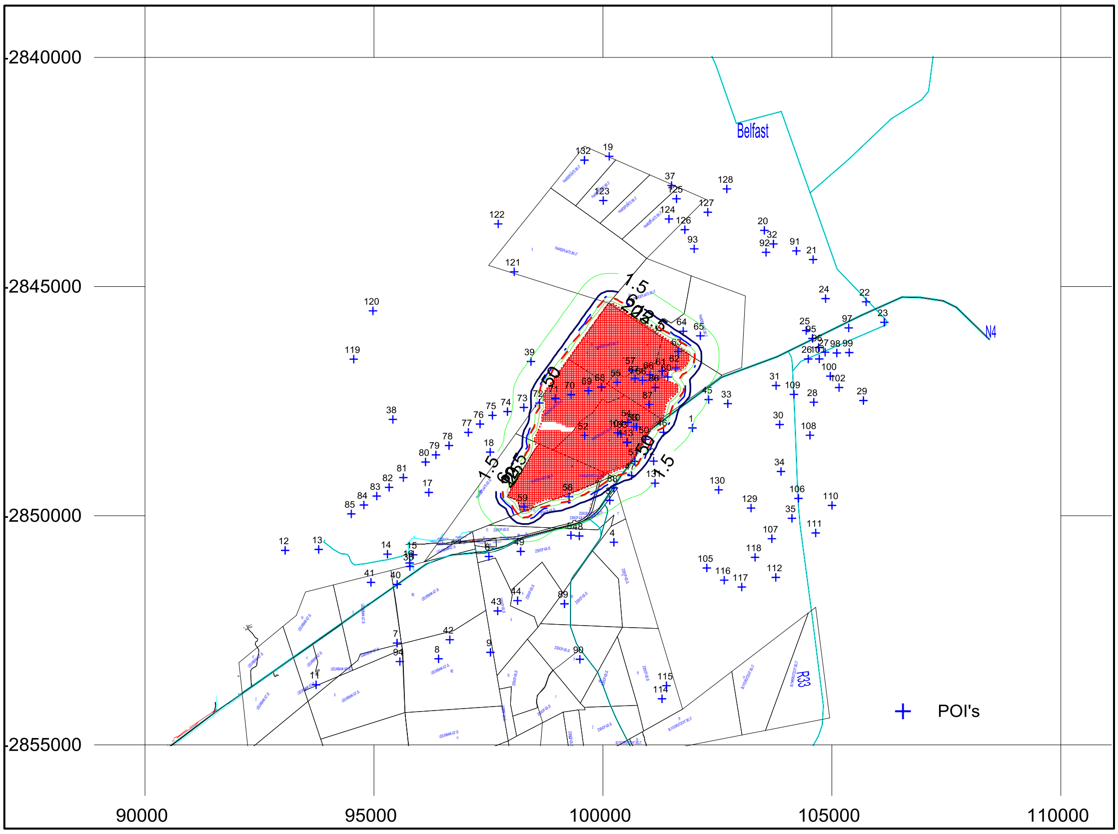

Figure 16: Ground vibration influence from minimum charge

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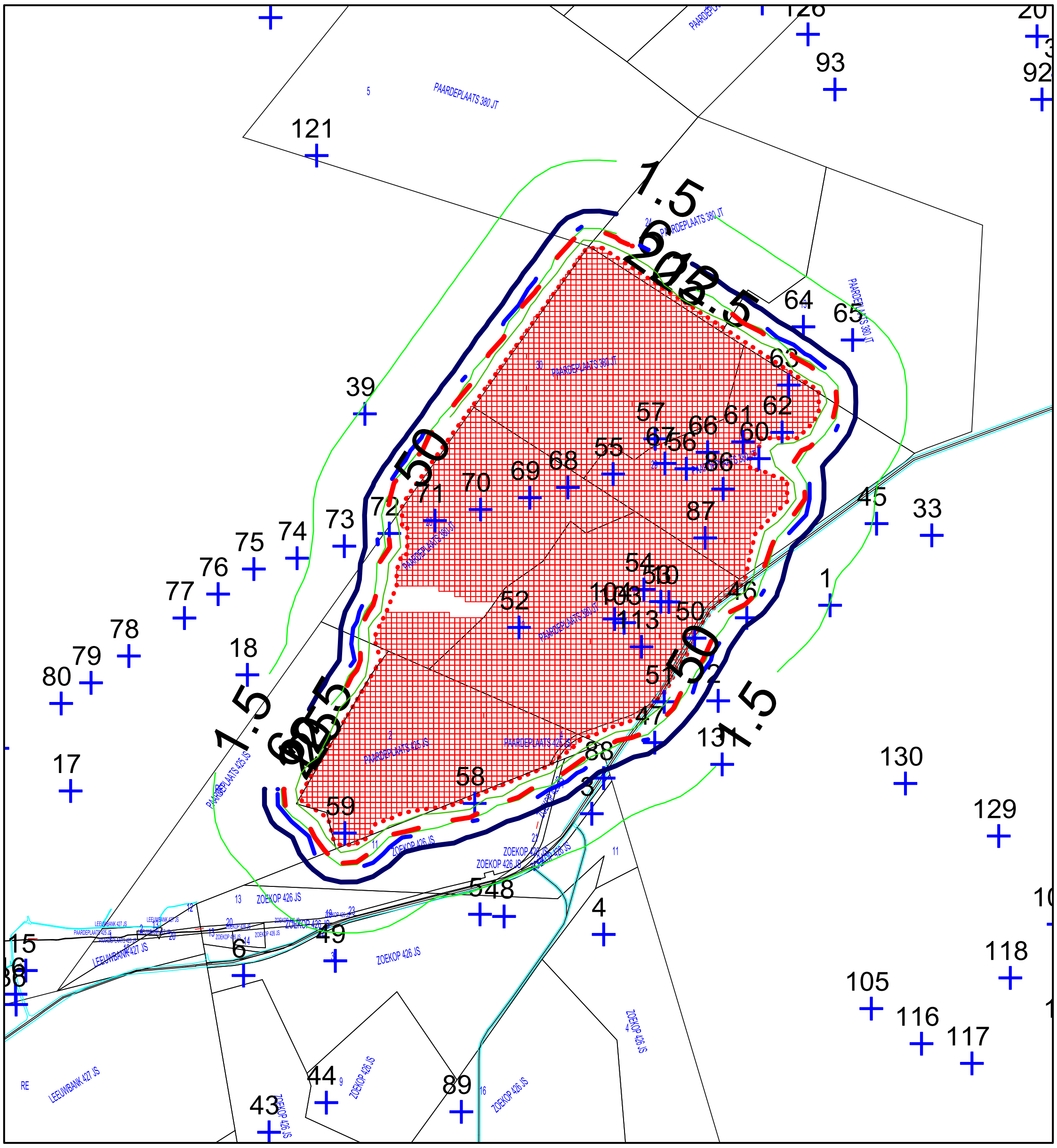

Figure 17: Zoomed area for ground vibration influence from minimum charge

Table 12: Ground vibration evaluation for minimum charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
1	Shed	25	674	1.5	Perceptible	Acceptable	Acceptable
2	Informal Housing	6	387	3.4	Perceptible	Acceptable	Acceptable
3	Farm House	25	486	2.4	Perceptible	Acceptable	Acceptable
4	Farmstead	25	1340	0.5	Too Low	Acceptable	Acceptable
5	Railway Substation	25	852	1.0	Perceptible	Acceptable	Acceptable
6	Buildings/Structures	25	1228	0.6	Too Low	Acceptable	Acceptable
7	Farmstead	25	3966	0.1	Too Low	Acceptable	Acceptable
8	Grain Storage	25	3704	0.1	Too Low	Acceptable	Acceptable
9	Dams	50	3161	0.1	Too Low	Acceptable	Acceptable
10	Telecom Tower	25	302	5.0	Perceptible	Acceptable	Acceptable
11	Farm House/Hot Houses	25	5876	0.1	Too Low	Acceptable	Acceptable
12	Farmstead	25	5202	0.1	Too Low	Acceptable	Acceptable
13	Farmstead	25	4480	0.1	Too Low	Acceptable	Acceptable

14	Farmstead	25	3057	0.1	Too Low	Acceptable	Acceptable
15	Shed	25	2536	0.2	Too Low	Acceptable	Acceptable
16	Informal Housing	6	2681	0.2	Too Low	Acceptable	Acceptable
17	Dam	50	1985	0.3	Too Low	Acceptable	Acceptable
18	Dam	50	1306	0.5	Too Low	Acceptable	Acceptable
19	Siyathuthuka Village Houses	25	3235	0.1	Too Low	Acceptable	Acceptable
20	Houses	25	3152	0.1	Too Low	Acceptable	Acceptable
21	Houses	25	3410	0.1	Too Low	Acceptable	Acceptable
22	Cattle Sales Yard	50	4040	0.1	Too Low	Acceptable	Acceptable
23	Filling Station	25	4330	0.1	Too Low	Acceptable	Acceptable
24	Farmstead	25	3226	0.1	Too Low	Acceptable	Acceptable
25	Sub Station	25	2619	0.2	Too Low	Acceptable	Acceptable
26	Farmstead	25	2613	0.2	Too Low	Acceptable	Acceptable
27	Sheds	25	2982	0.2	Too Low	Acceptable	Acceptable
28	Farmstead	25	2881	0.2	Too Low	Acceptable	Acceptable
29	Shed	25	3917	0.1	Too Low	Acceptable	Acceptable
30	Farmstead	25	2343	0.2	Too Low	Acceptable	Acceptable
31	Farmstead	25	1987	0.3	Too Low	Acceptable	Acceptable
32	Road	150	3025	0.2	Too Low	Acceptable	Acceptable
33	Farmstead	25	1128	0.7	Too Low	Acceptable	Acceptable
34	Informal Housing	6	2821	0.2	Too Low	Acceptable	Acceptable
35	Farmstead	25	3550	0.1	Too Low	Acceptable	Acceptable
36	School	25	2712	0.2	Too Low	Acceptable	Acceptable
37	Dam	50	2882	0.2	Too Low	Acceptable	Acceptable
38	Farmstead	25	3322	0.1	Too Low	Acceptable	Acceptable
39	Farmstead	25	2205	0.2	Too Low	Acceptable	Acceptable
40	Informal Housing	6	3147	0.1	Too Low	Acceptable	Acceptable
41	Farm House	25	3627	0.1	Too Low	Acceptable	Acceptable
42	Building/Structure	25	3221	0.1	Too Low	Acceptable	Acceptable
43	Farm House	25	2245	0.2	Too Low	Acceptable	Acceptable
44	Informal Housing	6	1957	0.3	Too Low	Acceptable	Acceptable
45	N4 Road	150	701	1.4	Perceptible	Acceptable	Acceptable
46	N4 Road	150	223	7.9	N/A	Acceptable	Acceptable
47	N4 Road	150	220	8.1	N/A	Acceptable	Acceptable
48	N4 Road	150	927	0.9	Perceptible	Acceptable	Acceptable
49	N4 Road	150	881	1.0	Perceptible	Acceptable	Acceptable
50	Houses	25	8	1354.3	Intolerable	Problematic	Problematic
51	Packing Sheds	25	47	84.4	Intolerable	Problematic	Problematic
52	Dam	50	971	0.8	Perceptible	Acceptable	Acceptable
53	Cement Dams	50	356	3.9	Perceptible	Acceptable	Acceptable
54	Farm House	25	513	2.2	Perceptible	Acceptable	Acceptable
55	Dam	50	1040	0.8	Perceptible	Acceptable	Acceptable
56	Informal Housing	6	484	2.4	Perceptible	Acceptable	Acceptable
57	Farm House	25	732	1.3	Perceptible	Acceptable	Acceptable
58	Farmstead	25	50	77.0	Intolerable	Problematic	Problematic
59	Dam	50	88	32.4	N/A	Acceptable	Acceptable
60	Cement Dam	50	49	80.0	N/A	Problematic	Problematic
61	Power lines/Pylon	75	110	23.1	N/A	Acceptable	Acceptable
62	Power lines/Pylon	75	43	95.6	N/A	Problematic	Problematic
63	Dam	50	91	31.1	N/A	Acceptable	Acceptable
64	Dam	50	339	4.2	Perceptible	Acceptable	Acceptable
65	Farmstead	25	462	2.6	Perceptible	Acceptable	Acceptable
66	Power lines/Pylon	75	324	4.5	Perceptible	Acceptable	Acceptable
67	Power lines/Pylon	75	646	1.6	Perceptible	Acceptable	Acceptable
68	Power lines/Pylon	75	1389	0.5	Too Low	Acceptable	Acceptable
69	Power lines/Pylon	75	1618	0.4	Too Low	Acceptable	Acceptable
70	Power lines/Pylon	75	1891	0.3	Too Low	Acceptable	Acceptable
71	Power lines/Pylon	75	1994	0.3	Too Low	Acceptable	Acceptable
72	Power lines/Pylon	75	2088	0.3	Too Low	Acceptable	Acceptable
73	Power lines/Pylon	75	2069	0.3	Too Low	Acceptable	Acceptable
74	Power lines/Pylon	75	2045	0.3	Too Low	Acceptable	Acceptable
75	Power lines/Pylon	75	2031	0.3	Too Low	Acceptable	Acceptable
76	Power lines/Pylon	75	1952	0.3	Too Low	Acceptable	Acceptable
77	Power lines/Pylon	75	1924	0.3	Too Low	Acceptable	Acceptable
78	Power lines/Pylon	75	1997	0.3	Too Low	Acceptable	Acceptable
79	Power lines/Pylon	75	2112	0.3	Too Low	Acceptable	Acceptable
80	Power lines/Pylon	75	2240	0.2	Too Low	Acceptable	Acceptable
81	Power lines/Pylon	75	2590	0.2	Too Low	Acceptable	Acceptable
82	Power lines/Pylon	75	2859	0.2	Too Low	Acceptable	Acceptable

83	Power lines/Pylon	75	3110	0.1	Too Low	Acceptable	Acceptable
84	Power lines/Pylon	75	3385	0.1	Too Low	Acceptable	Acceptable
85	Power lines/Pylon	75	3665	0.1	Too Low	Acceptable	Acceptable
86	Informal Housing	6	253	6.5	Unpleasant	Problematic	Problematic
87	Road	150	361	3.8	Perceptible	Acceptable	Acceptable
88	Informal Housing	6	328	4.4	Perceptible	Acceptable	Acceptable
89	Farm House	25	2182	0.2	Too Low	Acceptable	Acceptable
90	Farmstead	25	3433	0.1	Too Low	Acceptable	Acceptable
91	Houses	25	3251	0.1	Too Low	Acceptable	Acceptable
92	Informal Housing	6	2781	0.2	Too Low	Acceptable	Acceptable
93	Labour Housing	6	1973	0.3	Too Low	Acceptable	Acceptable
94	Informal Housing	6	4230	0.1	Too Low	Acceptable	Acceptable
95	Power lines/Pylons	75	2727	0.2	Too Low	Acceptable	Acceptable
96	Power lines/Pylons	75	2842	0.2	Too Low	Acceptable	Acceptable
97	Informal Housing	6	3543	0.1	Too Low	Acceptable	Acceptable
98	Sheds	25	3237	0.1	Too Low	Acceptable	Acceptable
99	Shed	25	3508	0.1	Too Low	Acceptable	Acceptable
100	Informal Housing	6	3114	0.1	Too Low	Acceptable	Acceptable
101	Housing	25	2854	0.2	Too Low	Acceptable	Acceptable
102	Informal Housing	6	3339	0.1	Too Low	Acceptable	Acceptable
103	Farm House	25	530	2.1	Perceptible	Acceptable	Acceptable
104	Cement Dam	50	606	1.7	Perceptible	Acceptable	Acceptable
105	Informal Housing	6	2818	0.2	Too Low	Acceptable	Acceptable
106	R33 Road	150	3428	0.1	Too Low	Acceptable	Acceptable
107	Dam	50	3462	0.1	Too Low	Acceptable	Acceptable
108	Shed	25	3044	0.1	Too Low	Acceptable	Acceptable
109	R33 Road	150	2416	0.2	Too Low	Acceptable	Acceptable
110	Farm House	25	4144	0.1	Too Low	Acceptable	Acceptable
111	Farmstead	25	4156	0.1	Too Low	Acceptable	Acceptable
112	Farmstead	25	4024	0.1	Too Low	Acceptable	Acceptable
113	Orchards	25	319	4.6	Perceptible	Acceptable	Acceptable
114	Hot Houses	25	4898	0.1	Too Low	Acceptable	Acceptable
115	Farmstead	25	4671	0.1	Too Low	Acceptable	Acceptable
116	Informal Housing	6	3266	0.1	Too Low	Acceptable	Acceptable
117	Informal Housing	6	3634	0.1	Too Low	Acceptable	Acceptable
118	Dam	50	3396	0.1	Too Low	Acceptable	Acceptable
119	Farmstead	25	4804	0.1	Too Low	Acceptable	Acceptable
120	Informal Housing	6	5275	0.1	Too Low	Acceptable	Acceptable
121	Dam	50	2302	0.2	Too Low	Acceptable	Acceptable
122	Farmstead	25	3088	0.1	Too Low	Acceptable	Acceptable
123	Farm House	25	2283	0.2	Too Low	Acceptable	Acceptable
124	Sheds	25	2214	0.2	Too Low	Acceptable	Acceptable
125	Sewer Works	25	2676	0.2	Too Low	Acceptable	Acceptable
126	Mine Activity	50	2209	0.2	Too Low	Acceptable	Acceptable
127	Graveyard	50	2804	0.2	Too Low	Acceptable	Acceptable
128	Graveyard	50	3457	0.1	Too Low	Acceptable	Acceptable
129	Dam	50	2729	0.2	Too Low	Acceptable	Acceptable
130	Dam	50	1924	0.3	Too Low	Acceptable	Acceptable
131	Structure	25	693	1.4	Perceptible	Acceptable	Acceptable
132	Graveyard	50	3218	0.1	Too Low	Acceptable	Acceptable

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7.2.2 Medium Charge per Delay - 1019kg

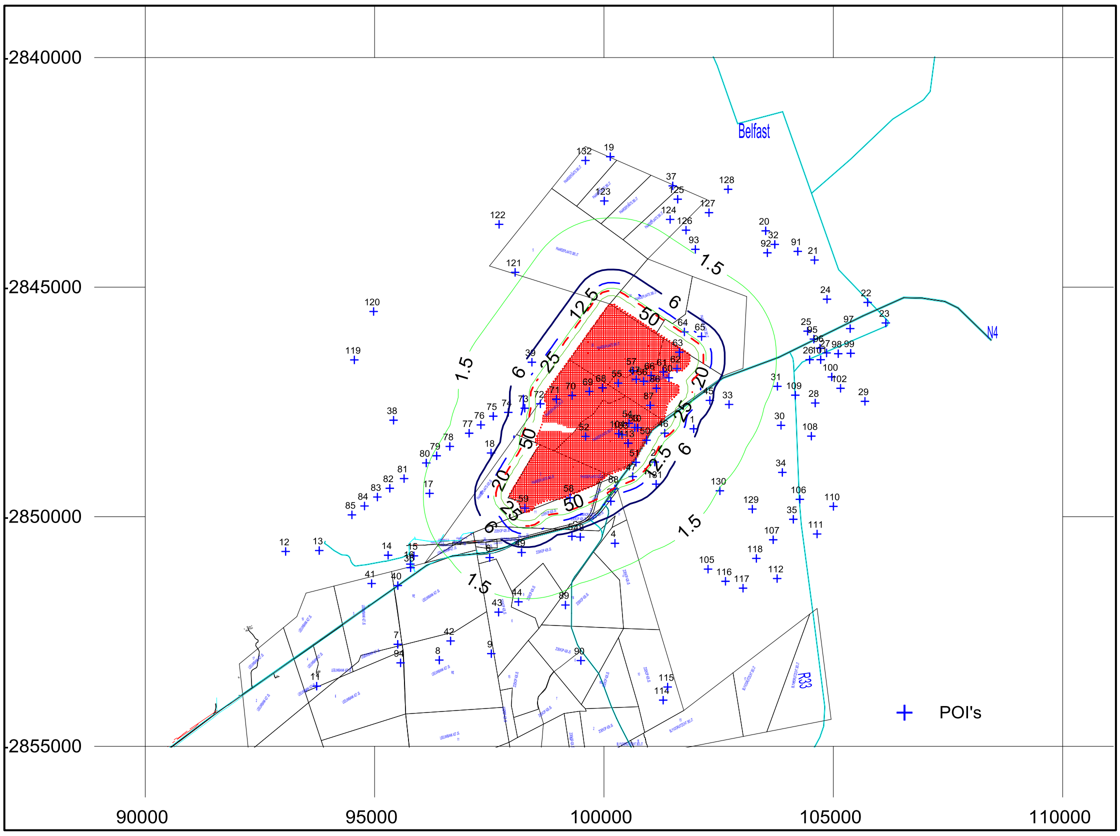

Figure 18: Ground vibration influence from medium charge

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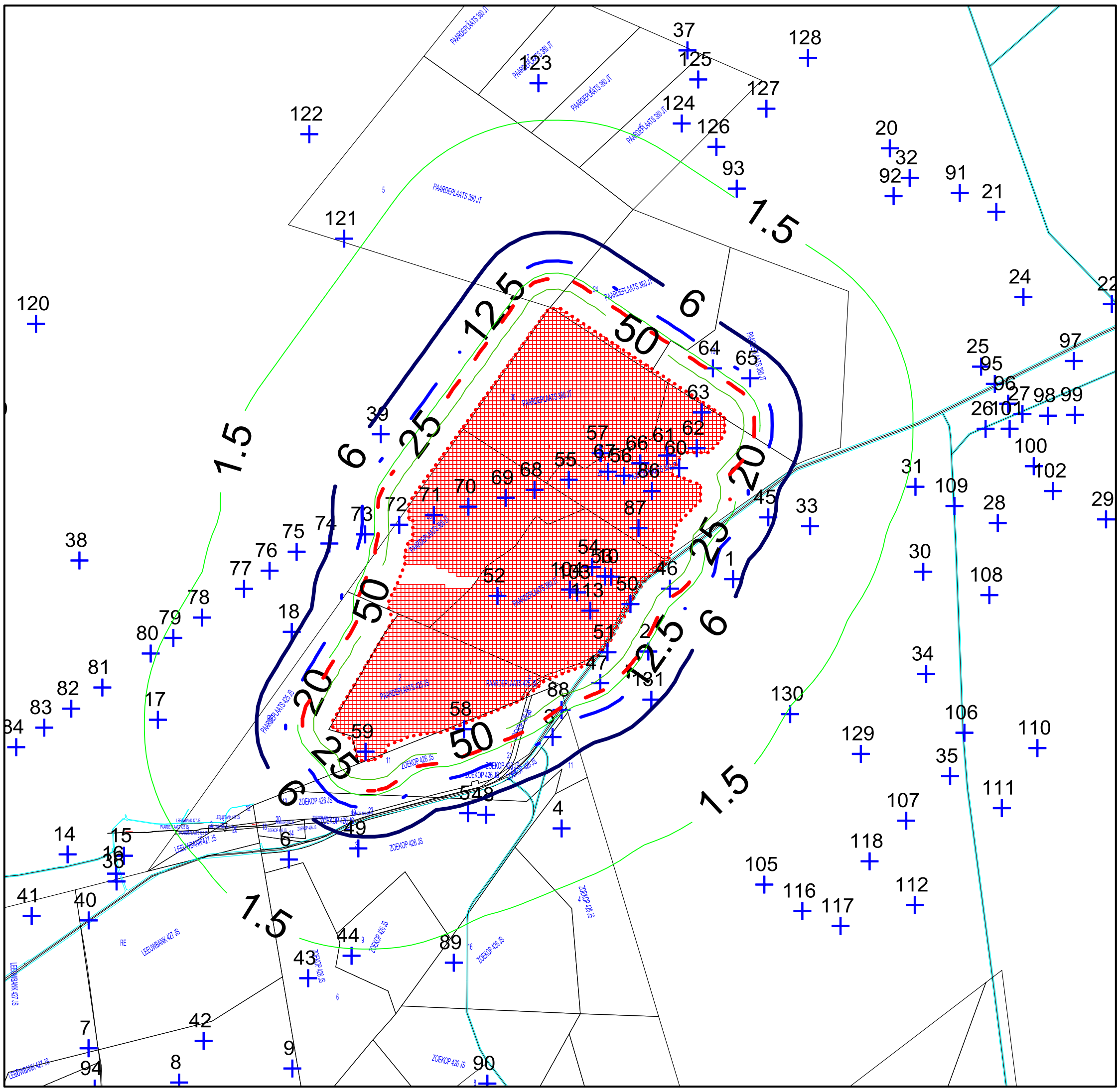

Figure 19: Zoomed area for Ground vibration influence from medium charge

Table 13: Ground vibration evaluation for medium charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
1	Shed	25	674	7.2	Unpleasant	Acceptable	Acceptable
2	Informal Housing	6	387	16.7	Unpleasant	Problematic	Problematic
3	Farm House	25	486	11.8	Unpleasant	Acceptable	Acceptable
4	Farmstead	25	1340	2.5	Perceptible	Acceptable	Acceptable
5	Railway Substation	25	852	5.0	Perceptible	Acceptable	Acceptable
6	Buildings/Structures	25	1228	2.9	Perceptible	Acceptable	Acceptable
7	Farmstead	25	3966	0.5	Too Low	Acceptable	Acceptable
8	Grain Storage	25	3704	0.5	Too Low	Acceptable	Acceptable
9	Dams	50	3161	0.7	Too Low	Acceptable	Acceptable
10	Telecom Tower	25	302	24.3	Intolerable	Acceptable	Acceptable
11	Farm House/Hot Houses	25	5876	0.3	Too Low	Acceptable	Acceptable
12	Farmstead	25	5202	0.3	Too Low	Acceptable	Acceptable
13	Farmstead	25	4480	0.4	Too Low	Acceptable	Acceptable
14	Farmstead	25	3057	0.7	Too Low	Acceptable	Acceptable
15	Shed	25	2536	1.0	Perceptible	Acceptable	Acceptable
16	Informal Housing	6	2681	0.9	Perceptible	Acceptable	Acceptable
17	Dam	50	1985	1.4	Perceptible	Acceptable	Acceptable
18	Dam	50	1306	2.6	Perceptible	Acceptable	Acceptable

19	Siyathuthuka Village Houses	25	3235	0.7	Too Low	Acceptable	Acceptable
20	Houses	25	3152	0.7	Too Low	Acceptable	Acceptable
21	Houses	25	3410	0.6	Too Low	Acceptable	Acceptable
22	Cattle Sales Yard	50	4040	0.5	Too Low	Acceptable	Acceptable
23	Filling Station	25	4330	0.4	Too Low	Acceptable	Acceptable
24	Farmstead	25	3226	0.7	Too Low	Acceptable	Acceptable
25	Sub Station	25	2619	0.9	Perceptible	Acceptable	Acceptable
26	Farmstead	25	2613	0.9	Perceptible	Acceptable	Acceptable
27	Sheds	25	2982	0.7	Too Low	Acceptable	Acceptable
28	Farmstead	25	2881	0.8	Perceptible	Acceptable	Acceptable
29	Shed	25	3917	0.5	Too Low	Acceptable	Acceptable
30	Farmstead	25	2343	1.1	Perceptible	Acceptable	Acceptable
31	Farmstead	25	1987	1.4	Perceptible	Acceptable	Acceptable
32	Road	150	3025	0.7	Too Low	Acceptable	Acceptable
33	Farmstead	25	1128	3.3	Perceptible	Acceptable	Acceptable
34	Informal Housing	6	2821	0.8	Perceptible	Acceptable	Acceptable
35	Farmstead	25	3550	0.6	Too Low	Acceptable	Acceptable
36	School	25	2712	0.9	Perceptible	Acceptable	Acceptable
37	Dam	50	2882	0.8	Perceptible	Acceptable	Acceptable
38	Farmstead	25	3322	0.6	Too Low	Acceptable	Acceptable
39	Farmstead	25	2205	1.2	Perceptible	Acceptable	Acceptable
40	Informal Housing	6	3147	0.7	Too Low	Acceptable	Acceptable
41	Farm House	25	3627	0.6	Too Low	Acceptable	Acceptable
42	Building/Structure	25	3221	0.7	Too Low	Acceptable	Acceptable
43	Farm House	25	2245	1.2	Perceptible	Acceptable	Acceptable
44	Informal Housing	6	1957	1.4	Perceptible	Acceptable	Acceptable
45	N4 Road	150	701	6.8	N/A	Acceptable	Acceptable
46	N4 Road	150	223	38.6	N/A	Acceptable	Acceptable
47	N4 Road	150	220	39.3	N/A	Acceptable	Acceptable
48	N4 Road	150	927	4.4	Perceptible	Acceptable	Acceptable
49	N4 Road	150	881	4.8	Perceptible	Acceptable	Acceptable
50	Houses	25	8	6592.3	Intolerable	Problematic	Problematic
51	Packing Sheds	25	47	410.6	Intolerable	Problematic	Problematic
52	Dam	50	971	4.1	Perceptible	Acceptable	Acceptable
53	Cement Dams	50	356	18.9	N/A	Acceptable	Acceptable
54	Farm House	25	513	10.9	N/A	Acceptable	Acceptable
55	Dam	50	1040	3.7	Perceptible	Acceptable	Acceptable
56	Informal Housing	6	484	11.9	Unpleasant	Problematic	Problematic
57	Farm House	25	732	6.3	Unpleasant	Acceptable	Acceptable
58	Farmstead	25	50	374.8	Intolerable	Problematic	Problematic
59	Dam	50	88	157.9	N/A	Problematic	Problematic
60	Cement Dam	50	49	389.6	N/A	Problematic	Problematic
61	Power lines/Pylon	75	110	112.5	N/A	Problematic	Problematic
62	Power lines/Pylon	75	43	465.2	N/A	Problematic	Problematic
63	Dam	50	91	151.5	N/A	Problematic	Problematic
64	Dam	50	339	20.3	N/A	Acceptable	Acceptable
65	Farmstead	25	462	12.7	Unpleasant	Acceptable	Acceptable
66	Power lines/Pylon	75	324	21.8	N/A	Acceptable	Acceptable
67	Power lines/Pylon	75	646	7.6	N/A	Acceptable	Acceptable
68	Power lines/Pylon	75	1389	2.4	Perceptible	Acceptable	Acceptable
69	Power lines/Pylon	75	1618	1.9	Perceptible	Acceptable	Acceptable
70	Power lines/Pylon	75	1891	1.5	Perceptible	Acceptable	Acceptable
71	Power lines/Pylon	75	1994	1.4	Perceptible	Acceptable	Acceptable
72	Power lines/Pylon	75	2088	1.3	Perceptible	Acceptable	Acceptable
73	Power lines/Pylon	75	2069	1.3	Perceptible	Acceptable	Acceptable
74	Power lines/Pylon	75	2045	1.3	Perceptible	Acceptable	Acceptable
75	Power lines/Pylon	75	2031	1.3	Perceptible	Acceptable	Acceptable
76	Power lines/Pylon	75	1952	1.4	Perceptible	Acceptable	Acceptable
77	Power lines/Pylon	75	1924	1.5	Perceptible	Acceptable	Acceptable
78	Power lines/Pylon	75	1997	1.4	Perceptible	Acceptable	Acceptable
79	Power lines/Pylon	75	2112	1.3	Perceptible	Acceptable	Acceptable
80	Power lines/Pylon	75	2240	1.2	Perceptible	Acceptable	Acceptable
81	Power lines/Pylon	75	2590	0.9	Perceptible	Acceptable	Acceptable
82	Power lines/Pylon	75	2859	0.8	Perceptible	Acceptable	Acceptable
83	Power lines/Pylon	75	3110	0.7	Too Low	Acceptable	Acceptable
84	Power lines/Pylon	75	3385	0.6	Too Low	Acceptable	Acceptable
85	Power lines/Pylon	75	3665	0.5	Too Low	Acceptable	Acceptable
86	Informal Housing	6	253	31.8	Intolerable	Problematic	Problematic
87	Road	150	361	18.5	N/A	Acceptable	Acceptable

88	Informal Housing	6	328	21.4	Intolerable	Problematic	Problematic
89	Farm House	25	2182	1.2	Perceptible	Acceptable	Acceptable
90	Farmstead	25	3433	0.6	Too Low	Acceptable	Acceptable
91	Houses	25	3251	0.7	Too Low	Acceptable	Acceptable
92	Informal Housing	6	2781	0.8	Perceptible	Acceptable	Acceptable
93	Labour Housing	6	1973	1.4	Perceptible	Acceptable	Acceptable
94	Informal Housing	6	4230	0.4	Too Low	Acceptable	Acceptable
95	Power lines/Pylons	75	2727	0.9	Perceptible	Acceptable	Acceptable
96	Power lines/Pylons	75	2842	0.8	Perceptible	Acceptable	Acceptable
97	Informal Housing	6	3543	0.6	Too Low	Acceptable	Acceptable
98	Sheds	25	3237	0.7	Too Low	Acceptable	Acceptable
99	Shed	25	3508	0.6	Too Low	Acceptable	Acceptable
100	Informal Housing	6	3114	0.7	Too Low	Acceptable	Acceptable
101	Housing	25	2854	0.8	Perceptible	Acceptable	Acceptable
102	Informal Housing	6	3339	0.6	Too Low	Acceptable	Acceptable
103	Farm House	25	530	10.3	Unpleasant	Acceptable	Acceptable
104	Cement Dam	50	606	8.4	N/A	Acceptable	Acceptable
105	Informal Housing	6	2818	0.8	Perceptible	Acceptable	Acceptable
106	R33 Road	150	3428	0.6	Too Low	Acceptable	Acceptable
107	Dam	50	3462	0.6	Too Low	Acceptable	Acceptable
108	Shed	25	3044	0.7	Too Low	Acceptable	Acceptable
109	R33 Road	150	2416	1.0	Perceptible	Acceptable	Acceptable
110	Farm House	25	4144	0.5	Too Low	Acceptable	Acceptable
111	Farmstead	25	4156	0.5	Too Low	Acceptable	Acceptable
112	Farmstead	25	4024	0.5	Too Low	Acceptable	Acceptable
113	Orchards	25	319	22.4	Intolerable	Acceptable	Acceptable
114	Hot Houses	25	4898	0.4	Too Low	Acceptable	Acceptable
115	Farmstead	25	4671	0.4	Too Low	Acceptable	Acceptable
116	Informal Housing	6	3266	0.7	Too Low	Acceptable	Acceptable
117	Informal Housing	6	3634	0.6	Too Low	Acceptable	Acceptable
118	Dam	50	3396	0.6	Too Low	Acceptable	Acceptable
119	Farmstead	25	4804	0.4	Too Low	Acceptable	Acceptable
120	Informal Housing	6	5275	0.3	Too Low	Acceptable	Acceptable
121	Dam	50	2302	1.1	Perceptible	Acceptable	Acceptable
122	Farmstead	25	3088	0.7	Too Low	Acceptable	Acceptable
123	Farm House	25	2283	1.1	Perceptible	Acceptable	Acceptable
124	Sheds	25	2214	1.2	Perceptible	Acceptable	Acceptable
125	Sewer Works	25	2676	0.9	Perceptible	Acceptable	Acceptable
126	Mine Activity	50	2209	1.2	Perceptible	Acceptable	Acceptable
127	Graveyard	50	2804	0.8	Perceptible	Acceptable	Acceptable
128	Graveyard	50	3457	0.6	Too Low	Acceptable	Acceptable
129	Dam	50	2729	0.9	Perceptible	Acceptable	Acceptable
130	Dam	50	1924	1.5	Perceptible	Acceptable	Acceptable
131	Structure	25	693	6.9	Unpleasant	Acceptable	Acceptable
132	Graveyard	50	3218	0.7	Too Low	Acceptable	Acceptable

(Intentionally Left Open)

7.2.3 Maximum Charge per Delay – 2035kg

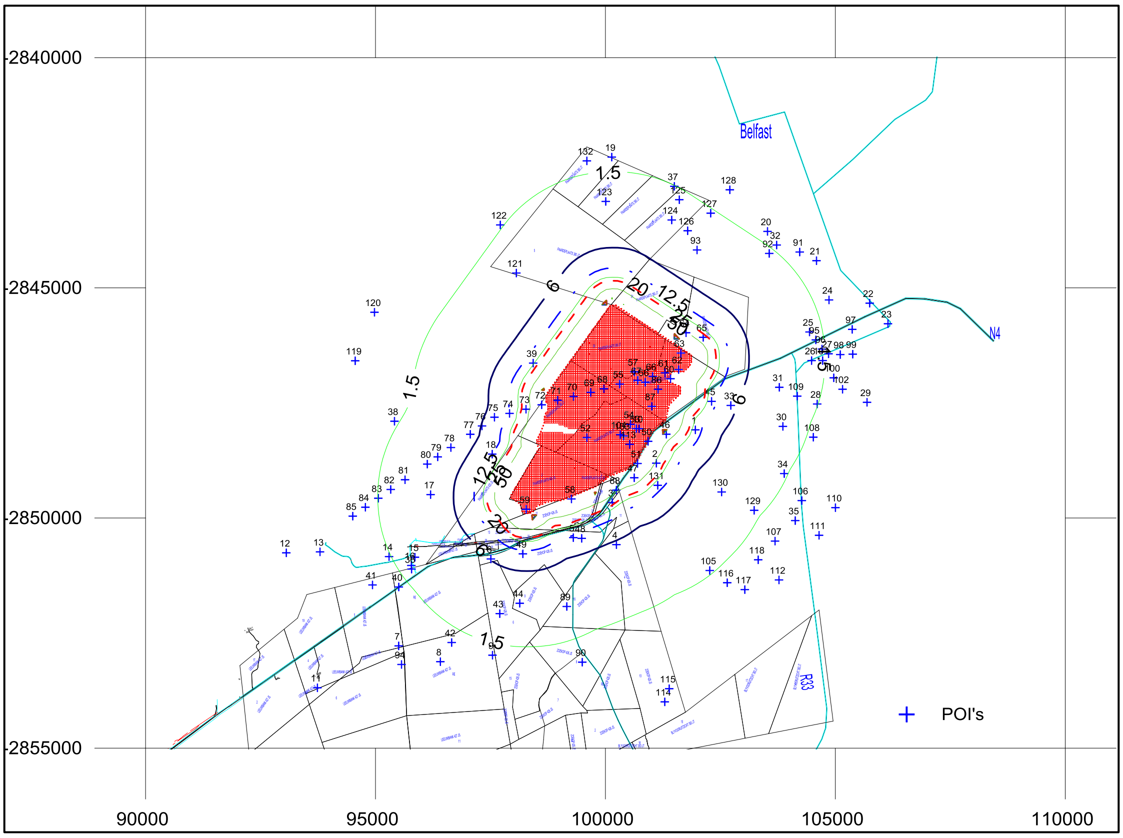

Figure 20: Ground vibration influence from maximum charge

Table 14: Ground vibration evaluation for maximum charge

Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
1	Shed	25	674	12.1	Unpleasant	Acceptable	Acceptable
2	Informal Housing	6	387	28.2	Intolerable	Problematic	Problematic
3	Farm House	25	486	19.9	Unpleasant	Acceptable	Acceptable
4	Farmstead	25	1340	4.3	Perceptible	Acceptable	Acceptable
5	Railway Substation	25	852	8.5	Unpleasant	Acceptable	Acceptable
6	Buildings/Structures	25	1228	4.9	Perceptible	Acceptable	Acceptable
7	Farmstead	25	3966	0.8	Perceptible	Acceptable	Acceptable
8	Grain Storage	25	3704	0.9	Perceptible	Acceptable	Acceptable
9	Dams	50	3161	1.2	Perceptible	Acceptable	Acceptable
10	Telecom Tower	25	302	41.1	Intolerable	Problematic	Problematic
11	Farm House/Hot Houses	25	5876	0.5	Too Low	Acceptable	Acceptable
12	Farmstead	25	5202	0.5	Too Low	Acceptable	Acceptable
13	Farmstead	25	4480	0.7	Too Low	Acceptable	Acceptable
14	Farmstead	25	3057	1.2	Perceptible	Acceptable	Acceptable
15	Shed	25	2536	1.6	Perceptible	Acceptable	Acceptable
16	Informal Housing	6	2681	1.5	Perceptible	Acceptable	Acceptable
17	Dam	50	1985	2.3	Perceptible	Acceptable	Acceptable
18	Dam	50	1306	4.4	Perceptible	Acceptable	Acceptable
19	Siyathuthuka Village Houses	25	3235	1.1	Perceptible	Acceptable	Acceptable

20	Houses	25	3152	1.2	Perceptible	Acceptable	Acceptable
21	Houses	25	3410	1.0	Perceptible	Acceptable	Acceptable
22	Cattle Sales Yard	50	4040	0.8	Perceptible	Acceptable	Acceptable
23	Filling Station	25	4330	0.7	Too Low	Acceptable	Acceptable
24	Farmstead	25	3226	1.1	Perceptible	Acceptable	Acceptable
25	Sub Station	25	2619	1.5	Perceptible	Acceptable	Acceptable
26	Farmstead	25	2613	1.5	Perceptible	Acceptable	Acceptable
27	Sheds	25	2982	1.3	Perceptible	Acceptable	Acceptable
28	Farmstead	25	2881	1.3	Perceptible	Acceptable	Acceptable
29	Shed	25	3917	0.8	Perceptible	Acceptable	Acceptable
30	Farmstead	25	2343	1.8	Perceptible	Acceptable	Acceptable
31	Farmstead	25	1987	2.3	Perceptible	Acceptable	Acceptable
32	Road	150	3025	1.2	Perceptible	Acceptable	Acceptable
33	Farmstead	25	1128	5.5	Perceptible	Acceptable	Acceptable
34	Informal Housing	6	2821	1.4	Perceptible	Acceptable	Acceptable
35	Farmstead	25	3550	1.0	Perceptible	Acceptable	Acceptable
36	School	25	2712	1.5	Perceptible	Acceptable	Acceptable
37	Dam	50	2882	1.3	Perceptible	Acceptable	Acceptable
38	Farmstead	25	3322	1.1	Perceptible	Acceptable	Acceptable
39	Farmstead	25	2205	2.0	Perceptible	Acceptable	Acceptable
40	Informal Housing	6	3147	1.2	Perceptible	Acceptable	Acceptable
41	Farm House	25	3627	0.9	Perceptible	Acceptable	Acceptable
42	Building/Structure	25	3221	1.1	Perceptible	Acceptable	Acceptable
43	Farm House	25	2245	1.9	Perceptible	Acceptable	Acceptable
44	Informal Housing	6	1957	2.4	Perceptible	Acceptable	Acceptable
45	N4 Road	150	701	11.4	N/A	Acceptable	Acceptable
46	N4 Road	150	223	65.3	N/A	Acceptable	Acceptable
47	N4 Road	150	220	66.4	N/A	Acceptable	Acceptable
48	N4 Road	150	927	7.5	N/A	Acceptable	Acceptable
49	N4 Road	150	881	8.1	N/A	Acceptable	Acceptable
50	Houses	25	8	11151.4	Intolerable	Problematic	Problematic
51	Packing Sheds	25	47	694.6	Intolerable	Problematic	Problematic
52	Dam	50	971	7.0	N/A	Acceptable	Acceptable
53	Cement Dams	50	356	31.9	N/A	Acceptable	Acceptable
54	Farm House	25	513	18.4	Unpleasant	Acceptable	Acceptable
55	Dam	50	1040	6.3	N/A	Acceptable	Acceptable
56	Informal Housing	6	484	20.1	Unpleasant	Problematic	Problematic
57	Farm House	25	732	10.7	Unpleasant	Acceptable	Acceptable
58	Farmstead	25	50	634.1	Intolerable	Problematic	Problematic
59	Dam	50	88	267.1	N/A	Problematic	Problematic
60	Cement Dam	50	49	659.1	N/A	Problematic	Problematic
61	Power lines/Pylon	75	110	190.3	N/A	Problematic	Problematic
62	Power lines/Pylon	75	43	787.0	N/A	Problematic	Problematic
63	Dam	50	91	256.3	N/A	Problematic	Problematic
64	Dam	50	339	34.4	N/A	Acceptable	Acceptable
65	Farmstead	25	462	21.5	Intolerable	Acceptable	Acceptable
66	Power lines/Pylon	75	324	36.9	N/A	Acceptable	Acceptable
67	Power lines/Pylon	75	646	12.9	N/A	Acceptable	Acceptable
68	Power lines/Pylon	75	1389	4.0	Perceptible	Acceptable	Acceptable
69	Power lines/Pylon	75	1618	3.2	Perceptible	Acceptable	Acceptable
70	Power lines/Pylon	75	1891	2.5	Perceptible	Acceptable	Acceptable
71	Power lines/Pylon	75	1994	2.3	Perceptible	Acceptable	Acceptable
72	Power lines/Pylon	75	2088	2.2	Perceptible	Acceptable	Acceptable
73	Power lines/Pylon	75	2069	2.2	Perceptible	Acceptable	Acceptable
74	Power lines/Pylon	75	2045	2.2	Perceptible	Acceptable	Acceptable
75	Power lines/Pylon	75	2031	2.3	Perceptible	Acceptable	Acceptable
76	Power lines/Pylon	75	1952	2.4	Perceptible	Acceptable	Acceptable
77	Power lines/Pylon	75	1924	2.5	Perceptible	Acceptable	Acceptable
78	Power lines/Pylon	75	1997	2.3	Perceptible	Acceptable	Acceptable
79	Power lines/Pylon	75	2112	2.1	Perceptible	Acceptable	Acceptable
80	Power lines/Pylon	75	2240	2.0	Perceptible	Acceptable	Acceptable
81	Power lines/Pylon	75	2590	1.6	Perceptible	Acceptable	Acceptable
82	Power lines/Pylon	75	2859	1.3	Perceptible	Acceptable	Acceptable
83	Power lines/Pylon	75	3110	1.2	Perceptible	Acceptable	Acceptable
84	Power lines/Pylon	75	3385	1.0	Perceptible	Acceptable	Acceptable
85	Power lines/Pylon	75	3665	0.9	Perceptible	Acceptable	Acceptable
86	Informal Housing	6	253	53.8	Intolerable	Problematic	Problematic
87	Road	150	361	31.3	N/A	Acceptable	Acceptable
88	Informal Housing	6	328	36.1	Intolerable	Problematic	Problematic
89	Farm House	25	2182	2.0	Perceptible	Acceptable	Acceptable

90	Farmstead	25	3433	1.0	Perceptible	Acceptable	Acceptable
91	Houses	25	3251	1.1	Perceptible	Acceptable	Acceptable
92	Informal Housing	6	2781	1.4	Perceptible	Acceptable	Acceptable
93	Labour Housing	6	1973	2.4	Perceptible	Acceptable	Acceptable
94	Informal Housing	6	4230	0.7	Too Low	Acceptable	Acceptable
95	Power lines/Pylons	75	2727	1.4	Perceptible	Acceptable	Acceptable
96	Power lines/Pylons	75	2842	1.4	Perceptible	Acceptable	Acceptable
97	Informal Housing	6	3543	1.0	Perceptible	Acceptable	Acceptable
98	Sheds	25	3237	1.1	Perceptible	Acceptable	Acceptable
99	Shed	25	3508	1.0	Perceptible	Acceptable	Acceptable
100	Informal Housing	6	3114	1.2	Perceptible	Acceptable	Acceptable
101	Housing	25	2854	1.4	Perceptible	Acceptable	Acceptable
102	Informal Housing	6	3339	1.1	Perceptible	Acceptable	Acceptable
103	Farm House	25	530	17.5	Unpleasant	Acceptable	Acceptable
104	Cement Dam	50	606	14.3	N/A	Acceptable	Acceptable
105	Informal Housing	6	2818	1.4	Perceptible	Acceptable	Acceptable
106	R33 Road	150	3428	1.0	Perceptible	Acceptable	Acceptable
107	Dam	50	3462	1.0	Perceptible	Acceptable	Acceptable
108	Shed	25	3044	1.2	Perceptible	Acceptable	Acceptable
109	R33 Road	150	2416	1.7	Perceptible	Acceptable	Acceptable
110	Farm House	25	4144	0.8	Perceptible	Acceptable	Acceptable
111	Farmstead	25	4156	0.8	Perceptible	Acceptable	Acceptable
112	Farmstead	25	4024	0.8	Perceptible	Acceptable	Acceptable
113	Orchards	25	319	37.8	Intolerable	Problematic	Problematic
114	Hot Houses	25	4898	0.6	Too Low	Acceptable	Acceptable
115	Farmstead	25	4671	0.6	Too Low	Acceptable	Acceptable
116	Informal Housing	6	3266	1.1	Perceptible	Acceptable	Acceptable
117	Informal Housing	6	3634	0.9	Perceptible	Acceptable	Acceptable
118	Dam	50	3396	1.0	Perceptible	Acceptable	Acceptable
119	Farmstead	25	4804	0.6	Too Low	Acceptable	Acceptable
120	Informal Housing	6	5275	0.5	Too Low	Acceptable	Acceptable
121	Dam	50	2302	1.9	Perceptible	Acceptable	Acceptable
122	Farmstead	25	3088	1.2	Perceptible	Acceptable	Acceptable
123	Farm House	25	2283	1.9	Perceptible	Acceptable	Acceptable
124	Sheds	25	2214	2.0	Perceptible	Acceptable	Acceptable
125	Sewer Works	25	2676	1.5	Perceptible	Acceptable	Acceptable
126	Mine Activity	50	2209	2.0	Perceptible	Acceptable	Acceptable
127	Graveyard	50	2804	1.4	Perceptible	Acceptable	Acceptable
128	Graveyard	50	3457	1.0	Perceptible	Acceptable	Acceptable
129	Dam	50	2729	1.4	Perceptible	Acceptable	Acceptable
130	Dam	50	1924	2.5	Perceptible	Acceptable	Acceptable
131	Structure	25	693	11.6	Unpleasant	Acceptable	Acceptable
132	Graveyard	50	3218	1.1	Perceptible	Acceptable	Acceptable

(Intentionally Left Open)

7.2.4 Portion 30 Maximum Charge per Delay – 2035kg

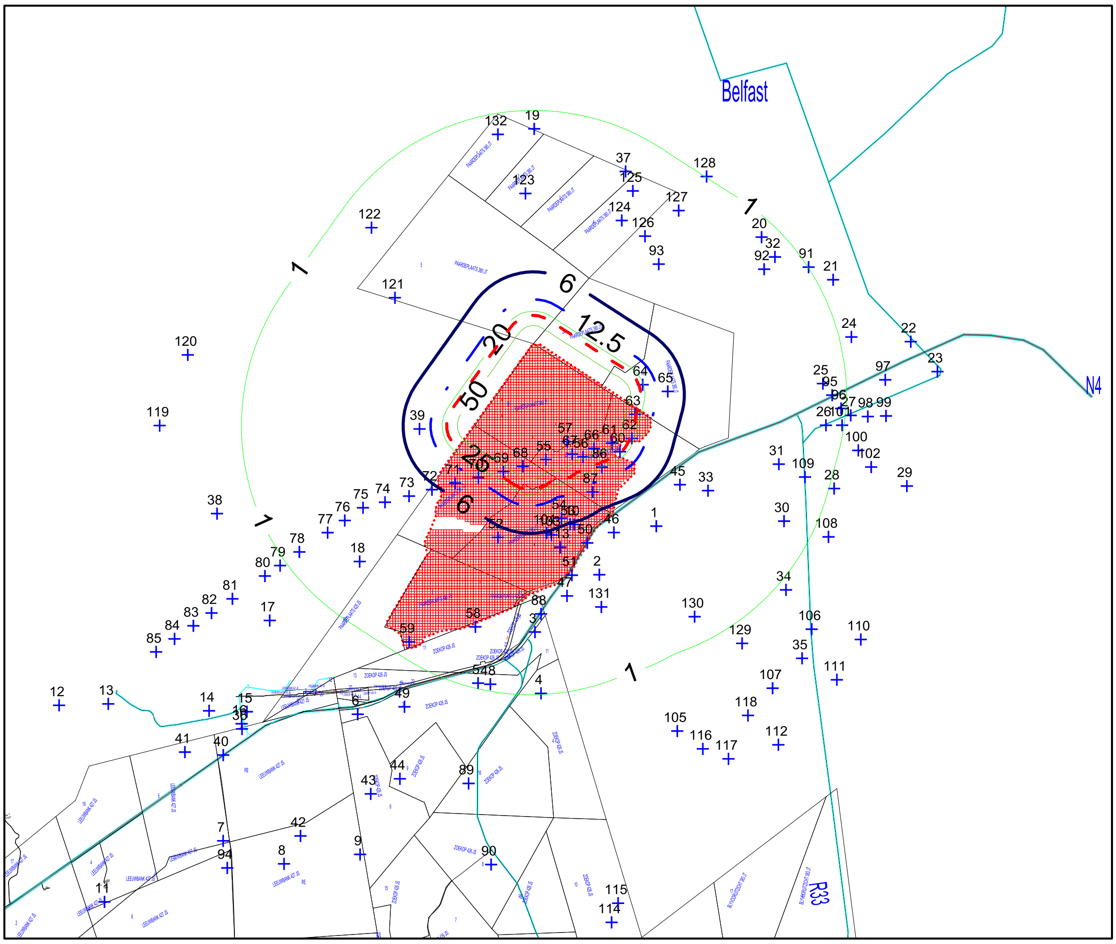

Figure 21: Ground vibration influence from maximum charge for Portion 30

Table 15: Ground vibration evaluation for maximum charge for Portion 30

Tag	Description	Specific Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
1	Shed	25	1624	3.2	Perceptible	Acceptable	Acceptable
2	Informal Housing	6	1934	2.4	Perceptible	Acceptable	Acceptable
3	Farm House	25	2546	1.6	Perceptible	Acceptable	Acceptable
4	Farmstead	25	3464	1.0	Perceptible	Acceptable	Acceptable
5	Railway Substation	25	3398	1.0	Perceptible	Acceptable	Acceptable
6	Buildings/Structures	25	4563	0.7	Too Low	Acceptable	Acceptable
7	Farmstead	25	7237	0.3	Too Low	Acceptable	Acceptable
8	Grain Storage	25	7036	0.3	Too Low	Acceptable	Acceptable
9	Dams	50	6387	0.4	Too Low	Acceptable	Acceptable
10	Telecom Tower	25	1109	5.7	Unpleasant	Acceptable	Acceptable
11	Farm House/Hot Houses	25	8995	0.2	Too Low	Acceptable	Acceptable
12	Farmstead	25	7469	0.3	Too Low	Acceptable	Acceptable
13	Farmstead	25	6861	0.4	Too Low	Acceptable	Acceptable

14	Farmstead	25	5812	0.5	Too Low	Acceptable	Acceptable
15	Shed	25	5454	0.5	Too Low	Acceptable	Acceptable
16	Informal Housing	6	5643	0.5	Too Low	Acceptable	Acceptable
17	Dam	50	4219	0.7	Too Low	Acceptable	Acceptable
18	Dam	50	2656	1.5	Perceptible	Acceptable	Acceptable
19	Siyathuthuka Village Houses	25	3206	1.1	Perceptible	Acceptable	Acceptable
20	Houses	25	3234	1.1	Perceptible	Acceptable	Acceptable
21	Houses	25	3708	0.9	Perceptible	Acceptable	Acceptable
22	Cattle Sales Yard	50	4515	0.7	Too Low	Acceptable	Acceptable
23	Filling Station	25	4855	0.6	Too Low	Acceptable	Acceptable
24	Farmstead	25	3663	0.9	Perceptible	Acceptable	Acceptable
25	Sub Station	25	3141	1.2	Perceptible	Acceptable	Acceptable
26	Farmstead	25	3215	1.1	Perceptible	Acceptable	Acceptable
27	Sheds	25	3565	1.0	Perceptible	Acceptable	Acceptable
28	Farmstead	25	3557	1.0	Perceptible	Acceptable	Acceptable
29	Shed	25	4592	0.7	Too Low	Acceptable	Acceptable
30	Farmstead	25	3024	1.2	Perceptible	Acceptable	Acceptable
31	Farmstead	25	2667	1.5	Perceptible	Acceptable	Acceptable
32	Road	150	3175	1.1	Perceptible	Acceptable	Acceptable
33	Farmstead	25	1809	2.7	Perceptible	Acceptable	Acceptable
34	Informal Housing	6	3617	0.9	Perceptible	Acceptable	Acceptable
35	Farmstead	25	4507	0.7	Too Low	Acceptable	Acceptable
36	School	25	5702	0.5	Too Low	Acceptable	Acceptable
37	Dam	50	2914	1.3	Perceptible	Acceptable	Acceptable
38	Farmstead	25	4062	0.8	Perceptible	Acceptable	Acceptable
39	Farmstead	25	830	8.8	Unpleasant	Acceptable	Acceptable
40	Informal Housing	6	6181	0.4	Too Low	Acceptable	Acceptable
41	Farm House	25	6510	0.4	Too Low	Acceptable	Acceptable
42	Building/Structure	25	6552	0.4	Too Low	Acceptable	Acceptable
43	Farm House	25	5500	0.5	Too Low	Acceptable	Acceptable
44	Informal Housing	6	5118	0.6	Too Low	Acceptable	Acceptable
45	N4 Road	150	1406	4.0	Perceptible	Acceptable	Acceptable
46	N4 Road	150	1464	3.7	Perceptible	Acceptable	Acceptable
47	N4 Road	150	2079	2.2	Perceptible	Acceptable	Acceptable
48	N4 Road	150	3377	1.0	Perceptible	Acceptable	Acceptable
49	N4 Road	150	4113	0.8	Perceptible	Acceptable	Acceptable
50	Houses	25	1426	3.9	Perceptible	Acceptable	Acceptable
51	Packing Sheds	25	1806	2.7	Perceptible	Acceptable	Acceptable
52	Dam	50	1233	4.8	Perceptible	Acceptable	Acceptable
53	Cement Dams	50	1093	5.8	N/A	Acceptable	Acceptable
54	Farm House	25	962	7.1	Unpleasant	Acceptable	Acceptable
55	Dam	50	159	109.4	N/A	Problematic	Problematic
56	Informal Housing	6	246	56.2	Intolerable	Problematic	Problematic
57	Farm House	25	52	587.1	Intolerable	Problematic	Problematic
58	Farmstead	25	2600	1.6	Perceptible	Acceptable	Acceptable
59	Dam	50	3240	1.1	Perceptible	Acceptable	Acceptable
60	Cement Dam	50	402	26.6	N/A	Acceptable	Acceptable
61	Power lines/Pylon	75	227	63.3	N/A	Acceptable	Acceptable
62	Power lines/Pylon	75	453	22.2	N/A	Acceptable	Acceptable
63	Dam	50	407	26.1	N/A	Acceptable	Acceptable
64	Dam	50	476	20.6	N/A	Acceptable	Acceptable
65	Farmstead	25	827	8.9	Unpleasant	Acceptable	Acceptable
66	Power lines/Pylon	75	188	84.6	N/A	Problematic	Problematic
67	Power lines/Pylon	75	149	120.4	N/A	Problematic	Problematic
68	Power lines/Pylon	75	123	160.8	N/A	Problematic	Problematic
69	Power lines/Pylon	75	345	33.6	N/A	Acceptable	Acceptable
70	Power lines/Pylon	75	622	13.7	N/A	Acceptable	Acceptable
71	Power lines/Pylon	75	880	8.1	N/A	Acceptable	Acceptable
72	Power lines/Pylon	75	1151	5.4	Perceptible	Acceptable	Acceptable
73	Power lines/Pylon	75	1439	3.8	Perceptible	Acceptable	Acceptable
74	Power lines/Pylon	75	1762	2.8	Perceptible	Acceptable	Acceptable
75	Power lines/Pylon	75	2070	2.2	Perceptible	Acceptable	Acceptable
76	Power lines/Pylon	75	2401	1.8	Perceptible	Acceptable	Acceptable
77	Power lines/Pylon	75	2714	1.5	Perceptible	Acceptable	Acceptable
78	Power lines/Pylon	75	3224	1.1	Perceptible	Acceptable	Acceptable
79	Power lines/Pylon	75	3576	1.0	Perceptible	Acceptable	Acceptable
80	Power lines/Pylon	75	3851	0.9	Perceptible	Acceptable	Acceptable
81	Power lines/Pylon	75	4442	0.7	Too Low	Acceptable	Acceptable
82	Power lines/Pylon	75	4819	0.6	Too Low	Acceptable	Acceptable

83	Power lines/Pylon	75	5149	0.6	Too Low	Acceptable	Acceptable
84	Power lines/Pylon	75	5491	0.5	Too Low	Acceptable	Acceptable
85	Power lines/Pylon	75	5827	0.5	Too Low	Acceptable	Acceptable
86	Informal Housing	6	490	19.7	Unpleasant	Problematic	Problematic
87	Road	150	786	9.6	N/A	Acceptable	Acceptable
88	Informal Housing	6	2281	1.9	Perceptible	Acceptable	Acceptable
89	Farm House	25	4891	0.6	Too Low	Acceptable	Acceptable
90	Farmstead	25	6042	0.4	Too Low	Acceptable	Acceptable
91	Houses	25	3487	1.0	Perceptible	Acceptable	Acceptable
92	Informal Housing	6	2934	1.3	Perceptible	Acceptable	Acceptable
93	Labour Housing	6	2010	2.3	Perceptible	Acceptable	Acceptable
94	Informal Housing	6	7543	0.3	Too Low	Acceptable	Acceptable
95	Power lines/Pylons	75	3275	1.1	Perceptible	Acceptable	Acceptable
96	Power lines/Pylons	75	3414	1.0	Perceptible	Acceptable	Acceptable
97	Informal Housing	6	4072	0.8	Perceptible	Acceptable	Acceptable
98	Sheds	25	3820	0.9	Perceptible	Acceptable	Acceptable
99	Shed	25	4090	0.8	Perceptible	Acceptable	Acceptable
100	Informal Housing	6	3758	0.9	Perceptible	Acceptable	Acceptable
101	Housing	25	3453	1.0	Perceptible	Acceptable	Acceptable
102	Informal Housing	6	4004	0.8	Perceptible	Acceptable	Acceptable
103	Farm House	25	1142	5.4	Perceptible	Acceptable	Acceptable
104	Cement Dam	50	1097	5.8	N/A	Acceptable	Acceptable
105	Informal Housing	6	4529	0.7	Too Low	Acceptable	Acceptable
106	R33 Road	150	4294	0.7	Too Low	Acceptable	Acceptable
107	Dam	50	4593	0.7	Too Low	Acceptable	Acceptable
108	Shed	25	3721	0.9	Perceptible	Acceptable	Acceptable
109	R33 Road	150	3094	1.2	Perceptible	Acceptable	Acceptable
110	Farm House	25	4947	0.6	Too Low	Acceptable	Acceptable
111	Farmstead	25	5093	0.6	Too Low	Acceptable	Acceptable
112	Farmstead	25	5358	0.5	Too Low	Acceptable	Acceptable
113	Orchards	25	1356	4.2	Perceptible	Acceptable	Acceptable
114	Hot Houses	25	6981	0.3	Too Low	Acceptable	Acceptable
115	Farmstead	25	6718	0.4	Too Low	Acceptable	Acceptable
116	Informal Housing	6	4930	0.6	Too Low	Acceptable	Acceptable
117	Informal Housing	6	5230	0.5	Too Low	Acceptable	Acceptable
118	Dam	50	4758	0.6	Too Low	Acceptable	Acceptable
119	Farmstead	25	4699	0.6	Too Low	Acceptable	Acceptable
120	Informal Housing	6	4408	0.7	Too Low	Acceptable	Acceptable
121	Dam	50	2078	2.2	Perceptible	Acceptable	Acceptable
122	Farmstead	25	2969	1.3	Perceptible	Acceptable	Acceptable
123	Farm House	25	2245	1.9	Perceptible	Acceptable	Acceptable
124	Sheds	25	2259	1.9	Perceptible	Acceptable	Acceptable
125	Sewer Works	25	2718	1.5	Perceptible	Acceptable	Acceptable
126	Mine Activity	50	2250	1.9	Perceptible	Acceptable	Acceptable
127	Graveyard	50	2843	1.4	Perceptible	Acceptable	Acceptable
128	Graveyard	50	3495	1.0	Perceptible	Acceptable	Acceptable
129	Dam	50	3785	0.9	Perceptible	Acceptable	Acceptable
130	Dam	50	3084	1.2	Perceptible	Acceptable	Acceptable
131	Structure	25	2402	1.8	Perceptible	Acceptable	Acceptable
132	Graveyard	50	3167	1.2	Perceptible	Acceptable	Acceptable

7.3 SUMMARY OF GROUND VIBRATION LEVELS

The opencast operation was evaluated for expected levels of ground vibration from future blasting operations. Review of the site and the surrounding installations / houses / buildings showed that structures varied in distances from the opencast pit area.

Review of ground vibration levels with regards to structure response on minimum charge mass per delay it is found that the following POI's are considered problematic. Six in total installations will need to be considered when blasting is done at pit edge closest to these structures. POI 50 – Houses, 62 - Powerlines/Pylon, 51 - Packing Sheds, 60 - Cement Dam, 58 – Farmstead and 86 - Informal Housing. These structures are located such that the expected levels of ground vibration are greater than the limit allowed. These structures and those found within the 223m from pit edge will also yield ground vibration levels experienced by humans as at least unpleasant.

The medium charge review showed an increased number of structures / installations that could experience ground vibration levels greater than the allowed limit. These structures are 50-Houses, 62-Powerlines/Pylon, 51-Packing Sheds, 60-Cement Dam, 58-Farmstead, 59-Dam, 63-Dam, 61-Powerlines/Pylon, 86-Informal Housing, 88-Informal Housing, 2-Informal Housing and 56-Informal Housing. A total of 12 installations. All structures found up 732m from pit edge will experience ground vibration levels that are at least unpleasant for humans. There are a total of 30 installations that is considered here where only 11 are houses or farmsteads. The rest of the structures are structures where people may congregate but not for long periods as at home.

The maximum charge review showed total of 14 installations / structures that are problematic with regards to ground vibration for structures. Levels are greater than allowed for these structures. These installations are found at 50-Houses, 62-Powerlines/Pylon, 51-Packing Sheds, 60-Cement Dam, 58-Farmstead, 59-Dam, 63-Dam, 61-Powerlines/Pylon, 86-Informal Housing, 10-Telecom Tower, 113-Orchards, 88-Informal Housing, 2-Informal Housing and 56-Informal Housing. 11 houses / farm houses / farmstead were observed that could experience levels of ground vibration that will cause humans to experience these levels as unpleasant.

Portion 30 maximum charge mass per delay showed 7 installations / structures that are of concern. Levels expected are greater than the allowed limits for these installations. Three of these POI's are house structures, three are powerline pylons and one dam. These POI's are 57-Farm House, 68-Powerlines/Pylon, 67-Powerlines/Pylon, 55-Dam, 66-Powerlines/Pylon, 56-Informal Housing and 86-Informal Housing. There are 21 POI's that indicated that expected levels of ground vibration could be experienced as at least unpleasant. Only 6 of these are however houses or similar.

In all of the evaluations done it must be remembered that this was done from pit edge. When blasting is done further from the edge – further away from the particular structure the levels will decrease. When ground conditions changes and voids are created levels are reduced even further.

Detail structure summary will be required to ensure that specific limitations for this area can be applied. Specific structures will dictate the allowed limits for this area. Poor state structures can reduce allowable limits to 6mm/s which will require significant mitigations to the blasting operations.

There are structures very close to the mining boundary and will certainly require specific attention by the client. The lowest charge mass is seen to have possibility of damage up to approximately 253m due to the type of structures found in this area. The areas will extent to approximately 484m for medium and maximum charge. This is based on the location of structures and the type of structures with the specific limits applicable.

All ground vibration levels expected are within limits with regards to the national N4 highway passing the site on the southern side. The N4 will be significantly less influenced if only portion 30 is considered for mining.

On minimum charge people will experience unpleasant levels of ground vibration at all structures within 223m from pit boundary. This increases to 732m for medium charge and this increase to 1040m for maximum charge.

7.4 GROUND VIBRATION AND HUMAN PERCEPTION

Considering the effect of ground vibration with regards to human perception, vibration levels calculated were applied to various frequencies and plotted with expected human perceptions on the safe blasting criteria graph (See Figure 16 below). On the graph are indicators of the effect of vibration amplitude at various distances for three specific frequencies 15, 30 and 60 Hz. The frequency range selected is the expected range for frequencies that will be measured for ground vibration.

Review of the maximum charge in relation to human perception it is seen that 3500m from the blast people could possibly experience the ground vibration as “Perceptible”. At 1250m the expected ground vibration levels are still less than the middle safe blasting limit – less than 12.5mm/s but will be experienced by people as “unpleasant”. At distance of 600m and closer there is strong indication that people will experience the ground vibration as “Intolerable”. Distances closer than 1250m will exceed the minimum 6mm/s proposed safe limit for poorly constructed structures. Figure 22 below shows this effect of ground vibration with regards to human perception for maximum charge.

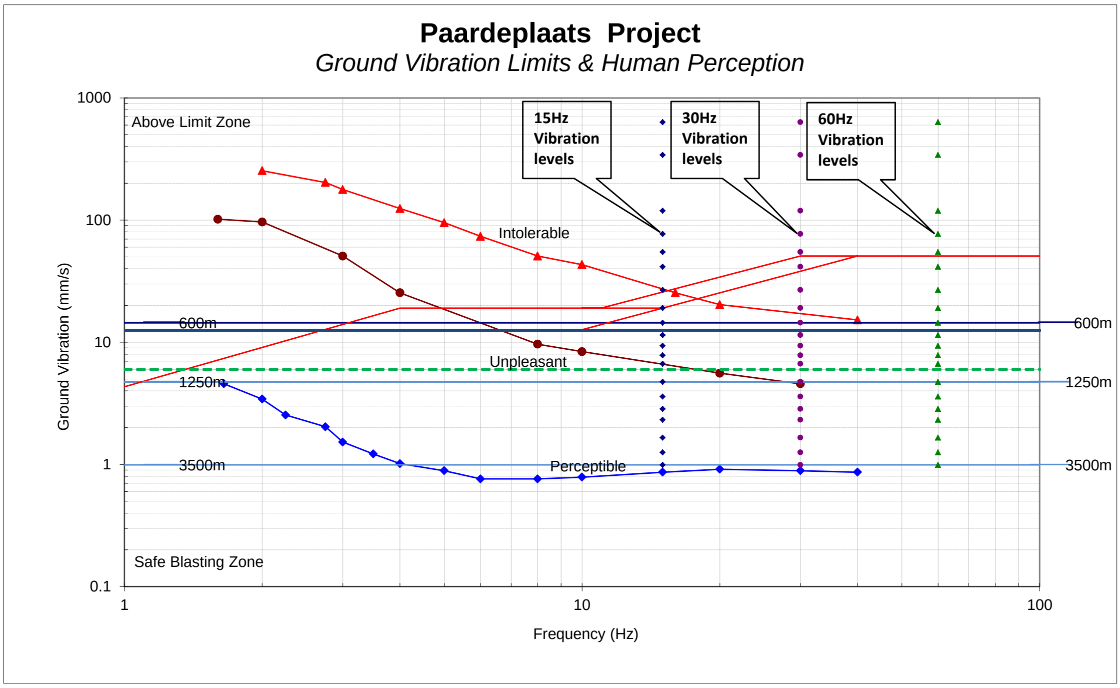

Figure 22: The Effect of Ground Vibration with Regards to Human Perception plotted with the criteria for safe blasting at the highest charge mass applied.

7.5 VIBRATION IMPACT ON ROADS

The N4 highway is closest to the project area at 220m. Ground vibration levels are significant at levels of 66mm/s but well below the normally accepted limit of 150mm/s. The R33 and other roads are also located at distance away from the project. Expected ground vibration levels are such that damage is not expected.

7.6 VIBRATION WILL UPSET ADJACENT COMMUNITIES

Ground vibration and air blast generally upset communities or people living in the vicinity of mining operations. There are farm steads, houses and informal settlements that are within the evaluated area of influence. There are structures located close to the project area and portion 30 where levels could be problematic. North East of the project area is Belfast town. In view of the evaluation where people experience vibration levels as perceptible it is certain that this perceptible level will extent to Belfast. This may give rise to complaints from home owners.

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.

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.

7.7 CRACKING OF HOUSES AND CONSEQUENT DEVALUATION

The structures in the areas of concern range from traditional mud houses to brick and mortar structures. These structures are found within the whole 3500m influence area investigated. 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. 6mm/s, 12.5mm/s and 25mm/s is 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.

7.8 AIR BLAST

The effect of air blast, if not controlled properly, is in my opinion a factor that could be problematic. Maybe not in the sense of damage being induced but rather having an impact – even at low levels rattling of roofs and windows due to air blast could result in complaints from people. In more than one case this effect is misunderstood and people consider this effect as being ground vibration and damaging to their house structures. Section 6.3 gives detail on the selection of the charges sizes applied.

As with ground vibration evaluation consideration is given for each structure with regards to the calculated levels of air blast and concerns if applicable. Evaluation is done in form of the criteria what humans experience and where by structures could be damaged. This is according to accepted criteria for prevention of damage to structures and when levels are low enough to have no significant influence. Tables provided with each of different charge modelling shows information with regards to No., Structure, Shortest Distance (m), Max Charge, Air blast (dB), and Possible Concern. The No." is POI number. "Structure" is description of the structure. The "Shortest Distance" is the distance between the structure and edge of the pit area. The "Max Charge" is the charge size in kg used for the specific modelling or calculations. The "Air Blast (dB)" is the calculated air blast level at the structure and the "possible concern" indicates if there is any concern for structure damage or not or human perception. Indicators used are "Problematic" where there is real concern for possible damage, "Complaint" where people will be complaining due to the experienced effect on structures – not necessarily damaging, "Acceptable" is if levels are less than 120 dB and low where there is very limited possibility that the levels will give rise to any influence on people or structures. Levels below 115dB could be considered as to be low or negligible possibility of influence.

Table 16 shows that the applied limits and recommended levels for each of the charges considered. The maximum charge may exceed limits at distances 1250m. The recommended limit of 120dB is observed at distance of 3500m. These distances are reduced to 900m for the medium charge allowed limit and 3500m for recommended limit. Further reduction to 500m for the smallest charge allowed limit and 2500m for the recommended limit. This clearly indicates that with increased charge masses the distances of influence increases.

Table 16: Expected air blast levels

No.	Distance (m)	Air blast (dB) for 127kg Charge	Air blast (dB) for 1019kg Charge	Air blast (dB) for 2035kg Charge
1	50.0	155	163	166
2	100.0	151	159	161
3	150.0	144	151	154
4	200.0	141	148	151
5	250.0	139	146	148
6	300.0	137	144	146
7	400.0	135	141	144
8	500.0	133	139	141
9	600.0	131	137	140
10	700.0	130	136	138
11	800.0	129	135	137
12	900.0	127	134	136
13	1000.0	127	133	135
14	1250.0	125	131	133
15	1500.0	123	129	131
16	1750.0	122	128	130
17	2000.0	121	127	129
18	2500.0	119	125	127
19	3000.0	117	123	125
20	3500.0	116	122	124

Presented herewith are the expected air blast level contours. Discussion of level of air blast and relevant influences are also given for the pit area. Air blast was calculated and modelled from the boundary for minimum, medium and maximum charge mass at specific distances from each of the pit areas. This means that air blast is taken from the edge – the most outer point of the pit area on plan as if it would be the closest place where drilling and blasting will be done to the area of influence. The calculated levels are then plotted and overlaid with current mining plans to observe possible influences at POI's identified. Air blast predictions were done considering distances ranging from 50 to 3500m around the opencast mining area.

7.9 REVIEW OF EXPECTED AIR BLAST

Presented are simulations for expected air blast levels from three different charge masses. Minimum, medium and maximum charge evaluations are shown in the figures below and summary table of outcome given after each charge configuration air blast contour. The main project area is considered followed by the portion 30 area.

7.9.1 Minimum Charge per Delay– 127kg

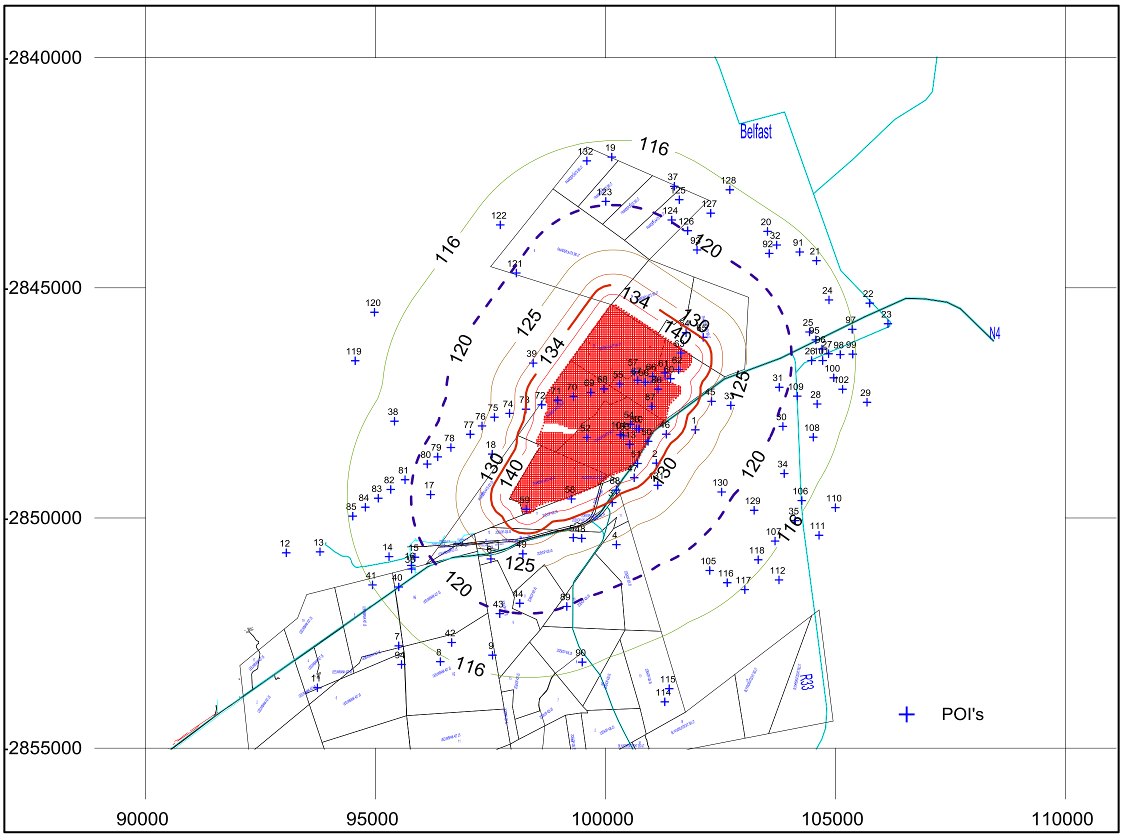

Figure 23: Air blast influence from minimum charge

Table 17: Air blast evaluation for minimum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Shed	674	130.0	Complaint
2	Informal Housing	387	135.1	Problematic
3	Farm House	486	133.0	Complaint
4	Farmstead	1340	124.1	Complaint
5	Railway Substation	852	128.0	Complaint
6	Buildings/Structures	1228	124.8	Complaint
7	Farmstead	3966	115.2	Acceptable
8	Grain Storage	3704	115.7	Acceptable
9	Dams	3161	117.0	Acceptable
10	Telecom Tower	302	137.4	N/A
11	Farm House/Hot Houses	5876	112.1	Acceptable
12	Farmstead	5202	113.0	Acceptable
13	Farmstead	4480	114.2	Acceptable
14	Farmstead	3057	117.2	Acceptable
15	Shed	2536	118.7	Acceptable
16	Informal Housing	2681	118.3	Acceptable
17	Dam	1985	120.8	N/A
18	Dam	1306	124.3	N/A
19	Siyathuthuka Village Houses	3235	116.8	Acceptable
20	Houses	3152	117.0	Acceptable
21	Houses	3410	116.4	Acceptable
22	Cattle Sales Yard	4040	115.0	Acceptable
23	Filling Station	4330	114.5	Acceptable
24	Farmstead	3226	116.8	Acceptable
25	Sub Station	2619	118.5	Acceptable

26	Farmstead	2613	118.5	Acceptable
27	Sheds	2982	117.4	Acceptable
28	Farmstead	2881	117.7	Acceptable
29	Shed	3917	115.3	Acceptable
30	Farmstead	2343	119.4	Acceptable
31	Farmstead	1987	120.7	Complaint
32	Road	3025	117.3	Acceptable
33	Farmstead	1128	125.5	Complaint
34	Informal Housing	2821	117.9	Acceptable
35	Farmstead	3550	116.0	Acceptable
36	School	2712	118.2	Acceptable
37	Dam	2882	117.7	Acceptable
38	Farmstead	3322	116.6	Acceptable
39	Farmstead	2205	119.9	Acceptable
40	Informal Housing	3147	117.0	Acceptable
41	Farm House	3627	115.9	Acceptable
42	Building/Structure	3221	116.8	Acceptable
43	Farm House	2245	119.7	Acceptable
44	Informal Housing	1957	120.9	Complaint
45	N4 Road	701	129.7	N/A
46	N4 Road	223	140.3	N/A
47	N4 Road	220	140.4	N/A
48	N4 Road	927	127.2	N/A
49	N4 Road	881	127.7	N/A
50	Houses	8	176.9	Problematic
51	Packing Sheds	47	156.1	Problematic
52	Dam	971	126.8	N/A
53	Cement Dams	356	135.9	N/A
54	Farm House	513	132.5	Complaint
55	Dam	1040	126.2	N/A
56	Informal Housing	484	133.0	Problematic
57	Farm House	732	129.3	Complaint
58	Farmstead	50	155.5	Problematic
59	Dam	88	149.5	N/A
60	Cement Dam	49	155.7	N/A
61	Power lines/Pylon	110	147.2	N/A
62	Power lines/Pylon	43	157.0	N/A
63	Dam	91	149.2	N/A
64	Dam	339	136.3	N/A
65	Farmstead	462	133.5	Problematic
66	Power lines/Pylon	324	136.7	N/A
67	Power lines/Pylon	646	130.4	N/A
68	Power lines/Pylon	1389	123.7	N/A
69	Power lines/Pylon	1618	122.5	N/A
70	Power lines/Pylon	1891	121.2	N/A
71	Power lines/Pylon	1994	120.7	N/A
72	Power lines/Pylon	2088	120.3	N/A
73	Power lines/Pylon	2069	120.4	N/A
74	Power lines/Pylon	2045	120.5	N/A
75	Power lines/Pylon	2031	120.6	N/A
76	Power lines/Pylon	1952	120.9	N/A
77	Power lines/Pylon	1924	121.0	N/A
78	Power lines/Pylon	1997	120.7	N/A
79	Power lines/Pylon	2112	120.2	N/A
80	Power lines/Pylon	2240	119.8	N/A
81	Power lines/Pylon	2590	118.6	Acceptable
82	Power lines/Pylon	2859	117.8	Acceptable
83	Power lines/Pylon	3110	117.1	Acceptable
84	Power lines/Pylon	3385	116.4	Acceptable
85	Power lines/Pylon	3665	115.8	Acceptable
86	Informal Housing	253	139.1	Problematic
87	Road	361	135.7	N/A
88	Informal Housing	328	136.6	Problematic
89	Farm House	2182	120.0	Acceptable
90	Farmstead	3433	116.3	Acceptable
91	Houses	3251	116.7	Acceptable
92	Informal Housing	2781	118.0	Acceptable
93	Labour Housing	1973	120.8	Complaint
94	Informal Housing	4230	114.6	Acceptable
95	Power lines/Pylons	2727	118.2	Acceptable

96	Power lines/Pylons	2842	117.8	Acceptable
97	Informal Housing	3543	116.1	Acceptable
98	Sheds	3237	116.8	Acceptable
99	Shed	3508	116.1	Acceptable
100	Informal Housing	3114	117.1	Acceptable
101	Housing	2854	117.8	Acceptable
102	Informal Housing	3339	116.5	Acceptable
103	Farm House	530	132.2	Complaint
104	Cement Dam	606	131.0	N/A
105	Informal Housing	2818	117.9	Acceptable
106	R33 Road	3428	116.3	Acceptable
107	Dam	3462	116.2	Acceptable
108	Shed	3044	117.3	Acceptable
109	R33 Road	2416	119.1	Acceptable
110	Farm House	4144	114.8	Acceptable
111	Farmstead	4156	114.8	Acceptable
112	Farmstead	4024	115.0	Acceptable
113	Orchards	319	136.9	Problematic
114	Hot Houses	4898	113.5	Acceptable
115	Farmstead	4671	113.9	Acceptable
116	Informal Housing	3266	116.7	Acceptable
117	Informal Housing	3634	115.8	Acceptable
118	Dam	3396	116.4	Acceptable
119	Farmstead	4804	113.7	Acceptable
120	Informal Housing	5275	112.9	Acceptable
121	Dam	2302	119.5	Acceptable
122	Farmstead	3088	117.2	Acceptable
123	Farm House	2283	119.6	Acceptable
124	Sheds	2214	119.9	Acceptable
125	Sewer Works	2676	118.3	Acceptable
126	Mine Activity	2209	119.9	Acceptable
127	Graveyard	2804	117.9	Acceptable
128	Graveyard	3457	116.2	Acceptable
129	Dam	2729	118.1	Acceptable
130	Dam	1924	121.0	N/A
131	Structure	693	129.8	Complaint
132	Graveyard	3218	116.8	Acceptable

(Intentionally Left Open)

7.9.2 Medium Charge per Delay – 1019kg

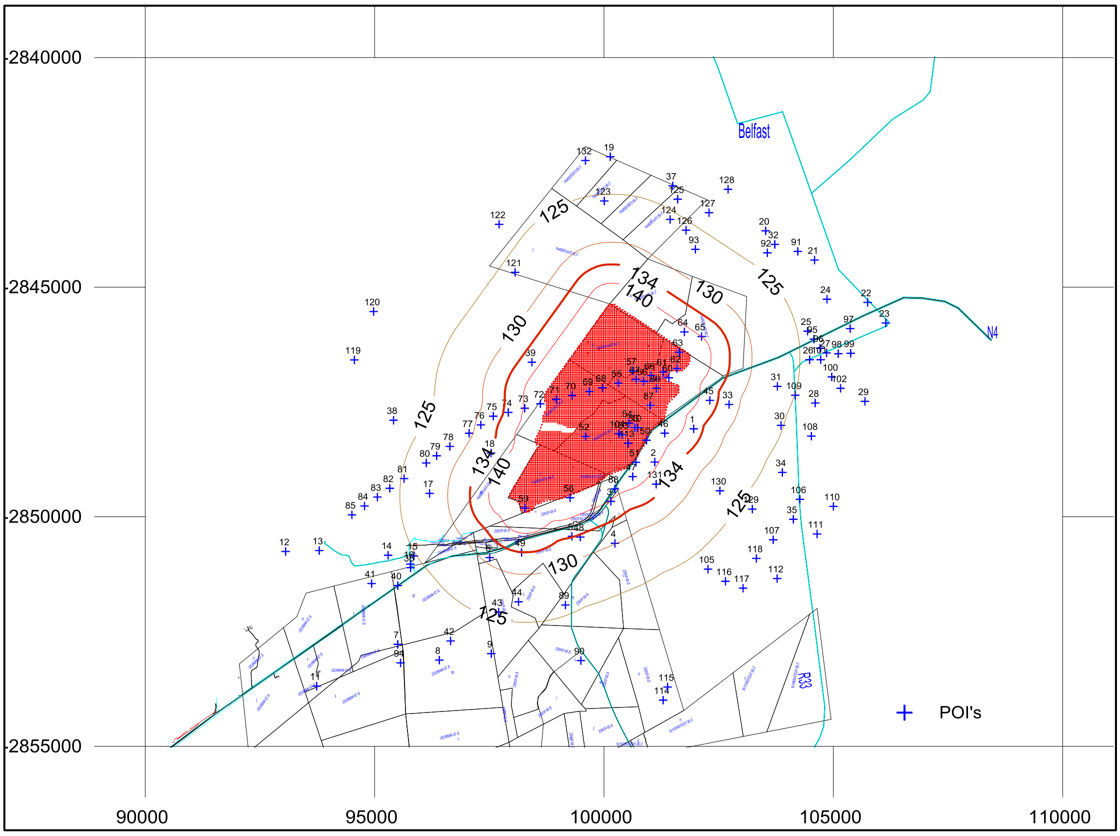

Figure 24: Air blast influence from medium charge

Table 18: Air blast evaluation for medium charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Shed	674	136.4	Problematic
2	Informal Housing	387	141.7	Problematic
3	Farm House	486	139.5	Problematic
4	Farmstead	1340	130.1	Complaint
5	Railway Substation	852	134.2	Problematic
6	Buildings/Structures	1228	130.9	Complaint
7	Farmstead	3966	120.8	Complaint
8	Grain Storage	3704	121.3	Complaint
9	Dams	3161	122.7	N/A
10	Telecom Tower	302	144.1	N/A
11	Farm House/Hot Houses	5876	117.6	Acceptable
12	Farmstead	5202	118.5	Acceptable
13	Farmstead	4480	119.8	Acceptable
14	Farmstead	3057	122.9	Complaint
15	Shed	2536	124.5	Complaint
16	Informal Housing	2681	124.1	Complaint
17	Dam	1985	126.6	N/A
18	Dam	1306	130.3	N/A
19	Siyathuthuka Village Houses	3235	122.5	Complaint
20	Houses	3152	122.7	Complaint
21	Houses	3410	122.0	Complaint
22	Cattle Sales Yard	4040	120.6	Complaint
23	Filling Station	4330	120.0	Complaint
24	Farmstead	3226	122.5	Complaint
25	Sub Station	2619	124.3	Complaint

26	Farmstead	2613	124.3	Complaint
27	Sheds	2982	123.2	Complaint
28	Farmstead	2881	123.4	Complaint
29	Shed	3917	120.9	Complaint
30	Farmstead	2343	125.2	Complaint
31	Farmstead	1987	126.6	Complaint
32	Road	3025	123.0	N/A
33	Farmstead	1128	131.6	Complaint
34	Informal Housing	2821	123.6	Complaint
35	Farmstead	3550	121.7	Complaint
36	School	2712	124.0	Complaint
37	Dam	2882	123.4	N/A
38	Farmstead	3322	122.2	Complaint
39	Farmstead	2205	125.7	Complaint
40	Informal Housing	3147	122.7	Complaint
41	Farm House	3627	121.5	Complaint
42	Building/Structure	3221	122.5	Complaint
43	Farm House	2245	125.6	Complaint
44	Informal Housing	1957	126.8	Complaint
45	N4 Road	701	136.0	N/A
46	N4 Road	223	147.1	N/A
47	N4 Road	220	147.3	N/A
48	N4 Road	927	133.4	N/A
49	N4 Road	881	133.9	N/A
50	Houses	8	185.6	Problematic
51	Packing Sheds	47	163.7	Problematic
52	Dam	971	133.0	N/A
53	Cement Dams	356	142.5	N/A
54	Farm House	513	139.0	Problematic
55	Dam	1040	132.4	N/A
56	Informal Housing	484	139.5	Problematic
57	Farm House	732	135.6	Problematic
58	Farmstead	50	163.0	Problematic
59	Dam	88	156.8	N/A
60	Cement Dam	49	163.3	N/A
61	Power lines/Pylon	110	154.4	N/A
62	Power lines/Pylon	43	164.6	N/A
63	Dam	91	156.5	N/A
64	Dam	339	142.9	N/A
65	Farmstead	462	140.0	Problematic
66	Power lines/Pylon	324	143.4	N/A
67	Power lines/Pylon	646	136.8	N/A
68	Power lines/Pylon	1389	129.8	N/A
69	Power lines/Pylon	1618	128.4	N/A
70	Power lines/Pylon	1891	127.1	N/A
71	Power lines/Pylon	1994	126.6	N/A
72	Power lines/Pylon	2088	126.2	N/A
73	Power lines/Pylon	2069	126.3	N/A
74	Power lines/Pylon	2045	126.4	N/A
75	Power lines/Pylon	2031	126.4	N/A
76	Power lines/Pylon	1952	126.8	N/A
77	Power lines/Pylon	1924	126.9	N/A
78	Power lines/Pylon	1997	126.6	N/A
79	Power lines/Pylon	2112	126.1	N/A
80	Power lines/Pylon	2240	125.6	N/A
81	Power lines/Pylon	2590	124.3	N/A
82	Power lines/Pylon	2859	123.5	N/A
83	Power lines/Pylon	3110	122.8	N/A
84	Power lines/Pylon	3385	122.1	N/A
85	Power lines/Pylon	3665	121.4	N/A
86	Informal Housing	253	145.9	Problematic
87	Road	361	142.3	N/A
88	Informal Housing	328	143.3	Problematic
89	Farm House	2182	125.8	Complaint
90	Farmstead	3433	122.0	Complaint
91	Houses	3251	122.4	Complaint
92	Informal Housing	2781	123.7	Complaint
93	Labour Housing	1973	126.7	Complaint
94	Informal Housing	4230	120.2	Complaint
95	Power lines/Pylons	2727	123.9	N/A

96	Power lines/Pylons	2842	123.6	N/A
97	Informal Housing	3543	121.7	Complaint
98	Sheds	3237	122.5	Complaint
99	Shed	3508	121.8	Complaint
100	Informal Housing	3114	122.8	Complaint
101	Housing	2854	123.5	Complaint
102	Informal Housing	3339	122.2	Complaint
103	Farm House	530	138.6	Problematic
104	Cement Dam	606	137.4	N/A
105	Informal Housing	2818	123.6	Complaint
106	R33 Road	3428	122.0	N/A
107	Dam	3462	121.9	N/A
108	Shed	3044	123.0	Complaint
109	R33 Road	2416	124.9	N/A
110	Farm House	4144	120.4	Complaint
111	Farmstead	4156	120.4	Complaint
112	Farmstead	4024	120.6	Complaint
113	Orchards	319	143.6	Problematic
114	Hot Houses	4898	119.0	Acceptable
115	Farmstead	4671	119.4	Acceptable
116	Informal Housing	3266	122.4	Complaint
117	Informal Housing	3634	121.5	Complaint
118	Dam	3396	122.1	N/A
119	Farmstead	4804	119.2	Acceptable
120	Informal Housing	5275	118.4	Acceptable
121	Dam	2302	125.4	N/A
122	Farmstead	3088	122.9	Complaint
123	Farm House	2283	125.4	Complaint
124	Sheds	2214	125.7	Complaint
125	Sewer Works	2676	124.1	Complaint
126	Mine Activity	2209	125.7	Complaint
127	Graveyard	2804	123.7	Complaint
128	Graveyard	3457	121.9	Complaint
129	Dam	2729	123.9	N/A
130	Dam	1924	126.9	N/A
131	Structure	693	136.1	Problematic
132	Graveyard	3218	122.5	Complaint

(Intentionally Left open)

7.9.3 Maximum Charge per Delay for – 2035kg

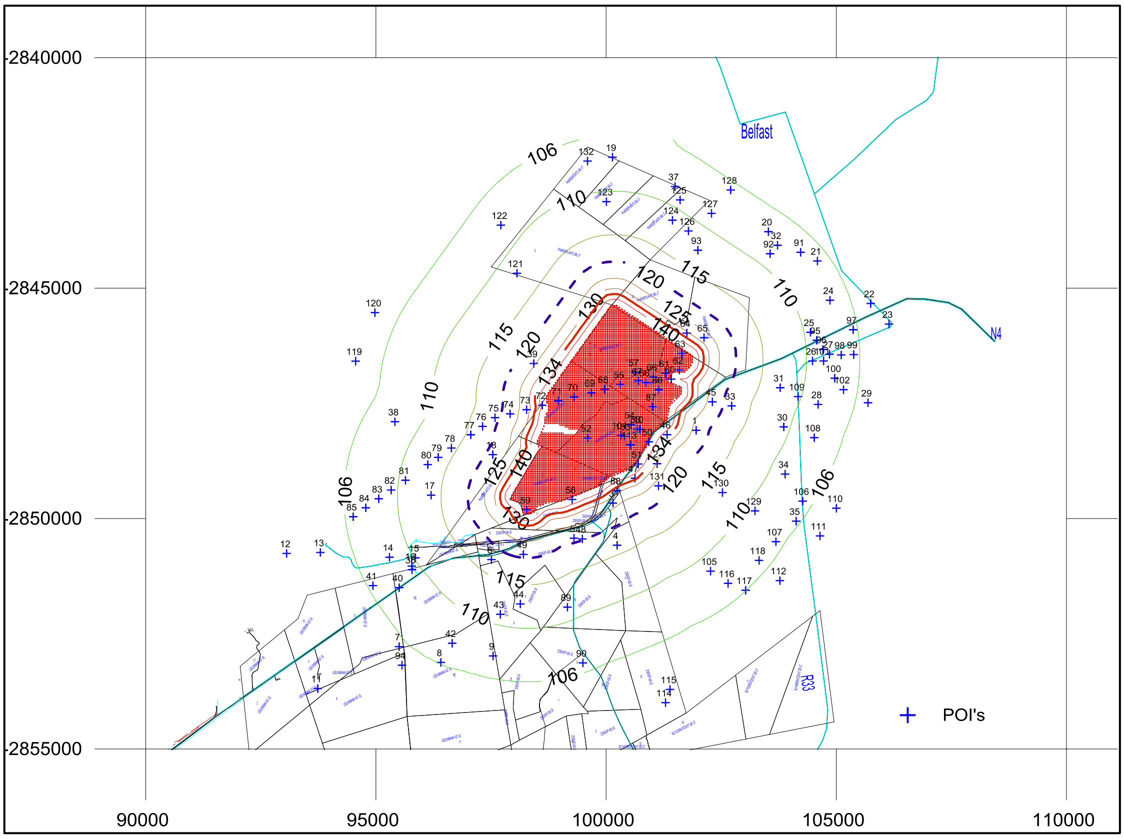

Figure 25: Air blast influence from maximum charge

Table 19: Air blast evaluation for maximum charge

Tag	Description	Distance (m)	Air blast (dB)	Possible Concern?
1	Shed	674	138.6	Problematic
2	Informal Housing	387	143.9	Problematic
3	Farm House	486	141.7	Problematic
4	Farmstead	1340	132.2	Complaint
5	Railway Substation	852	136.3	Problematic
6	Buildings/Structures	1228	133.0	Complaint
7	Farmstead	3966	122.7	Complaint
8	Grain Storage	3704	123.3	Complaint
9	Dams	3161	124.6	N/A
10	Telecom Tower	302	146.4	N/A
11	Farm House/Hot Houses	5876	119.4	Acceptable
12	Farmstead	5202	120.4	Complaint
13	Farmstead	4480	121.7	Complaint
14	Farmstead	3057	124.9	Complaint
15	Shed	2536	126.5	Complaint
16	Informal Housing	2681	126.0	Complaint
17	Dam	1985	128.7	N/A
18	Dam	1306	132.4	N/A
19	Siyathuthuka Village Houses	3235	124.4	Complaint
20	Houses	3152	124.6	Complaint
21	Houses	3410	124.0	Complaint
22	Cattle Sales Yard	4040	122.5	Complaint
23	Filling Station	4330	122.0	Complaint
24	Farmstead	3226	124.4	Complaint
25	Sub Station	2619	126.2	Complaint

26	Farmstead	2613	126.3	Complaint
27	Sheds	2982	125.1	Complaint
28	Farmstead	2881	125.4	Complaint
29	Shed	3917	122.8	Complaint
30	Farmstead	2343	127.2	Complaint
31	Farmstead	1987	128.6	Complaint
32	Road	3025	125.0	N/A
33	Farmstead	1128	133.7	Problematic
34	Informal Housing	2821	125.6	Complaint
35	Farmstead	3550	123.6	Complaint
36	School	2712	125.9	Complaint
37	Dam	2882	125.4	N/A
38	Farmstead	3322	124.2	Complaint
39	Farmstead	2205	127.7	Complaint
40	Informal Housing	3147	124.7	Complaint
41	Farm House	3627	123.4	Complaint
42	Building/Structure	3221	124.5	Complaint
43	Farm House	2245	127.6	Complaint
44	Informal Housing	1957	128.8	Complaint
45	N4 Road	701	138.2	N/A
46	N4 Road	223	149.5	N/A
47	N4 Road	220	149.6	N/A
48	N4 Road	927	135.6	N/A
49	N4 Road	881	136.0	N/A
50	Houses	8	188.5	Problematic
51	Packing Sheds	47	166.3	Problematic
52	Dam	971	135.1	N/A
53	Cement Dams	356	144.7	N/A
54	Farm House	513	141.2	Problematic
55	Dam	1040	134.5	N/A
56	Informal Housing	484	141.7	Problematic
57	Farm House	732	137.8	Problematic
58	Farmstead	50	165.6	Problematic
59	Dam	88	159.3	N/A
60	Cement Dam	49	165.9	N/A
61	Power lines/Pylon	110	156.9	N/A
62	Power lines/Pylon	43	167.3	N/A
63	Dam	91	159.0	N/A
64	Dam	339	145.2	N/A
65	Farmstead	462	142.2	Problematic
66	Power lines/Pylon	324	145.7	N/A
67	Power lines/Pylon	646	138.9	N/A
68	Power lines/Pylon	1389	131.8	N/A
69	Power lines/Pylon	1618	130.5	N/A
70	Power lines/Pylon	1891	129.1	N/A
71	Power lines/Pylon	1994	128.6	N/A
72	Power lines/Pylon	2088	128.2	N/A
73	Power lines/Pylon	2069	128.3	N/A
74	Power lines/Pylon	2045	128.4	N/A
75	Power lines/Pylon	2031	128.5	N/A
76	Power lines/Pylon	1952	128.8	N/A
77	Power lines/Pylon	1924	128.9	N/A
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