Blast Management & Consulting

Report:

Environmental Impact Assessment:
Ground Vibration and Air Blast Study
For Universal Coal Plc Kangala JV: Wolvenfontein Project

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Table of Contents

List of Figures

List of Tables

List of Acronyms used in this Report:

Air Pressure Pulse	APP
Blasted Tonnage	T
East	E
Explosives (Trinitrotoluene)	TNT
Frequency	Freq
Gas Release Pulse	GRP
North	N
North East	NE
North West	NW
Noxious Fumes	NOx's
Rock Pressure Pulse	RPP
Peak Particle Velocity	PPV
South	S
South East	SE
South West	SW
United States Bureau of Mine	USBM
West	W

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	msec
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)	WGS 84

1. Executive Summary

The Wolvenfontein Project forms part of Universal Coal's Kangala (Elof) Coal Venture. The Kangala (Elof) Project incorporates three new order prospecting rights in the Delmas District of Mpumalanga Province, South Africa. The Wolvenfontein 244 IR, Portion 1and R/E of Portion 2 was evaluated with consideration of expected influence of ground vibration and air blast on the current surroundings and installations. In order to achieve the outcome of this investigation typical blast designs was done, expected ground vibration and air blast calculated and evaluated for possible influence.

Concerns were identified from review of the expected ground vibration and air blast levels. These concerns are however manageable and in no way such that blasting should be prohibited. The main concerns are related to distance between the mining area and the nearest structures. Expected levels of ground vibration and air blast are within the allowed limits but levels are such that it could be perceptible. This in turn may lead to complains and subsequent investigations. Considering the reduced charge modelled, this will have a decreased ground vibration effect and reduce the risk significantly. The predicted levels of ground vibration were within the general safety limit of 25 mm/s. All the structures / installations were well within limits with no significant effect. Mitigation in reducing the maximum charge mass per delay and design of blasts in the area will assist to control the ground vibration.

Air blast levels reviewed showed no direct concern with regards to damage to structures, but did indicate that mitigation of the ground vibration will also bring about reduced air blast levels. The air blast is within accepted norm of 134dB when public are considered. The levels observed for some of the broilers may be problematic and will certainly require mitigation. Strict controls will need to be imposed as well on surface initiation of any explosive as this will immediately induce undesirable effects into the surroundings. Reduced charges and control on stemming will be assisting in reducing the possibilities of complaints from home owners.

This report summarises the evaluation of expected effects from blasting operations in the new Wolvenfontein 244 IR project. It is concluded that blasting will be possible but careful consideration should also be given to the recommendations made.

Specific recommendations applicable for mining of the opencast area includes mitigation of blasting methodology, structure inspections for privately owned houses or installations, evacuation and road closures of main roads in close proximity of the opencast areas.

2. Introduction

The proposed project is a coal mine to be located on portions 1 and the remaining extent of portion 2 of Wolvenfontein 244 IR in the Delmas area of the Mpumalanga Province. The Project area is located 80km due east of the centre of Johannesburg close to the operating coal mines Leeuwpan and Stuart Coal, close to good road and railway infrastructure and within a radius of 30-70km from four coal-fired power stations.

Blast Management & Consulting was contracted to perform an initial desktop review of possible impacts with regards to blasting operations due to the mining operation. This study reviews possible influences that blasting may have on the surrounding area of the opencast mining area. A typical drill and blast design is used as guideline for ground vibration and air blast related effects from blasting operations.

This report covers mainly the expected ground vibration and air blast, but will also address aspects of fly rock, fumes and general safe blasting considerations.

3. 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. 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. This study investigate the effect of blasting operations and the related influences with regards to 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.

- Visualisation of the Proposed Site
- Blasting Requirements
- Ground Vibration and Prediction
- Limitations on Structures
- Limitations with regards to Human perceptions
- Air Blast and Prediction
- Fly Rock
- Dust & Noxious Fumes
- Site Specific Recommendations: Specific attention is then given to the site and discussed in particular to the following aspects:
    a) Ground Vibration and Human Perception
    b) Air Blast and Concerns
    c) Fly Rock
    d) Dust and Noxious Fumes
    e) Blast Initiation
    f) Safe Blasting Procedures
    g) Monitoring
    h) Risk Assessment
- Baseline Study
- Recommendations
- Conclusion

4. Visualisation of the Proposed Site

The Wolvenfontein farm is located South of Delmas. Figure 1 shows an aerial view of the planned project area with surroundings. Figure 2 shows a plan provided with mining area and surroundings.

The site was reviewed and presented hereafter. Site was reviewed / scanned using Google Earth imagery and information provided by Digby Wells & Associates. Information sought from review was typically what surface structures are present in a 4500m 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 for the type of surface structures and direction from the mine operation position. This is required for determining the allowable ground vibration limits, air blast limits and possible wind direction constrains that might be applicable.

The surface structure concerns are provided in Table 1 & 2 below. Graphical visualisation of mining operation and the expected ground vibration and air blast levels is presented on figures and is supplied in the discussion section. Due to the fact that no design is available yet for such a mine operation, the maximum depth was used as guideline for determining the expected charge size. Detail of typical design is provided in the discussion.

Figure 1: Aerial View of Project Area

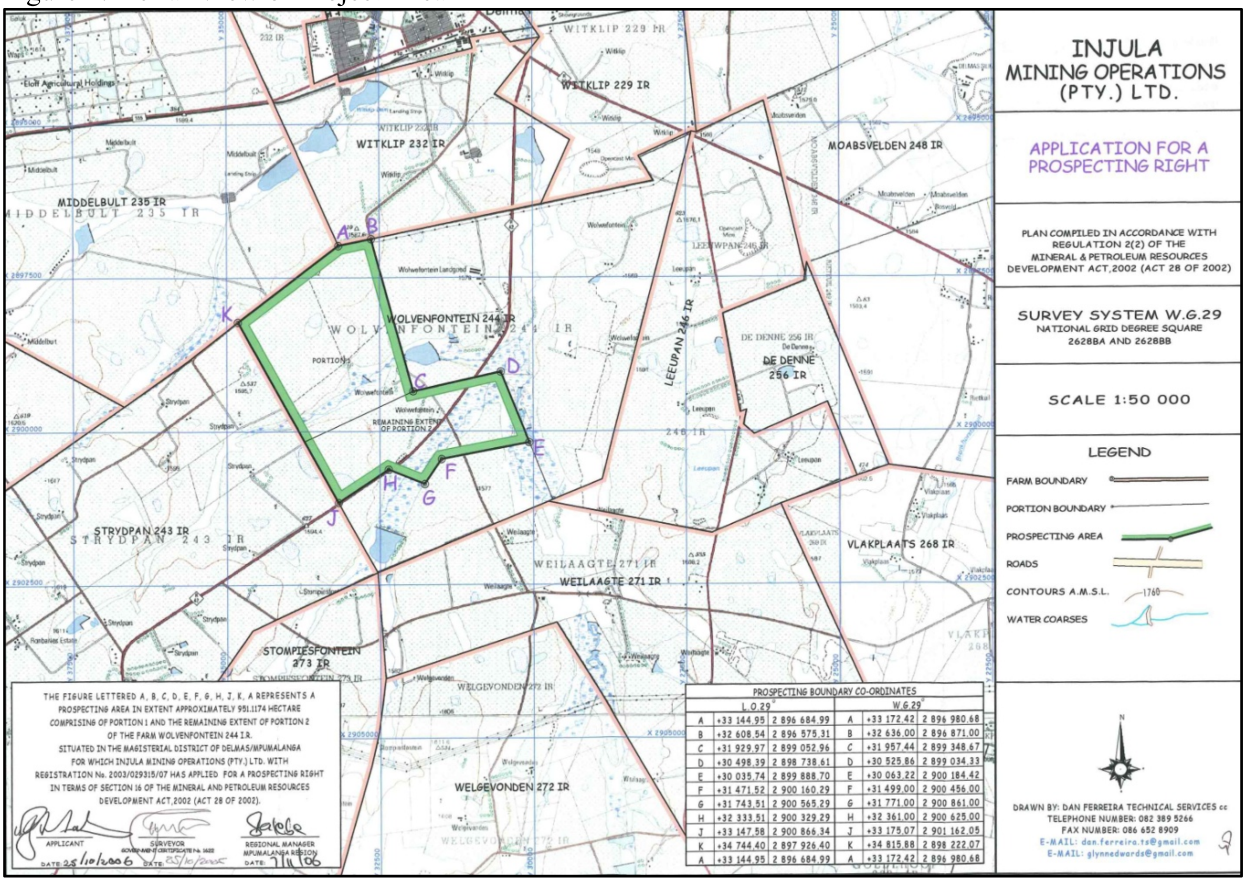

Figure 2: Surface Plan of the Project Area

The proposed mining operation location was reviewed and a list of surface structures was identified surrounding the mine area as seen as in Figure 3. Table 1 below is a list of all the farmers surrounding the mining area and Table 2 shows a list of the farmer's structures / farmsteads that was used for review in this document.

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Figure 3: Surface Structures Identified Around Mining Area

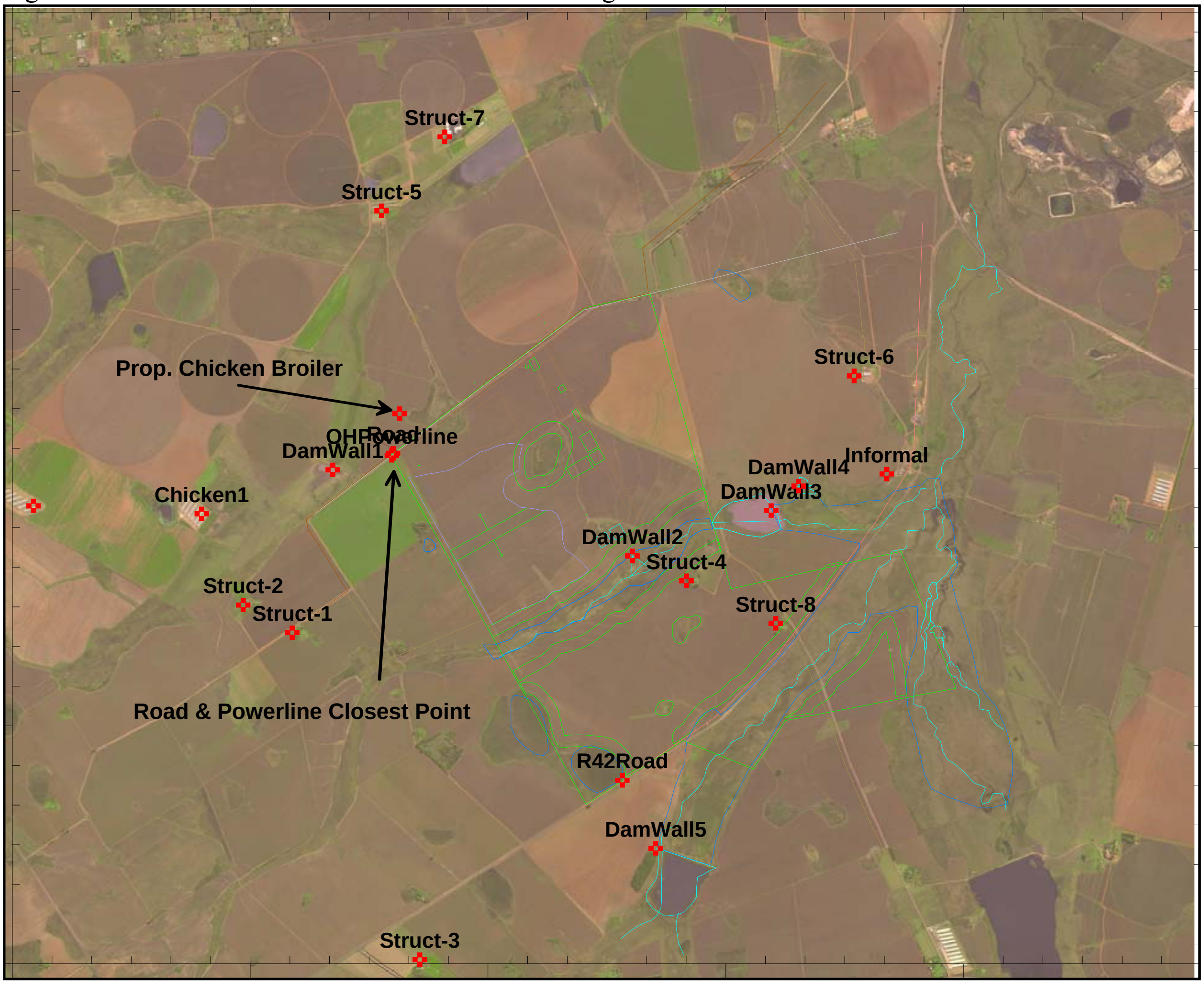


Table 1: Farms and Farmers Surrounding the Mining Area

Farm Name	Portion	Deed Holder	Name of Farmer/Owner	Tel
Wolvenfontein 244 IR	RE, 1, 2	Kallie Mandel Trust	Mr Kallie Schoeman & Mr Brent Parrot	071 678 3730
Wolvenfontein 244 IR	3	Exxaro Coal Pty Ltd	Ms Igna Dougal	083 259 5822
Wolvenfontein 244 IR	4	Mariwija Boerdery	Mr Wimpie Oosterhuis	082 410 0304
Wolvenfontein 244 IR	5	Willem Oosterhuis Boerdery	Mr Jaco Oosterhuis	083 283 2716
Wolvenfontein 244 IR	6	Petrus Loedewikus Haefele	Mr Peet Haefele & Mr AP Van Wyk	083 754 1037
Witklip 232 IR	2, 16, 18, 28	Hendrik Schoeman & Seuns	Mr Kallie Schoeman & Mr Brent Parrot	071 678 3730
Middelbult 235 IR	39, 82	Eloff Landgoed Pty Ltd	Mr Jozua du Plessis	082 524 8601
Middelbult 235 IR	40	W2 Eiendomme Pty Ltd	Mr Chris Rossouw	082 414 5038
Strydpan 243 IR	16, 20, 24,	Total Coal (Eloff Mining Co Pty Ltd)	Mr Riaan Joubert	082 411 8590
Strydpan 243 IR	33, 44	Hendrik Schoeman Weilaagte	Mr Kallie Schoeman & Mr Brent Parrot	071 678 3730

Table 2: Private Structures Identified for Consideration

No.	Tag	Y	X	Direction from Mine Position	Specific Vibration Limit (mm/s)	Distance
3	Chicken1	36407.837	2898717.771	W	USBM	1769
22	Chicken2	37822.691	2898650.826	W	USBM	3166
12	DamWall1	35306.288	2898348.076	W	50	643
16	DamWall2	32785.709	2899071.804	E	50	385
17	DamWall3	31618.458	2898689.256	E	50	1613
18	DamWall4	31387.581	2898484.473	E	50	1900
23	DamWall5	32590.23	2901530.792	E	50	2294
19	Informal	30646.628	2898382.319	E	USBM	2632
29	OHPowerline	34809.118	2898226.086	N	75	233
30	Prop. Chicken Broiler	34744.035	2897876.111	N	USBM	539
15	R42Road	32869.572	2900957.95	SE	150	1658
13	Road	34798.216	2898208.962	N	150	240
1	Struct-1	35646.47	2899716.821	W	USBM	1498
2	Struct-2	36059.15	2899484.362	W	USBM	1803
4	Struct-3	34574.288	2902465.839	S	USBM	2880
5	Struct-4	32331.16	2899280.471	E	USBM	824
11	Struct-5	34895.651	2896169.574	E	USBM	2204
20	Struct-6	30920.586	2897557.72	NW	USBM	2757
21	Struct-7	34364.824	2895547.331	N	USBM	2634
27	Struct-8	31580.412	2899638.679	NE	USBM	1632

Table 3: Mine Structures Identified for Consideration

Code	Tag	Y	X	Direction from Mine Position	Specific Vibration Limit (mm/s)	Distance
6	Offices	33268.71	2897891.249	NE	USBM	507
7	WashPlant	33129.014	2898261.41	E	USBM	540
8	Workshop	33314.967	2898373.458	E	USBM	351
9	ExploStore	33397.314	2897677.66	NE	USBM	561
10	PollControl	33075.076	2898961.712	E	100	207
14	SubStation	33685.514	2897490.471	NE	N/A	643
24	Topsoil	34066.16	2898155.874	NW	N/A	37
25	Stockpile	33193.614	2898134.417	E	N/A	517
26	WasteDump	33369.799	2898700.067	E	N/A	58
28	WeighBridge	33609.424	2897514.278	NE	100	627

5. Blasting Requirements

The mining operation has not yet been detailed in blasting plans and expected drill and blast procedures. Considering the geological report provided estimates were taken of min and maximum over burden depths to be considered for blasting.

The geological profile (borehole WN244_005 seen in Figure 4) taken from the report indicates that overburden above coal ranges between 7 and 41 m depths. *See Report: Wolvenfontein Coal Project Geological and Resource Report – January 2009*. As a guide of 18 m and 16 m overburden depth was used in calculations (weathered and sandstone material). Basic designs were done (see Table 4) that incorporate these expected overburden levels and these designs used for determining the required charge mass per delays for ground vibration and air blast modelling. Calculations used in this document are based on the typical designs provided below.

Figure 4: Geological Profile of Borehole WN244_005

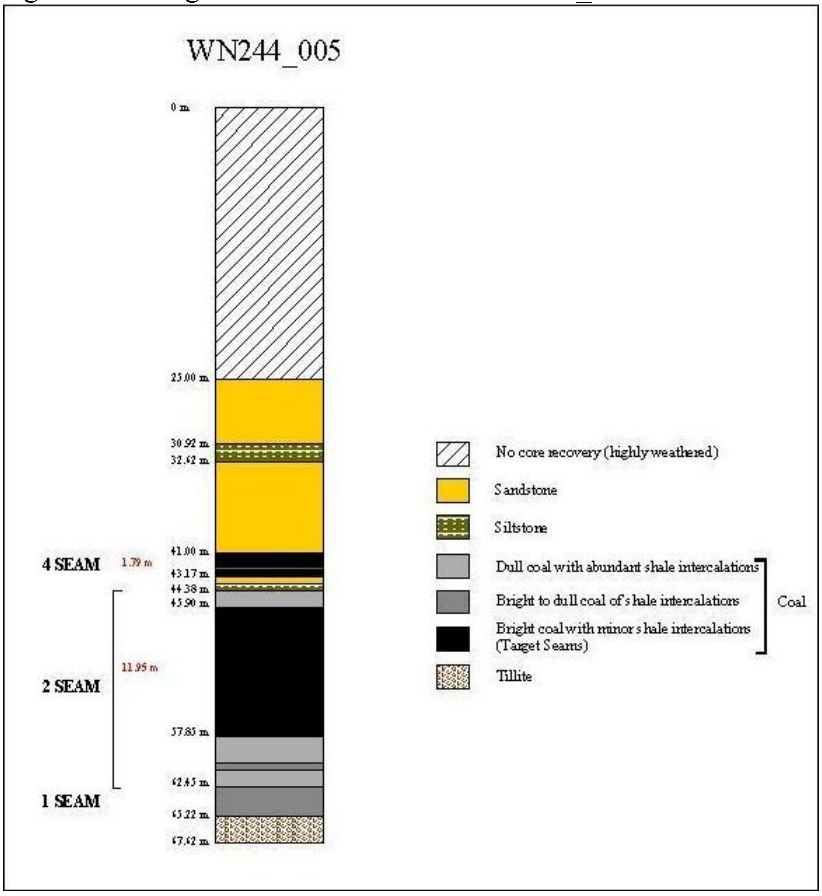


Table 4: Information on Possible Blast Designs to be used

Aspect	Bench~18m Weathered	Bench~16m Sandstone	Coal~#2&1
B/H Diameter (mm)	165	165	127
Explosive Density (g/cm^3)	1.15	1.15	1.15
Burden (m)	5	4.5	6
Spacing (m)	5	4.5	6
Bench Height (m)	18	16	22
Min Depth (m)	18	16	22
P/F Blast hole (kg/m^3)	0.71	0.84	0.33
Stemming Length (m)(30BHDia)	4.95	4.95	3.81
Column Length (incl. Sub drill.)	13.1	11.1	18.2
Explosives Per B/H (incl. Sub drill + air gap)	321	272	265

The three basic models considered during the evaluation process are two on a 165 mm and one 127 mm diameter blast hole sizes with different depths used as Option 1(Weathered Material), Option 2 (Sandstone Material) and Option 3 (Seam # 2 &1 Coal). There is a significant difference in the resultant charge mass per blast hole between the depths. A further consideration used is the type of initiation system used.

A typical shock tube system is considered with the 165 and 127 mm diameter blast hole, added with these designs a basic blast layout and timing design was done using typical 17 msec and 42 msec delays on surface to confirm maximum quantity of blast holes per delay. This will typically result in 6 blast holes detonating simultaneously and on the deeper blast hole will yield a maximum charge 1925 kg. This mass was used as a worst case scenario. The use of an electronic initiation system can reduce the quantity of blast holes detonating to a single blast hole. A single 127 mm diameter blast hole at 22 m depth will yield 265 kg charge, a single 165 mm diameter blast hole 16 m deep will yield 272 kg and a single 165 mm diameter blast hole 18m deep will yield 321 kg. In all cases it is based on the depths and stemming lengths as per table above.

A basic layout of the blast design can be seen in Figure 5 and the typical result in 6 holes detonating simultaneously in Figure 6 & 7. A typical blast hole's information as in Figure 8.

Figure 5: Basic Blast Layout

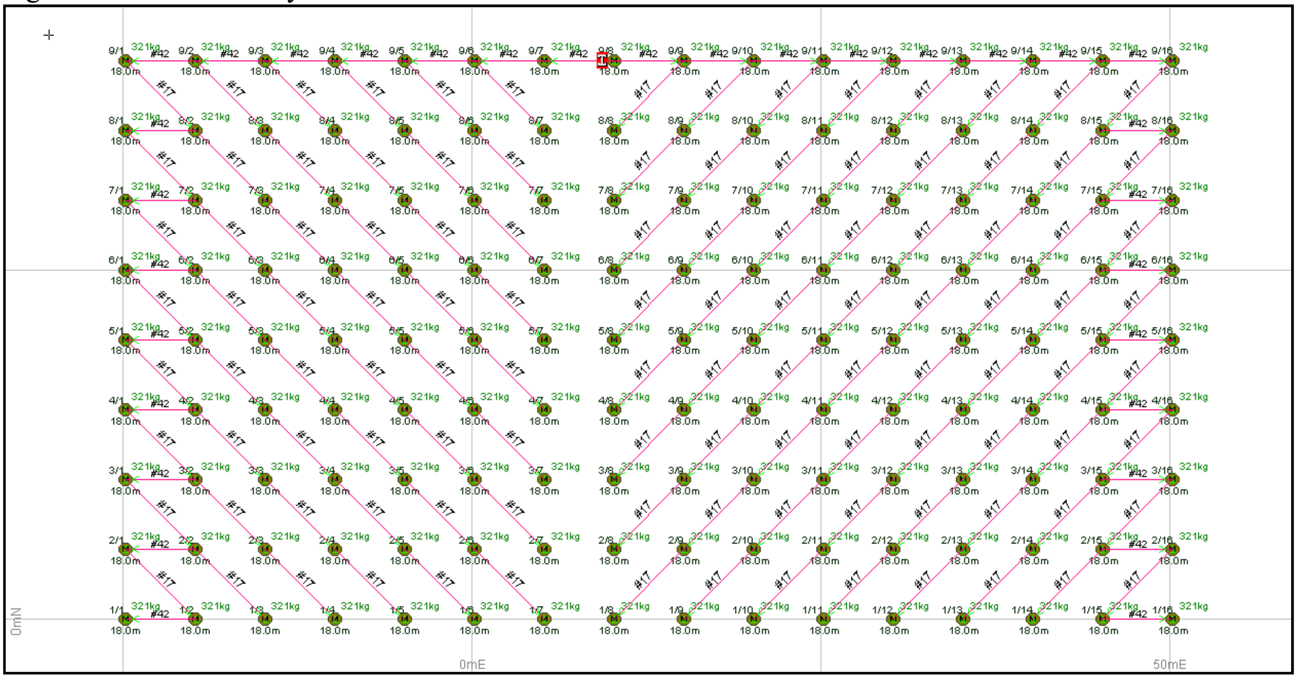


Figure 6: Graph with Delays per Instance Detonating

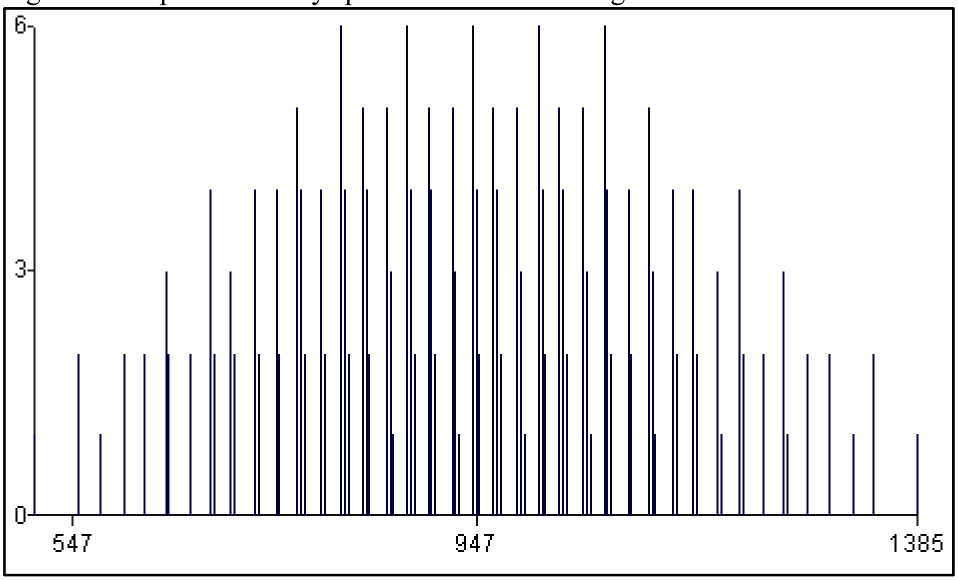


Figure 7: Graph with Charge Mass per Instance Detonating

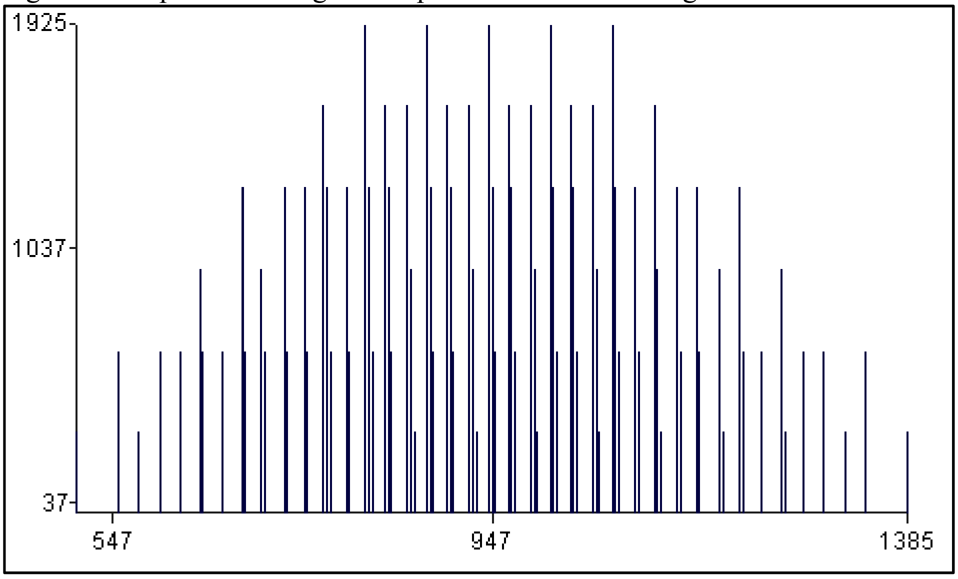
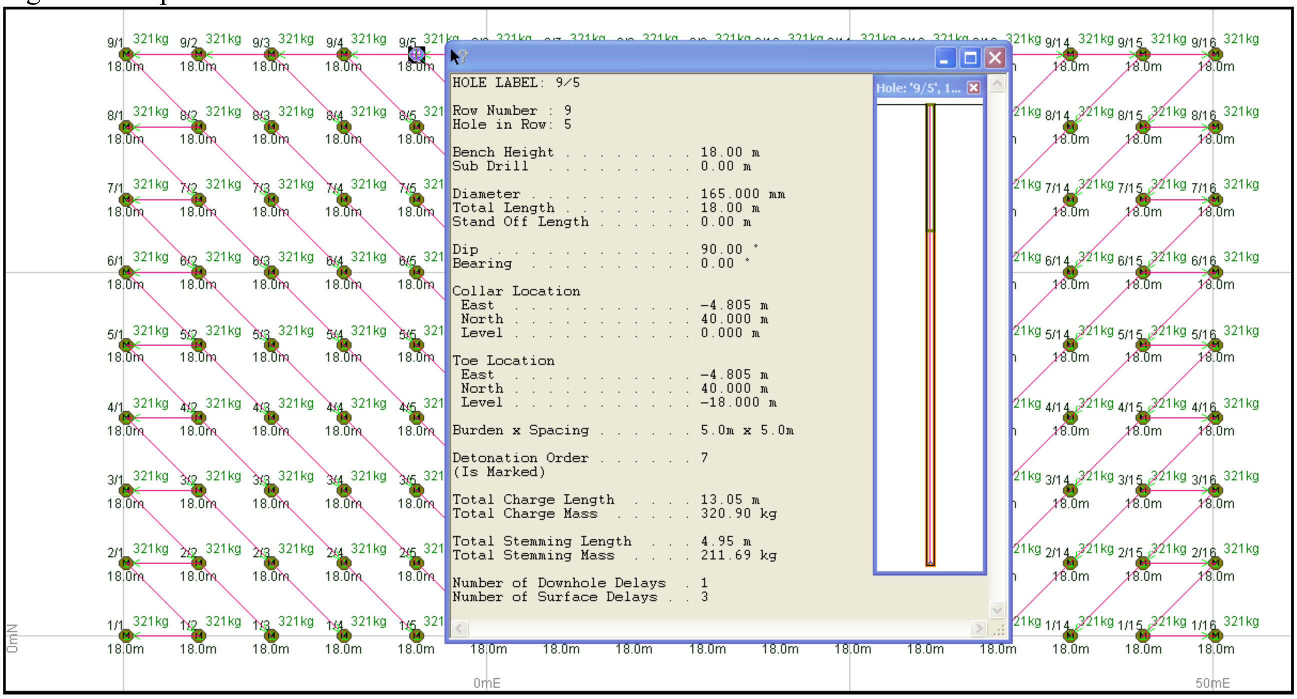


Figure 8: Graph with Blast Hole Information



6. Ground Vibration and Prediction

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.

Normally, in order to determine effective control measures, it will be required to do signature hole trace study. This process consists of charging and blasting test holes that are measured for ground vibration and air blast at various distances. Signature trace data can then be used to determine site specific constants for prediction of ground vibration and assist in determining timing of blasts in order to minimize the effect of vibration.

6.1 Prediction of Ground Vibration

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. In new opencast operations a process of testing for the constants is normally done using a signature trace study in order to predict ground vibrations accurately and safely. The peak particle velocity (PPV) or ground vibration in mm/s is plotted against the scaled distance ($D/\sqrt{E}$) on a log/log graph. From this graph the slope and y-intercept for the trend line through the points are determined. The site constants *a* and *b* are your y-intercept and your slope of the trend line respectively. The utilization of this formula is standard practice. The analysis of the data will also give an indication of frequency decay over distance.

In the absence of a signature trace study there is however constants used prior to actual tests which will take most of the factors into account. The signature trace process can be applied and will be useful in long term mining on surface and in sensitive blasting areas.

Equation 1:
$y = a(D/\sqrt{E})^b$

Where:
y = Predicted ground vibration
a = Site constant
b = Site constant
D = Distance
E = Explosive Mass

In the absence of tested values for a and b the following factors are normally used and applied for prediction of ground vibration. It is also these factors that were applied for predicting expected ground vibrations in the area for the blasting to be done at the mining area.

Factors:
a = 1143
b = -1.65

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

Review of the type of structures observed around the mine operation and the limitations that may be typically applicable indicated that three different levels of ground vibration are necessary to consider. These are the 10 mm/s, 25 mm/s and 75 mm/s levels. The blast design considered showed that the maximum charge per delay expected on a worst case scenario could be 1925 kg. Considering the parameters, ground vibration and charge mass, the following calculations were done for consideration in this report.

Firstly the distance required from specific charge masses to maintain different vibration limits (10mm/s, 25 mm/s and 75 mm/s) was calculated and presented in Table 5 below. The charge masses used are representative of minimum and maximum charges that can be expected in a typical blast. Figure 9 shows the graphic representation of data provided in Table 4.

Table 5: Distances Required for Maintaining Specific Vibration Levels at Specific Charge Masses

No.	Charge Mass (kg)	Distance (m) 10mm/s PPV Limit	Distance (m) 25mm/s PPV Limit	Distance (m) 75mm/s PPV Limit
1	100.0	177	101	52
2	200.0	250	143	74
3	300.0	306	176	90
4	400.0	353	203	104
5	500.0	395	227	117
6	600.0	433	248	128
7	700.0	468	268	138
8	800.0	500	287	147
9	900.0	530	304	156
10	1000.0	559	321	165
11	1100.0	586	336	173
12	1200.0	612	351	181
13	1300.0	637	366	188
14	1400.0	661	379	195
15	1500.0	684	393	202
16	1600.0	707	406	208
17	1700.0	729	418	215
18	1800.0	750	430	221
19	1900.0	770	442	227
20	2000.0	790	454	233

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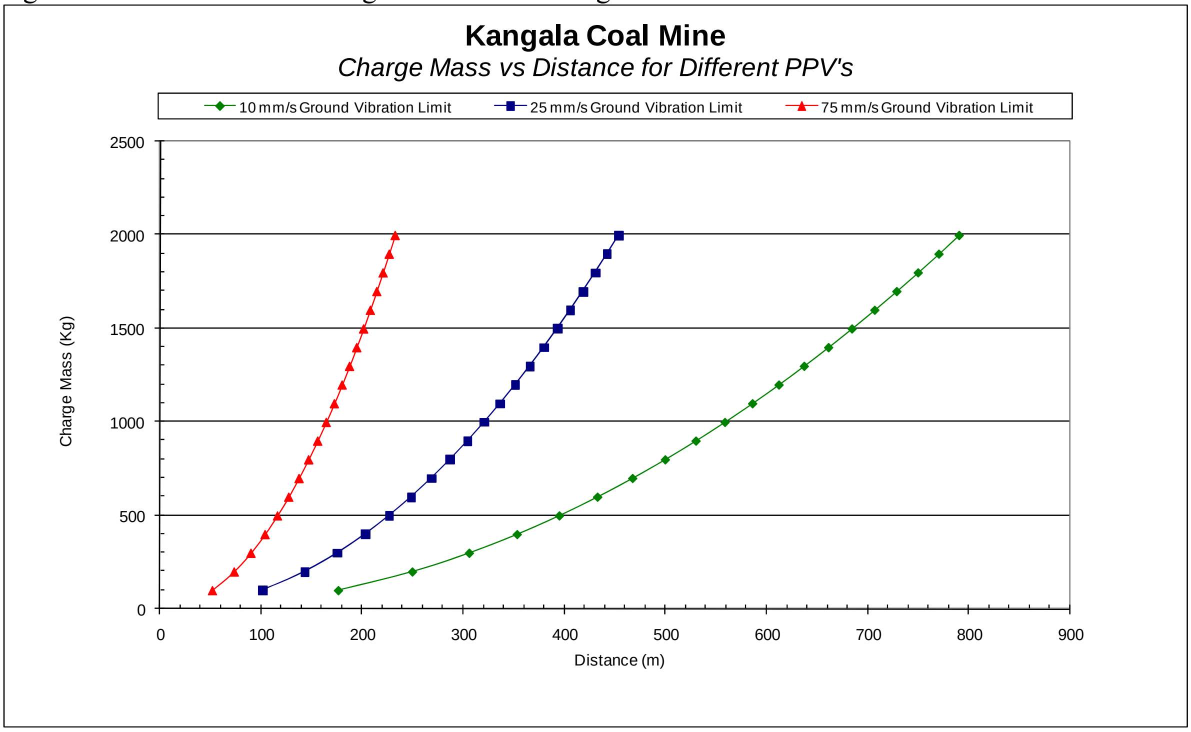
Figure 9: Distance versus Charge Mass for Limiting Vibration Levels



Secondly the required charge masses to yield different vibration levels (10mm/s, 25 mm/s and 75 mm/s) at various distances was calculated and presented in Table 6 below. This is used to consider what maximum charge mass can be allowed for specific distance of interest.

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

No.	Distance (m)	Max Charge Mass (kg) 10mm/s PPV Limit	Max Charge Mass (kg) 25mm/s PPV Limit	Max Charge Mass (kg) 75mm/s PPV Limit
1	50.0	8	24	92
2	100.0	32	97	368
3	125.0	50	152	575
4	150.0	72	219	828
5	175.0	98	298	1128
6	200.0	128	389	1473
7	300.0	288	875	3314
8	400.0	512	1556	5891
9	500.0	800	2430	9205
10	600.0	1153	3500	13255
11	700.0	1569	4764	18042
12	800.0	2049	6222	23565
13	900.0	2593	7875	29824
14	1000.0	3202	9722	36820
15	1250.0	5003	15190	57531
16	1500.0	7204	21874	82844
17	1750.0	9806	29773	112760
18	2000.0	12807	38888	147278
19	2500.0	20011	60762	230122
20	3000.0	28816	87497	331376

Based on the design presented on expected drilling and charging design, the following Table 7 shows expected ground vibration levels (PPV) for various distances calculated at three different charge masses. A low charge mass, the expected maximum charge mass per delay and a maximum charge mass as worst case scenario.

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

No.	Distance (m)	Expected PPV (mm/s) for Charge (kg) - 1 x 127mm BH 22m	Expected PPV (mm/s) for Charge (kg) - 1 x 165mm BH 18m	Expected PPV (mm/s) for Charge (kg) - 6 x 165mm BH 18m
1	50.0	179.4	210.2	921.3
2	100.0	57.2	67.0	293.6
3	125.0	39.6	46.3	203.1
4	150.0	29.3	34.3	150.4
5	175.0	22.7	26.6	116.6
6	200.0	18.2	21.3	93.5
7	300.0	9.3	10.9	47.9
8	400.0	5.8	6.8	29.8
9	500.0	4.0	4.7	20.6
10	600.0	3.0	3.5	15.3
11	700.0	2.3	2.7	11.8
12	800.0	1.8	2.2	9.5
13	900.0	1.5	1.8	7.8
14	1000.0	1.3	1.5	6.6
15	1250.0	0.9	1.0	4.5
16	1500.0	0.7	0.8	3.4
17	1750.0	0.5	0.6	2.6
18	2000.0	0.4	0.5	2.1
19	2500.0	0.3	0.3	1.4
20	3000.0	0.2	0.2	1.1

Figure 10 below shows the relationship of ground vibration over distance for the three charges considered as given in Table 7 above. The attenuation of ground vibration over distance is clearly seen from the graph. Ground vibration attenuation follows a logarithmic trend and the graph indicates this trend. 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.

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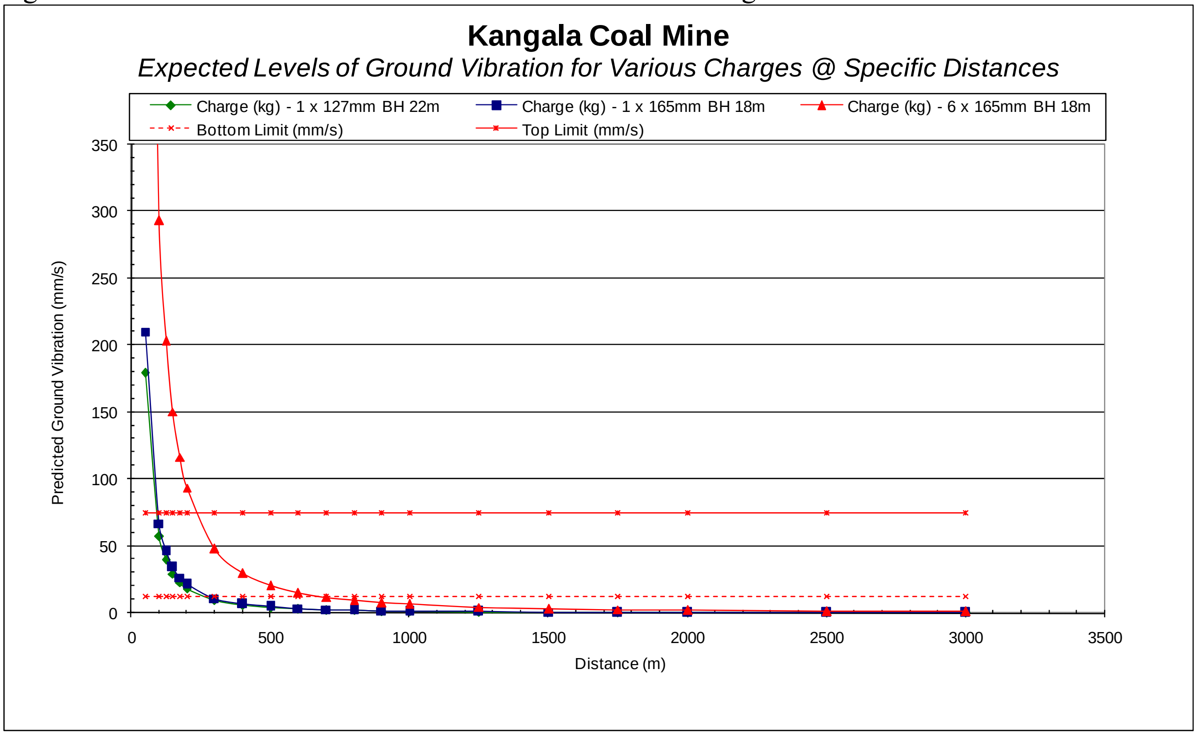
Figure 10: Ground Vibration over Distance for Maximum Charge Mass



6.2 Limitations on Structures

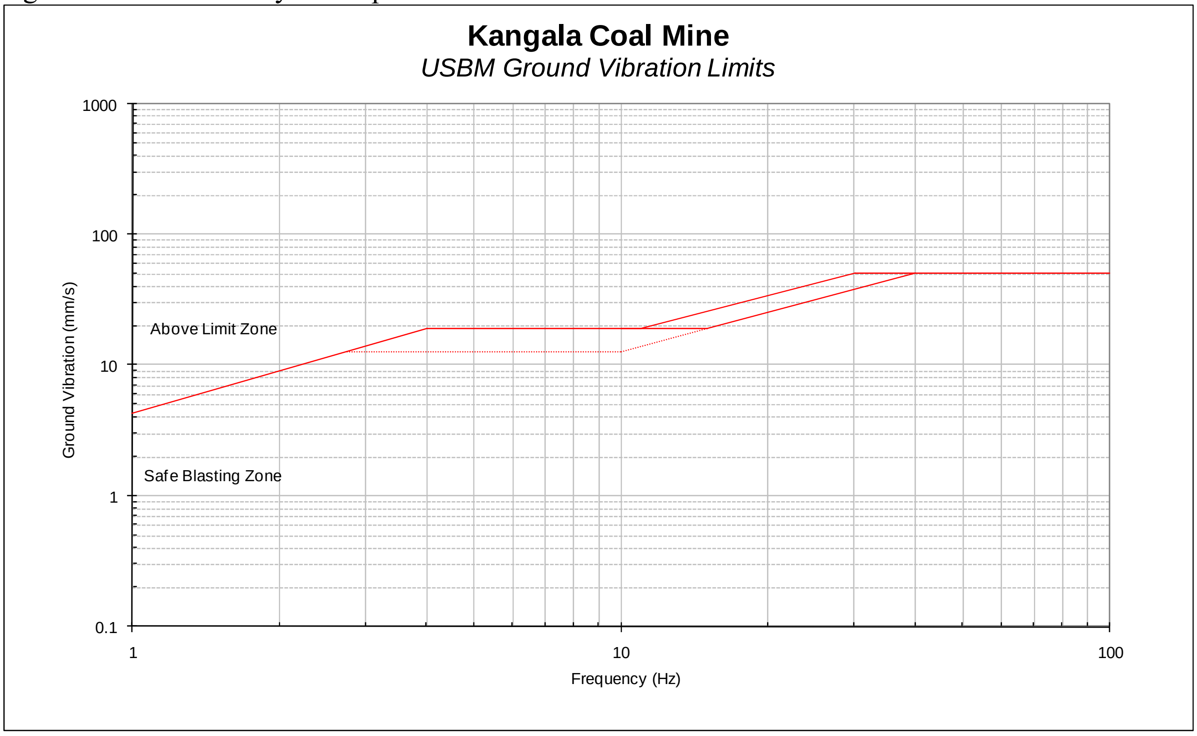
Limitations on ground vibration are in the form of maximum allowable levels for different installations and structures. These levels are normally quoted in millimetres per second i.e. velocity of the particles. There are fixed South African criteria for safe ground vibration levels. Early day recommendations were as follows: 25 mm/s maximum at private structures if frequency of ground vibration is greater than 10 Hz and 12.5 mm/s where frequency of ground vibration is less than 10 Hz.

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:

a) The Safe Blasting Criteria Area
b) The Unsafe Blasting Criteria Area

When ground vibration is recorded and the amplitude in 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 graph. 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 11 shows an example of a USBM analysis graph.

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:

a) USBM criteria for safe blasting
b) The additional limitations provided
c) Consideration of private structures
d) Should these structures be in poor condition is the basic limit of 25 mm/s reduced to 12.5 mm/s

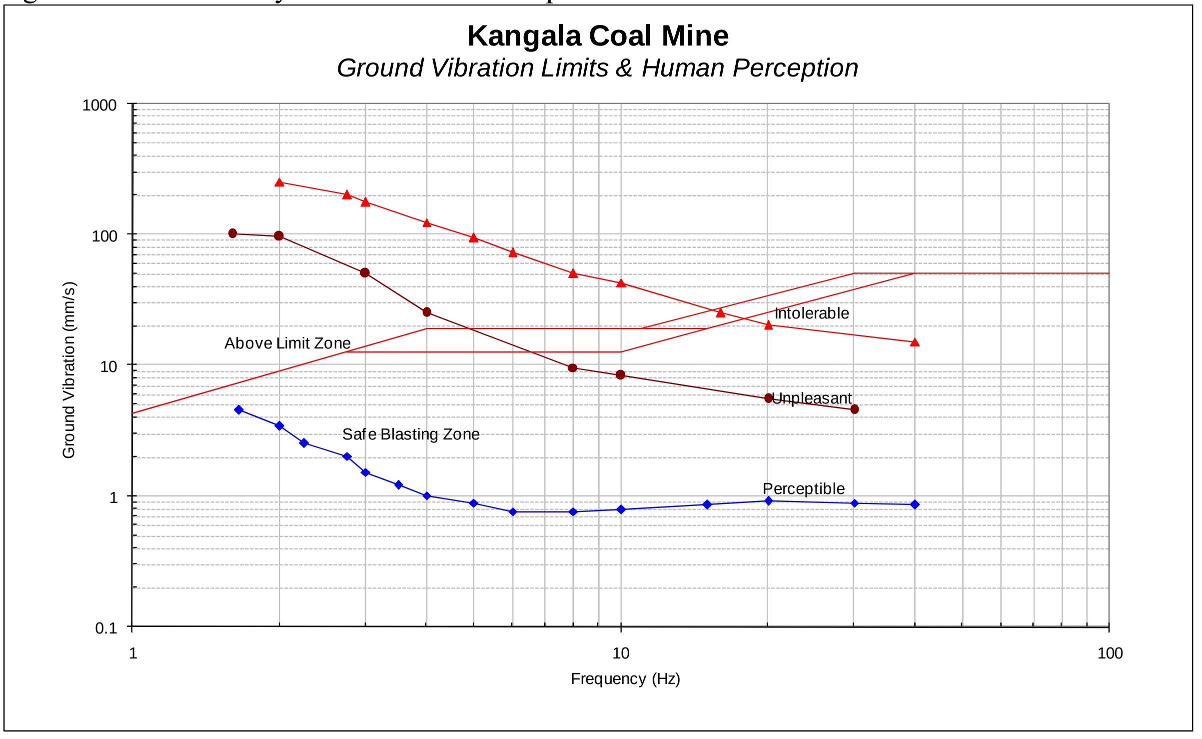
6.3 Limitations with Regards to Human Perceptions

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



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 USBM safe blasting criteria graph (See Figure 13 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. The graph also shows the relationship of ground vibration and the USBM analysis / criteria for safe blasting. Considering the maximum charge per delay of 1925 kg there is indication that though levels of ground vibration are well within the safe blasting criteria at 3000 m it will be strongly perceptible by people. At 1250 m the people's perception would have changed from perceptible to unpleasant whilst the levels of ground vibration are still within the safe blasting zone. Ground vibration expected is still below the 10 mm/s level. Damage to structures (normal brick and mortar) is still not induced. Even at some intolerable levels for humans at the higher frequencies the amplitude of ground vibration is still within the safe blasting zone with regards to structures. People experience ground vibration more severely than what would be required to induce damage to structures. Figure 13 below shows this effect of ground vibration with regards to human perception.

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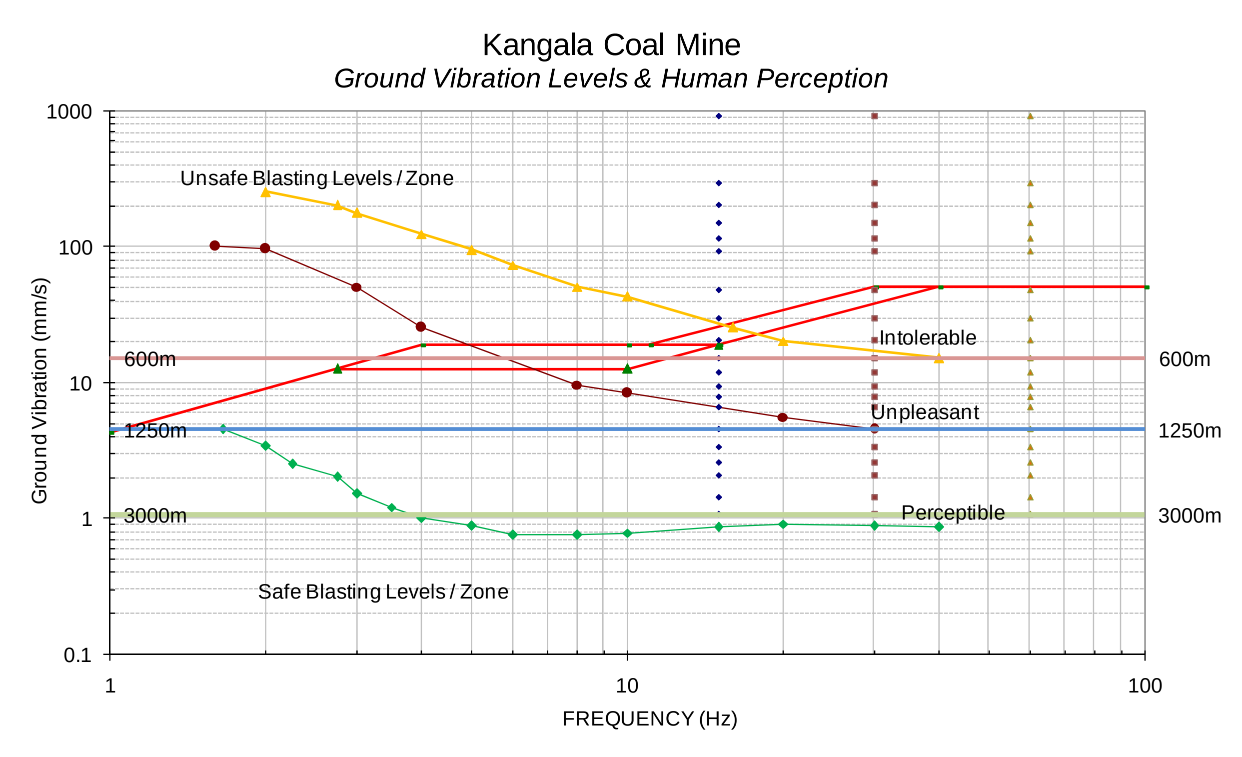
Figure 13: The Effect of Ground Vibration with Regards to Human Perception plotted with the USBM criteria for safe blasting. Highest charge mass was applied.



7. Air Blast and Prediction

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:

a) Direct rock displacement at the blast; the air pressure pulse (APP)
b) Vibrating ground some distance away from the blast; rock pressure pulse (RPP)
c) Venting of blast holes or blowouts; the gas release pulse (GRP)

7.1 Limitations with Regards to Air Blast

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, as 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 8 are at the point of measurement.

Table 8: 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

7.2 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 factor 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.

Standards do exist and predictions can be made, but it must be taken in to account that predictions of air blast is most effective only when used in conjunction with charges on surface and normally referred to detonation of TNT as a reference. Blasts that are normally covered show the least effect on air blast. However even covered blasts with the use of detonating cord can yield high air blast levels when pieces of the detonation cord that is used for indicators are not covered. Covered blasting is normally used in blasting of trenches etc. in close proximity of structures.

The following equation is associated with predictions of air blast, but is considered by the author as subjective. The only real fact is that air blast does decrease over distance and nominally at a rate of -6dB for each doubling of the distance from the source. However applying equation 2 gives some indication of expected levels of air blast and the attenuation over distance.

Equation 2:
$L = 165 – 24 \text{ Log10 } (D/ E^{1/3})$

Where:
L = Air blast level (dB)
D = Distance from source (m)
E = Maximum charge mass per delay (kg)

All though 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 9 below is a summary of values predicted according to Equation 2.

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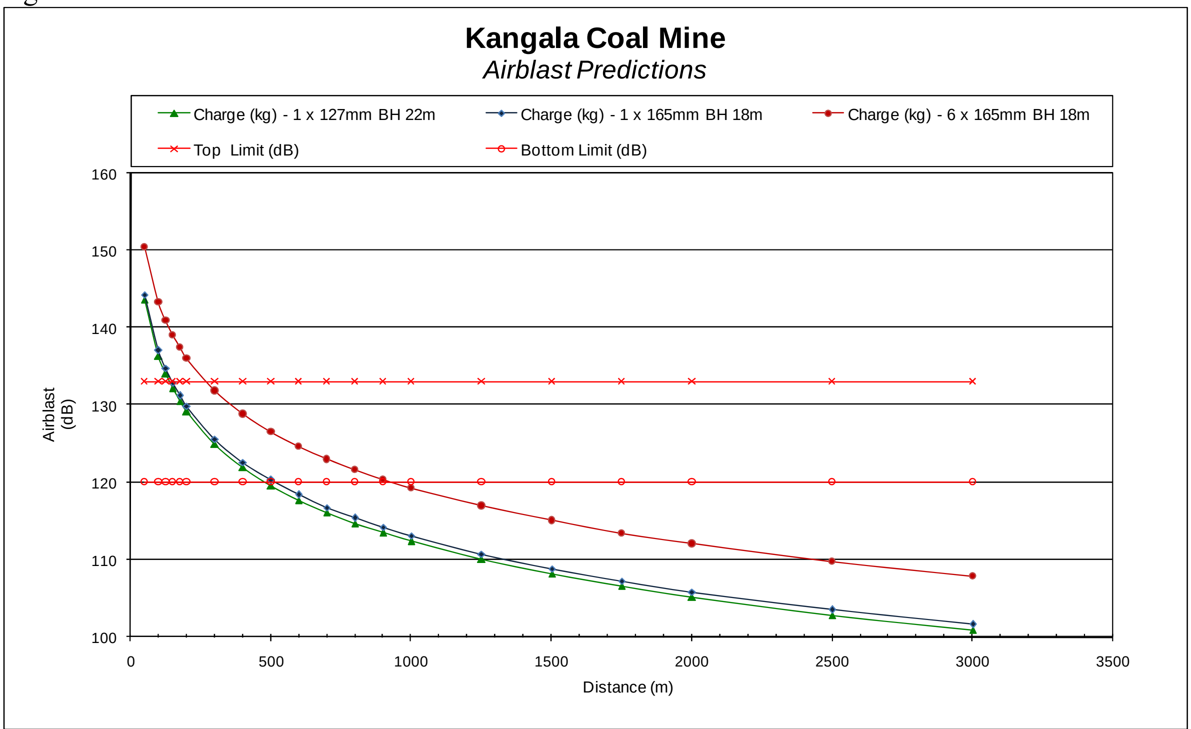
Table 9: Air Blast Predicted Values

No.	Distance (m)	Air blast (dB) 1 x 127mm BH 22m	Air blast (dB) 1 x 165mm BH 18m	Air blast (dB) 6 x 165mm BH 18m
1	50.0	144	144	151
2	100.0	136	137	143
3	125.0	134	135	141
4	150.0	132	133	139
5	175.0	131	131	137
6	200.0	129	130	136
7	300.0	125	126	132
8	400.0	122	123	129
9	500.0	120	120	127
10	600.0	118	118	125
11	700.0	116	117	123
12	800.0	115	115	122
13	900.0	113	114	120
14	1000.0	112	113	119
15	1250.0	110	111	117
16	1500.0	108	109	115
17	1750.0	107	107	113
18	2000.0	105	106	112
19	2500.0	103	104	110
20	3000.0	101	102	108

Figure 14 below shows the predicted values for air blast as given in Table 9 with values for air blast predicted with cover.

Figure 14: Predicted Air Blast



8. Fly Rock

Blasting practices require some movement of rock to facilitate the excavation process. The extent of movement is dependent on the scale and type of operation. For example, blasting activities within large coal mines are designed to cast the blasted material much greater distances than practices in a quarrying or hard rock operation. 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. Fly rock can occur if there is insufficient burden for the hole diameter or a zone of weak rock occurs in the face, the main mechanisms are:

a) Face burst - burden conditions usually control fly rock distances in front of the face
b) Cratering - If the stemming height to hole diameter ratio is too small or the collar rock is weak
c) Rifling - If the stemming material is ejected with insufficient stemming height or inappropriate stemming material is used

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.

Strict controls of blast loading practices should include the following:

a) Minimum confinement of explosives with respect to both stemming heights (minimum height of 30 times the blasthole diameter) and front row burdens are to be maintained at all times
b) Downloading of front row blast holes if minimum burden requirements are not met
c) Free faces should be checked to ensure there are no areas which are under burdened
d) Accurate loading of charge weights ensuring holes are not overloaded
e) Depth to the top of the explosive column to be checked with explosive product to be removed from overloaded holes prior to adding stemming material
f) Appropriate stemming material (10% of blasthole diameter aggregate size) to be used

The processes which control air overpressure levels and fly rock are the same and therefore, the restrictions imposed to blasting activities based on regulatory compliance requirements will in turn act as a safety control, restricting the extent of rock displacement.

9. 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. 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.

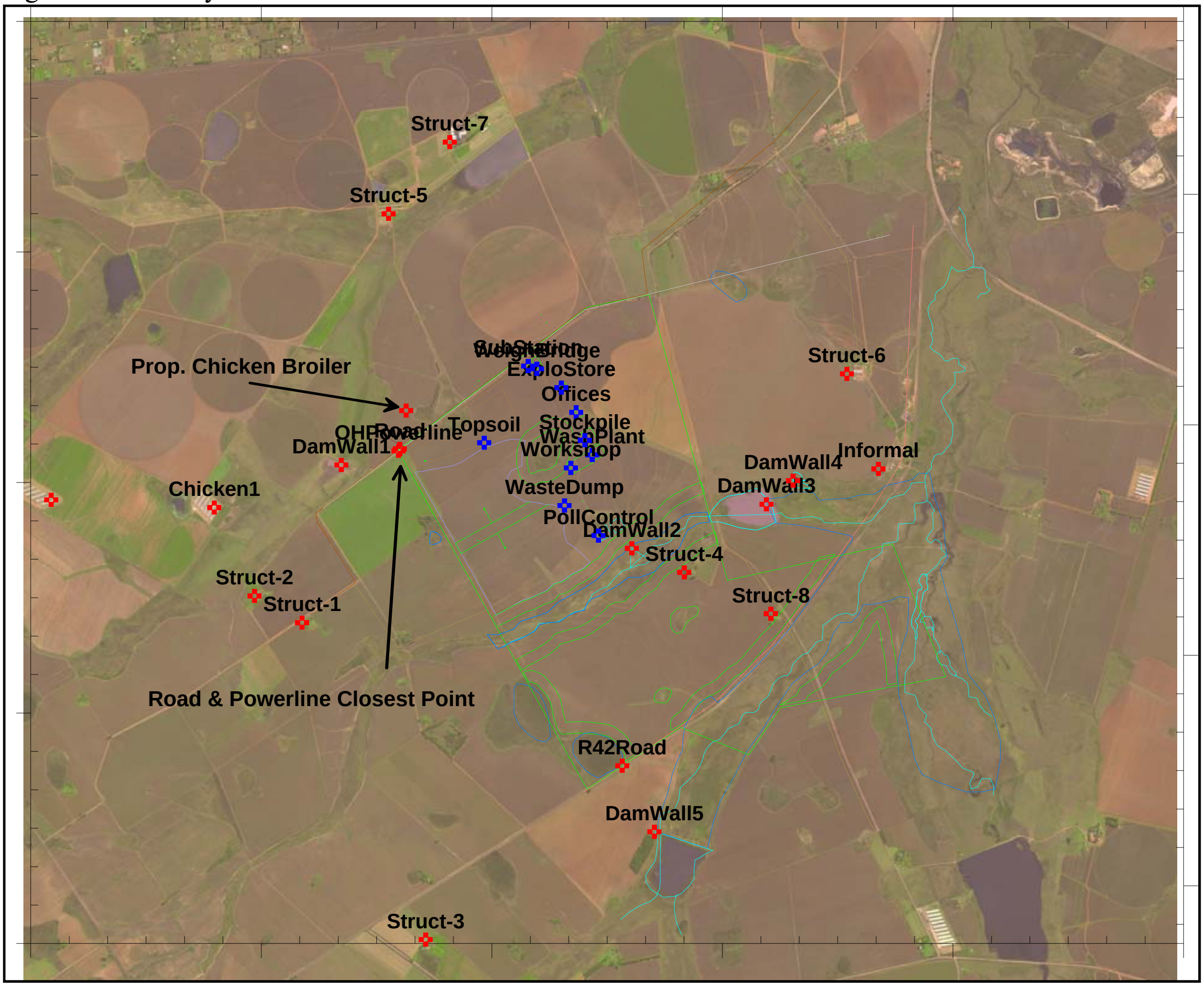
10. Discussion of Possible Effects due to Blasting Operations

Possible effects of blasting operations are presented here. Review of the area surrounding the Kangala Mine showed various structures and installations that were identified and taken into consideration. Expected ground vibration and air blast levels were calculated for each of these structure locations surrounding the mining area. Ground vibration and air blast was calculated from the boundary of the mining area. This means that calculations were done from the edge as if it would be the closest place where drilling and blasting will be done to the various structures.

The pit area was considered with charge masses applied are according to the blast designs done. The minimum and maximum charge mass was used. Ground vibration and air blast was calculated, then plotted and overlaid with current mining plans to observe possible influences at structures identified. Structures for consideration are also plotted in each model. Ground vibration predictions were done considering distances ranging from 50 to 4500 m around the opencast mining area. The expected levels for each of the identified structures, possible influence and concern is also considered and presented in a table prior to modelling graphic. The outcome of the simulations is presented in the following figures for the pit area. In some cases zoomed areas are shown where details are too much for specific region.

Provided with the simulation are the limits as applied for ground vibration is indicated as a red short dotted lines for 25 mm/s and red long dotted lines for 12.5 mm/s. Air blast limits is indicated as a red short dotted lines for 120 dB and red long dotted lines for 134 dB. This enables immediate review of possible concerns that may be applicable to any of the privately owned structures or installations. Figure 15 below shows the mining areas with identified structures.

Figure 15: Site Layout with Structures



10.1 Evaluation of Ground Vibration

10.1.1 Ground Vibration Modelling and Calculations

The opencast pit was reviewed for expected ground vibration. Presented in Table 10, 11, 12 and 13 below is the structure list with distance between the pit boundary and the structure and direction of the structure from the pit area just as done in Table 2 & 3. Table 10 & 11 shows the ground vibration predictions for minimum charge with possible concern for human tolerances and structure response. Figure 16 shows ground vibration contours indicating spheres of influence for the minimum charge of 265kg. Table 12 & 13 shows the ground vibration predictions for maximum charge with possible concern for human tolerances and structure response. Figure 17 shows ground vibration contours indicating spheres of influence for the maximum charge of 1925kg. Ground vibration predictions were done considering distances ranging from 50 to 4500 m around the opencast mining area. A Minimum charge of 265 kg and maximum charge of 1925 kg was modelled. Please note that the red short dotted line is for 25 mm/s and red long dotted lines for 12.5 mm/s. Indications of "No Human Interface" on the following tables indicate that the structure is not normally occupied by humans that will be influenced by the ground vibration.

Table 10: Expected Ground Vibration Levels for Minimum Charge at the Various Private Structures

No.	Structure	Direction from Mine Position	Specific Vibration Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
29	OHPowerline	N	75	233	14.2	No Human Interface	Acceptable	Acceptable
13	Road	N	150	240	13.5	No Human Interface	Acceptable	Acceptable
16	DamWall2	E	50	385	6.2	No Human Interface	Acceptable	Acceptable
30	Prop.Chicken Broiler	N	USBM	539	3.5	Perceptible	Acceptable	Acceptable
12	DamWall1	W	50	643	2.7	No Human Interface	Acceptable	Acceptable
5	Struct-4	E	USBM	824	1.8	Perceptible	Acceptable	Acceptable
1	Struct-1	W	USBM	1498	0.7	Low	Acceptable	Acceptable
17	DamWall3	E	50	1613	0.6	No Human Interface	Acceptable	Acceptable
27	Struct-8	NE	USBM	1632	0.6	Low	Acceptable	Acceptable
15	R42Road	SE	150	1658	0.6	Low	Acceptable	Acceptable
3	Chicken1	W	USBM	1769	0.5	Low	Acceptable	Acceptable
2	Struct-2	W	USBM	1803	0.5	Low	Acceptable	Acceptable
18	DamWall4	E	50	1900	0.4	No Human Interface	Acceptable	Acceptable
11	Struct-5	E	USBM	2204	0.3	Low	Acceptable	Acceptable
23	DamWall5	E	50	2294	0.3	No Human Interface	Acceptable	Acceptable
19	Informal	E	USBM	2632	0.3	Low	Acceptable	Acceptable
21	Struct-7	N	USBM	2634	0.3	Low	Acceptable	Acceptable
20	Struct-6	NW	USBM	2757	0.2	Low	Acceptable	Acceptable
4	Struct-3	S	USBM	2880	0.2	Low	Acceptable	Acceptable
22	Chicken2	W	USBM	3166	0.2	Low	Acceptable	Acceptable

Table 11: Expected Ground Vibration Levels for Minimum Charge at the Mine Structures

No.	Structure	Direction from Mine Position	Specific Vibration Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
24	Topsoil	NW	N/A	37	294.9	No Human Interface	Acceptable	Acceptable
26	WasteDump	E	N/A	58	140.5	No Human Interface	Acceptable	Acceptable
10	PollControl	E	100	207	17.2	No Human Interface	Acceptable	Acceptable
8	Workshop	E	USBM	351	7.2	Unpleasant	Acceptable	Acceptable

6	Offices	NE	USBM	507	3.9	Perceptible	Acceptable	Acceptable
25	Stockpile	E	N/A	517	3.8	No Human Interface	Acceptable	Acceptable
7	WashPlant	E	USBM	540	3.5	Perceptible	Acceptable	Acceptable
9	ExploStore	NE	USBM	561	3.3	Perceptible	Acceptable	Acceptable
28	WeighBridge	NE	100	627	2.8	Perceptible	Acceptable	Acceptable
14	SubStation	NE	USBM	643	2.7	Perceptible	Acceptable	Acceptable

Figure 16: Ground Vibration Levels from Minimum charge 265 kg

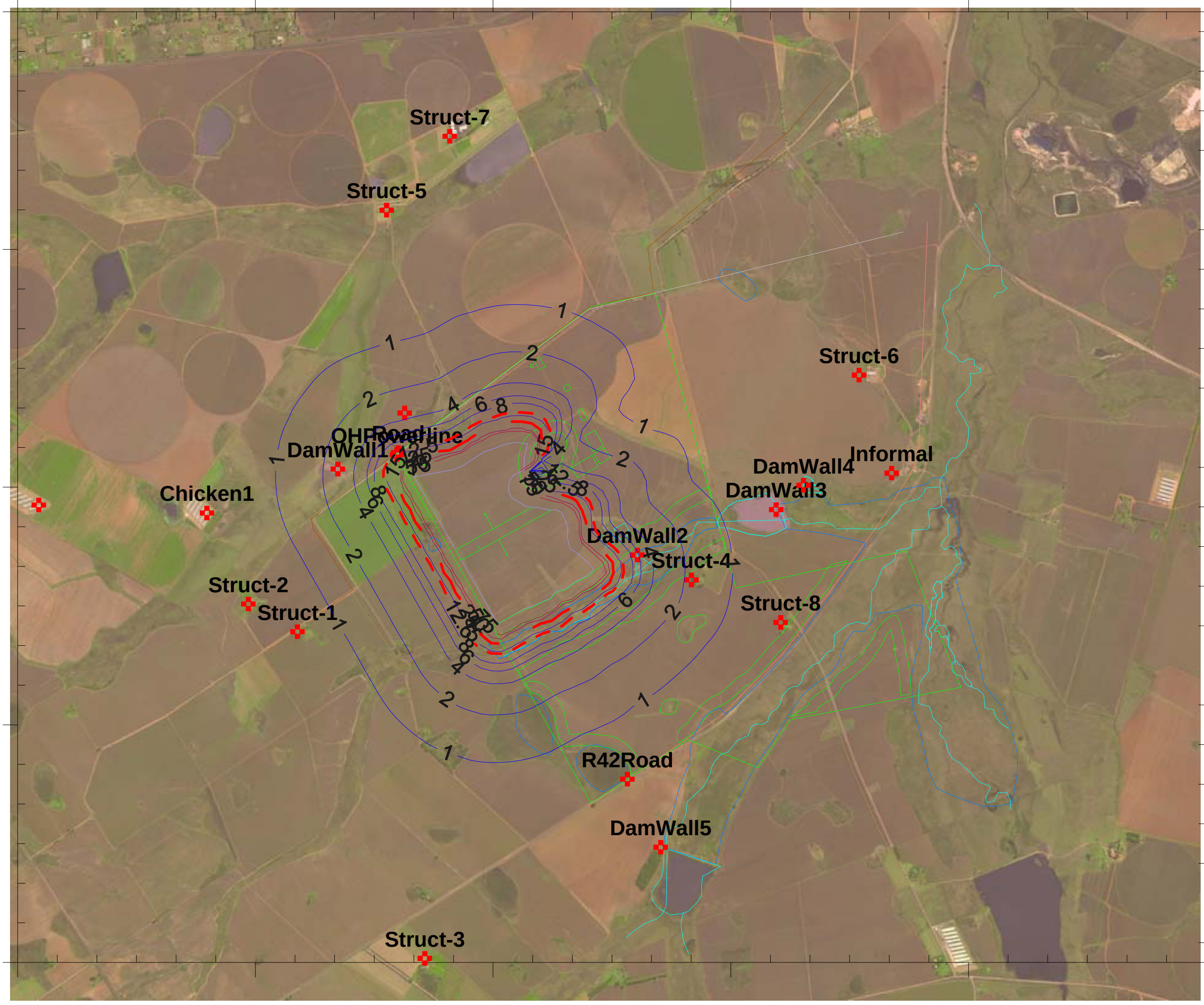


Table 12: Expected Ground Vibration Levels for Maximum Charge at the Various Private Structures

No.	Structure	Direction from Mine Position	Specific Vibration Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
29	OHPowerline	N	75	233	72.7	No Human Interface	Acceptable	Acceptable
13	Road	N	150	240	69.2	No Human Interface	Acceptable	Acceptable
16	DamWall2	E	50	385	31.7	No Human Interface	Acceptable	Acceptable
30	Prop.Chicken Broiler	N	USBM	539	18.2	Unpleasant	Acceptable	Acceptable
12	DamWall1	W	50	643	13.6	No Human	Acceptable	Acceptable

						Interface		
5	Struct-4	E	USBM	824	9.0	Unpleasant	Acceptable	Acceptable
1	Struct-1	W	USBM	1498	3.4	Perceptible	Acceptable	Acceptable
17	DamWall3	E	50	1613	3.0	No Human Interface	Acceptable	Acceptable
27	Struct-8	NE	USBM	1632	2.9	Perceptible	Acceptable	Acceptable
15	R42Road	SE	150	1658	2.9	Perceptible	Acceptable	Acceptable
3	Chicken1	W	USBM	1769	2.6	Perceptible	Acceptable	Acceptable
2	Struct-2	W	USBM	1803	2.5	Perceptible	Acceptable	Acceptable
18	DamWall4	E	50	1900	2.3	No Human Interface	Acceptable	Acceptable
11	Struct-5	E	USBM	2204	1.8	Perceptible	Acceptable	Acceptable
23	DamWall5	E	50	2294	1.7	No Human Interface	Acceptable	Acceptable
19	Informal	E	USBM	2632	1.3	Perceptible	Acceptable	Acceptable
21	Struct-7	N	USBM	2634	1.3	Perceptible	Acceptable	Acceptable
20	Struct-6	NW	USBM	2757	1.2	Perceptible	Acceptable	Acceptable
4	Struct-3	S	USBM	2880	1.1	Perceptible	Acceptable	Acceptable
22	Chicken2	W	USBM	3166	1.0	Perceptible	Acceptable	Acceptable

Table 13: Expected Ground Vibration Levels for Maximum Charge at the Mine Structures

No.	Structure	Direction from Mine Position	Specific Vibration Limit (mm/s)	Distance (m)	Predicted PPV (mm/s)	Human Tolerance @ 30Hz	Structure Response @ 10Hz	Structure Response @ 30Hz
24	Topsoil	NW	N/A	37	1514.1	No Human Interface	Acceptable	Acceptable
26	WasteDump	E	N/A	58	721.2	No Human Interface	Acceptable	Acceptable
10	PollControl	E	100	207	88.4	No Human Interface	Acceptable	Acceptable
8	Workshop	E	USBM	351	37.0	Intolerable	Acceptable	Acceptable
6	Offices	NE	USBM	507	20.2	Unpleasant	Acceptable	Acceptable
25	Stockpile	E	N/A	517	19.5	No Human Interface	Acceptable	Acceptable
7	WashPlant	E	USBM	540	18.2	Unpleasant	Acceptable	Acceptable
9	ExploStore	NE	USBM	561	17.1	Unpleasant	Acceptable	Acceptable
28	WeighBridge	NE	100	627	14.2	Unpleasant	Acceptable	Acceptable
14	SubStation	NE	USBM	643	13.6	Unpleasant	Acceptable	Acceptable

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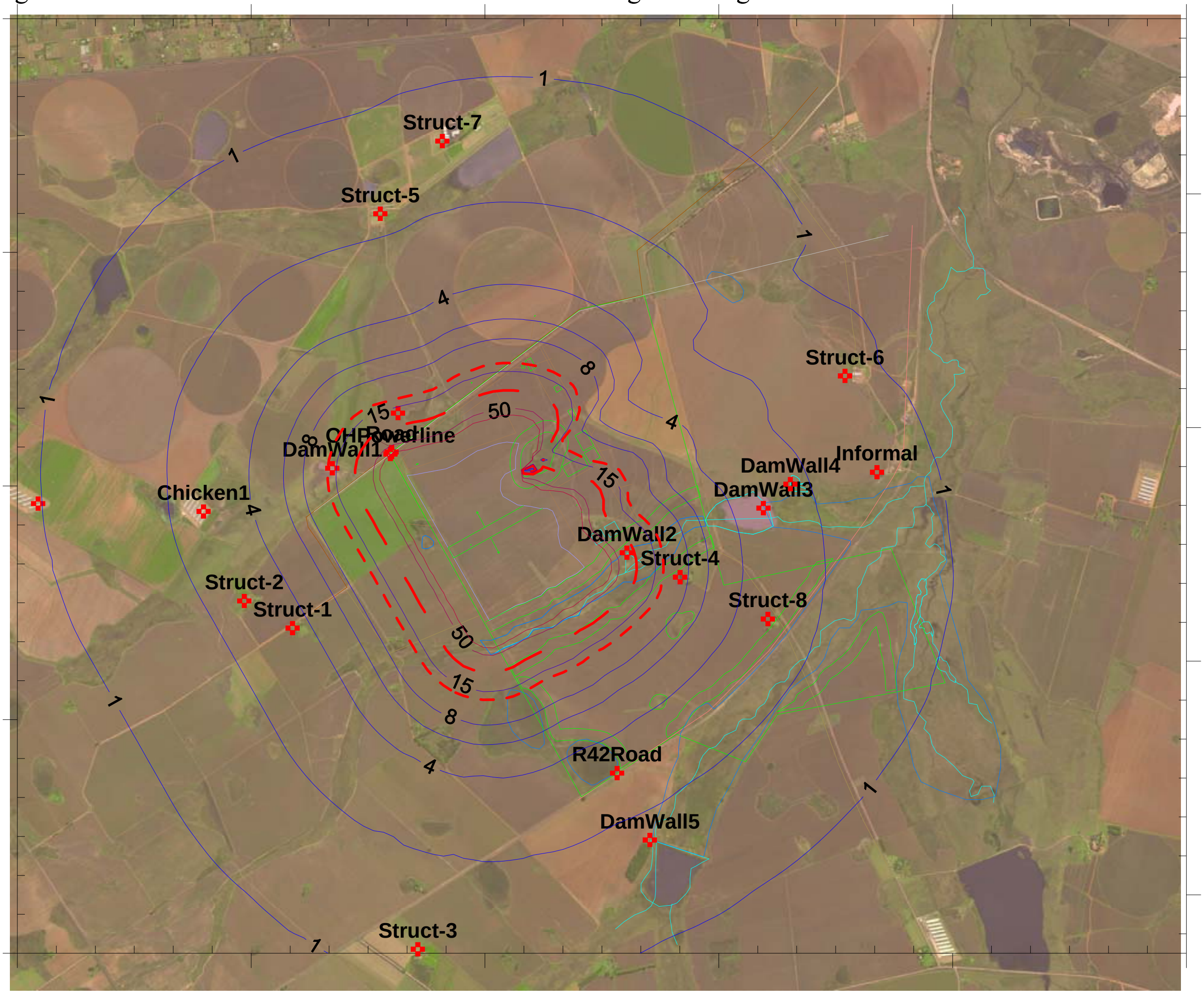
Figure 17: Ground Vibration Levels from Maximum charge 1925 kg



10.1.2 Summary of Ground Vibration Modelling and Calculations

Evaluation of expected ground vibration levels surrounding the pit area showed levels relatively acceptable at all the structures identified. Review of data for the maximum charge showed levels for private structures to be within acceptable limits. The data showed that maximum charge levels could be problematic for the mine structures. These acceptable limits for specific areas of concern still need to be finalised. These concerns are based on distances from the pit boundary and will certainly be different at different blast block locations inside the pit area. Levels observed at private structures observed are indicated as levels ranging between perceptible and unpleasant for humans but are well within the safe boundaries for structures. Structures at further distances are even less influenced then by the blasting operations as modelled for this study. Mitigation measures to be considered for ensuring safe blasting practices are discussed later in the document.

10.2 Evaluation of Air Blast

The effect of air blast, if not controlled properly, is in my opinion a factor that could be problematic. Air blast normally generates rattling of roofs and windows which could be easily misjudged by house owners as ground vibration. These levels do not need to be excessively high in order to upset the owners. Levels of air blast required to induce damage are in the order of 145 dB and greater. In some areas the levels could be perceptible but possible damage to the nearest structures is low and is not expected to be problematic. However considering the human perception the air blast was remodelled using the smallest charge mass per delay and is presented here. Review of expected data for the various charge masses was evaluated and presented in this section.

10.2.1 Air Blast Modelling and Calculations

The opencast pit was reviewed for expected air blast. Presented in Table 14, 15, 16 and 17 below is the structure list with distance between the pit boundary and the structure and direction of the structure from the pit area just as done in Table 2 & 3. Table 14 & 15 shows the air blast predictions for minimum charge and the possible concern for human tolerances and structure response. Figure 18 shows air blast contours indicating spheres of influence for the minimum charge of 265kg. Table 16 & 17 shows the air blast predictions for maximum charge and the possible concern for human tolerances and structure response. Figure 19 shows air blast contours indicating spheres of influence for the maximum charge of 1925kg. Air blast predictions were done considering distances ranging from 50 to 4500 m around the opencast mining area. A Minimum charge of 265 kg and maximum charge of 1925 kg was modelled. Please note that the red short dotted line is for 120 dB and red long dotted lines for 134 dB. Indications of "N/A" on the following tables indicate that the structure is not particularly influenced by air blast.

Table 14: Expected Air Blast Levels for Minimum Charge at the Various Private Structures

No.	Structure	Direction from Mine Position	Distance (m)	Air blast (dB)	Possible Concern?
29	OHPowerline	N	233	127.6	N/A
13	Road	N	240	127.3	N/A
16	DamWall2	E	385	122.3	N/A
30	Prop.Chicken Broiler	N	539	118.8	Acceptable
12	DamWall1	W	643	117.0	N/A
5	Struct-4	E	824	114.4	Acceptable
1	Struct-1	W	1498	108.2	Acceptable
17	DamWall3	E	1613	107.4	N/A
27	Struct-8	NE	1632	107.3	Acceptable
15	R42Road	SE	1658	107.1	Acceptable
3	Chicken1	W	1769	106.4	Acceptable
2	Struct-2	W	1803	106.2	Acceptable
18	DamWall4	E	1900	105.7	N/A
11	Struct-5	E	2204	104.1	Acceptable
23	DamWall5	E	2294	103.7	N/A
19	Informal	E	2632	102.3	Acceptable
21	Struct-7	N	2634	102.3	Acceptable
20	Struct-6	NW	2757	101.8	Acceptable
4	Struct-3	S	2880	101.4	Acceptable
22	Chicken2	W	3166	100.4	Acceptable

(Intentionally Left Open)

Table 15: Expected Air Blast Levels for Minimum Charge at the Mine Structures

No.	Structure	Direction from Mine Position	Distance (m)	Air blast (dB)	Possible Concern?
24	Topsoil	NW	37	146.7	N/A
26	WasteDump	E	58	142.1	N/A
10	PollControl	E	207	128.8	N/A
8	Workshop	E	351	123.3	Complaint
6	Offices	NE	507	119.5	Acceptable
25	Stockpile	E	517	119.3	Acceptable
7	WashPlant	E	540	118.8	Acceptable
9	ExploStore	NE	561	118.4	Acceptable
28	WeighBridge	NE	627	117.3	Acceptable
14	SubStation	NE	643	117.0	Acceptable

Figure 18: Air Blast Levels from Minimum charge 265 kg

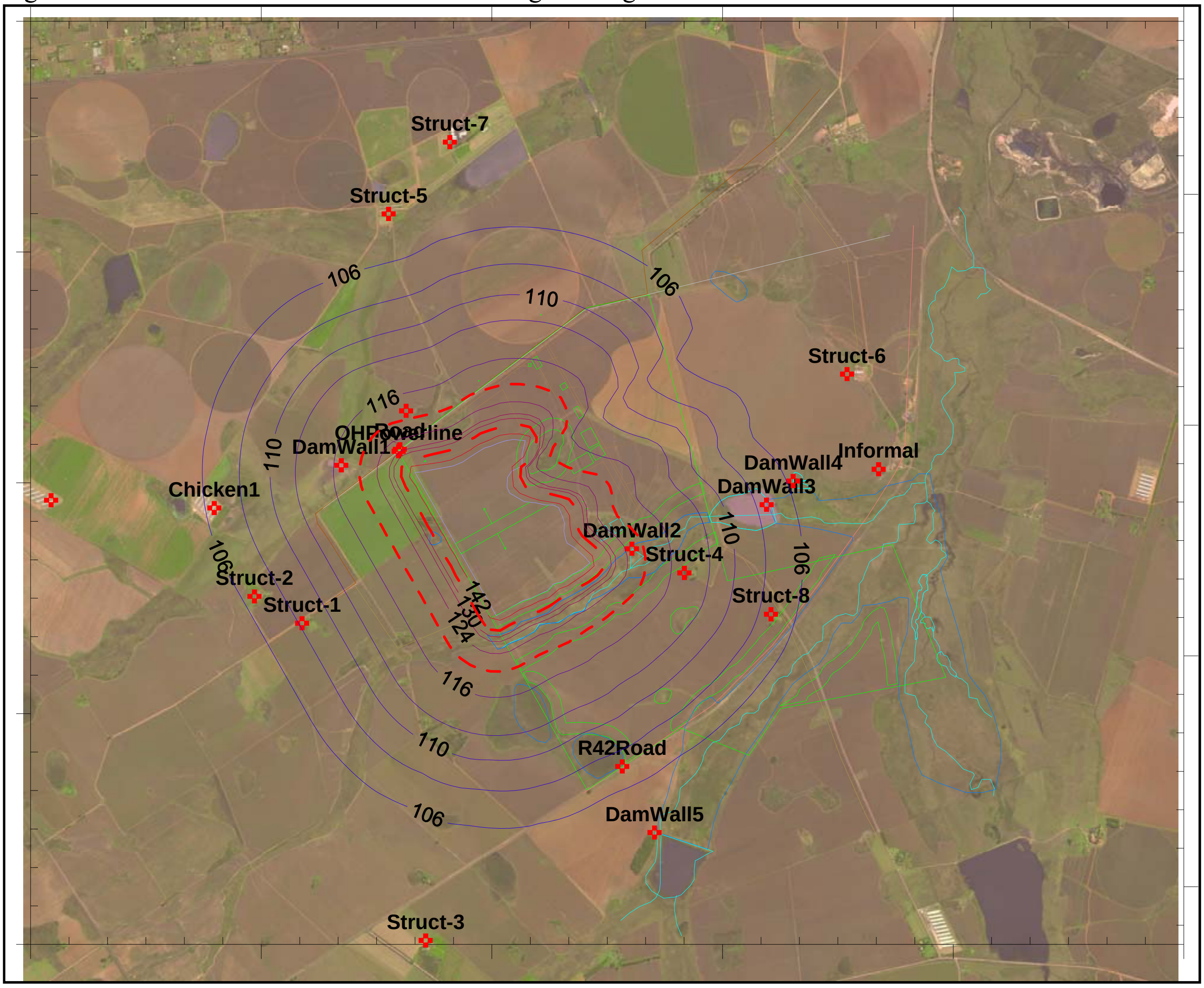


Table 16: Expected Air Blast Levels for Maximum Charge at the Various Private Structures

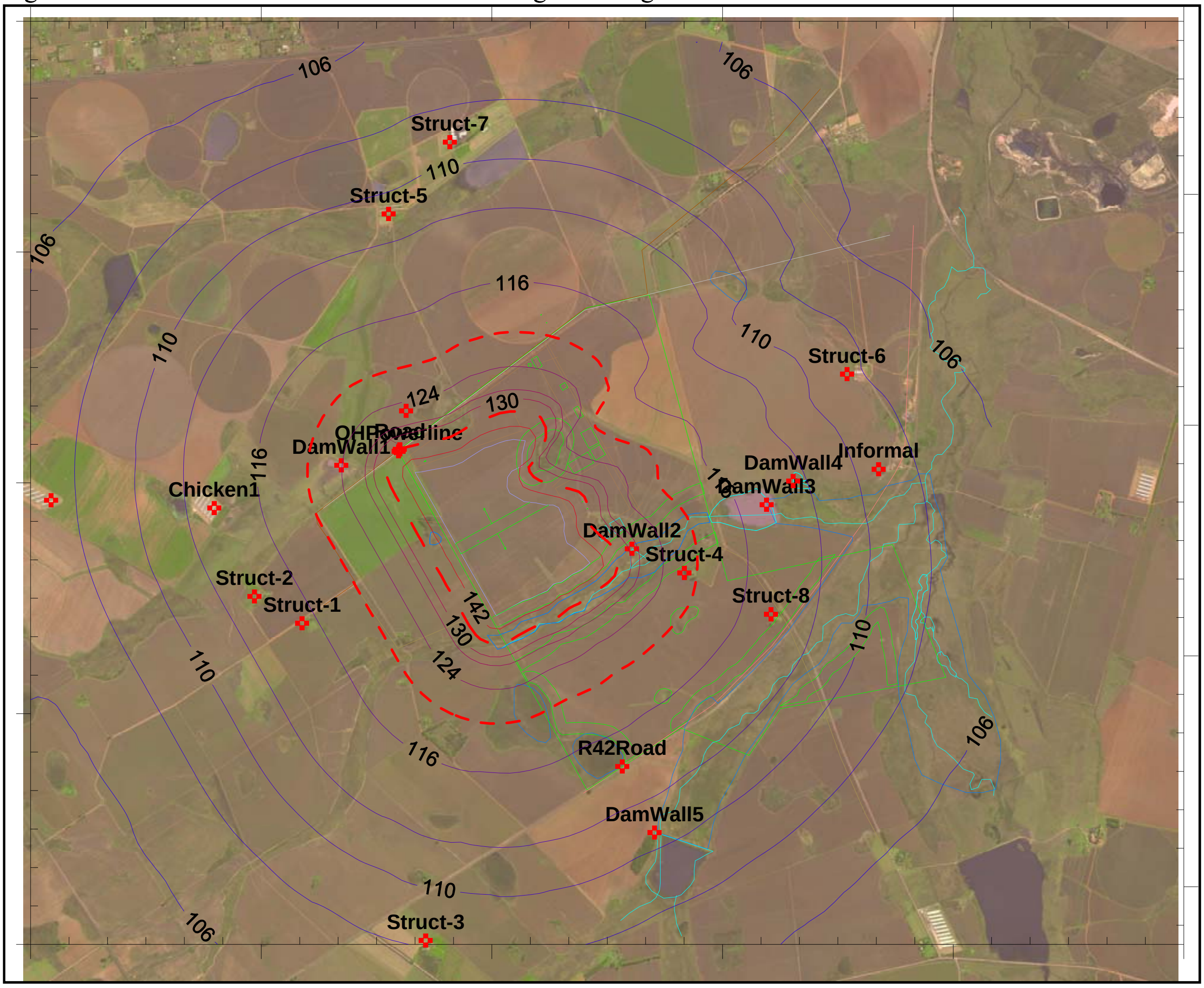
No.	Structure	Direction from Mine Position	Distance (m)	Air blast (dB)	Possible Concern?
29	OHPowerline	N	233	134.5	N/A
13	Road	N	240	134.2	N/A
16	DamWall2	E	385	129.2	N/A
30	Prop.Chicken Broiler	N	539	125.7	Complaint / problematic
12	DamWall1	W	643	123.9	N/A
5	Struct-4	E	824	121.3	Complaint
1	Struct-1	W	1498	115.1	Acceptable
17	DamWall3	E	1613	114.3	N/A
27	Struct-8	NE	1632	114.2	Acceptable
15	R42Road	SE	1658	114.0	Acceptable
3	Chicken1	W	1769	113.3	Acceptable
2	Struct-2	W	1803	113.1	Acceptable
18	DamWall4	E	1900	112.6	N/A
11	Struct-5	E	2204	111.0	Acceptable
23	DamWall5	E	2294	110.6	N/A
19	Informal	E	2632	109.2	Acceptable
21	Struct-7	N	2634	109.2	Acceptable
20	Struct-6	NW	2757	108.7	Acceptable
4	Struct-3	S	2880	108.3	Acceptable
22	Chicken2	W	3166	107.3	Acceptable

Table 17: Expected Air Blast Levels for Maximum Charge at the Mine Structures

No.	Structure	Direction from Mine Position	Distance (m)	Air blast (dB)	Possible Concern?
24	Topsoil	NW	37	146.7	N/A
26	WasteDump	E	58	142.1	N/A
10	PollControl	E	207	128.8	N/A
8	Workshop	E	351	123.3	Complaint
6	Offices	NE	507	119.5	Acceptable
25	Stockpile	E	517	119.3	N/A
7	WashPlant	E	540	118.8	Acceptable
9	ExploStore	NE	561	118.4	Acceptable
28	WeighBridge	NE	627	117.3	Acceptable
14	SubStation	NE	643	117.0	Acceptable

(Intentionally Left Open)

Figure 19: Air Blast Levels from Maximum charge 1925 kg



10.2.2 Summary of Air Blast Modelling and Calculations

Evaluation of expected air blast levels surrounding the pit area showed levels relatively acceptable at all the structures identified. Review of data for the maximum charge showed levels for private and mine structures to be within acceptable limits. These concerns are based on distances from the pit boundary and will certainly be different at different blast block locations inside the pit area. Levels observed at private structures observed are indicated as levels ranging between acceptable and the possibility for complaints. Structures at further distances are even less influenced then by the blasting operations as modelled for this study. Levels observed at the structures indicate levels of caution, rather a nuisance with low probability of damage.

A concern to be considered is the possible effect on the proposed new chicken broiler that Mr. Schoeman intends to construct north east of the mining area. The predicted air blast levels for this structure ranges between 118 and 126 dB for the minimum and maximum charge. Levels greater than 120dB and sudden load bangs could be problematic. The problem with chickens is that they are frightened by sudden load bangs and then tends to trample each other as they ran into a corner of the broiler. The construction of this broiler will certainly have influence on the permissible levels of air blast from blasting operations.

10.3 Fly Rock

Blasting operations in general will yield fly rock if blasts are not prepared properly. This will include consideration of stemming lengths, stemming material, first row burdens, timing etc. Review of the area for

Kangala Coal Mine there is a concern of public installations around the mine. North of the mine there are overhead power lines, north and south of the mine there is provincial roads that will need to be considered as well. There is almost no area around the pit that could allow free blasting without consideration the various surface structures in the area for each of the proposed opencast mining area. The biggest influence on fly rock will be the control on the type of stemming material and the appropriate stemming lengths. A full Risk Assessment will be required in order to address these aspects and to put proper controls in place.

10.4 Dust and Noxious Fumes

Dust and Noxious fumes should be controlled as best as possible. Fumes are generated by all explosives. Emulsion explosives that have been standing for a while and where water or certain geology factors are present could be generating fumes when blasting is done. Consideration should also be given to prevailing wind direction when blasting is done.

Typical controls that can be used are:

- Proper stemming and stemming material
- Blasts can be delayed when prevailing wind is blowing towards the area of concern
- Do not leave blasts standing for long periods of time

10.5 Blast Initiation

The mining area is rather large and the influence will vary from actual position of the blast to be done. Considering the location of each blast, specifically close to the mining boundaries, blast design should be considered. Careful design of blasts and layout will ensure effective initiation and detonation. The use of effective timing and the proper down hole accessories, according to accepted standard practices must be considered. The use of the proper size primer according to blast hole diameter and depth must be applied. Proper surface timing in order to provide proper movement and relief must be designed. Incorrect initiation of a blast will lead to poor blast results i.e. poor fragmentation, blow outs, fly rock etc. Increased distance between receptors and the blasts will see reduced levels of ground vibration and air blast. These distances must be considered when decision is made between multiple blasthole detonation or single hole firing.

10.6 Safe Blasting Procedures

Standard safety procedures associated with blasting operations should be applicable. Each bench that will be drilled and blasted will require standard rules and regulations with regards to all safety aspects of drilling and blasting.

Some aspects that should be considered as well:

- Placement of guards will be required to ensure that there are no people or animals within the safe distance as determined by the blaster when blasting
- The closing of roads within a safe radius as determined by the blaster. Traffic stops could be considered where necessary
- Pre-Blast Meeting & Documentation: A Pre-Blast meeting should be conducted prior to each blast to ensure that all aspects of safety are covered. This meeting should facilitate the procedures and actions required by each party or person and its responsibilities. This will be mainly for lasting on the closest bench
- Time of blasting should not be more than once per day

10.7 Monitoring

It is recommended that a process of monitoring the blasting operations must be applied for all blasting to be done in the mine operation. This process should be to ensure that levels are within limits at all times. Early monitoring will also give indications of what ground vibrations levels are recorded at what distances and help with being proactive on the levels observed. It is proposed that at least four seismographs be placed at the positions as indicated on the Figure 20 below. One at the Dam Wall, one at the Chicken Pen West of the mine, one at the new Chicken Pen North of the mine and one at Structure 4, east of the mine.

Figure 20: Proposed Monitoring Positions

 Monitor Icon

10.8 Risk Assessments

Following is risk assessment of the various concerns covered by this report. The matrix below shows outcomes before any mitigation done and considers the worst case scenarios as basis. This risk assessment is a one side analysis and needs to be discussed with role players in order to obtain a proper outcome and mitigation.

Table 18: Risk Assessment Matrix

1. Activity	Blasting	Blasting	Blasting	Blasting
2. Environmental Aspect	2.1 Ground Vibration			
		2.2 Air blast		
			2.3 Fly Rock	
				2.4 Fumes
3. Environmental Impacts				

• Receptors	People, Structures	People, Structures	People, Structures	People
• Resources	Blasting process	Blasting process	Blasting process	Blasting process
• Frequency Of Activity	Daily	Daily	Daily	Daily
• Frequency Of Impact	Daily	Daily	Daily	Daily
• Severity	Large	Large	Large	Large
• Spatial Scope	3km Radius	3km Radius	0.5km Radius	1km Radius
• Duration	LOM	LOM	LOM	LOM
Severity Of Impact Rating	3	3	2	4
Spatial Scope Of Impact Rating	3	3	2	2
Duration Of Impact Rating	4	4	4	4
Consequence	10	10	8	10
Frequency Of Activity / Duration Of Aspect Rating	4	4	4	4
Frequency Of Impact Rating	3	3	3	3
Likelihood	7	7	7	7
Risk Rating	17	17	15	17
Risk Level	High	High	High	High

Mitigation will be required for blasts done close to the mining border. The distance between blasts and the receptors will be the most influential. The greater the distance between receptors and the blast the less is the influence. Mitigation is specifically required with regards to ground vibration and air blast. Air blast is most probably the biggest concern as people will react to it and this could lead to complains. Fly rock will always require specific attention with regards to proper stemming lengths. Stemming length and proper stemming material is the appropriate method of controlling fly rock.

11. Additional Recommendations

Consideration should be given to the following recommendations:

a) Pre blast survey of all structures identified surrounding the mining area,
b) Ground vibration survey in the form of signature trace study to be done for determination of ground vibration constants that can be used for accurate prediction of ground vibration,
c) Considerations must be given to air blast control in respect to the closest chicken broilers, specifically the proposed new structure,
d) Design of blasts to ensure safe levels of ground vibration and air blast is maintained,
e) Redesign with alternative diameter blast holes and charge masses to accomplish safe blasting,
f) Investigate the possibility of electronic initiation,
g) Monitoring of blasting operations as per discussion.

12. Baseline Study

12.1 Background

A baseline study was done in order to determine what typical levels of ground vibration and air blast is present around the Kangala Coal area. The location of the mine is public structures and various installations.

The process followed for the baseline study is one of placing monitors at specific points for a time period and monitoring levels of ground vibration and air blast continuously. Monitors are normally placed at positions of specific interest for periods ranging from 24 hrs extending to days, pending the specific requirement. Recording done on ground vibration utilises the tri-axial geophone sensors and air blast is recorded on the pressure microphone of the seismograph. Ground vibrations levels between 0 and 254 mm/s and air blast between 88 and 148 dB can be recorded. Recording of data is done on a continuous basis with variable sampling rates i.e. 2, 5 or 15 seconds or 1, 5 or 15 minutes pending the detail and length of time for information required. The quantity of data recorded is governed by the storage memory for the system. Data recorded is presented on a histogram format. Further to this the equipment is setup to record specific events of ground vibration and air blast when a specific threshold is reached. Meaning that whilst histogram recording is done the system will record specific events as well. The specific event can then be matched to actual levels recorded as these will normally also show on the histogram at higher peaks. Confirmation can then be obtained of the type of event that generated the levels observed.

Monitors are checked frequently to ensure that memory is not exceeded. Ground vibration and air blast sensors are setup pointing in a northerly direction in the absence of a probable source of ground vibration or air blast. The actual location of the monitor is fixed on GPS.

Objective of this report is presentation of results recorded to the client consisting of the following information:

a) Firstly in summary table with start and end dates and times, maximums recorded, date and time of maximums and notes where applicable
b) Graphs showing the maximums per position monitored
c) Figure showing location of monitor positions
d) Actual histogram recordings that were made
e) Results from specific events recorded where applicable
f) Discussion of outcome of baseline recording made

12.2 Test Setup Information

Equipment consisted of Instantel Minimate Plus seismographs. Equipment was setup to monitor Histogram Combo methodology as per information provide in Table 19. Set-up of the monitor include times when the unit is active, set trigger levels for vibration as well as general information about the location. In histogram recording mode all data is monitored at specific sample rate and with event recording the trigger levels are those levels that are programmed in the system to start recording of any event greater than the set limit. The system is to trigger on vibration and air blast.

(Intentionally Left Open)

Figure 21: Shows Location of the Various Monitoring Positions

Table 19: Shows Ground Vibration and Air Blast Setups used for Monitoring Equipment

Point	Coordinates		Distance from Blasting Area	Distance to Closest Structure	Histogram Setup	Event Setup
	Y	X				
Point 01	31033	2895412	Approx 4662m North East	Approx 50m	Rate: 2sec Max Geo: 254 mm/s Max Mic: 148dB(L)	Geo: 1.20 mm/s Mic: 120 dB(L) 1.0 sec at 1024 sps
Point 02	28720	2898518	Approx 5498m East	Approx 38m	Rate: 2sec Max Geo: 254 mm/s Max Mic: 148dB(L)	Geo: 1.20 mm/s Mic: 120 dB(L) 1.0 sec at 1024 sps
Point 03	32312	2899319	Approx 1963m East	Approx 31m	Rate: 2sec Max Geo: 254 mm/s Max Mic: 148dB(L)	Geo: 1.20 mm/s Mic: 120 dB(L) 1.0 sec at 1024 sps
Point 04	32124	2901707	Approx 3554m South East	On Top of Dam Wall	Rate: 2sec Max Geo: 254 mm/s Max Mic: 148dB(L)	Geo: 1.20 mm/s Mic: 120 dB(L) 1.0 sec at 1024 sps

12.3 Results

Results obtained for the baseline study is presented. Results were effectively recorded at all points monitored. Two sets of data are presented for the histogram data. The systems were downloaded at approximately 10h00 to ensure that system memory is not exceeded and data lost due to this. This was done to observe typical levels recorded and adjustments can then be made and also to remove any individual events from memory. All sets for each point are presented as well as a combined graph for each point. The seismograph software does not allow combination of various files of this type. Data was exported and graphed using third party software.

Both histogram data as well as individual events were recorded during the baseline monitoring period. Individual events were mainly recorded at points 1, 2, and 4. Ten events were recorded at all three monitoring points. Most of these events registered are due to system sensitivity when system is approached for download or stop monitoring actions. Points 3 did not show any individual events.

Table 20 shows summary table with start and end dates and times, maximums recorded, date and time of maximums and notes where applicable and Table 21 shows all of the results for individual events recorded (no blast related events were recorded).

Figure 22 shows summary graph of the results recorded, Figure 23 shows graph of histogram data results recorded and Figure 24 shows graph of individual events recorded.

Appendix I: All Original File Histogram Data Results
Appendix II: All Graphed Histogram Results using Alternative Software
Appendix III: All Events Reports for Individual Events Recorded

Table 20: Summary Table

Point	Start Date time	End Date Time	Date Time Max VPPV	Max VPPV	Date Time Max dB	Max dB	Avg. VS	Avg. dB	Max PPV	Max MicL Pa
Point 01	Oct 20 /09 11:58:54	Oct 22 /09 09:06:43	Oct 21 /09 12:57:13	7.99	Oct 21 /09 14:46:09	139.9	0.3	86.2	5.97	198.50
Point 02	Oct 19 /09 08:26:32	Oct 22 /09 09:15:32	Oct 20 /09 11:08:07	4.84	Oct 20 /09 12:57:55	147.9	0.3	83.7	3.56	500.25
Point 03	Oct 19 /09 08:53:34	Oct 22 /09 09:39:17	Oct 21 /09 18:27:09	1.28	Oct 19 /09 08:53:52	121.3	0.2	85.4	0.89	23.25
Point 04	Oct 19 /09 11:28:58	Oct 22 /09 08:46:56	Oct 19 /09 18:08:56	9.08	Oct 19 /09 18:08:56	140.9	0.3	83.8	7.11	223.00

Explanation of Headings:

Point:	Seismograph position where placed
Start Date time:	Start date and Time of Histogram
End Date Time:	End date and Time of Histogram
Date Time Max VPPV:	Date and Time of Maximum Vector sum of Vibration Recorded (mm/s)
Max VPPV:	Maximum Vibration Vector Sum in peak particle velocities (mm/s)
Date Time Max dB:	Date and Time of Maximum Air blast Recorded (mm/s)
Max dB:	Maximum Air blast (dB)
Avg. VS:	Average Vector Sum for Vibration calculated from the channels: Longitudinal, Transverse & Vertical in peak particle velocities (mm/s)
Avg. dB:	Average Air blast (dB)
Max PPV:	Maximum Vibration of any of the channels: Longitudinal, Transverse & Vertical peak particle velocities (mm/s)
Max MicL Pa:	Maximum Air blast (Pa)

Table 21: Shows All of Results for Individual Events Recorded (Not Blast Related)

Date	Time	Seis. Location	L-PPV	T-PPV	V-PPV	L-Freq	T-Freq	V-Freq	Resultant PPV (mm/s)	Air Blast (dB)	Appl. Format
2009/10/19	13:38:02	Point 2	0.25	0.13	0.13	>100	>100	>100	0.25	138.70	1~Point 2
2009/10/19	14:26:05	Point 4	2.67	1.02	0.76	>100	>100	85.30	2.74	97.50	2~Point 4
2009/10/19	14:34:01	Point 2	0.25	0.13	0.13	>100	>100	***	0.28	129.00	3~Point 2
2009/10/19	15:39:11	Point 4	2.29	1.90	0.64	>100	>100	>100	2.30	132.20	4~Point 4
2009/10/19	16:33:10	Point 4	3.30	1.02	0.51	>100	>100	>100	1.72	131.30	5~Point 4
2009/10/19	16:46:19	Point 4	0.25	0.13	0.13	>100	>100	***	0.28	130.40	6~Point 4

2009/10/19	17:12:46	Point 4	1.90	1.02	0.89	>100	>100	>100	2.01	128.10	7~Point 4
2009/10/20	11:07:47	Point 2	1.65	1.40	1.65	>100	85.30	64.00	2.17	125.50	8~Point 2
2009/10/20	11:08:07	Point 2	3.56	2.67	1.90	56.90	>100	>100	4.62	125.30	9~Point 2
2009/10/20	12:41:29	Point 2	0.25	0.13	0.13	>100	>100	>100	0.25	140.10	10~Point 2
2009/10/20	12:57:56	Point 2	0.13	0.13	0.13	***	>100	***	0.22	148.00	11~Point 2
2009/10/20	14:08:42	Point 2	0.25	0.13	0.25	>100	>100	>100	0.28	148.00	12~Point 2
2009/10/20	16:34:19	Point 4	1.02	1.02	0.51	>100	>100	>100	1.37	127.70	13~Point 4
2009/10/20	16:41:49	Point 4	1.14	0.89	0.51	>100	>100	>100	1.25	125.90	14~Point 4
2009/10/20	16:44:07	Point 4	1.14	1.02	0.76	>100	>100	>100	1.31	131.50	15~Point 4
2009/10/20	17:51:24	Point 4	0.89	1.14	1.14	>100	>100	>100	1.84	133.10	16~Point 4
2009/10/20	18:02:33	Point 4	4.30	1.65	0.51	>100	>100	>100	1.66	128.30	17~Point 4
2009/10/21	08:35:27	Point 1	0.13	0.13	0.13	>100	>100	***	0.22	127.90	18~Point 1
2009/10/21	08:35:55	Point 1	0.13	0.25	0.13	***	>100	>100	0.28	130.80	19~Point 1
2009/10/21	08:36:23	Point 1	0.13	0.25	0.13	>100	>100	>100	0.28	130.70	20~Point 1
2009/10/21	08:36:45	Point 1	0.13	0.25	0.13	>100	>100	***	0.28	125.50	21~Point 1
2009/10/21	10:08:50	Point 1	0.25	0.13	0.25	>100	>100	>100	0.31	129.10	22~Point 1
2009/10/21	10:13:19	Point 1	0.25	0.13	0.25	>100	>100	>100	0.31	129.20	23~Point 1
2009/10/21	10:28:16	Point 2	0.25	0.13	0.13	>100	>100	>100	0.28	144.60	24~Point 2
2009/10/21	10:58:05	Point 2	0.25	0.25	0.25	>100	>100	>100	0.28	132.10	25~Point 2
2009/10/21	11:04:25	Point 1	0.25	0.13	0.25	>100	>100	>100	0.31	130.30	26~Point 1
2009/10/21	11:32:08	Point 1	0.25	0.13	0.25	>100	>100	>100	0.31	127.90	27~Point 1
2009/10/21	12:11:19	Point 1	0.25	0.13	0.25	>100	>100	>100	0.31	129.60	28~Point 1
2009/10/21	12:13:22	Point 1	5.30	0.13	0.25	>100	>100	>100	0.36	132.60	29~Point 1
2009/10/22	09:03:52	Point 2	0.13	0.25	0.13	>100	>100	>100	0.31	128.90	30~Point 2

Explanation of 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-Freq:	Longitudinal, Transverse & Vertical dominate frequencies (Hz)
RPPV:	Resultant Peak Particle velocity (mm/s)
dB:	Peak Air blast Recorded (dB)
***:	Levels exceeded maximum range of unit

(Intentionally Left Open)

Figure 22: Baseline Study Results Summary

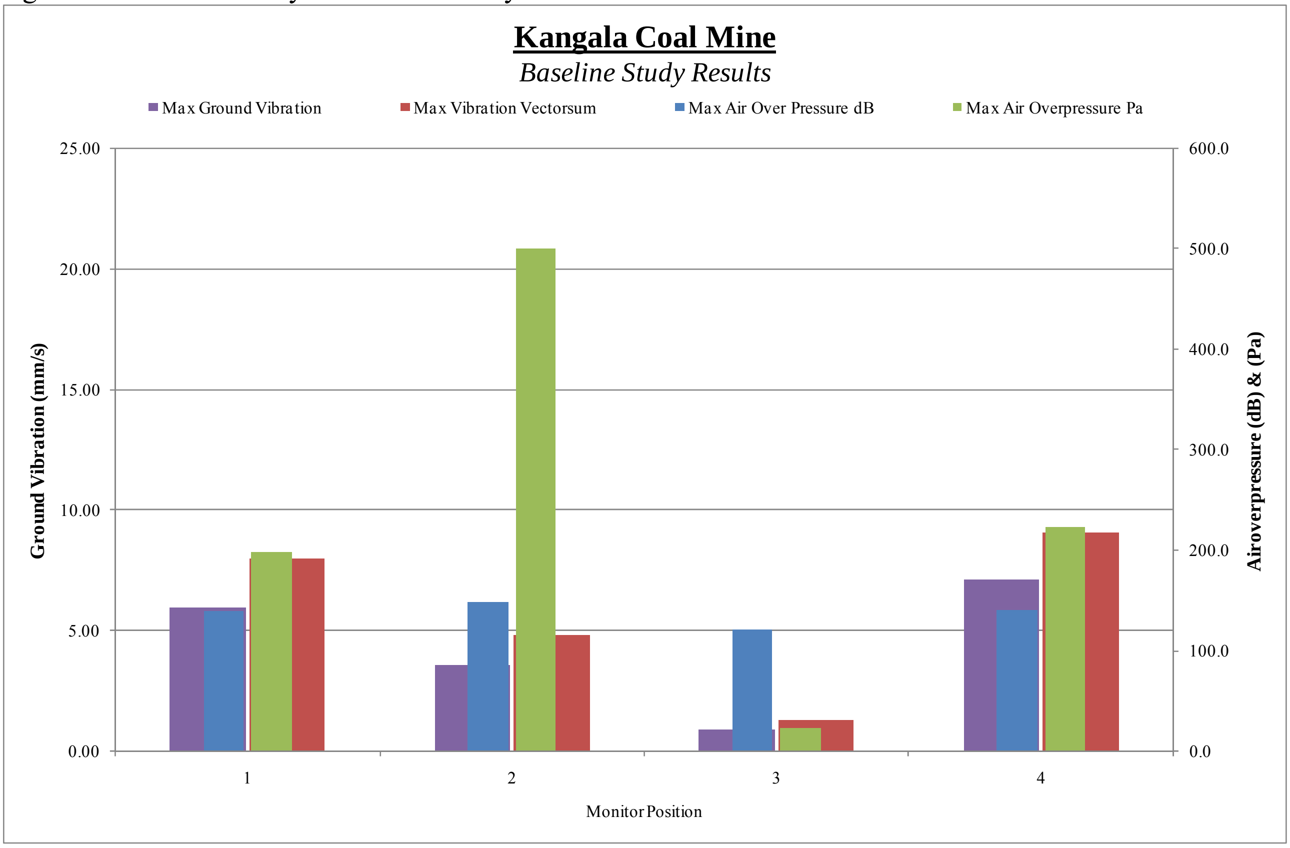


Figure 23: Graph of Results from Histogram Data

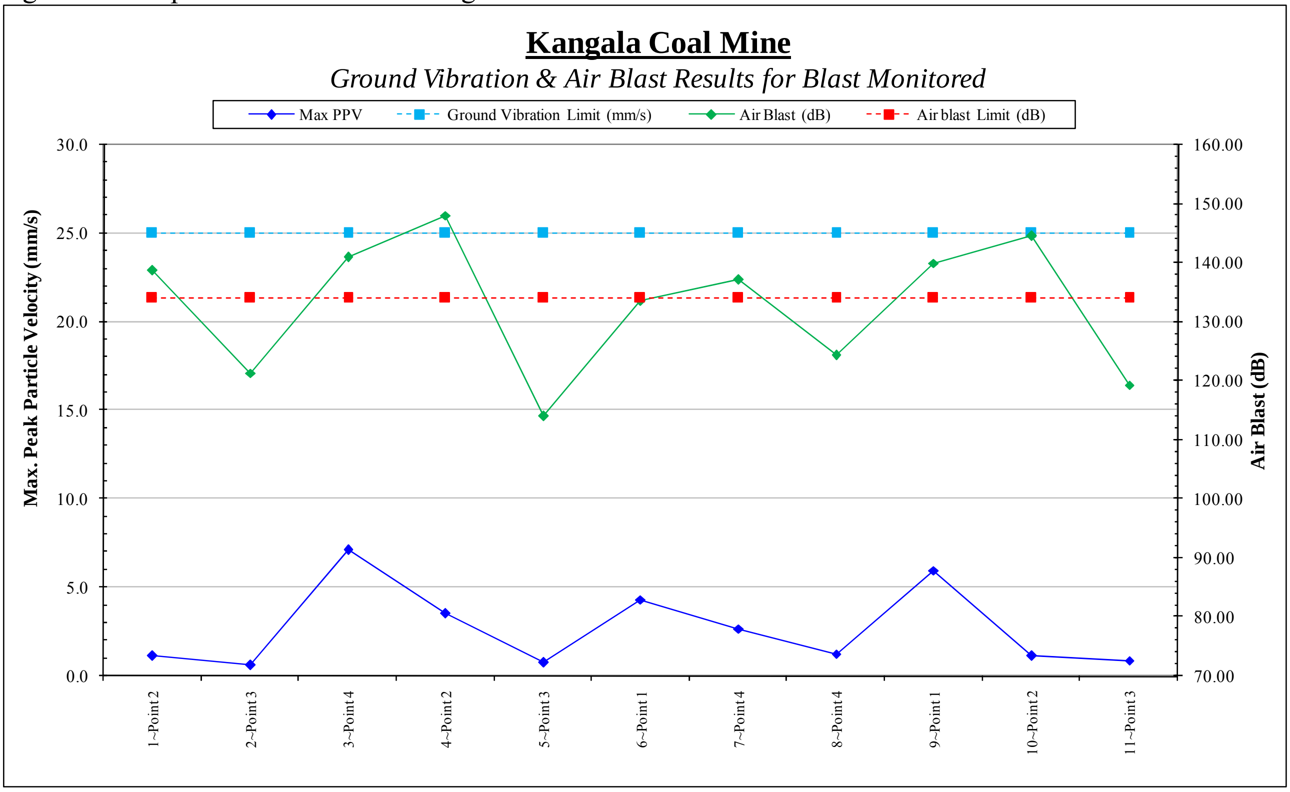
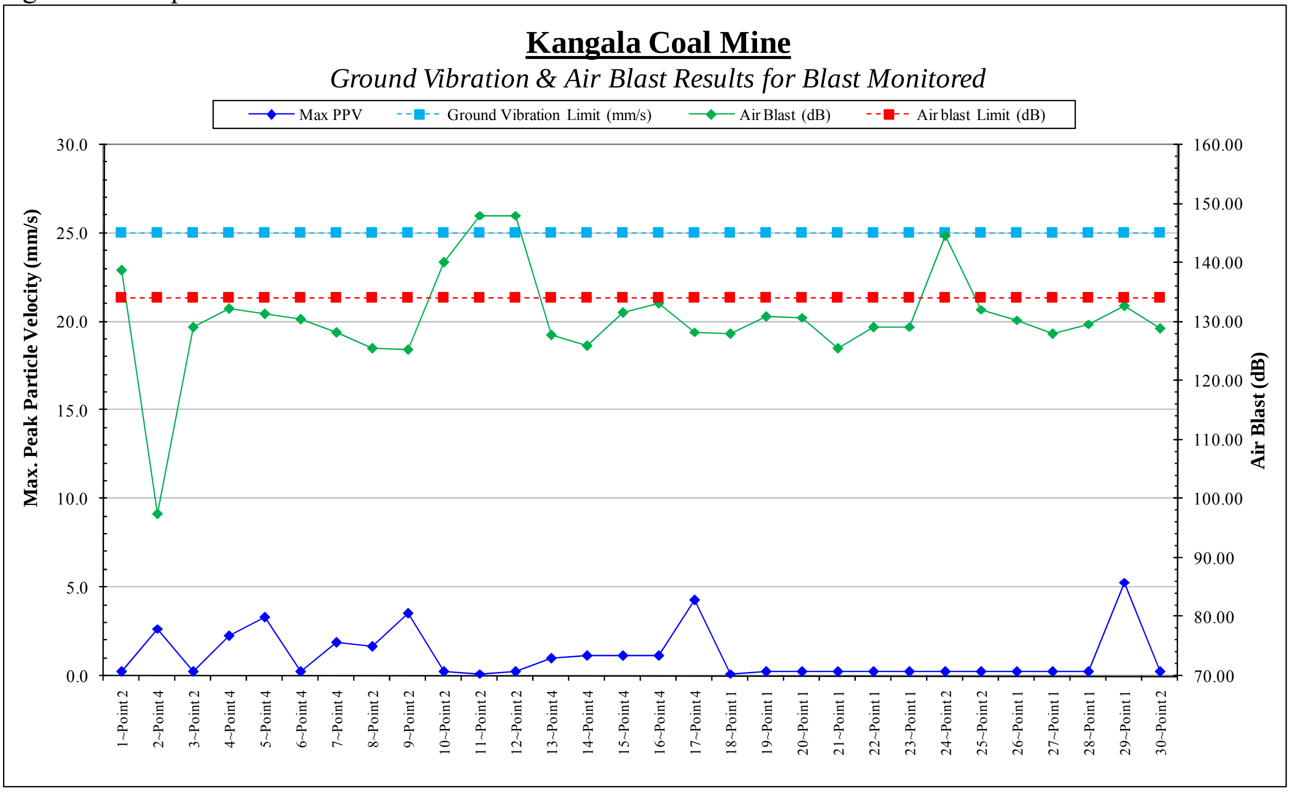


Figure 24: Graph of Individual Events Recorded



12.4 Discussion

Baseline recording of ground vibration and air blast was successfully conducted. Data recorded showed some areas more active than others. Air blast was more active on direct view of results. Thirty individual events were recorded at all the positions monitored; none of them were blast related. Review of the events showed data to be erroneous and no effects that are directly related to ground vibration or air blast due to blasting operations on surface or underground. Ground vibration levels were generally very low and of no significant value. Most of the ground vibration results observed is due to effect on system when approached for data downloading or stopping or people approaching the systems.

Various individual events were recorded as well. These events were analysed and found to be related to wind influence with no specific data that is related to possible effects on structures. The level values may look high but with no real value. Individual events recorded showed events that are associated with disturbance of the monitor in recording mode.

Histogram ground vibration recorded showed vector sum levels ranging between 1.28 and 9.08 mm/s. The average vector sum of all the data are between 0.2 and 0.3 mm/s. Air blast recorded ranged between 121.3 and 147.9 dB (L). The data is linear pressure data with no weighing. The highest air blast levels were recorded at Point 2 and the highest ground vibration at Point 03.

None of the points monitored showed actual ground vibration or air blast results. The maximum results recorded are that can be associated with activities around the systems. The results for the spikes observed are attributed to human action. The baseline clearly indicates no definite ground vibration or air blast that's active in the area surrounding the mine in the village area. This means that any additional influence to the area will be over and above the results recorded.

12.5 Baseline concluding notes

Baseline ground vibration and air blast study has been conducted. Results recorded and observed does not show any event that can be associated directly with blasting operations either on surface or underground. No specific influence has been observed. Various events were recorded but analyses of these showed events associated with natural or human disturbances at the systems. No blast was heard or observed during the recording time. Data clearly shows that no specific ground vibration or air blast / air overpressures exist in the area. This concludes this study with all recorded data presented with this report.

13. Knowledge Gaps

To the knowledge of the author there is no immediate concern with regards to shortfall in the information provided. More detailed mine plan may prove to be helpful for further mitigation of ground vibration and air blast. Considering the stage of the project, the data observed was sufficient to conduct an initial study. Surface surroundings change continuously and this should be taken into account prior to any final design and review of this report. This report is based on data provided and international accepted methods and methodology used for calculations and predictions.

14. Conclusion

The expected ground vibration and air blast levels from blasting operations required at the Kangala Coal, Wolvenfontein 244 IR, Portion 1and R/E of Portion 2 was calculated and considered in relation to the surrounding structures and installations. Some concerns were identified from review of the expected ground vibration and air blast levels. These concerns are however manageable and in no way such that blasting should be prohibited. The main concerns are related to distance between the mining area and the nearest structures. Expected levels of ground vibration and air blast are within the allowed limits but levels are such that it could be perceptible. This in turn may lead to complains and subsequent investigations. Considering the reduced charge modelled, this will have a decreased ground vibration effect and reduce the risk significantly. This is within the general safety limit of 25 mm/s. All the structures / installations were well within limits with no significant effect. Mitigation in reducing the maximum charge mass per delay and design of blasts in the area will assist to control the ground vibration.

Air blast levels reviewed showed no direct concern with regards to damage to structures, but did indicate that mitigation of the ground vibration will also bring about reduced air blast levels. The air blast is within accepted norm of 134dB when people are considered. The levels observed for some of the broilers may be problematic and will certainly require mitigation. Strict controls will need to be imposed as well on surface initiation of any explosive as this will immediately induce undesirable effects into the surroundings. Reduced charges and control on stemming will be assisting in reducing the possibilities of complaints from home owners.

This report summarises the evaluation of expected effects from blasting operations in the new Wolvenfontein 244 IR project. It is concluded that blasting will be possible but careful consideration should also be given to the recommendations made.

15. Curriculum Vitae of Author

Author joined Permanent Force at the SA Ammunition Core for period Jan 1983 - Jan 1990. During this period I was involved in testing at SANDF Ammunition Depots and Proofing ranges. Work entailed munitions maintenance, proofing and lot acceptance of ammunition. For the period Jul 1992 - Des 1995 Worked at AECI Explosives Ltd. Initially I was involved in testing science on small scale laboratory work and large scale field work. Later on work entailed managing various testing facilities and testing projects. Due to the restructuring of Technical Department I was retrenched but fortunately could take up appointment with AECI Explosives Ltd’s Pumpable Emulsion explosives group for underground applications. December 1995 to June 1997 I gave technical support to the Underground Bulk Systems Technology business unit and performed project management on new products. I started Blast Management & Consulting in June 1997. Main areas of concern were Pre-blast monitoring, Insitu monitoring, Post blast monitoring and specialized projects.

I have obtained the following Qualifications:

1985 - 1987	Diploma: Explosives Technology, Technikon Pretoria
1990 - 1992	BA Degree, University Of Pretoria
1994	National Higher Diploma: Explosives Technology, Technikon Pretoria
1997	Project Management Certificate: Damelin College
2000	Advanced Certificate in Blasting, Technikon SA

Member: International Society of Explosives Engineers

Blast Management & Consulting has been active in the mining industry since 1997 and work has been on various levels for all the major mining companies in South Africa. Some of the projects where BM&C has been involved are:

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

BM&C have installed a World class calibration facility for seismographs, which is accredited by Instantel, Ontario Canada as an accredited Instantel facility. The projects describe and discussed here are only part of the capability and professional work that is done by BM&C.

16. References

- Siskind, D.E., V.J. Stachura, M.S. Stagg and J.W. Kopp, 1980a. Structure Response and Damage Produced by Air blast From Surface Mining. US Bureau of Mines RI 8485.
- Persson, P. A., R. Holmberg and J. Lee, 1994, Rock Blasting and Explosives Engineering, Boca Raton, Florida: CRC Press.
- Scott, A., Open Pit Blast Design, 1996, Julius Kruttschnitt Mineral Research Centre, The University of Queensland.
- Client Report: Air Overpressure from Le Maitre Flash Report: Dr R. Farnfield, Technical Services Manager, Dated: 27 April 2007.
- Chiapetta, F., A Van Vreden, 2000. Vibration/Air blast Controls, Damage Criteria, Record Keeping and Dealing with Complaints. 9th Annual BME Conference on Explosives, Drilling and Blasting Technology, CSIR Conference Centre, Pretoria, 2000.
- Dowding, C.H., Construction Vibrations, 1996, Prentice Hall, Upper Saddle River, NJ 07458.
- Mechanical vibration and shock – Vibration of buildings – Guidelines for the measurement and evaluation of their effects on buildings, SABS ISO 4886:1990.

Appendix I: All Original File Histogram Data Results

Blast Management & Consulting

Histogram Start Time	08:44:53 September 6, 1995	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	07:53:53 September 7, 1995	Battery Level	6.0 Volts
Number of Intervals	41670 at 2 seconds	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I7495KMW.AT0
Sample Rate	1024sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

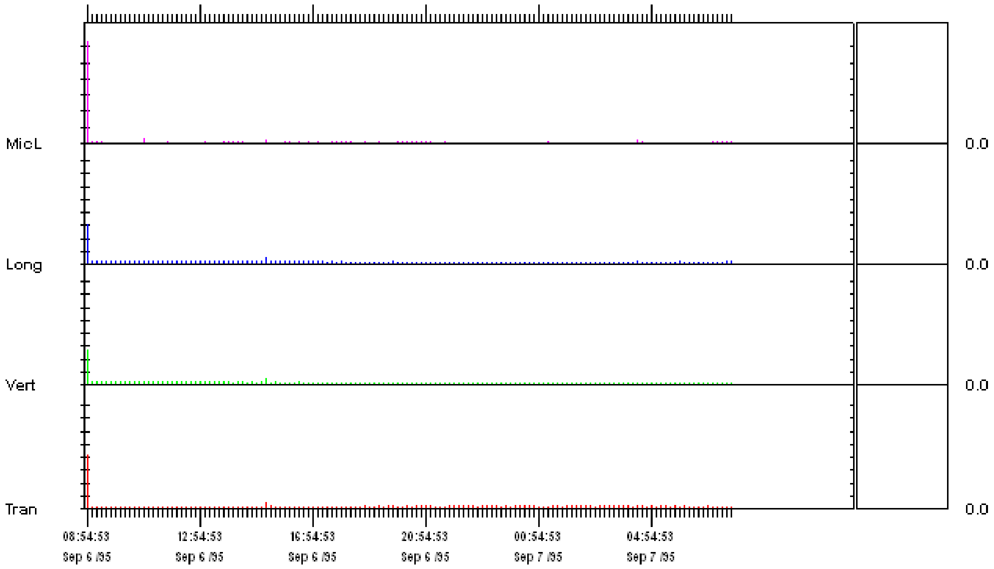
Post Event Notes

Microphone Linear Weighting
PSPL 136.0 dB(L) 126 pa.(L) on September 6, 1995 at 08:44:55
ZC Freq 85 Hz
Channel Test Passed (Freq = 20.5 Hz Amp = 656 mv)

	Tran	Vert	Long	
PPV	4.19	2.67	3.05	mm/s
ZC Freq	73	>100	>100	Hz
Date	Sep 6 /95	Sep 6 /95	Sep 6 /95	
Time	08:44:55	08:44:55	08:44:55	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.3	7.6	7.3	Hz
Overswing Ratio	3.9	3.4	4.0	

Peak Vector Sum 4.74 mm/s on September 6, 1995 at 08:44:55

Monitor Log
Sep 6 /95 08:44:52 Sep 7 /95 07:53:53 Event recorded. (Memory Full Exit)



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Histogram Start Time	08:26:32 October 19, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Histogram Finish Time	07:35:32 October 20, 2009	Battery Level	5.9 Volts (Battery Low)
Number of Intervals	41670 at 2 seconds	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CXWV.G80
Sample Rate	1024sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

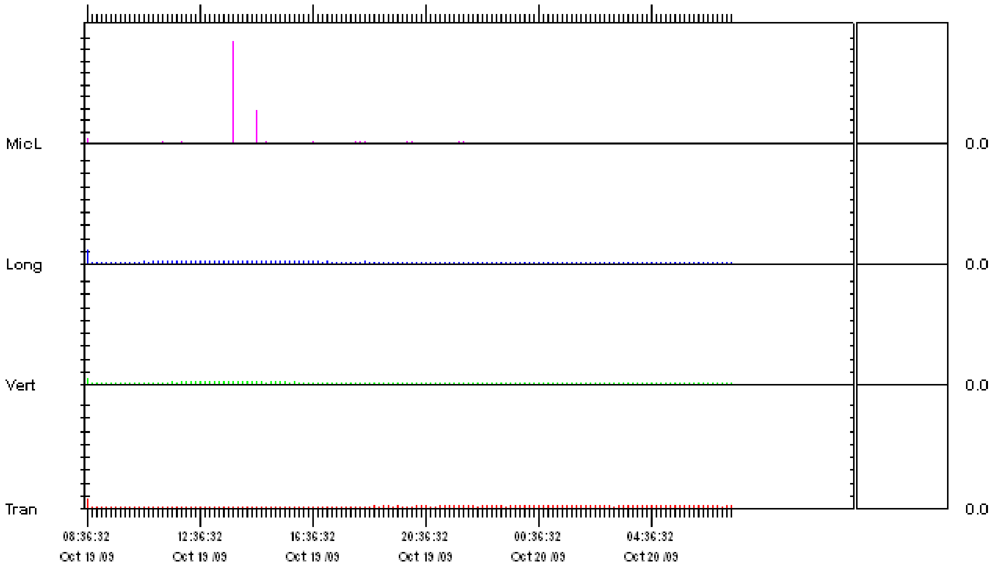
Post Event Notes

Microphone Linear Weighting
PSPL 138.7 dB(L) 173 pa.(L) on October 19, 2009 at 13:38:04
ZC Freq <1.0 Hz
Channel Test Passed (Freq = 20.5 Hz Amp = 682 mv)

	Tran	Vert	Long	
PPV	0.762	0.508	1.14	mm/s
ZC Freq	>100	>100	>100	Hz
Date	Oct 19 /09	Oct 19 /09	Oct 19 /09	
Time	08:26:34	08:26:34	08:29:20	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.6	7.4	7.7	Hz
Overswing Ratio	3.8	3.7	3.8	

Peak Vector Sum 1.31 mm/s on October 19, 2009 at 08:29:20

Monitor Log
Oct 19 /09 08:26:31 Oct 20 /09 07:35:32 Event recorded. (Memory Full Exit)



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12) Format Copyrighted 2006-2007 Instantel, a division of VeriChip Corporation

Instantel **Blast Management & Consulting**

Histogram Start Time	08:53:34 October 19, 2009	Serial Number	BE13079 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	08:02:34 October 20, 2009	Battery Level	6.0 Volts
Number of Intervals	41670 at 2 seconds	Calibration	January 2, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O079CXWW.PA0
Sample Rate	1024sps		

Notes
Location: Point 3
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

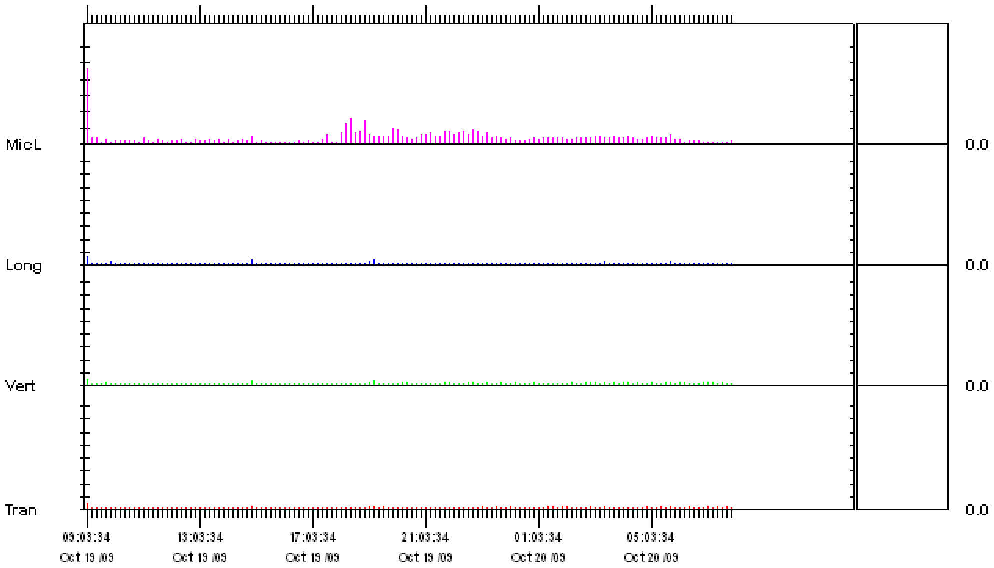
Post Event Notes

Microphone Linear Weighting
PSPL 121.3 dB(L) 23.3 pa.(L) on October 19, 2009 at 08:53:54
ZC Freq 64 Hz
Channel Test Passed (Freq = 20.1 Hz Amp = 567 mv)

	Tran	Vert	Long	
PPV	0.508	0.508	0.635	mm/s
ZC Freq	>100	>100	>100	Hz
Date	Oct 19 /09	Oct 19 /09	Oct 19 /09	
Time	08:53:54	08:53:54	08:53:54	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.3	7.5	7.4	Hz
Overswing Ratio	3.8	3.6	4.0	

Peak Vector Sum 0.730 mm/s on October 19, 2009 at 08:53:54

Monitor Log
Oct 19 /09 08:53:33 Oct 20 /09 08:02:34 Event recorded. (Memory Full Exit)



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 5.00 pa.(L)/div Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Histogram Start Time	11:28:58 October 19, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	10:37:58 October 20, 2009	Battery Level	6.1 Volts
Number of Intervals	41670 at 2 seconds	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXX3.WA0
Sample Rate	1024sps		

Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

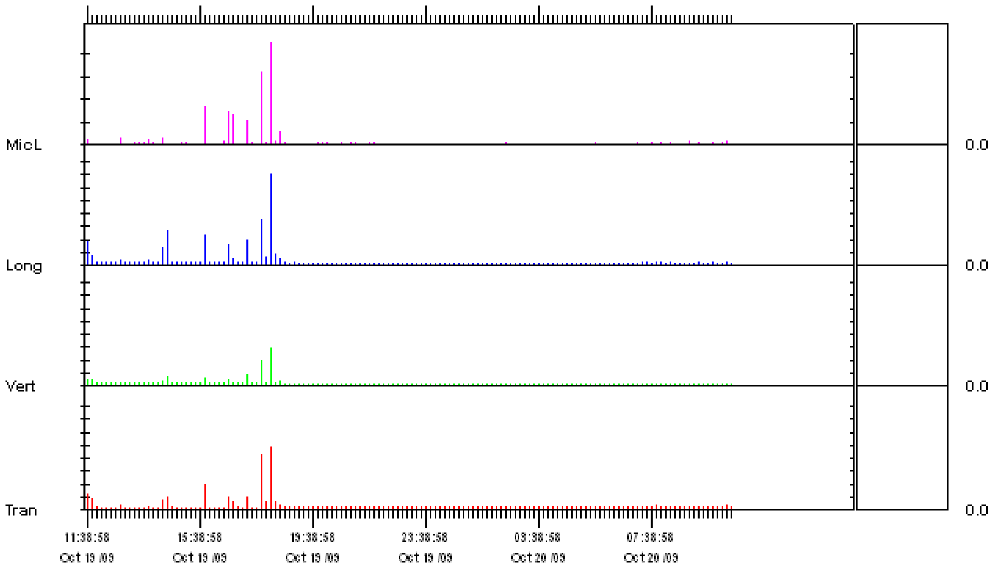
Post Event Notes

Microphone Linear Weighting
PSPL 140.9 dB(L) 223 pa.(L) on October 19, 2009 at 18:08:58
ZC Freq 85 Hz
Channel Test Check (Freq = 0.0 Hz Amp = 0 mv)

	Tran	Vert	Long	
PPV	4.83	2.92	7.11	mm/s
ZC Freq	>100	>100	>100	Hz
Date	Oct 19 /09	Oct 19 /09	Oct 19 /09	
Time	18:08:58	18:08:58	18:08:58	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.4	7.7	7.4	Hz
Overswing Ratio	3.6	3.4	3.8	

Peak Vector Sum 7.84 mm/s on October 19, 2009 at 18:08:58

Monitor Log
Oct 19 /09 11:28:57 Oct 20 /09 10:37:58 Event recorded. (Memory Full Exit)



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 50.0 pa.(L)/div Sensorcheck

Blast Management & Consulting

Histogram Start Time	11:07:41 October 20, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Histogram Finish Time	10:12:24 October 21, 2009	Battery Level	6.6 Volts
Number of Intervals	41541 at 2 seconds	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CXYX.KT0
Sample Rate	1024sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

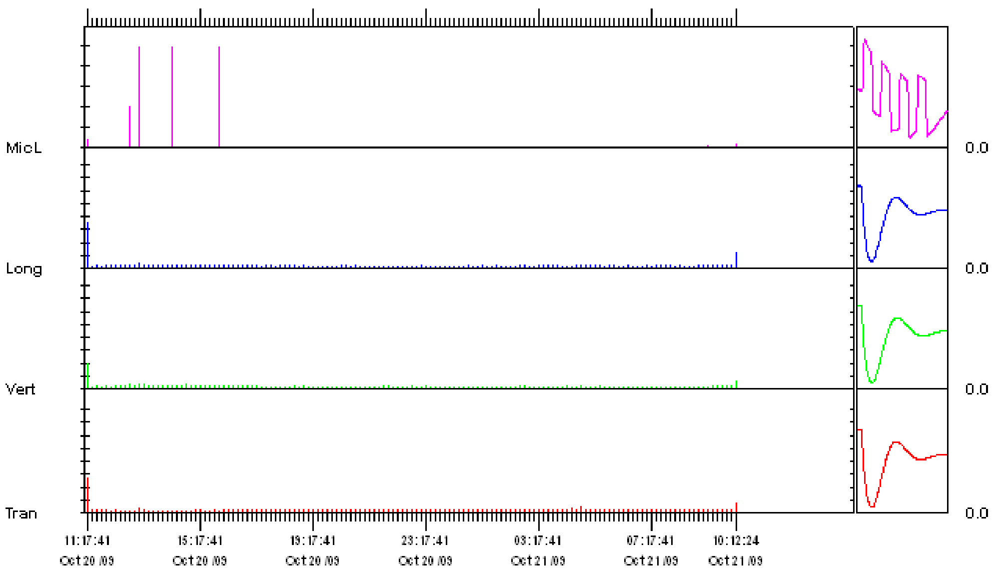
Post Event Notes

Microphone	Linear Weighting
PSPL	*** dB(L) on October 20, 2009 at 12:57:57
ZC Freq	1.6 Hz
Channel Test	Passed (Freq = 20.5 Hz Amp = 660 mv)

	Tran	Vert	Long	
PPV	2.67	1.90	3.56	mm/s
ZC Freq	>100	>100	57	Hz
Date	Oct 20 /09	Oct 20 /09	Oct 20 /09	
Time	11:08:09	11:08:09	11:08:09	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.6	7.4	7.6	Hz
Overswing Ratio	3.7	3.7	3.8	

Peak Vector Sum 4.62 mm/s on October 20, 2009 at 11:08:09

*** : Out of Range



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 100.0 pa.(L)/div Sensorcheck

Blast Management & Consulting

Histogram Start Time	11:34:25 October 20, 2009	Serial Number	BE13079 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	10:36:56 October 21, 2009	Battery Level	6.6 Volts
Number of Intervals	41475 at 2 seconds	Calibration	January 2, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O079CXYY.TD0
Sample Rate	1024sps		

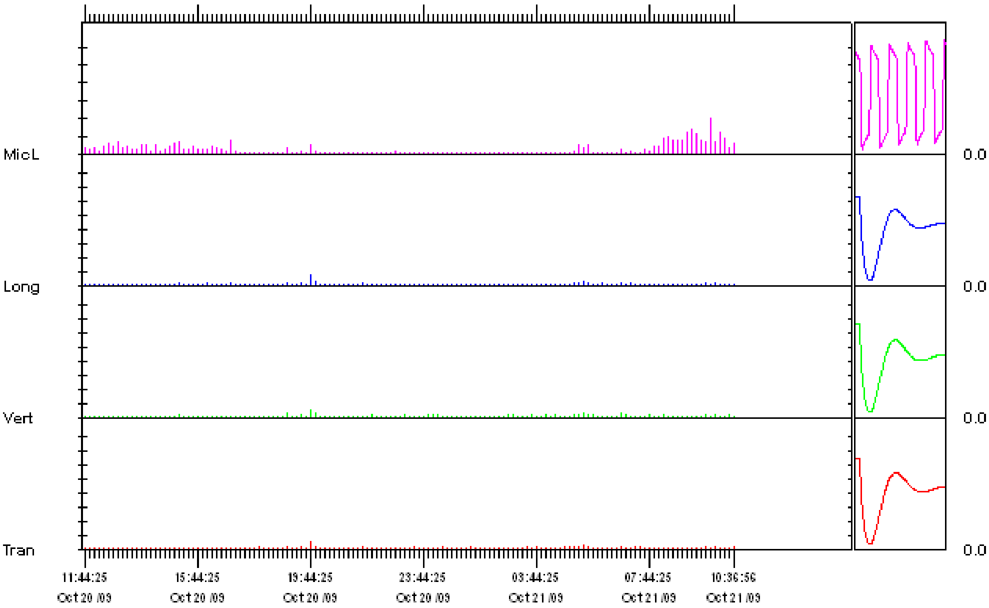
Notes
Location: Point 3
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting
PSPL 114.0 dB(L) 10.0 pa.(L) on October 21, 2009 at 09:50:45
ZC Freq 30 Hz
Channel Test Passed (Freq = 20.1 Hz Amp = 438 mv)

	Tran	Vert	Long	
PPV	0.508	0.508	0.762	mm/s
ZC Freq	57	73	57	Hz
Date	Oct 20 /09	Oct 20 /09	Oct 20 /09	
Time	19:40:07	19:40:07	19:40:07	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.3	7.5	7.4	Hz
Overswing Ratio	3.8	3.5	3.9	

Peak Vector Sum 0.783 mm/s on October 20, 2009 at 19:40:07



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 5.00 pa.(L)/div Sensorcheck

Blast Management & Consulting

Histogram Start Time	11:58:54 October 20, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	09:52:33 October 21, 2009	Battery Level	6.6 Volts
Number of Intervals	39409 at 2 seconds	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CXYZ.Y60
Sample Rate	1024sps		

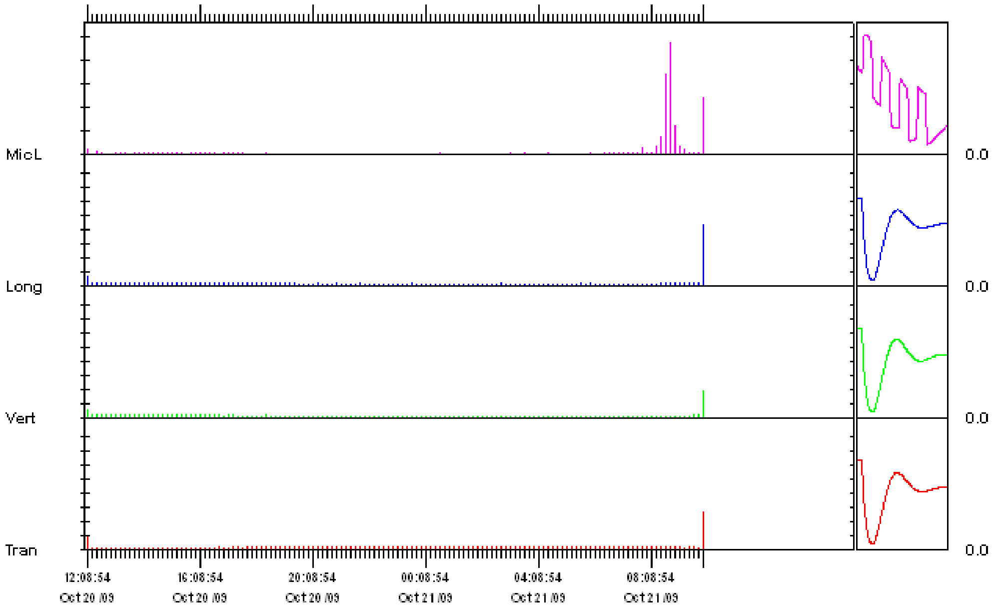
Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting
PSPL 133.5 dB(L) 95.0 pa.(L) on October 21, 2009 at 08:42:24
ZC Freq 1.6 Hz
Channel Test Passed (Freq = 20.5 Hz Amp = 531 mv)

	Tran	Vert	Long	
PPV	2.67	1.90	4.32	mm/s
ZC Freq	>100	>100	>100	Hz
Date	Oct 21 /09	Oct 21 /09	Oct 21 /09	
Time	09:52:18	09:52:18	09:52:18	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.4	7.6	7.3	Hz
Overswing Ratio	3.8	3.4	4.0	

Peak Vector Sum 4.72 mm/s on October 21, 2009 at 09:52:18



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Histogram Start Time	12:22:49 October 20, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	09:26:27 October 21, 2009	Battery Level	6.6 Volts
Number of Intervals	37909 at 2 seconds	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXZ1.210
Sample Rate	1024sps		

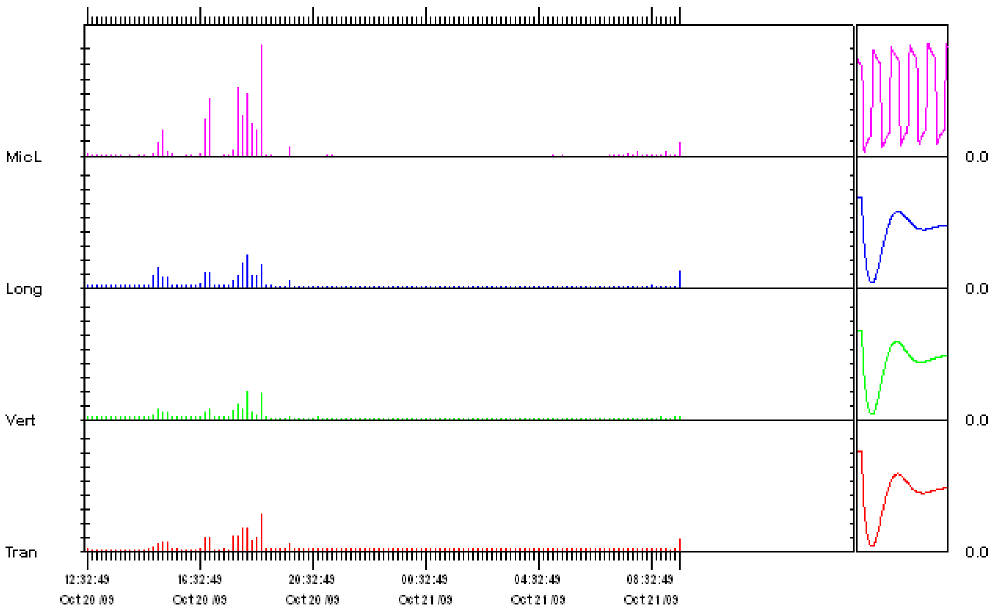
Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting
PSPL 137.1 dB(L) 144 pa.(L) on October 20, 2009 at 18:32:55
ZC Freq 73 Hz
Channel Test Passed (Freq = 20.1 Hz Amp = 432 mv)

	Tran	Vert	Long	
PPV	2.67	2.03	2.29	mm/s
ZC Freq	>100	>100	>100	Hz
Date	Oct 20 /09	Oct 20 /09	Oct 20 /09	
Time	18:32:55	18:03:17	18:03:17	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.4	7.6	7.3	Hz
Overswing Ratio	3.6	3.4	3.8	

Peak Vector Sum 2.79 mm/s on October 20, 2009 at 18:32:55



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck

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Blast Management & Consulting

Histogram Start Time	09:38:58 October 21, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	08:47:58 October 22, 2009	Battery Level	6.6 Volts
Number of Intervals	41670 at 2 seconds	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CY0O.4Y0
Sample Rate	1024sps		

Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

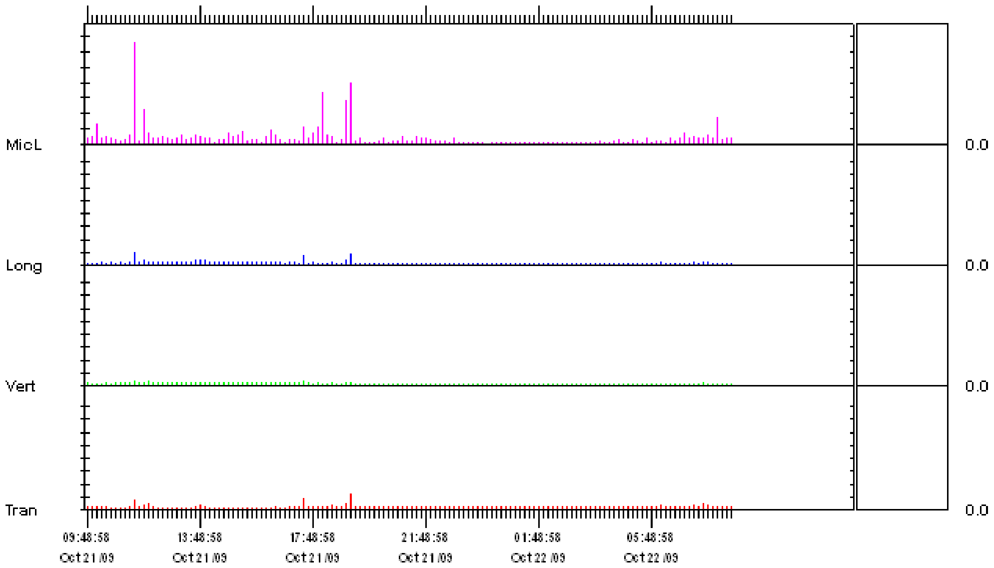
Post Event Notes

Microphone Linear Weighting
PSPL 124.3 dB(L) 32.8 pa.(L) on October 21, 2009 at 11:25:08
ZC Freq 73 Hz
Channel Test Passed (Freq = 20.1 Hz Amp = 500 mv)

	Tran	Vert	Long	
PPV	1.27	0.381	1.02	mm/s
ZC Freq	>100	64	>100	Hz
Date	Oct 21 /09	Oct 21 /09	Oct 21 /09	
Time	19:06:06	11:25:08	11:25:08	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.4	7.7	7.4	Hz
Overswing Ratio	3.6	3.4	3.7	

Peak Vector Sum 1.47 mm/s on October 21, 2009 at 19:06:06

Monitor Log
Oct 21 /09 09:38:57 Oct 22 /09 08:47:58 Event recorded. (Memory Full Exit)



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 5.00 pa.(L)/div Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Histogram Start Time	10:04:25 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	09:06:46 October 22, 2009	Battery Level	6.7 Volts
Number of Intervals	41470 at 2 seconds	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0P.BD0
Sample Rate	1024sps		

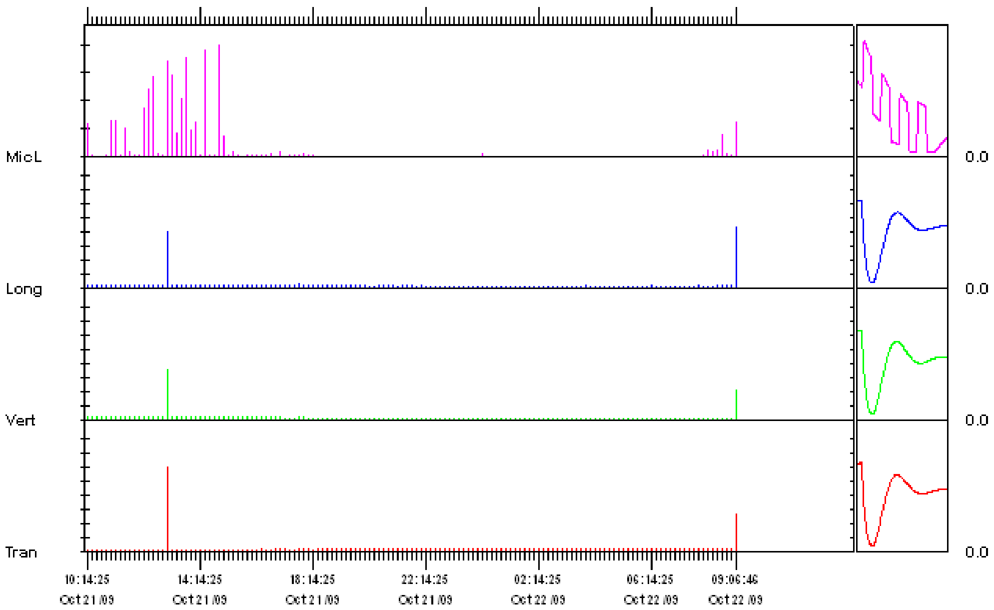
Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting
PSPL 139.9 dB(L) 199 pa.(L) on October 21, 2009 at 14:46:13
ZC Freq 1.7 Hz
Channel Test Passed (Freq = 20.5 Hz Amp = 584 mv)

	Tran	Vert	Long	
PPV	5.97	3.56	4.32	mm/s
ZC Freq	>100	>100	>100	Hz
Date	Oct 21 /09	Oct 21 /09	Oct 22 /09	
Time	12:57:15	12:57:15	09:06:39	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.4	7.6	7.3	Hz
Overswing Ratio	3.8	3.4	4.0	

Peak Vector Sum 6.83 mm/s on October 21, 2009 at 12:57:15



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 50.0 pa.(L)/div Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Histogram Start Time	10:24:00 October 21, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Histogram Finish Time	09:15:35 October 22, 2009	Battery Level	6.7 Volts
Number of Intervals	41147 at 2 seconds	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CY0Q.800
Sample Rate	1024sps		

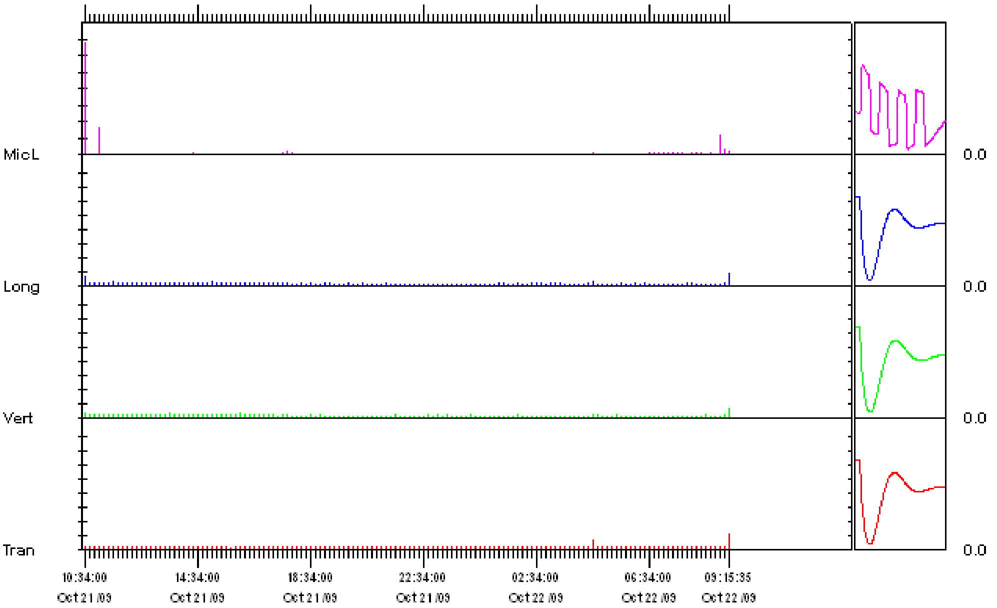
Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting
PSPL 144.6 dB(L) 340 pa.(L) on October 21, 2009 at 10:28:18
ZC Freq <1.0 Hz
Channel Test Passed (Freq = 20.5 Hz Amp = 650 mv)

	Tran	Vert	Long	
PPV	1.14	0.635	0.889	mm/s
ZC Freq	>100	>100	>100	Hz
Date	Oct 22 /09	Oct 22 /09	Oct 22 /09	
Time	09:15:30	09:15:26	09:15:26	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.5	7.4	7.6	Hz
Overswing Ratio	3.8	3.7	3.7	

Peak Vector Sum 1.36 mm/s on October 22, 2009 at 09:15:30



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 50.0 pa.(L)/div Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Histogram Start Time	10:48:45 October 21, 2009	Serial Number	BE13079 V 8.12-8.0 MiniMate Plus
Histogram Finish Time	09:39:20 October 22, 2009	Battery Level	6.6 Volts
Number of Intervals	41117 at 2 seconds	Calibration	January 2, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O079CY0R.D90
Sample Rate	1024sps		

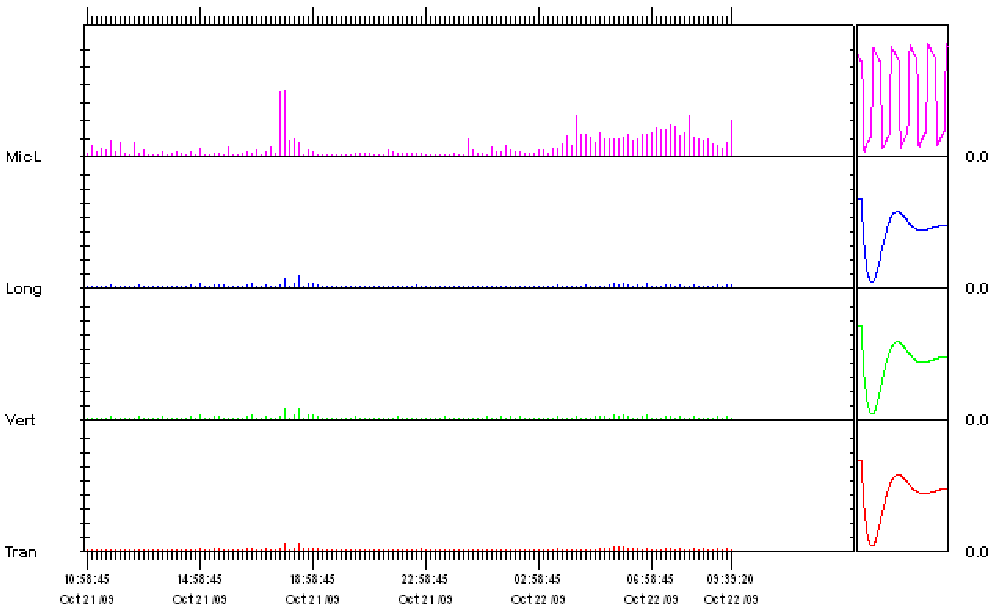
Notes
Location: Point 3
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting
PSPL 119.3 dB(L) 18.5 pa.(L) on October 21, 2009 at 17:52:09
ZC Freq 51 Hz
Channel Test Passed (Freq = 20.5 Hz Amp = 493 mv)

	Tran	Vert	Long	
PPV	0.508	0.762	0.889	mm/s
ZC Freq	57	57	64	Hz
Date	Oct 21 /09	Oct 21 /09	Oct 21 /09	
Time	17:48:47	17:48:47	18:27:11	
Sensorcheck	Passed	Passed	Passed	
Frequency	7.3	7.5	7.5	Hz
Overswing Ratio	3.8	3.5	3.9	

Peak Vector Sum 0.898 mm/s on October 21, 2009 at 17:48:47



Time Scale: 10 minutes /div Amplitude Scale: Geo: 1.000 mm/s/div Mic: 5.00 pa.(L)/div Sensorcheck

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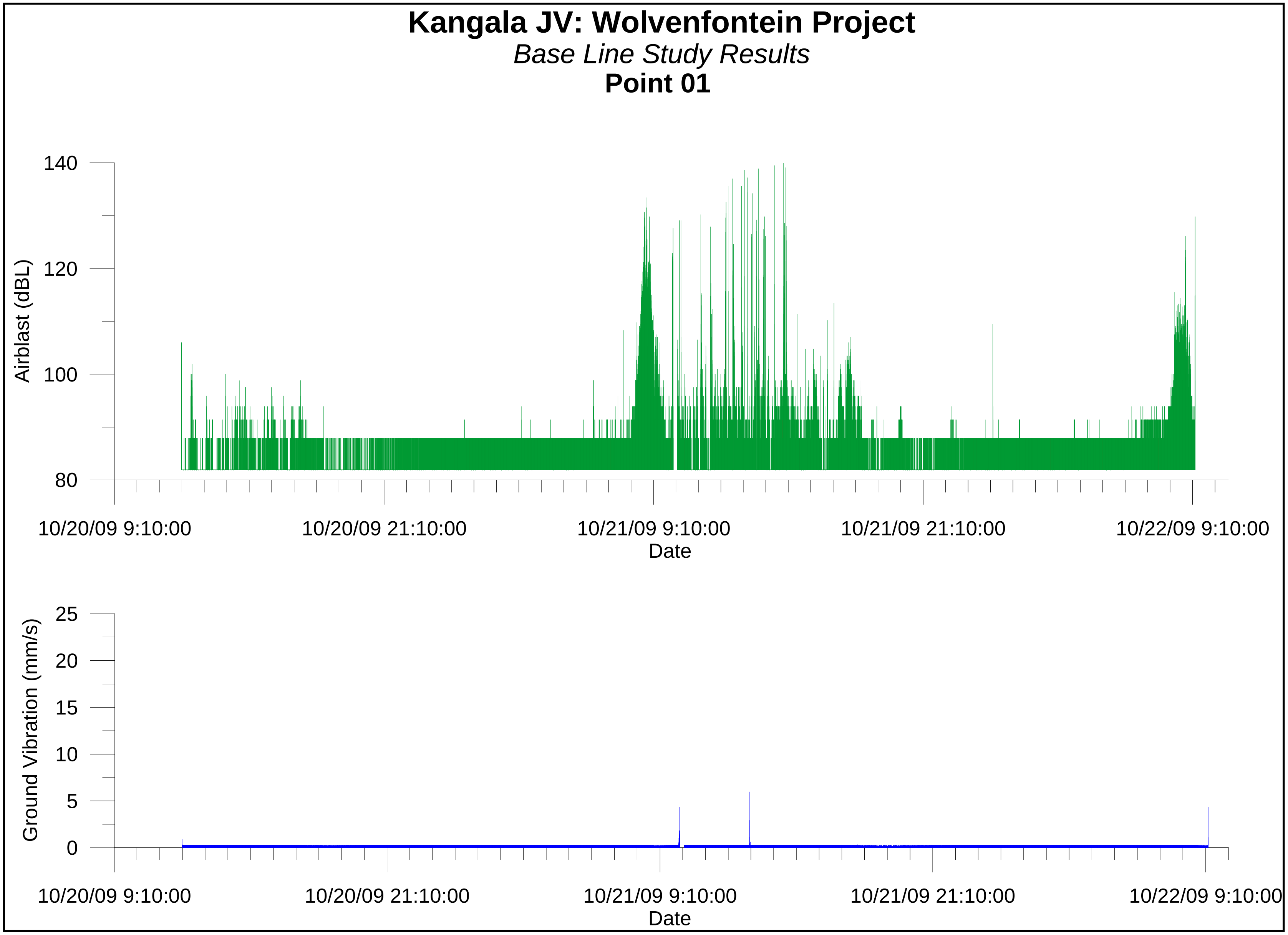
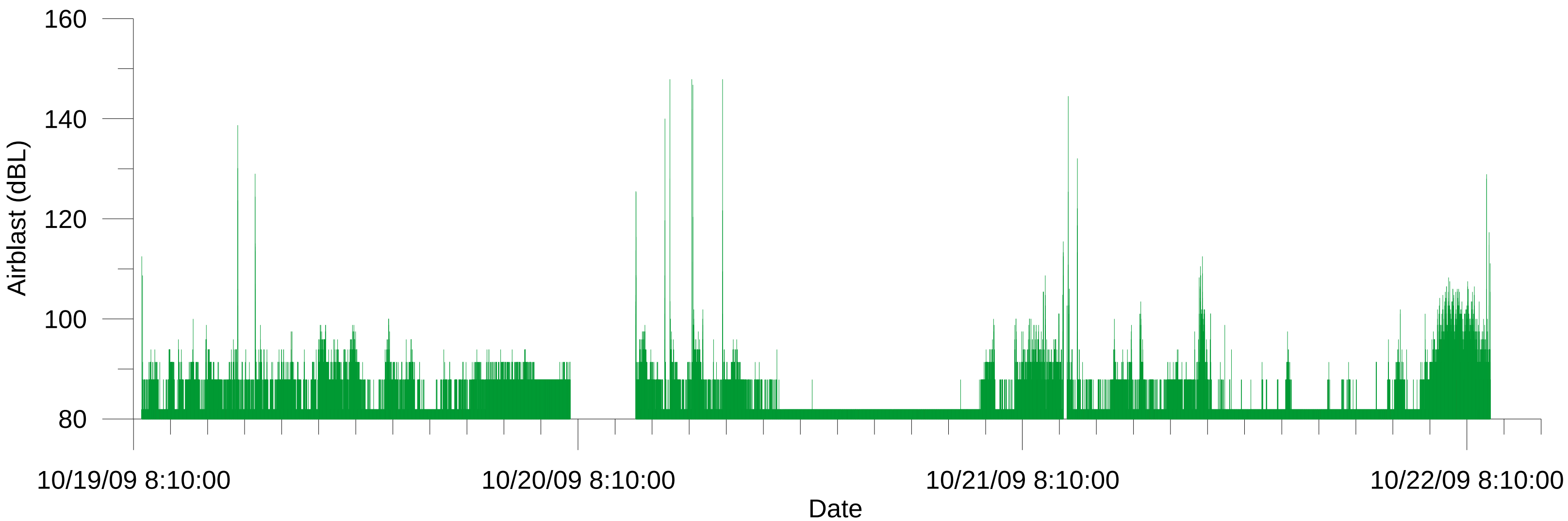
Appendix II: All Graphed Histogram Results using Alternative Software

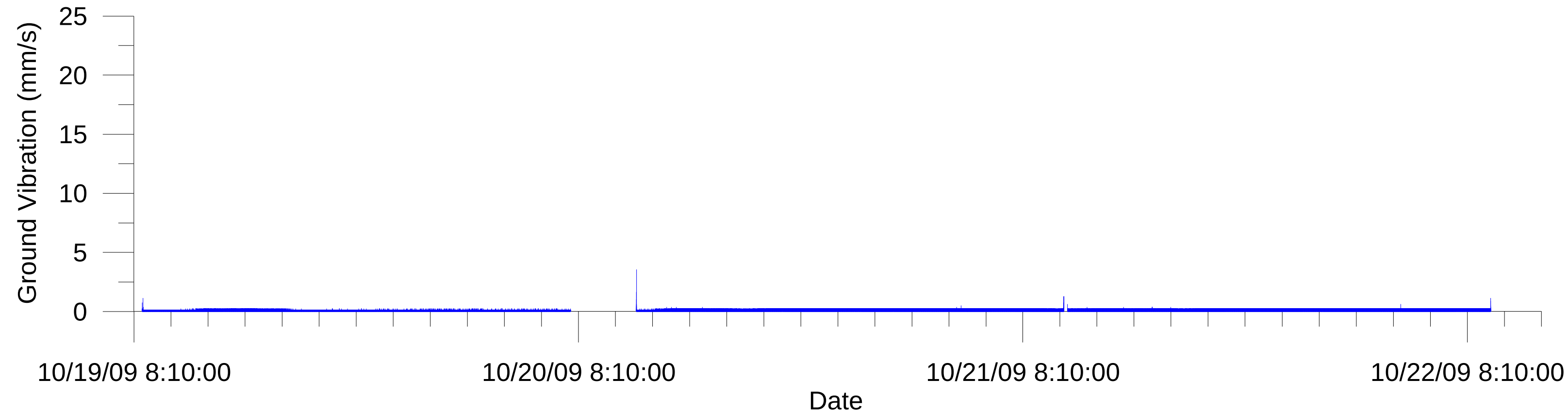

Kangala JV: Wolvenfontein Project
Base Line Study Results
Point 01
Airblast (dBL)
140
120
100
80
10/20/09 9:10:00
10/20/09 21:10:00
10/21/09 9:10:00
10/21/09 21:10:00
10/22/09 9:10:00
Date
Ground Vibration (mm/s)
25
20
15
10
5
0
10/20/09 9:10:00
10/20/09 21:10:00
10/21/09 9:10:00
10/21/09 21:10:00
10/22/09 9:10:00
Date

Kangala JV: Wolvenfontein Project

Base Line Study Results

Point 02

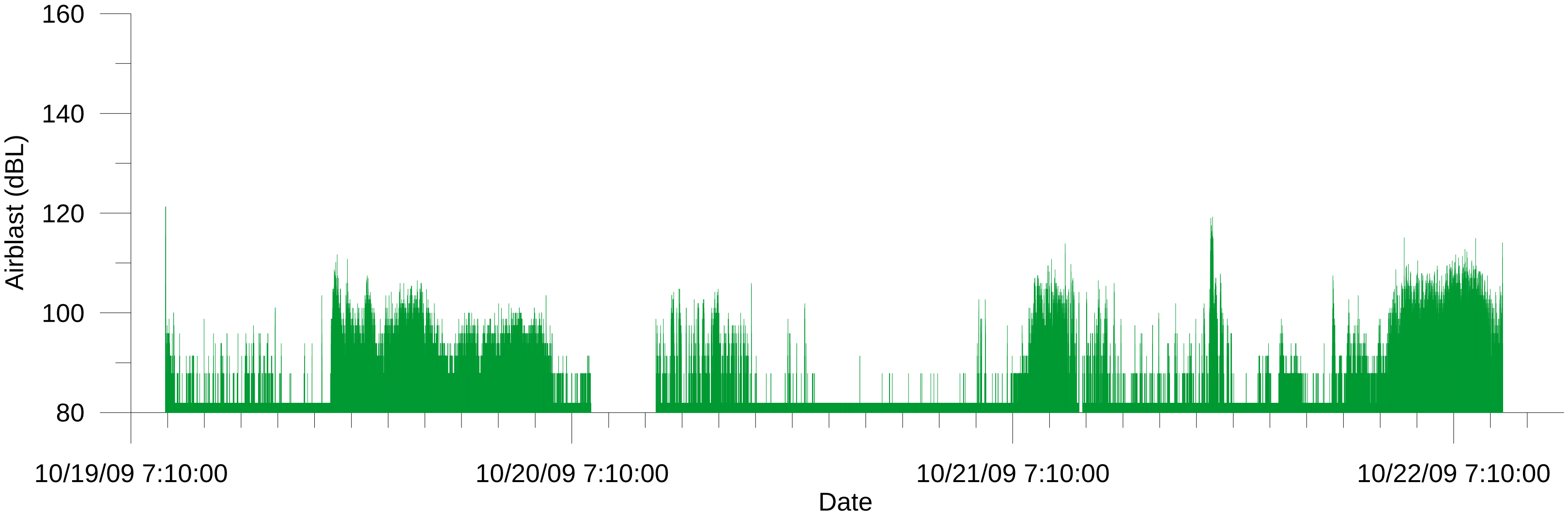


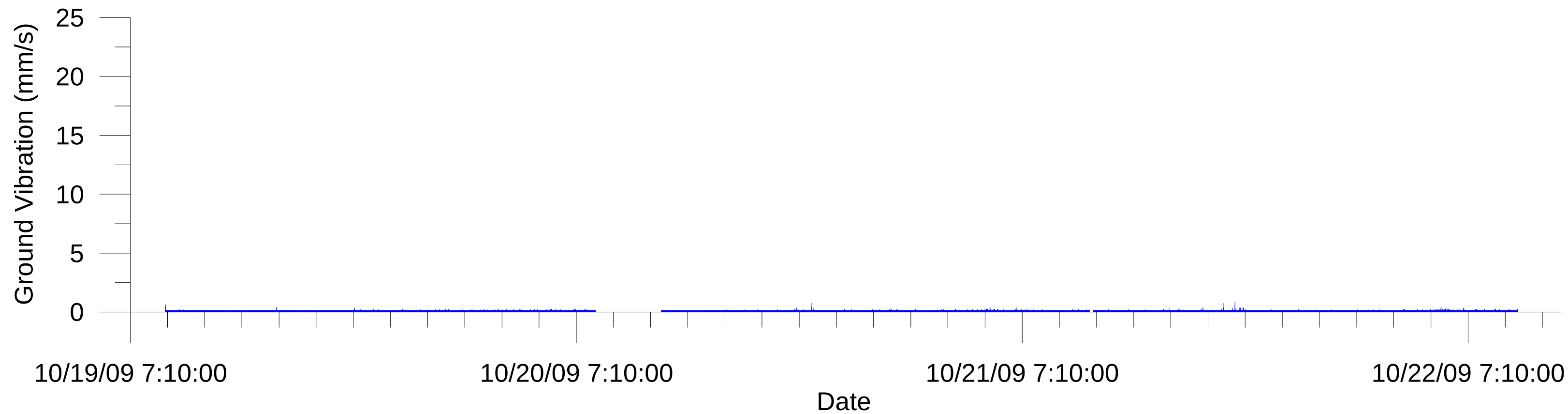


Kangala JV: Wolvenfontein Project

Base Line Study Results

Point 03

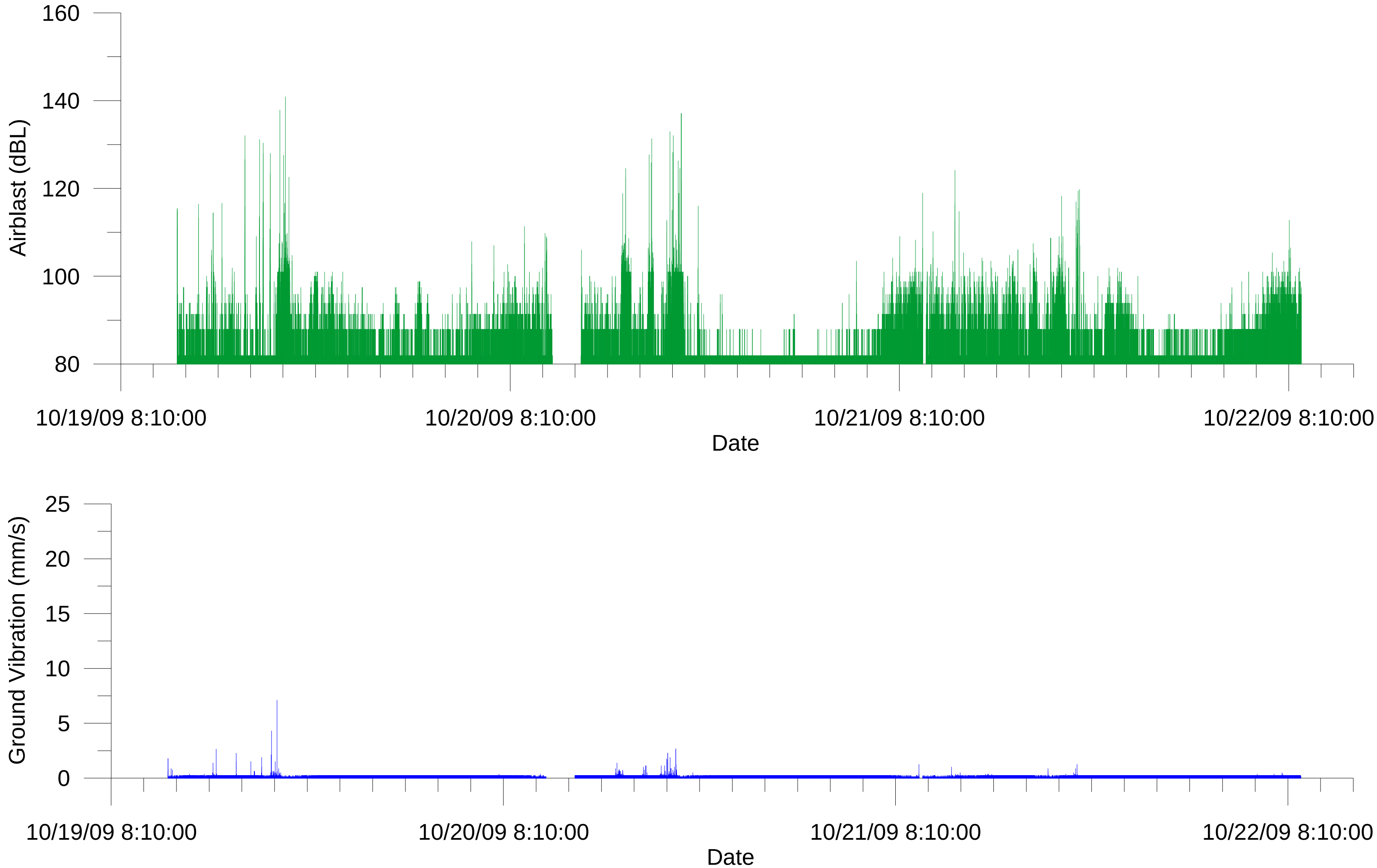




Kangala JV: Wolvenfontein Project

Base Line Study Results

Point 04



Appendix III: All Events Reports for Individual Events Recorded

Blast Management & Consulting

Date/Time	MicL at 13:38:02 October 19, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.1 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CXX9.VE0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

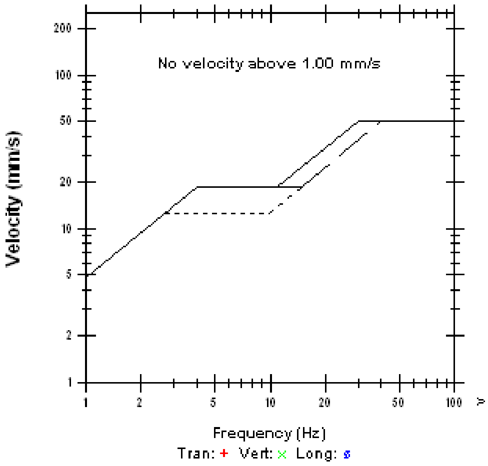
Microphone Linear Weighting
PSPL 138.7 dB(L) 173 pa.(L) at 0.469 sec
ZC Freq N/A
Channel Test Disabled

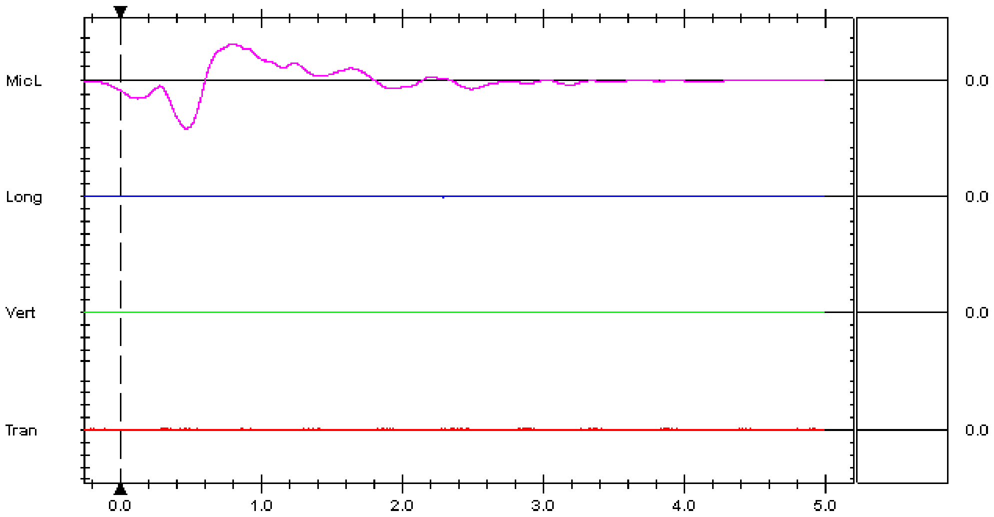
	Tran	Vert	Long	
PPV	0.127	0.127	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.201	-0.248	2.295	sec
Peak Acceleration	0.0133	0.0133	0.0133	g
Peak Displacement	0.0	0.0	0.00012	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.254 mm/s at 2.295 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 50.0 pa.(L)/div
Trigger = ▶— —◀

Sensorcheck

Blast Management & Consulting

Date/Time	Long at 14:26:05 October 19, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.3 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXXC.3H0
Record Time	5.0 sec at 1024 sps		

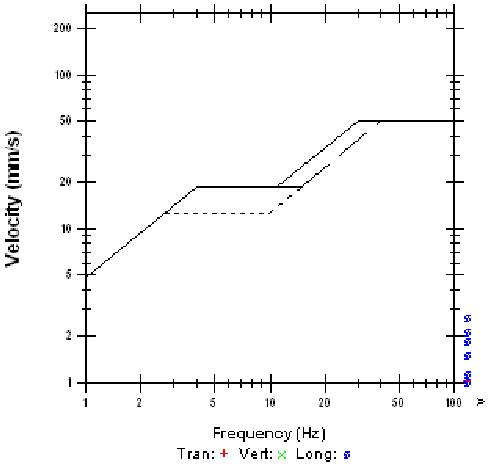
Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

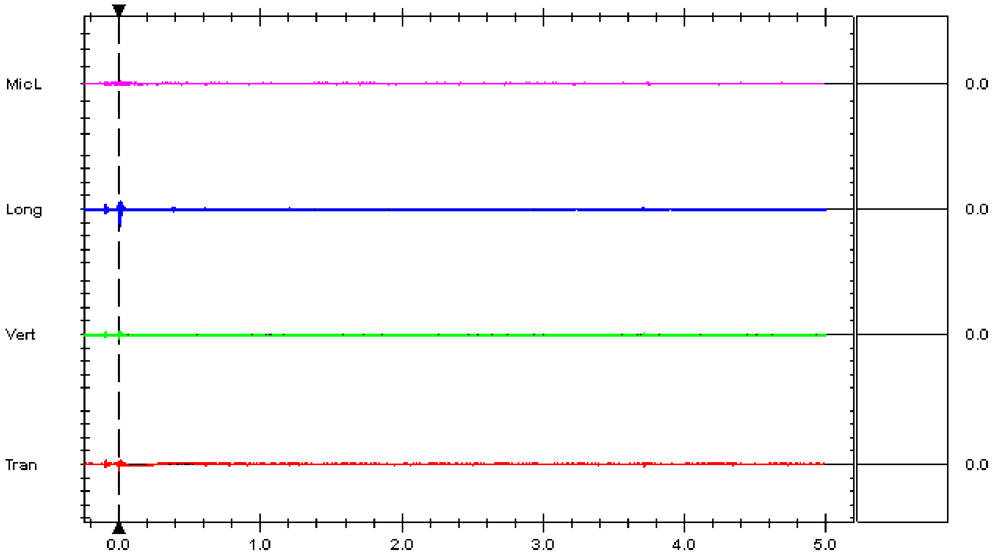
Microphone Linear Weighting
PSPL 97.5 dB(L) 1.50 pa.(L) at 0.007 sec
ZC Freq >100 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	1.02	0.762	2.67	mm/s
ZC Freq	>100	85	>100	Hz
Time (Rel. to Trig)	0.001	0.000	0.004	sec
Peak Acceleration	0.0928	0.0663	0.345	g
Peak Displacement	0.00087	0.00112	0.00130	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

USBM RI8507 And OSMRE



Peak Vector Sum 2.74 mm/s at 0.004 sec



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div Sensorcheck
Trigger =

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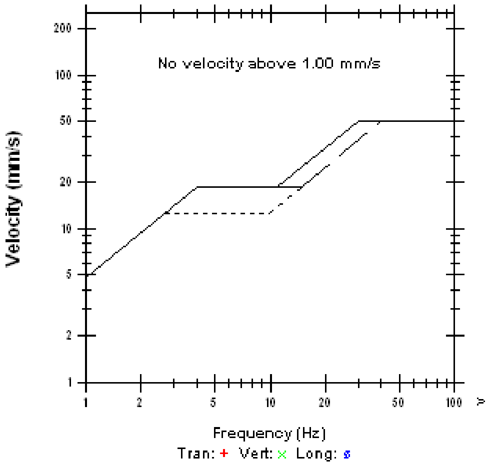
Blast Management & Consulting

Date/Time	MicL at 14:34:01 October 19, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.2 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CXXC.GP0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

USBM RI8507 And OSMRE

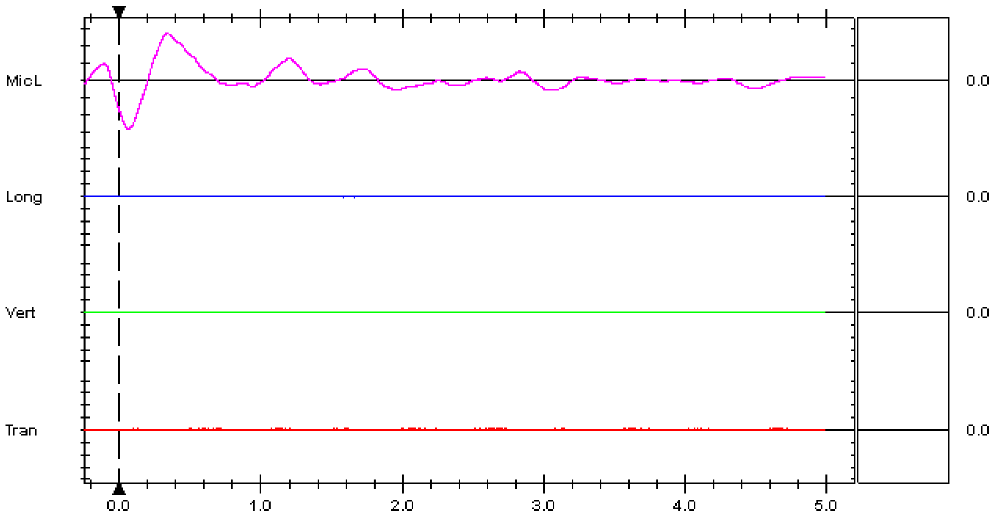


Microphone	Linear Weighting
PSPL	129.0 dB(L) 56.5 pa.(L) at 0.059 sec
ZC Freq	1.9 Hz
Channel Test	Disabled

	Tran	Vert	Long	
PPV	0.127	0.127	0.254	mm/s
ZC Freq	>100	N/A	>100	Hz
Time (Rel. to Trig)	0.098	-0.248	1.582	sec
Peak Acceleration	0.0133	0.0133	0.0133	g
Peak Displacement	0.0	0.0	0.00012	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.284 mm/s at 1.582 sec

N/A: Not Applicable



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— — ◀

Instantel Blast Management & Consulting

Date/Time	MicL at 15:39:11 October 19, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.3 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXXF.HB0
Record Time	5.0 sec at 1024 sps		

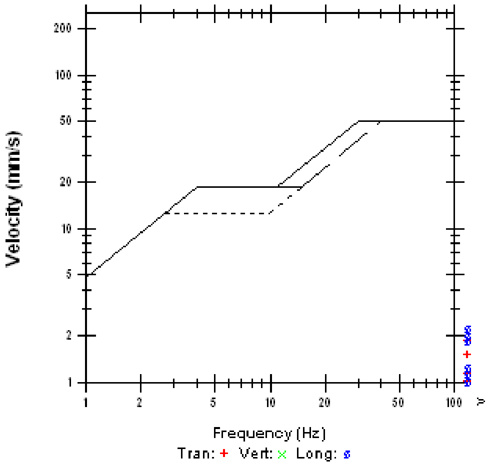
Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

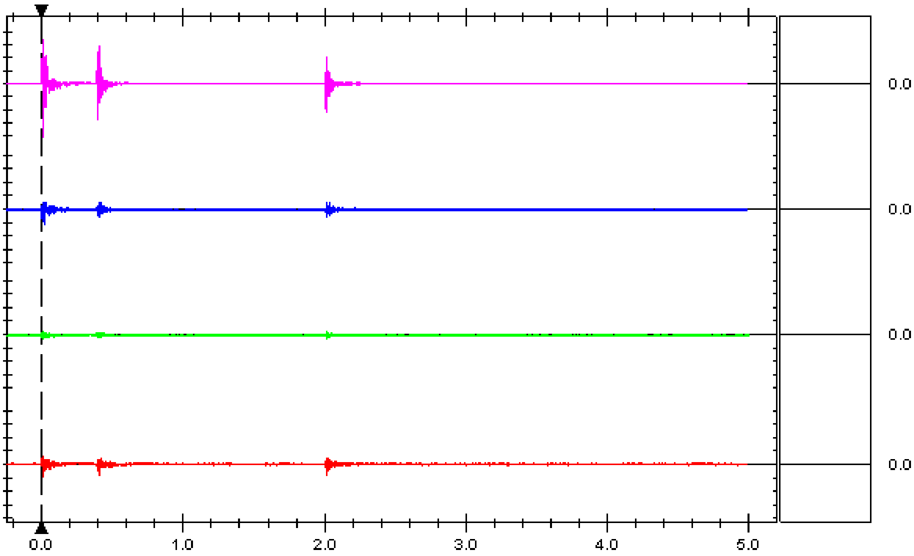
Microphone Linear Weighting
PSPL 132.2 dB(L) 81.3 pa.(L) at 0.006 sec
ZC Freq 85 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	1.90	0.635	2.29	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.012	0.003	0.016	sec
Peak Acceleration	0.159	0.0795	0.265	g
Peak Displacement	0.00136	0.00050	0.00205	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

USBM RI8507 And OSMRE



Peak Vector Sum 2.30 mm/s at 0.016 sec



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— —◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 16:33:10 October 19, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s Mic: 125 dB(L)	Battery Level	6.3 Volts
		Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXXH.ZA0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

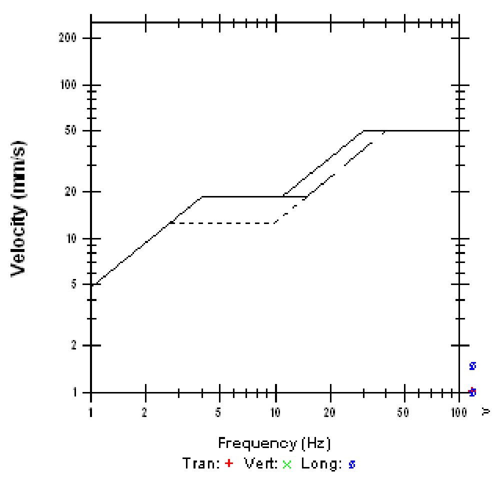
Post Event Notes

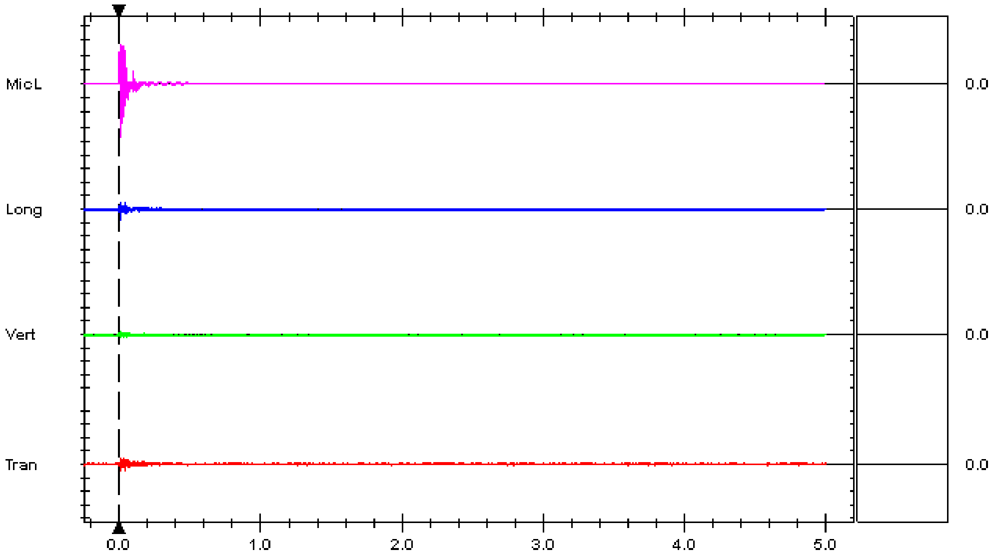
Microphone	Linear Weighting
PSPL	131.3 dB(L) 73.3 pa.(L) at 0.005 sec
ZC Freq	85 Hz
Channel Test	Disabled

	Tran	Vert	Long	
PPV	1.02	0.508	1.52	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.006	0.007	0.003	sec
Peak Acceleration	0.119	0.0530	0.172	g
Peak Displacement	0.00118	0.00062	0.00155	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 1.72 mm/s at 0.003 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger =

Blast Management & Consulting

Date/Time	MicL at 16:46:19 October 19, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.3 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXXI.L70
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

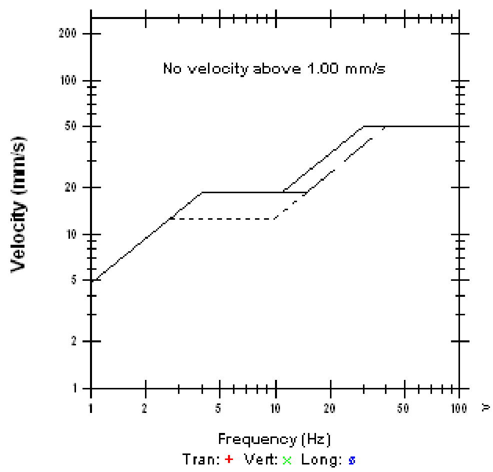
Microphone Linear Weighting
PSPL 130.4 dB(L) 66.5 pa.(L) at 0.000 sec
ZC Freq 4.6 Hz
Channel Test Disabled

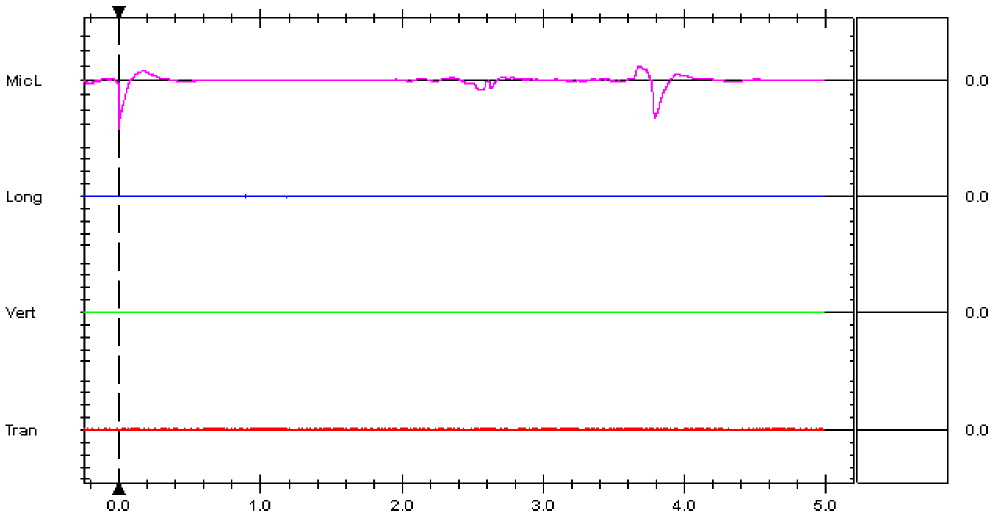
	Tran	Vert	Long	
PPV	0.127	0.127	0.254	mm/s
ZC Freq	>100	N/A	>100	Hz
Time (Rel. to Trig)	-0.246	-0.248	0.893	sec
Peak Acceleration	0.0133	0.0133	0.0265	g
Peak Displacement	0.0	0.0	0.00012	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.284 mm/s at 0.893 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger =

Printed: November 3, 2009 (V 8.12 - 8.12)

Instantel Blast Management & Consulting

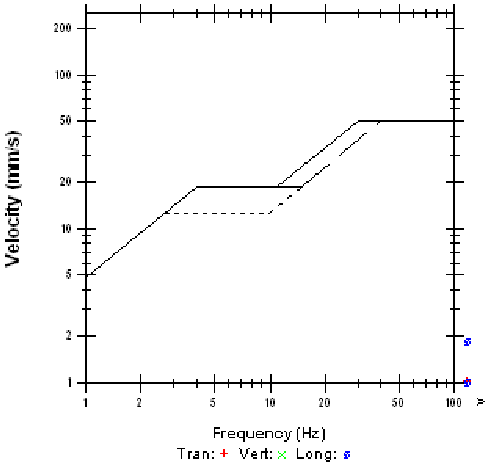
Date/Time	MicL at 17:12:46 October 19, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.3 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXXJ.TA0
Record Time	3.126 sec at 1024 sps		

Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting
PSPL 128.1 dB(L) 50.8 pa.(L) at 0.001 sec
ZC Freq 64 Hz
Channel Test Disabled

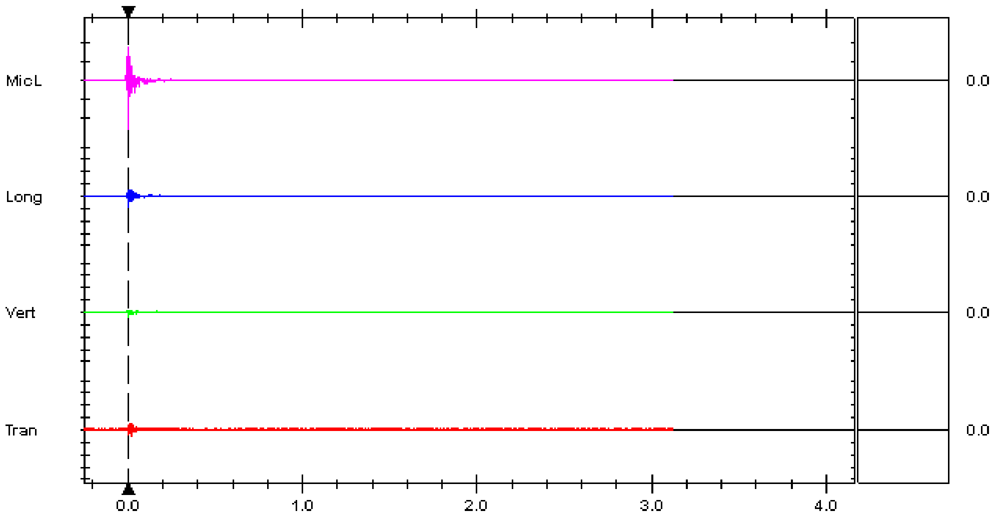
USBM RI8507 And OSMRE



	Tran	Vert	Long	
PPV	1.02	0.889	1.90	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.017	0.006	0.007	sec
Peak Acceleration	0.119	0.0795	0.199	g
Peak Displacement	0.00081	0.00087	0.00105	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 2.01 mm/s at 0.007 sec

Monitor Log
Oct 19 /09 17:12:46 Oct 19 /09 17:12:50 Event recorded. (Memory Full Exit)



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— —◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 11:07:47 October 20, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CXYX.KZ0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

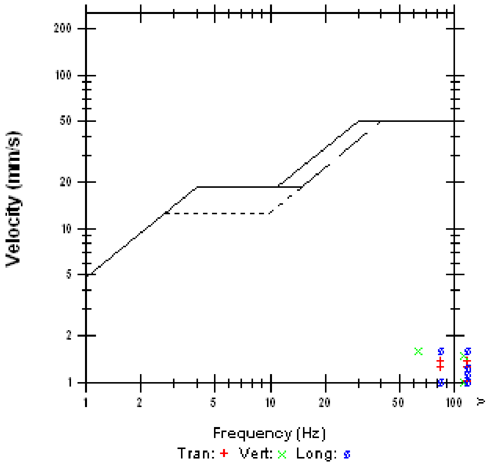
Post Event Notes

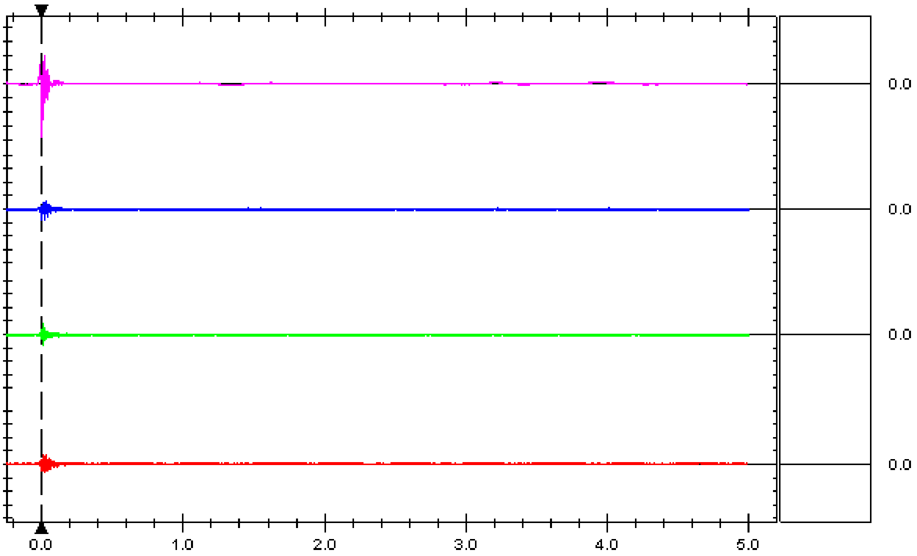
Microphone Linear Weighting
PSPL 125.5 dB(L) 37.8 pa.(L) at 0.000 sec
ZC Freq 64 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	1.40	1.65	1.65	mm/s
ZC Freq	85	64	>100	Hz
Time (Rel. to Trig)	0.007	0.007	0.000	sec
Peak Acceleration	0.0928	0.133	0.119	g
Peak Displacement	0.00229	0.00316	0.00279	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 2.17 mm/s at 0.007 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div
Trigger =

Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	Tran at 11:08:07 October 20, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CXYX.LJ0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

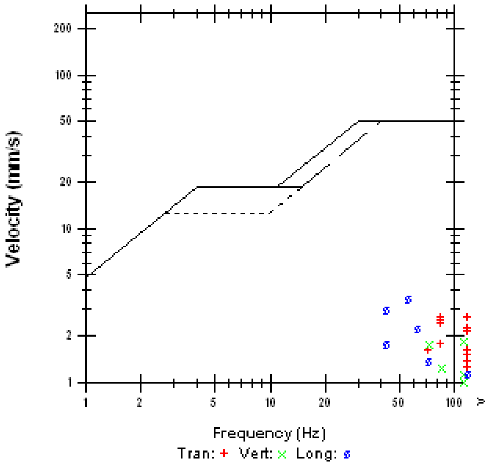
Post Event Notes

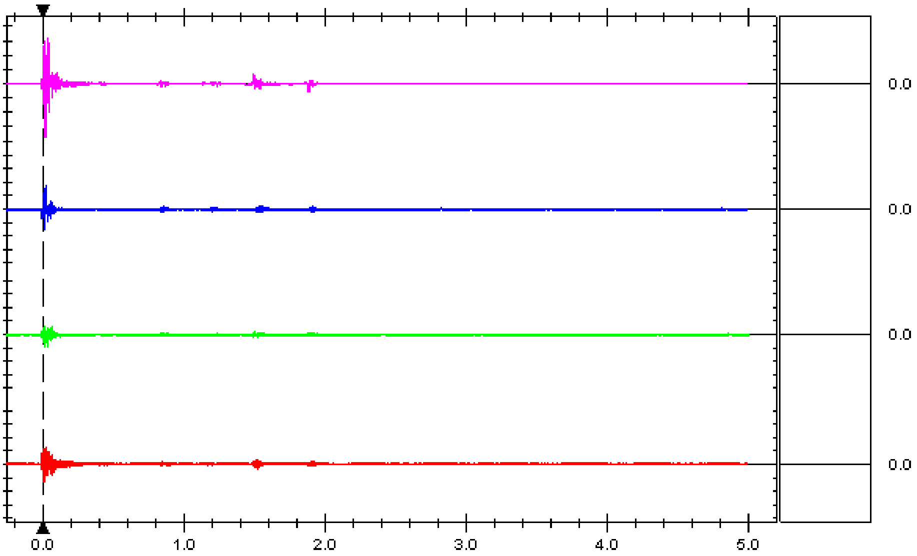
Microphone	Linear Weighting
PSPL	125.3 dB(L) 37.0 pa.(L) at 0.026 sec
ZC Freq	85 Hz
Channel Test	Disabled

	Tran	Vert	Long	
PPV	2.67	1.90	3.56	mm/s
ZC Freq	>100	>100	57	Hz
Time (Rel. to Trig)	0.017	0.043	0.022	sec
Peak Acceleration	0.186	0.159	0.199	g
Peak Displacement	0.00459	0.00291	0.00936	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 4.62 mm/s at 0.022 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div Sensorcheck
Trigger = ▶— —◀

Blast Management & Consulting

Date/Time	MicL at 12:41:29 October 20, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CXZ1.X50
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

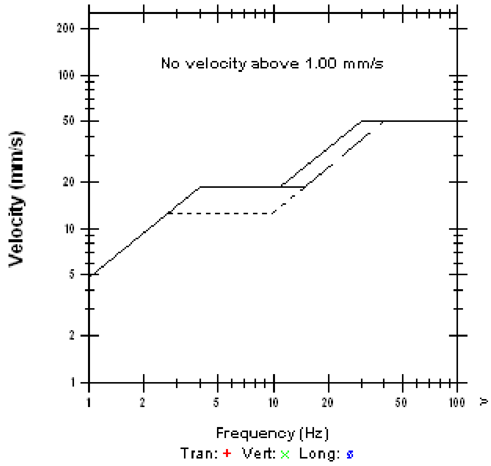
Post Event Notes

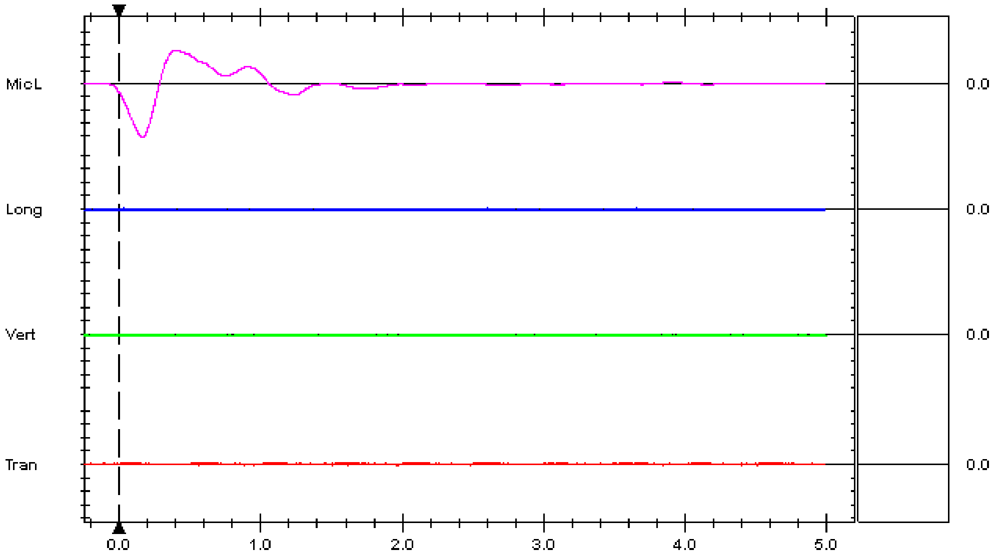
Microphone Linear Weighting
PSPL 140.1 dB(L) 202 pa.(L) at 0.161 sec
ZC Freq 1.3 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.127	0.127	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.206	-0.246	2.041	sec
Peak Acceleration	0.0265	0.0133	0.0265	g
Peak Displacement	0.0	0.0	0.00012	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.254 mm/s at 2.041 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 50.0 pa.(L)/div Sensorcheck
Trigger =

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 12:57:56 October 20, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CXZ2.OK0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

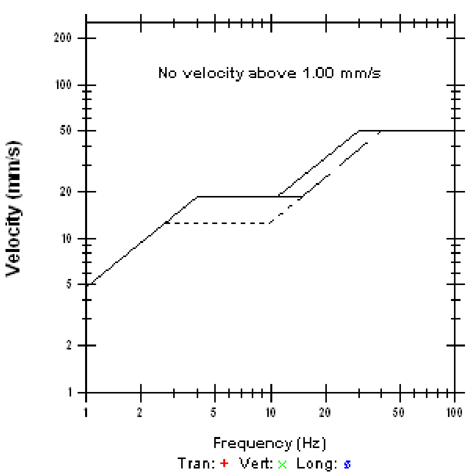
Microphone Linear Weighting
PSPL *** dB(L) at 0.134 sec
ZC Freq 1.6 Hz
Channel Test Disabled

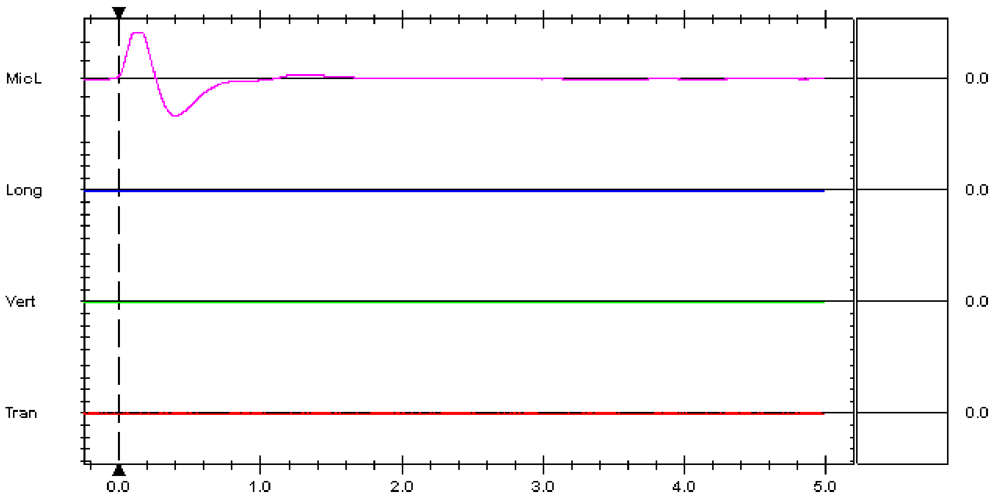
	Tran	Vert	Long	
PPV	0.127	0.127	0.127	mm/s
ZC Freq	>100	N/A	N/A	Hz
Time (Rel. to Trig)	-0.246	-0.248	-0.248	sec
Peak Acceleration	0.0265	0.0133	0.0133	g
Peak Displacement	0.0	0.0	0.0	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.220 mm/s at -0.216 sec

N/A: Not Applicable
*** : Out of Range

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 200 pa.(L)/div Sensorcheck
Trigger = ▶— —◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 14:08:42 October 20, 2009
Trigger Source	Geo: 2.20 mm/s
	Mic: 125 dB(L)
Range	Geo :254 mm/s
Record Time	2.757 sec at 1024 sps

Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Battery Level	6.6 Volts
Calibration	May 18, 2009 by Blast Man. & Cons
File Name	I750CXZ5.YI0

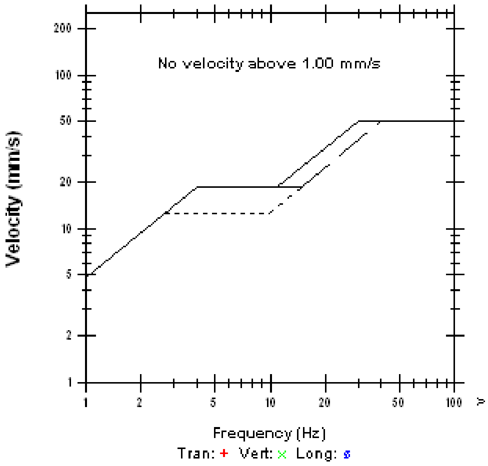
Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting
PSPL *** dB(L) at 0.271 sec
ZC Freq 1.6 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.127	0.254	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.242	0.438	-0.033	sec
Peak Acceleration	0.0133	0.0133	0.0133	g
Peak Displacement	0.0	0.00012	0.00012	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

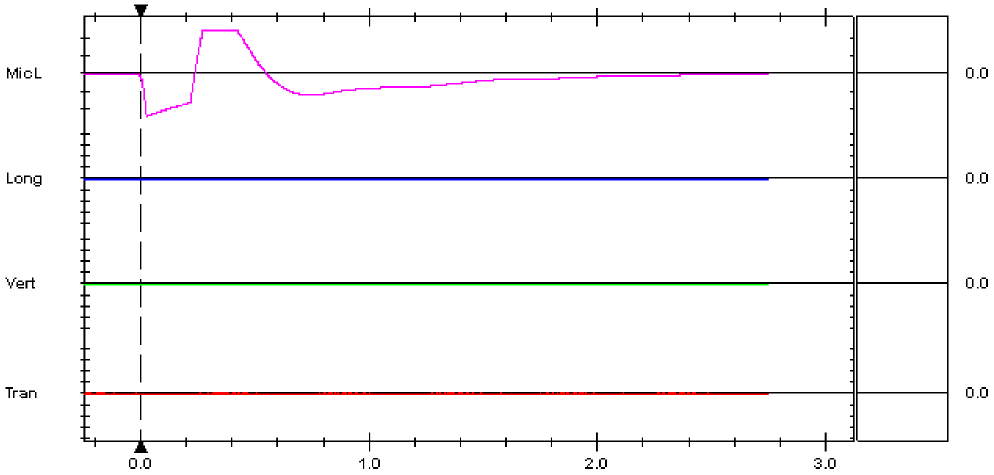
USBM RI8507 And OSMRE



Peak Vector Sum 0.284 mm/s at 0.296 sec

*** : Out of Range

Monitor Log
Oct 20 /09 14:08:42 Oct 20 /09 14:08:45 Event recorded. (Memory Full Exit)



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 200 pa.(L)/div Sensorcheck
Trigger = ▶— — ◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 16:34:19 October 20, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXZC.P70
Record Time	5.0 sec at 1024 sps		

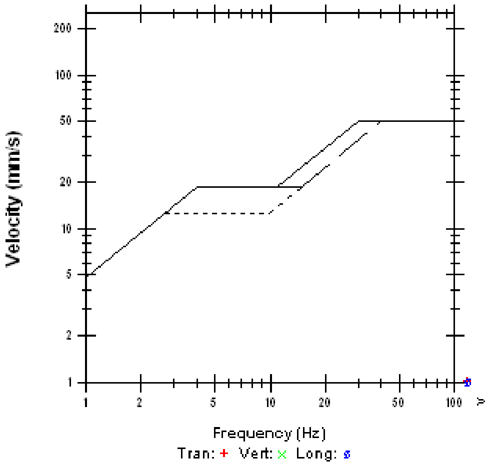
Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

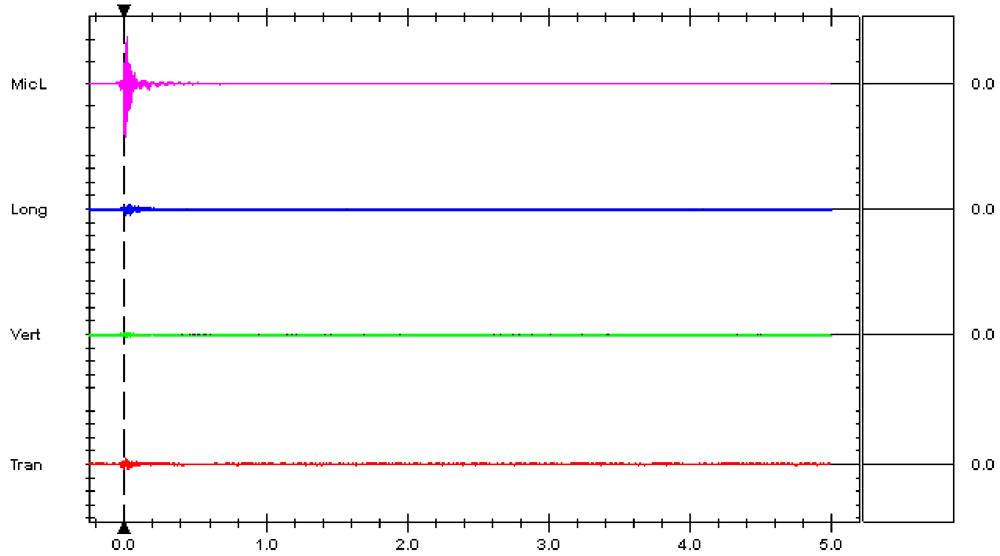
Microphone Linear Weighting
PSPL 127.7 dB(L) 48.8 pa.(L) at 0.001 sec
ZC Freq 64 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	1.02	0.508	1.02	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.009	0.035	0.011	sec
Peak Acceleration	0.0663	0.0398	0.119	g
Peak Displacement	0.00149	0.00112	0.00155	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

USBM RI8507 And OSMRE



Peak Vector Sum 1.37 mm/s at 0.010 sec



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— —◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Instantel

Blast Management & Consulting

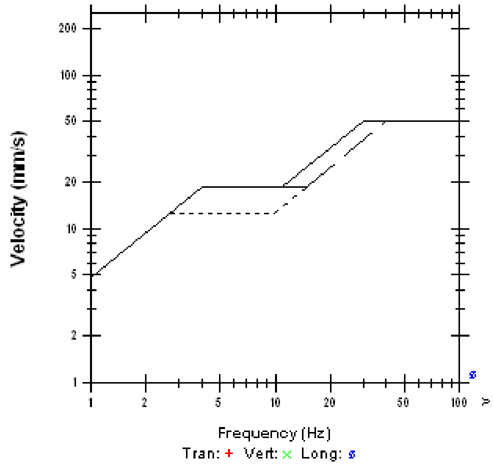
Date/Time	MicL at 16:41:49 October 20, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.5 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXZD.1P0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

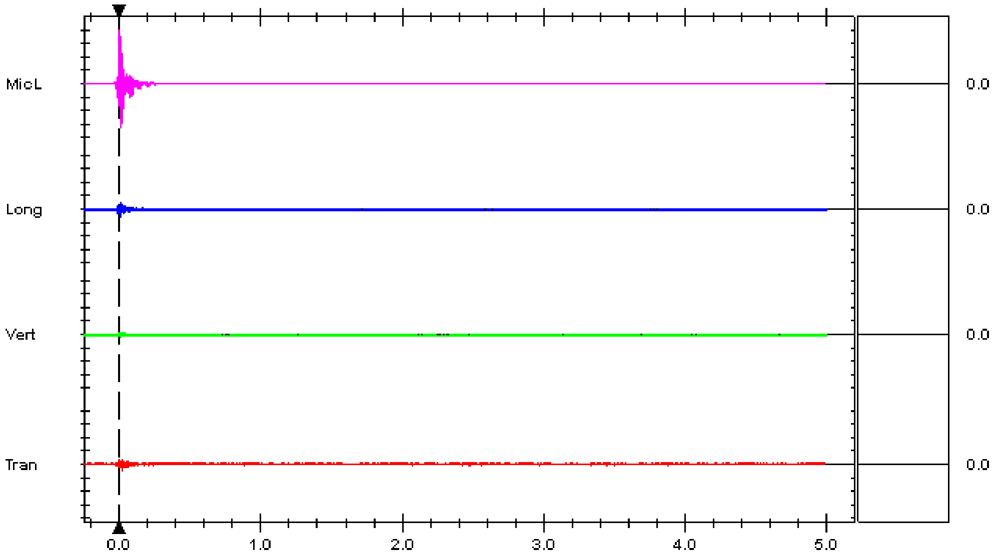
Post Event Notes

Microphone Linear Weighting
PSPL 125.9 dB(L) 39.5 pa.(L) at 0.000 sec
ZC Freq >100 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.889	0.508	1.14	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.021	0.013	0.007	sec
Peak Acceleration	0.0928	0.0398	0.119	g
Peak Displacement	0.00093	0.00050	0.00087	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	



Peak Vector Sum 1.25 mm/s at 0.007 sec



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div Sensorcheck
Trigger =

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 16:44:07 October 20, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXZD.5J0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

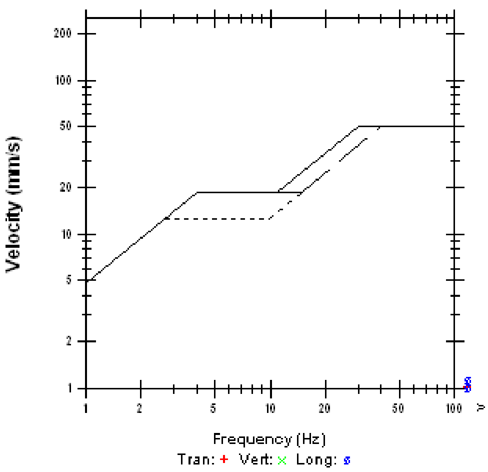
Post Event Notes

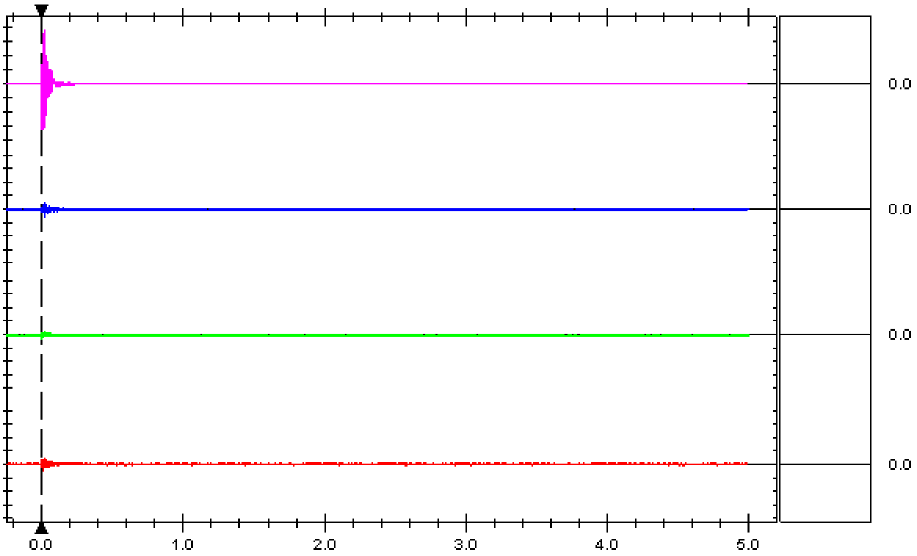
Microphone Linear Weighting
PSPL 131.5 dB(L) 74.8 pa.(L) at 0.021 sec
ZC Freq 85 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	1.02	0.762	1.14	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.011	0.001	0.015	sec
Peak Acceleration	0.106	0.0530	0.172	g
Peak Displacement	0.00124	0.00099	0.00130	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 1.31 mm/s at 0.015 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div
Trigger = ▶— —◀

Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Instantel

Blast Management & Consulting

Date/Time	MicL at 17:51:24 October 20, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXZG.900
Record Time	5.0 sec at 1024 sps		

Notes

Location: Point 4

Client: Universal Coal - Kangala Mine

Operation: EIA Baseline Study

User Name: Blast Management & Consulting

Post Event Notes

Microphone Linear Weighting

PSPL 133.1 dB(L) 90.0 pa.(L) at 0.002 sec

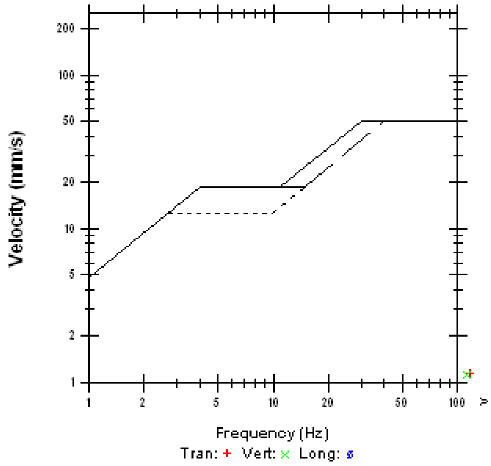
ZC Freq 64 Hz

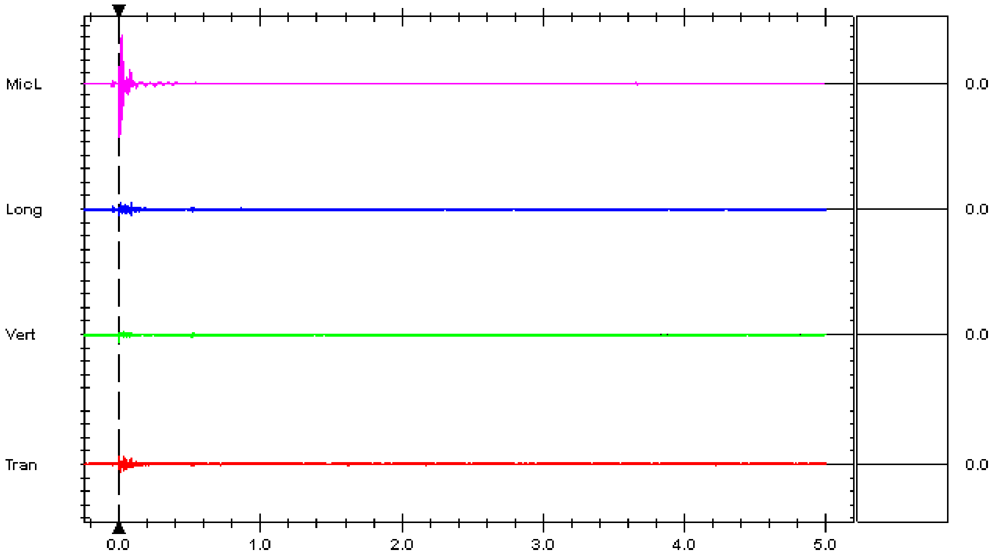
Channel Test Disabled

	Tran	Vert	Long	
PPV	1.14	1.14	0.889	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.001	0.001	0.001	sec
Peak Acceleration	0.133	0.0663	0.0928	g
Peak Displacement	0.00136	0.00118	0.00248	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 1.84 mm/s at 0.001 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck

Trigger = ▶— —◀

Blast Management & Consulting

Date/Time	MicL at 18:02:33 October 20, 2009	Serial Number	BE13230 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	December 1, 2008 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	O230CXZG.S90
Record Time	3.71 sec at 1024 sps		

Notes
Location: Point 4
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

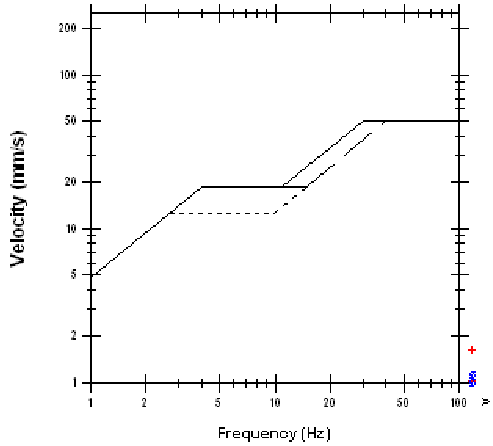
Microphone Linear Weighting
PSPL 128.3 dB(L) 52.0 pa.(L) at 0.005 sec
ZC Freq 85 Hz
Channel Test Disabled

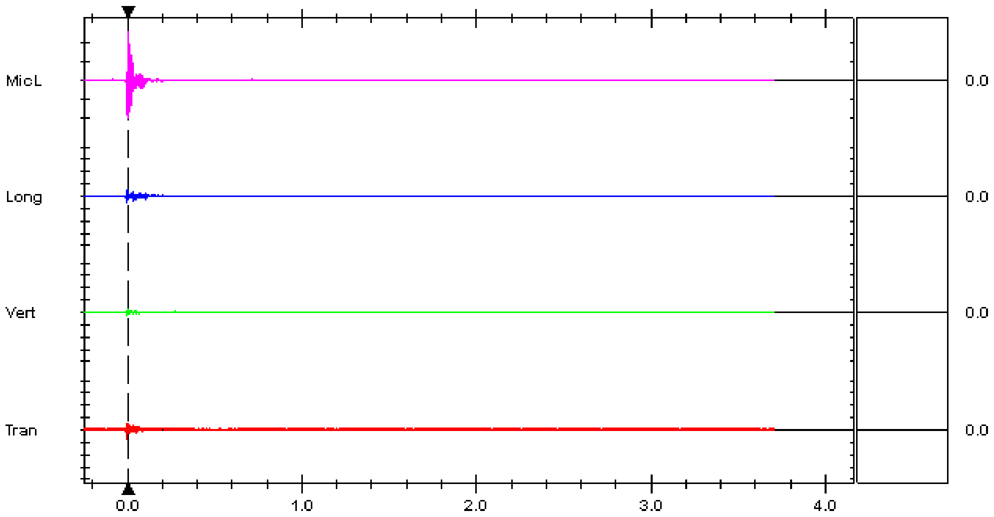
	Tran	Vert	Long	
PPV	1.65	0.508	1.14	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.002	-0.004	-0.001	sec
Peak Acceleration	0.172	0.0663	0.146	g
Peak Displacement	0.00130	0.00037	0.00062	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 1.66 mm/s at -0.002 sec

Monitor Log
Oct 20 /09 18:02:33 Oct 20 /09 18:02:37 Event recorded. (Memory Full Exit)

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger =

Printed: November 3, 2009 (V 8.12 - 8.12)

Instantel

Blast Management & Consulting

Date/Time	MicL at 08:35:27 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0L.730
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

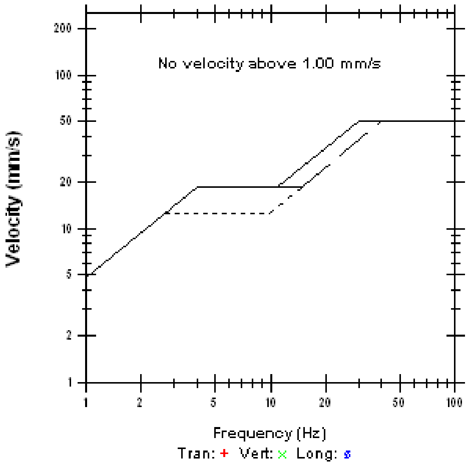
Microphone	Linear Weighting
PSPL	127.9 dB(L) 49.8 pa.(L) at 0.083 sec
ZC Freq	1.5 Hz
Channel Test	Disabled

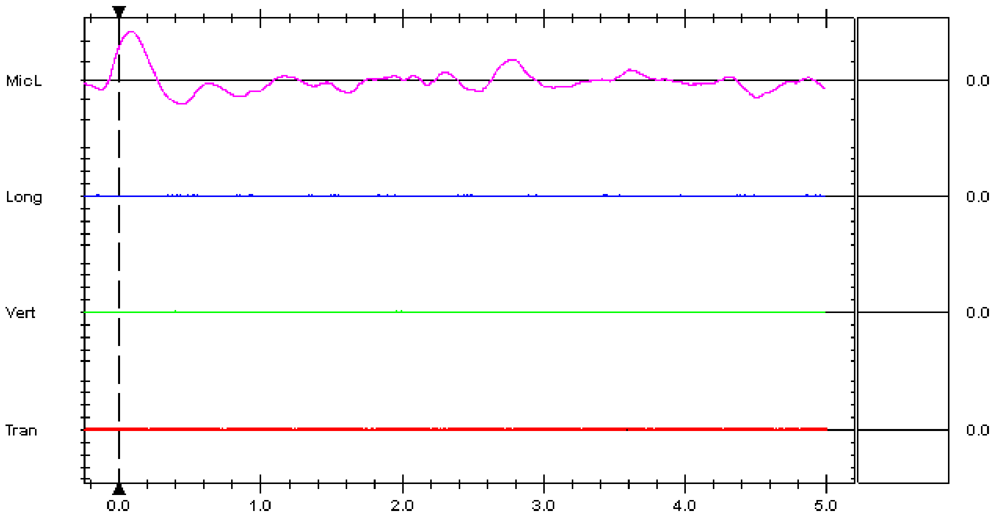
	Tran	Vert	Long	
PPV	0.127	0.127	0.127	mm/s
ZC Freq	>100	N/A	>100	Hz
Time (Rel. to Trig)	-0.240	-0.248	-0.239	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.0	0.0	0.0	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.220 mm/s at -0.239 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div

Sensorcheck

Trigger = ▶— — ◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 08:35:55 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0L.7V0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

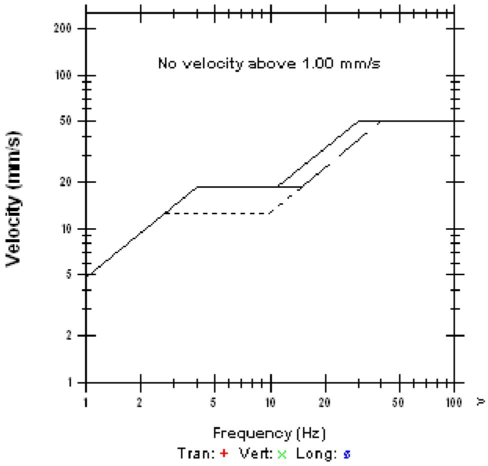
Post Event Notes

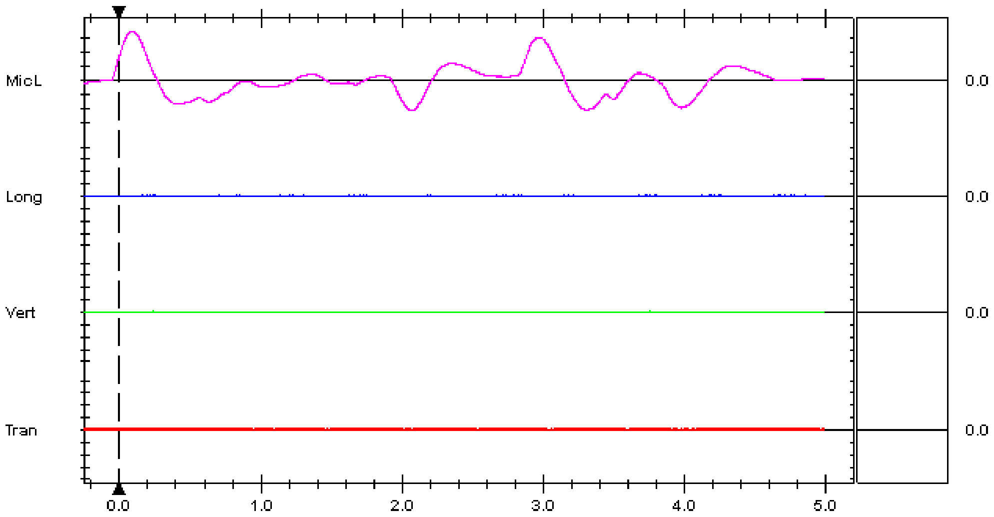
Microphone Linear Weighting
PSPL 130.8 dB(L) 69.0 pa.(L) at 0.080 sec
ZC Freq 1.5 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.254	0.127	0.127	mm/s
ZC Freq	>100	>100	N/A	Hz
Time (Rel. to Trig)	0.838	-0.246	-0.249	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.00012	0.0	0.0	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.284 mm/s at 0.838 sec

N/A: Not Applicable





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger =

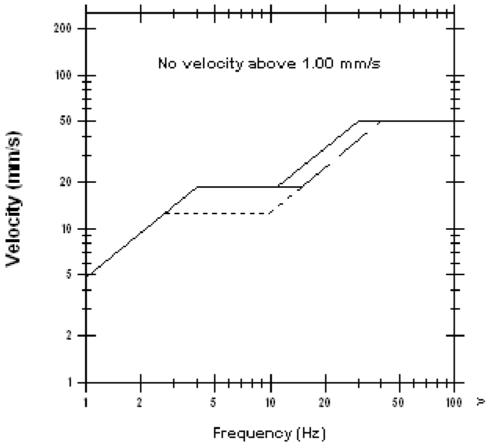
Blast Management & Consulting

Date/Time	MicL at 08:36:23 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0L.8N0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

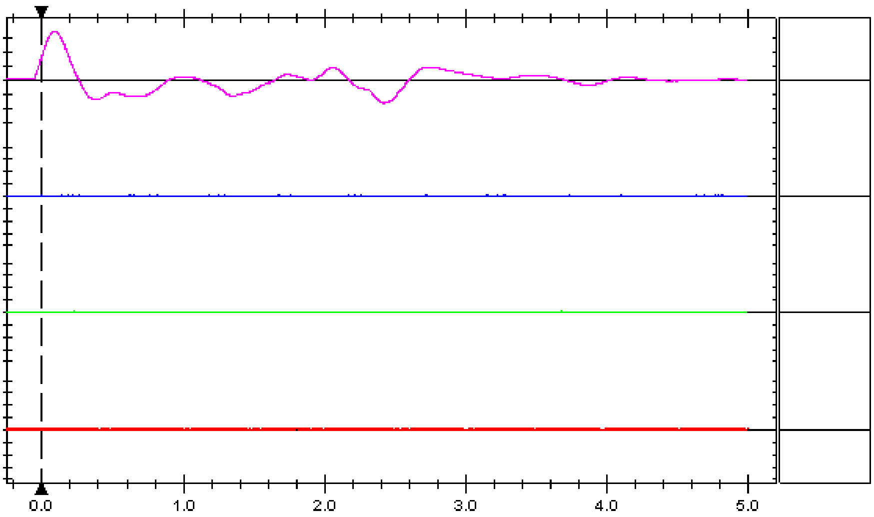
Microphone Linear Weighting
PSPL 130.7 dB(L) 68.3 pa.(L) at 0.084 sec
ZC Freq N/A
Channel Test Disabled



	Tran	Vert	Long	
PPV	0.254	0.127	0.127	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	3.765	-0.248	-0.245	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.00012	0.0	0.0	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.284 mm/s at 3.765 sec

N/A: Not Applicable



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger =

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Blast Management & Consulting

Date/Time	MicL at 08:36:45 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0L.990
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

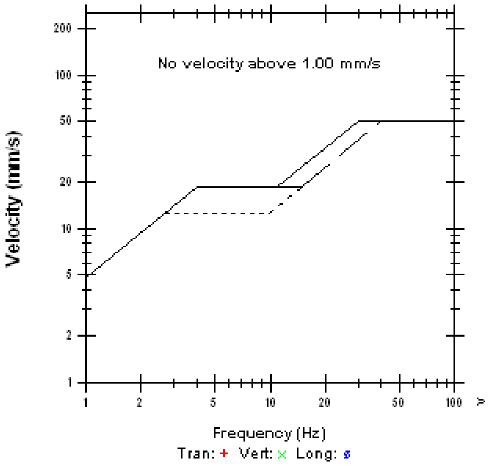
Microphone Linear Weighting
PSPL 125.5 dB(L) 37.5 pa.(L) at 0.023 sec
ZC Freq N/A
Channel Test Disabled

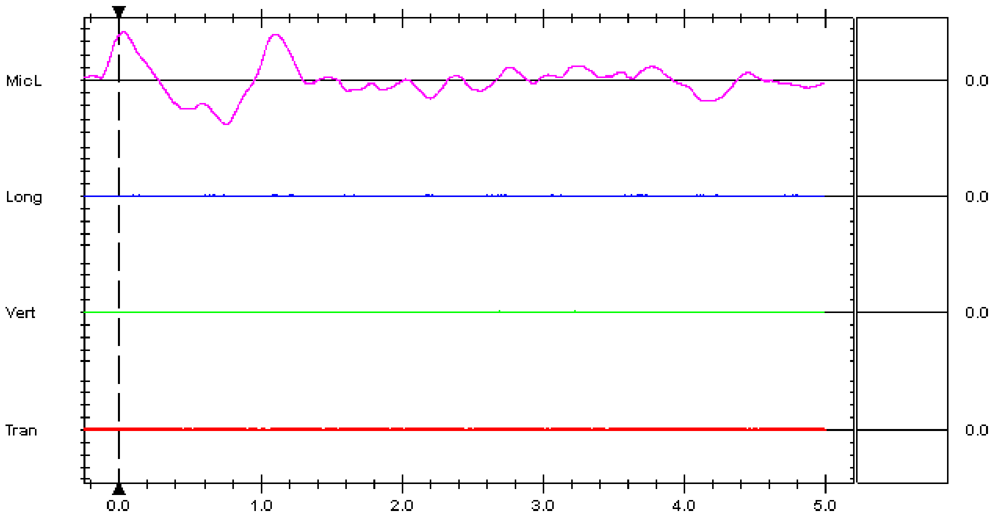
	Tran	Vert	Long	
PPV	0.254	0.127	0.127	mm/s
ZC Freq	>100	N/A	>100	Hz
Time (Rel. to Trig)	1.220	-0.249	-0.238	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.00012	0.0	0.0	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.284 mm/s at 1.220 sec

N/A: Not Applicable

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div Sensorcheck
Trigger = ▶— —◀

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Blast Management & Consulting

Date/Time	MicL at 10:08:50 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0P.IQ0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

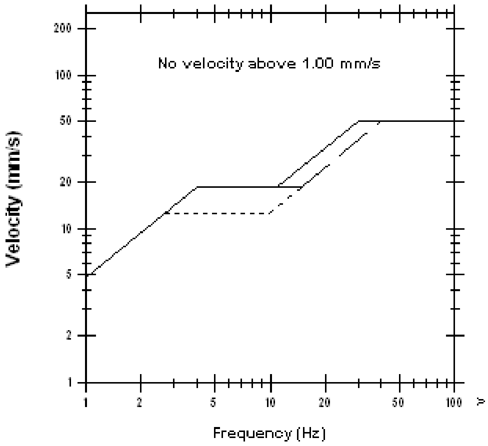
Post Event Notes

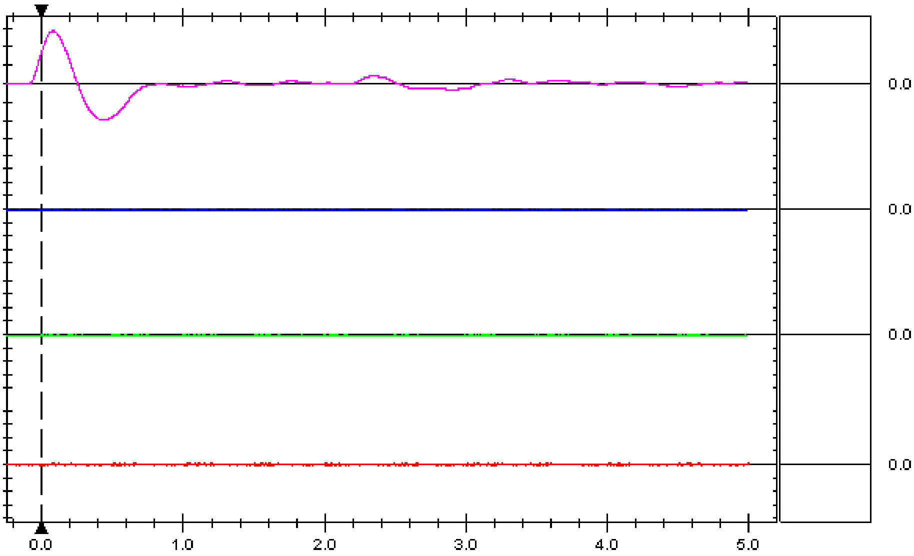
Microphone Linear Weighting
PSPL 129.1 dB(L) 57.3 pa.(L) at 0.073 sec
ZC Freq 1.5 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.127	0.254	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.179	1.003	-0.196	sec
Peak Acceleration	0.0265	0.0133	0.0265	g
Peak Displacement	0.0	0.00012	0.00050	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.311 mm/s at 0.088 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger =

Printed: November 3, 2009 (V 8.12 - 8.12) Format Copyrighted 2006-2007 Instantel, a division of VeriChip Corporation

Blast Management & Consulting

Date/Time	MicL at 10:13:19 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0P.Q70
Record Time	5.0 sec at 1024 sps		

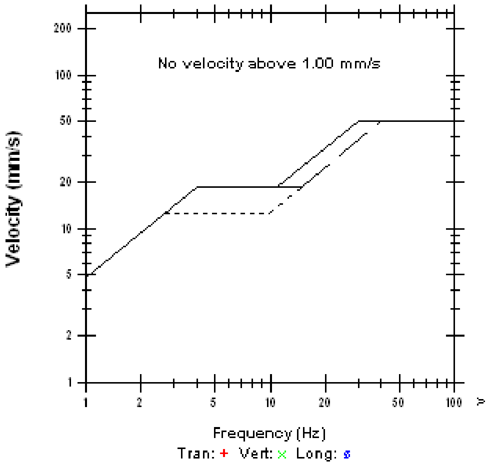
Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

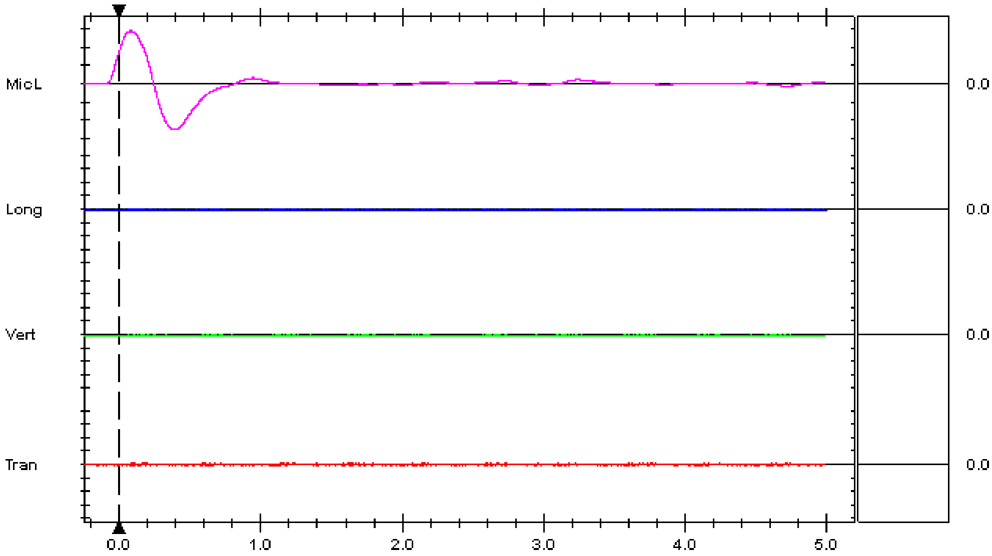
Post Event Notes

Microphone Linear Weighting
PSPL 129.2 dB(L) 57.5 pa.(L) at 0.078 sec
ZC Freq 1.6 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.127	0.254	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.153	0.995	0.119	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.0	0.00012	0.00025	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.311 mm/s at 0.715 sec





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— — ◀

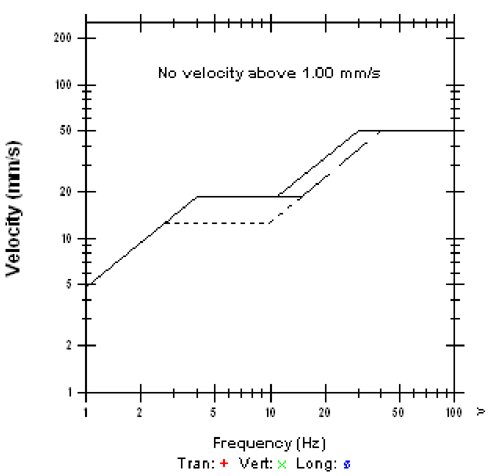
Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 10:28:16 October 21, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CY0Q.F40
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

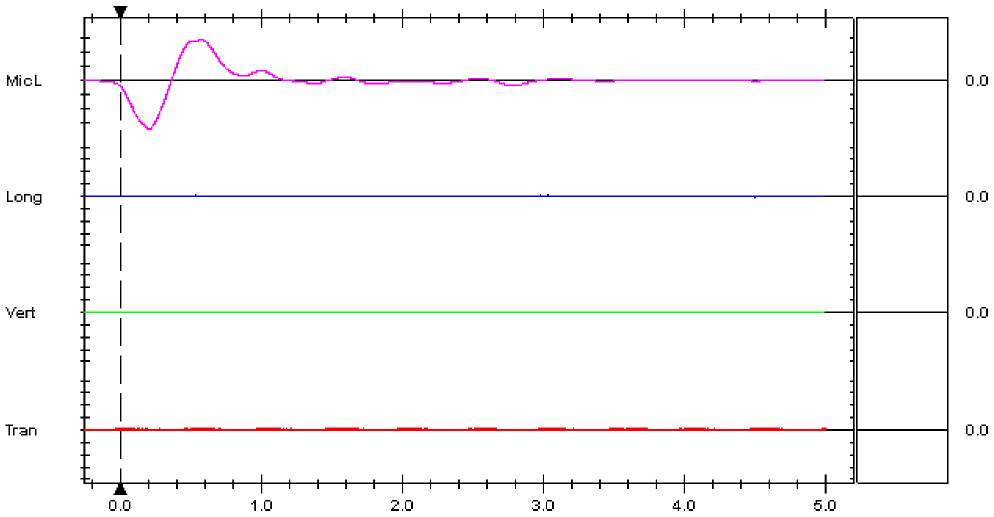


Microphone Linear Weighting
PSPL 144.6 dB(L) 340 pa.(L) at 0.210 sec
ZC Freq N/A
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.127	0.127	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.032	-0.249	4.497	sec
Peak Acceleration	0.0265	0.0133	0.0265	g
Peak Displacement	0.0	0.0	0.0	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.284 mm/s at 4.497 sec

N/A: Not Applicable



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 100.0 pa.(L)/div Sensorcheck
Trigger = ▶— — ◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Instantel

Blast Management & Consulting

Date/Time	MicL at 10:58:05 October 21, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CY0R.ST0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

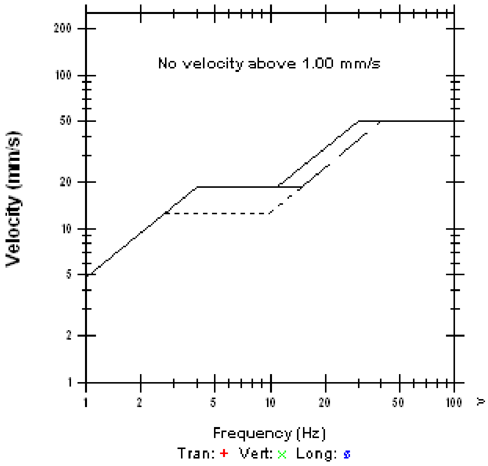
Post Event Notes

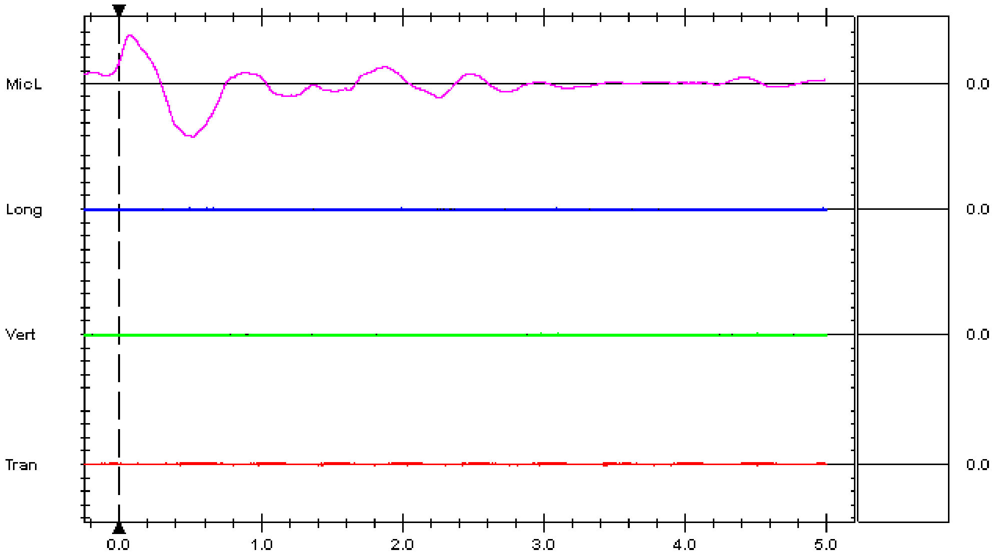
Microphone Linear Weighting
PSPL 132.1 dB(L) 81.0 pa.(L) at 0.510 sec
ZC Freq 1.1 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.254	0.254	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	3.050	1.540	0.929	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.00012	0.0	0.0	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.284 mm/s at 1.540 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— —◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Instantel

Blast Management & Consulting

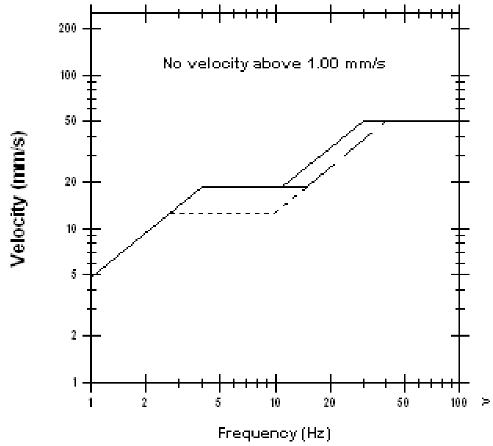
Date/Time	MicL at 11:04:25 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0S.3D0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

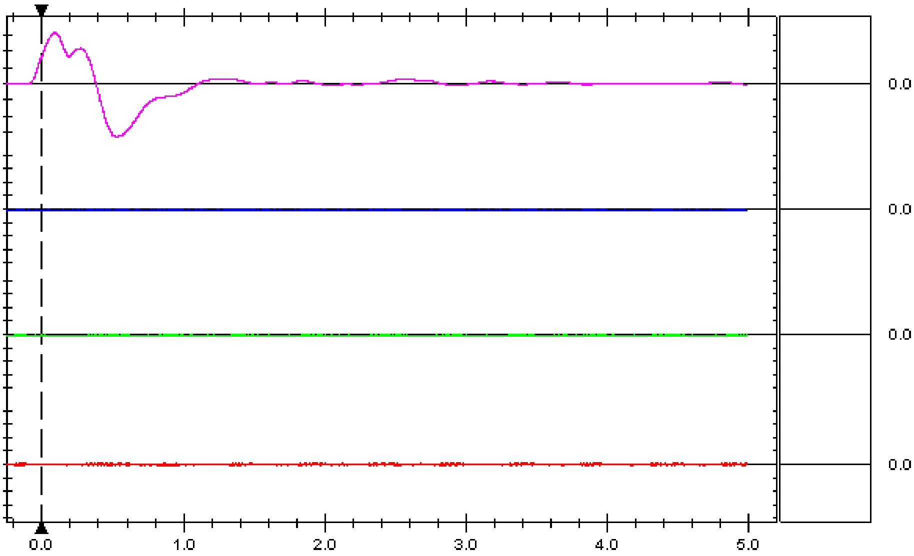
Post Event Notes

Microphone Linear Weighting
PSPL 130.3 dB(L) 65.5 pa.(L) at 0.518 sec
ZC Freq <1.0 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.127	0.254	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.189	-0.170	-0.185	sec
Peak Acceleration	0.0265	0.0133	0.0265	g
Peak Displacement	0.0	0.00012	0.00025	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	



Peak Vector Sum 0.311 mm/s at -0.158 sec



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger =

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Blast Management & Consulting

Date/Time	MicL at 11:32:08 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0T.DK0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

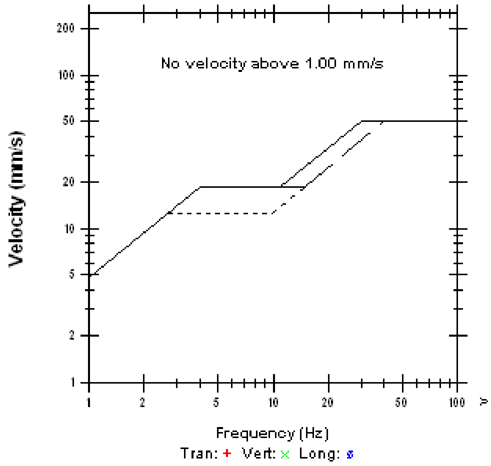
Post Event Notes

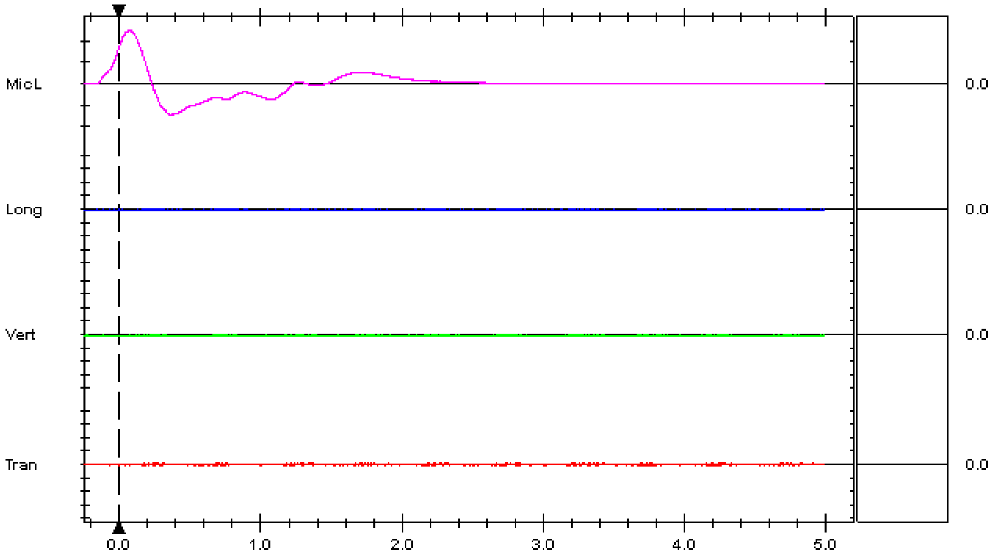
Microphone	Linear Weighting
PSPL	127.9 dB(L) 49.8 pa.(L) at 0.063 sec
ZC Freq	1.3 Hz
Channel Test	Disabled

	Tran	Vert	Long	
PPV	0.127	0.254	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	-0.074	0.165	0.269	sec
Peak Acceleration	0.0265	0.0133	0.0265	g
Peak Displacement	0.0	0.00012	0.00025	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.311 mm/s at 1.242 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— —◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 12:11:19 October 21, 2009
Trigger Source	Geo: 2.20 mm/s
	Mic: 125 dB(L)
Range	Geo :254 mm/s
Record Time	5.0 sec at 1024 sps

Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Battery Level	6.6 Volts
Calibration	May 18, 2009 by Blast Man. & Cons
File Name	I749CY0V.6V0

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

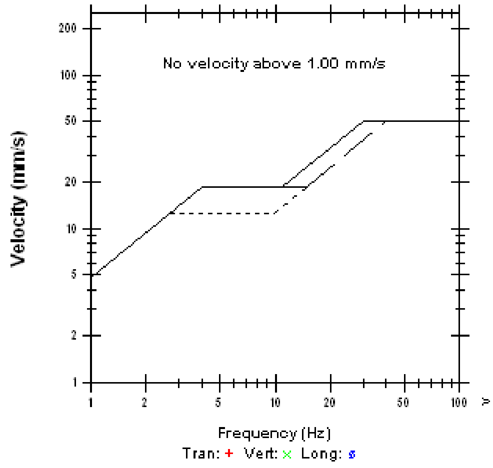
Post Event Notes

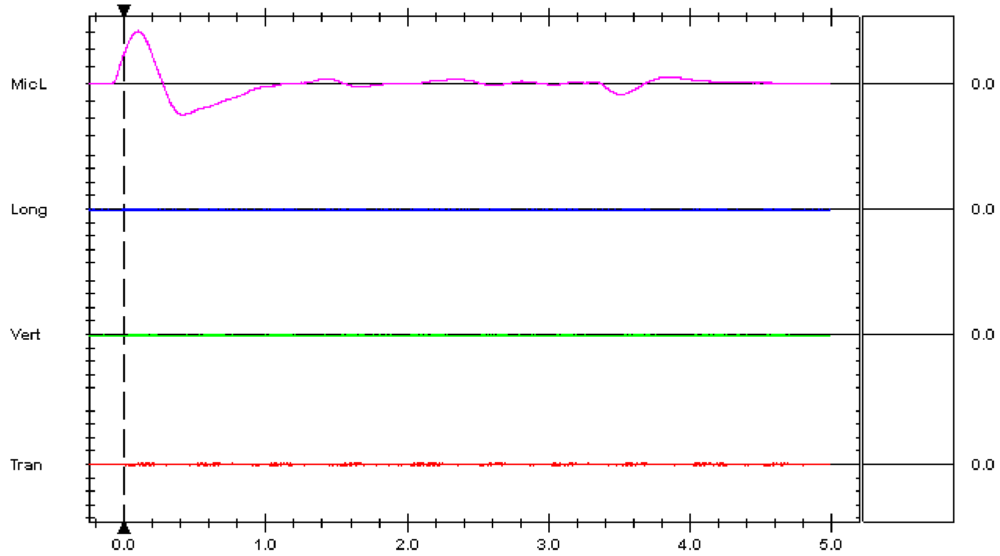
Microphone	Linear Weighting
PSPL	129.6 dB(L) 60.5 pa.(L) at 0.092 sec
ZC Freq	1.4 Hz
Channel Test	Disabled

	Tran	Vert	Long	
PPV	0.127	0.254	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.009	0.681	0.081	sec
Peak Acceleration	0.0265	0.0133	0.0265	g
Peak Displacement	0.0	0.00012	0.00025	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.311 mm/s at 0.156 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div

Trigger = ▶— —◀

Sensorcheck

Printed: November 3, 2009 (V 8.12 - 8.12)

Instantel

Blast Management & Consulting

Date/Time	MicL at 12:13:22 October 21, 2009	Serial Number	BC7749 V 8.12-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.6 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I749CY0V.AA0
Record Time	5.0 sec at 1024 sps		

Notes
Location: Point 1
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

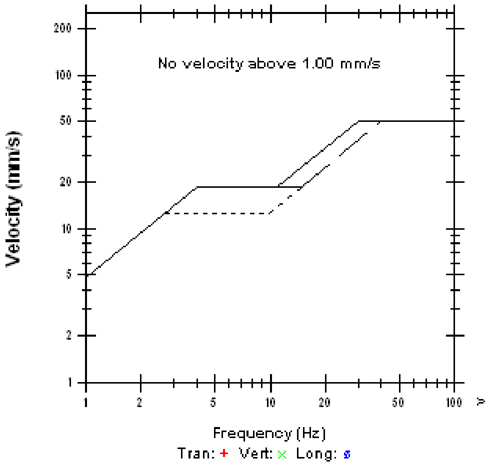
Post Event Notes

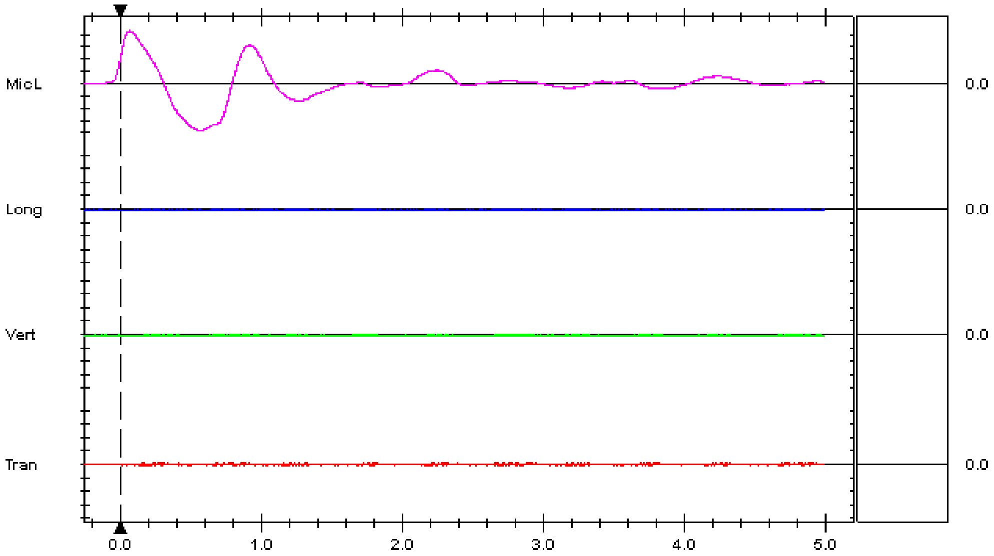
Microphone	Linear Weighting
PSPL	132.6 dB(L) 85.5 pa.(L) at 0.069 sec
ZC Freq	1.1 Hz
Channel Test	Disabled

	Tran	Vert	Long	
PPV	0.127	0.254	0.254	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.015	0.282	0.186	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.0	0.00012	0.00025	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

Peak Vector Sum 0.359 mm/s at 0.282 sec

USBM RI8507 And OSMRE





Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— — ◀

Printed: November 3, 2009 (V 8.12 - 8.12)

Blast Management & Consulting

Date/Time	MicL at 09:03:52 October 22, 2009	Serial Number	BC7750 V 10.02-8.0 MiniMate Plus
Trigger Source	Geo: 2.20 mm/s	Battery Level	6.7 Volts
	Mic: 125 dB(L)	Calibration	May 18, 2009 by Blast Man. & Cons
Range	Geo :254 mm/s	File Name	I750CY2H.6G0
Record Time	5.0 sec at 1024 sps		

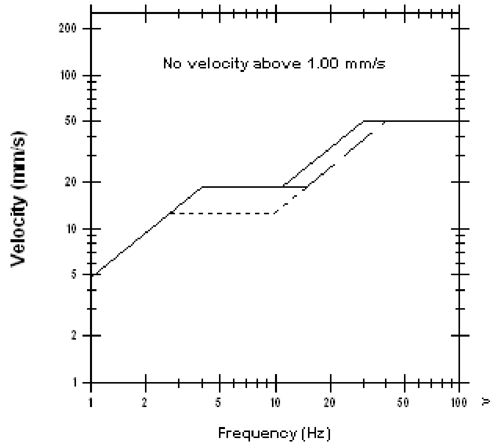
Notes
Location: Point 2
Client: Universal Coal - Kangala Mine
Operation: EIA Baseline Study
User Name: Blast Management & Consulting

Post Event Notes

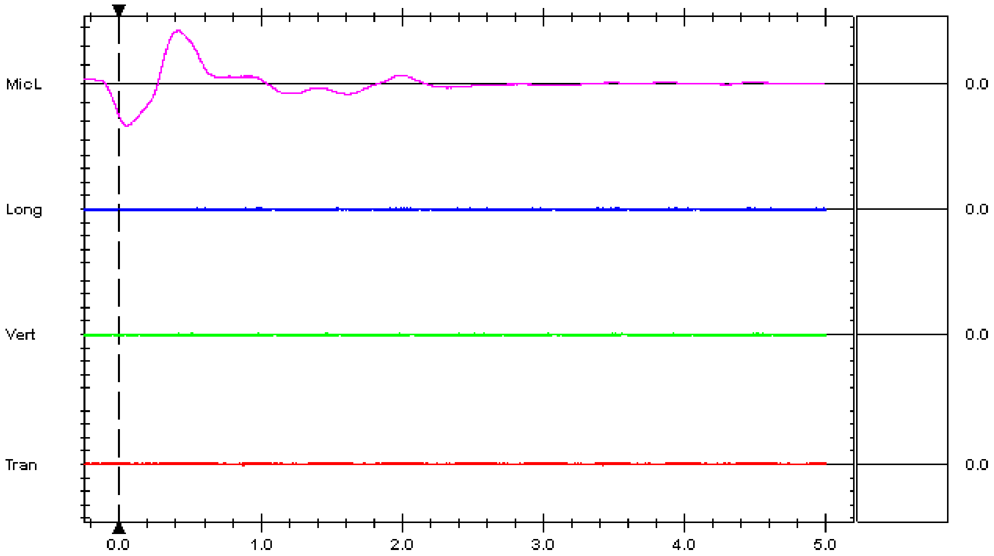
Microphone Linear Weighting
PSPL 128.9 dB(L) 55.8 pa.(L) at 0.408 sec
ZC Freq <1.0 Hz
Channel Test Disabled

	Tran	Vert	Long	
PPV	0.254	0.127	0.127	mm/s
ZC Freq	>100	>100	>100	Hz
Time (Rel. to Trig)	0.541	-0.244	-0.245	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.00012	0.0	0.0	mm
Sensorcheck	Disabled	Disabled	Disabled	
Frequency	***	***	***	Hz
Overswing Ratio	***	***	***	

USBM RI8507 And OSMRE



Peak Vector Sum 0.311 mm/s at 3.486 sec



Time Scale: 0.20 sec/div Amplitude Scale: Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensorcheck
Trigger = ▶— — ◀