HGC ENGINEERING

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Report on Vibration and Overpressure Measured during a Luce Pit Blast on September 23, 2014, Labrador City, Labrador

Prepared For:

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EXECUTIVE SUMMARY

HGC Engineering was retained by Iron Ore Company of Canada ("IOC") to undertake measurements of blast vibration and overpressure at five locations around the mining operations at Labrador City, Labrador. The measurements were conducted during a major blast in the Luce Pit which occurred on September 23, 2014. The measurements were required in order to assist IOC in considering the feasibility of future blasting in the proposed Wabush 3 Pit. This report summarizes the data that was collected during the blasts. A previous noise and vibration assessment was completed by HGC Engineering dated June 12, 2014.

The additional noise and overpressure measurements described in this report suggest that at distances similar to what may exist between Wabush 3 and the ski lift equipment at the top of Smokey Mountain, damaging levels of vibration and overpressure can be expected from blasts similar to that which occurred on September 23, 2014. At distances similar to the distance from Wabush 3 to the ski lodges, potentially damaging overpressure levels can be expected. At distances similar to that from Wabush 3 to the new hospital and college, the data indicates that vibration and overpressure would not pose a problem for structures, but ground-borne vibration exceeding limits for vibration-sensitive equipment such as MRIs may be exceeded.

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1 INTRODUCTION

Howe Gastmeier Chapnik Limited ("HGC Engineering") undertook a series of blast vibration and overpressure (airblast) measurements during blasting which took place on September 23, 2014 in the Luce Pit at the Iron Ore Company of Canada ("IOC") mine in Labrador City, Labrador.

The blasts which occurred on September 23, 2014 were designated LU-37-02, a small sump pit blast, LU-36-13, a large but narrow pattern located along the west wall of the pit, and LU-34-44, a large pattern located east of LU-36-13. Fortis Clear 70 explosive was used with 1 and 2 lb boosters. Drill holes were 15" in diameter, drilled for a 13.7 metre bench height, with a 1.5 metre subdrill depth. Five to six metres of stemming was typical. The total length of the blast was roughly 9.5 seconds.

The purpose of the monitoring was to collect information to be used by IOC in the consideration of the feasibility of blasting at the proposed Wabush 3 pit.

2 SITE DESCRIPTION

The IOC mine at Labrador City has been in operation since the 1950s, and several pit areas have been mined since that time. The mine is located north of Labrador City in West Labrador. Figure 1 illustrates the mine in relation to the surrounding land uses.

As shown in Figure 1, the existing Luce Pit is the pit area which is currently closest to the town, and also to the nearby Smokey Mountain Alpine Ski Club and the Menihek Nordic Ski Club. For the most part, blasts in the Luce Pit have occurred at least 5000 metres from the closest parts of the town. The new Labrador City hospital, now under construction, will be one of the closest in-town buildings to the mine area, and will be located about 4900 metres from the Luce Pit. The Luce Pit blasts which have been closest to the two ski lodges have been about 2560 metres away. Because of the orientation of the Smokey Mountain ski area, the top of the lift equipment is located about 2000 metres from the edge of the Luce Pit.

The new Wabush 3 Pit will be considerably closer both to the town and to the ski clubs. Figure 2 shows the identified points of measurement and reception locations, while Table 1 summarizes the

estimated minimum distances from past blasting operations at the Luce Pit and proposed blasting at the Wabush 3 Pit to the various receptor locations.

Table 1: Distances from Existing and Future Pits to Offsite Receptor Locations

Location	Receptor ID	Estimated Distance from Closest Blasts to Receptor [m]	
		Existing Luce Pit	Proposed Wabush 3 Pit
New Hospital and College	R1 / R2	4920	2400
Centre of Labrador City	R3	6250	3920
Harry Lake Subdivision	R4	6210	3590
Smokey Mountain Ski Lodge	R5	2560	880
Dumbbell Lake Residence	R6	2600	940
Menihek Ski Lodge	R7	2800	1110
Menihek Ski Trails*	R8	780	370
Menihek Ski Trail - Summit	R9	3030	1430
Smokey Mountain – Top of Lifts	R10	1990	240

*Note – closest trail to the mine (a portion of the Koch trails forming a loop) is to be removed since it directly conflicts with the new pit. Different trails are therefore used for the existing and proposed cases throughout this report.

3 CRITERIA FOR BLASTING NOISE AND VIBRATION

3.1 Blasting Vibration

Criteria for Cosmetic Structural Damage

Vibration is typically measured in terms of oscillatory displacement, velocity or acceleration. For blast vibration, most references refer to vibration velocity in units of in/s or mm/s peak. In addition to considerations of the level or amplitude of vibration, another important vibration quantity is the frequency of vibration (the rate of oscillation), generally discussed in units of Hertz (Hz).

Most guidelines for allowable levels of blast vibration which are used in North America are based on criteria developed by the US Federal Office of Surface Mining Reclamation and Enforcement (“OSM”) or reports of the former US Bureau of Mines (“USBM”).

Assessment criteria from OSM publications are summarized in Table 2. The limits apply at any offsite dwelling, school, church, or public, community, or institutional building.

Table 2: OSM Criteria

Distance from Blast Site	Maximum Allowable Particle Velocity	Minimum Required Scaled Distance Factor
0 to 91 m (0 to 300 ft)	32 mm/s (1.25 in/s)	50
92 to 1524 m (301 to 5000 ft)	25 mm/s (1.00 in/s)	55
> 1524 m (> 5001 ft)	19 mm/s (0.75 in/s)	65

Many standards make reference to USBM report RI8507 [1]. That report cited a limit for modern homes with drywall interiors of 19 mm/s (0.75 in/s), although the limit is relaxed at higher frequencies (greater than 40 Hz). Other standards, such as the Ontario Ministry of the Environment publication NPC-119 [2] use a more conservative limit of 12.5 mm/s (0.5 in/s) when routine monitoring of the vibration is conducted.

Both the OSM and USBM guidelines have a more complex criterion option which is frequency dependant. These criteria are the least conservative of the typical assessment methods since they allow for a more rigorous assessment of the measured vibration. These are summarized in Figure 3.

Criteria for Sensitive Uses

The above limits are intended to guard against cosmetic damage to structures. The new hospital and college are located relatively near to the Wabush 3 site. These types of buildings can present an additional complication, since many types of equipment used in hospitals and research settings are far more sensitive to vibration than are building constructions. The 1989 version of ISO standard 2631-2, *Evaluation of human exposure to whole-body vibration – Part 2: continuous and shock-induced vibration in buildings (1 to 80 Hz)* [3], as well as the current (2007) version of ISO standard 10137, *Bases for design of structures – Serviceability of buildings and walkways against vibrations*

[4] provide a limit for critical working areas such as some hospital operating-theatres and precision laboratories, which is shown in Figure 3, and compared to the more typical blasting criteria.

Criteria for sensitive instruments such as microscopes are even more stringent. Generic spectral vibration criteria for different classes of sensitive equipment are generally based on the "VC" curves, variously referred to as the BBN criteria or the IEST criteria. The curves are identified as VC-A (the least restrictive, typically applied to low power optical microscopes and other minimally sensitive equipment) to VC-E (very restrictive: long path, laser based, small target systems and other highly sensitive systems). A common standard defining these criteria is the 2007 guide IEST-RP-CC012.2, *Considerations of Cleanroom Design* [5], published by the Institute of Environmental Sciences and Technology (IEST). The VC-A criterion is also shown in Figure 3. Since these criteria are intended to eliminate adverse impacts to testing or imaging procedures, they are only applicable to equipment while it is in use.

Ski Lift Equipment

Ski lift equipment is naturally subject to vibration as part of its routine operation, and some form of elevated criteria is likely appropriate. HGC Engineering understands that IOC is considering replacing the existing equipment on Smokey Mountain in conjunction with the development of Wabush 3, but in any case, no criteria directly applicable to ski lift equipment has been identified at this time.

Avalanche

There may also be some risk of vibration (or airblast) inducing avalanches on the steeper portions of the alpine ski trails. HGC Engineering is not aware of any criteria governing safe levels of vibration mitigating avalanche risk. IOC should consider means to ensure that people are excluded from the nearby areas during blasts. HGC Engineering understands that IOC intends to enforce an exclusion zone for blasting of 1200 meters.

3.2 Airblast

For assessment of air blast amplitudes, both OSM and USBM documents make reference to criteria which are dependent on the ability of the monitoring instrumentation to detect low frequency sound. For large scale blasts, the airblast tends to be characterized by very low frequency pressure waves. Since the sensitivity of monitoring equipment to low frequency sound varies, the criteria summarized in Table 3 are more conservative for instruments with less sensitivity to low frequencies (i.e., for instruments with higher high-pass cutoff frequencies). Criteria in units of both dB and psi are included in Table 3, although this report utilizes units of dB herein.

Table 3: OSM and USBM Criteria for Airblast

Highpass Cut-off Frequency of Measurement Instrumentation [Hz]	Maximum Allowable Airblast [dB]	Maximum Allowable Airblast [psi]
0.1 Hz	134	0.015
2 Hz	133	0.013
6 Hz	129	0.0082
C-weighted slow response of a sound level meter	105	0.00052

These criteria may be somewhat conservative, as many references indicate 140 dB as a safe level, with some breakage of window glass expected near 150 dB, and general breakage near 170 dB. However, for the ongoing, very large scale blasts at IOC, the use of criteria lower than 140 dB is appropriate. The Ontario Ministry of the Environment uses a standard limit of 128 dB, reduced to 120 dB if routine monitoring is not undertaken.

4 MEASUREMENTS

Measurements were conducted at five locations, shown on Figure 2. The approximate distances from the blast to the measurement locations are shown in Table 4.

Table 4: Measurement Locations

Location		Nominal Distance to Blast [m]
M1	Luce Pit	250
M2	Luce Pit	1000
M3	Toward Labrador City	2500
M4	Smokey Mountain Ski Lodge	3000
M5	College	5900

For Location M1, a distance of 250 metres was selected, as this distance is similar to the minimum horizontal distance which could exist between the closest edge of the Wabush 3 Pit and the top of Smokey Mountain. At Location M1, HGC Engineering deployed an Instantel Minimate plus seismograph equipped with a standard geophone and overpressure microphone. An attempt was made to locate a piece of exposed native rock not in the line of fire from the blast, but no such location could be found. As a result, the geophone was bolted into a large boulder.

A distance of 1000 metres was selected for Location M2, as this distance is similar to the distance which could exist between blasting at Wabush 3 and the ski lodges. At Location M2, HGC Engineering deployed an Instantel Minimate plus seismograph equipped with a standard geophone and overpressure microphone. The geophone was bolted into what appeared to be a section of exposed native rock. IOC also deployed two Instantel Blastmate III seismographs at this location, both equipped with a geophone and mic. We have no details of the installation.

A distance of 2500 metres was selected for Location M3, as Wabush 3 could be approximately this distance from the College and new hospital. At Location M3, an Instantel Minimate plus seismograph equipped with a standard geophone and overpressure microphone was installed on a large rock exposed along the edge of an access road. The geophone was bolted to the rock.

At a higher elevation near location M3, a Norsonic Nor-140 sound level meter capable of audio recordings was installed. The objective was to install the equipment at the top of Smokey Mountain, but access to this area was not feasible within the available time. The selected location is shown on Figure 2, however no data was recorded by the instrument during the blast.

At Location M4, Smokey Mountain Lodge, two Minimate plus seismographs were deployed. One was located indoors, equipped with only a standard geophone which was bolted to the concrete basement floor slab-on-grade. The second was located outside of the Lodge, equipped with both a microphone and a geophone which was bolted to a large exposed piece of rock. A Norsonic Nor-140 sound level meter was also deployed at this location.

At Location M5, the college, a Minimate plus seismograph was deployed in the building, equipped with only a standard geophone which was adhered to the concrete floor. Outdoors at this location, a Norsonic Nor-140 sound level meter was deployed.

In total, HGC Engineering deployed ten instruments, and IOC deployed an additional two. The peak vibration and overpressure data measured by the instruments are shown in Table 5.

Table 5: Measurement Locations and Overall Results.

Location		Measurement Data		
		PVS Peak Vibration [mm/s]	Peak Overpressure (Minimate) [dB]	Peak Overpressure (Norsonic) [dB]
M1	Luce Pit, (Nominal 250 metres)	70.7	Overload	N/A
M2	Luce Pit, (Nominal 1000 metres)	9.0	146	N/A
	Luce Pit, Nom. 1000 m [IOC Monitor]	11.0	146	N/A
	Luce Pit, Nom. 1000 m [IOC Monitor]	12.0	146	N/A
M3	Toward Labrador City (2500 metres)	1.0	129[2]	N/A
M4	Smokey Mountain Ski Lodge – Basement (3000 metres)	2.2	N/A[3]	N/A[3]
	Smokey Mountain Ski Lodge – Outdoors (3000 metres)	3.4	126[2]	121[1, 2]
M5	College (5900 metres)	0.5	N/A[3]	112[1, 2]

Notes:

[1] The Nor-140 does not have the track record of the Minimate Plus for use in blast overpressure monitoring, and as a result, this data should be assumed to be an estimate only.

[2] These locations were acoustically shielded from the blast.

[3] No instrumentation was deployed at this location to measure this quantity.

As shown in the notes to the table, all locations other than M1 and M2 were acoustically shielded from the blast due to the depth of the pit, and the intervening topography. If a direct line-of-sight had existed from the blast to the measurement locations, higher overpressure levels may have resulted.

5 DISCUSSION OF VIBRATION AND OVERPRESSURE DATA

Location M1

Location M1 was measured at a nominal distance of 250 metres from the blasts. As shown in Table 5, peak vibration of about 71 mm/s was measured at this location. The 250 metres distance was intended to represent the closest distance which could exist between the Wabush 3 Pit and the ski lift equipment at the top of Smokey Mountain, although the change in elevation to the top of the mountain will result in a greater actual separation in practice (ie. the diagonal distance from the blast to the equipment will be greater than the horizontal distance in many cases). More detailed measurement data collected at the five locations is provided in the first five appendices to this report. The measurement summarized in Appendix 1 represents the data measured at Location M1. The vibration and overpressure data clearly shows the effect of all three blasts. The chart in the upper right hand corner of the page in Appendix 1 represents a frequency analysis of the vibration data, superimposed on the more complex spectral criteria of the OSM and USBM guidelines.

A vibration level of 71 mm/s exceeds the common standards for vibration at buildings (see Table 2). The spectral criteria was also exceeded as shown in Appendix 1. The overpressure level measured at this location was off the scale. These facts indicate that there may be an incompatibility between buildings or other structures at the top of Smokey Mountain and future similar blasts at Wabush 3 at this distance, or at least that great care will need to be taken in the design of new ski lift equipment and the design of blasts at Wabush 3. Such large vibration and overpressure data also suggests that access to the top of Smokey Mountain will need to be controlled if such blasts are to occur at such close distances. HGC Engineering understands IOC will be installing fencing around Wabush 3 pit to control access to the area. As well, during blasting, a 1200 meter exclusion zone will be enforced.

Location M2

As shown in Table 5, peak vibration of about 9 to 12 mm/s was recorded at Location M2, together with an overpressure of 146 dB. While such a vibration measurements may be considered acceptable if it were recorded at a residence or other building (see Table 2), the overpressure level would not (see Table 3). Appendix 2 summarizes the data collected at Location M2. As shown, vibration data

was captured by all three monitors only for the third (and largest) of the three blasts, indicating that the vibration caused by the earlier blasts was lower. Overpressure data was captured for the second and third blasts. The spectral analysis of the vibration data indicates that at this location, the spectral OSM and USBM guidelines were not exceeded.

The 1000 metre distance between the blasts and Location M2 was intended to represent the future distance between blasts at Wabush 3 and the ski lodges. This suggests that if this blast were to have occurred at Wabush 3, near to the ski lodges, acceptable vibration may have resulted, but the airblast would have been excessive.

Location M3

At Location M3, data was captured for the entire blast. This location was intended to represent a location approximately the same distance between future blasts at Wabush 3 and the college and hospital, both the peak vibration and overpressure actually measured (see Tables 2 and 3) were compatible with typical criteria for damage to structures. However the maximum vibration level of 1.0 mm/s was greater than typical vibration criteria for vibration sensitive equipment such as MRIs, and the ISO guideline for hospitals. The significance of this for the actual hospital and college is not known as no information about vibration sensitive equipment used in these facilities has been provided. HGC Engineering understands the hospital does not anticipate having highly sensitive equipment such as an MRI or CT scanner, which may limit the applicability of the criteria for sensitive equipment. If it is found that blasting does interfere with certain procedures or tests at the hospital or college, the potential for scheduling of affected procedures or tests around the blast schedule or vice versa, should be explored. Close communication between IOC and the hospital and college will be required.

Location M4

At Location 4 (Smokey Mountain Ski Lodge), vibration data was captured only for the largest blast (see Appendix 4), since the earlier blast components did not trigger the monitor, although overpressure data was captured for all three. Both the overpressure and vibration data were below typical limits for the observed blast in the Luce Pit.

Location M5

Location M5 (hospital and college), vibration data was captured only for the largest blast (see Appendix 4). The peak vibration level at this location was 0.5 mm/s, which exceeds the ISO guideline for critical areas such as hospitals. At a frequency of 14 Hz, which the measured vibration data indicates is generally the dominant frequency of ground motion at IOC, the ISO guideline limit is 0.1 mm/s, which is below the measured level of 0.5 mm/s. This indicates that vibration caused by existing blasts already exceeds criteria for critical areas, and close communication between the hospital and IOC should be ongoing to determine the significance of this finding.

General Discussion

The blast explosive weight envelope is shown in Appendix 6. The maximum charge weight per delay (grouped into time periods of at least 8 ms) was about 32,200 kg during the blast. Considering this value, and the distances from the blast to the various monitor locations, scaled distances have been calculated to allow a comparison of the new vibration and over pressure data with the earlier data supplied by IOC. Figure 4 illustrates the vibration data, and Figure 5 illustrates the overpressure data. In both cases, various standard predictions and scaled predictions are provided.

As discussed in the previous report prepared by HGC Engineering, and as illustrated in Figure 4, the measured vibration data is less than what might be expected based on typical prediction methods, scaled up for the size of the blast. However, as more data is collected at IOC, a more accurate and practical prediction curve will emerge. The overpressure data is more closely predicted by typical guidelines, as shown in Figure 5.

It should be reiterated that all of the measurement locations other than those in the pit were at locations which were acoustically shielded from the blasts. Therefore, it should be expected that locations not shielded from the blast, but located the same distance away, would be exposed to larger overpressure levels.

6 CONCLUSIONS

The new measured data suggest that at distances similar to what may exist between the closest approach of Wabush 3 and the ski lift equipment, damaging levels of vibration and overpressure can be expected from blasts similar to that which occurred on September 23, 2014. At distances similar to the distance from Wabush 3 to the ski lodges, potentially damaging overpressure levels can be expected. At distances similar to that from Wabush 3 to the new hospital and college, the data indicates that vibration and overpressure would not pose a problem for structures, but vibration exceeding limits for vibration-sensitive equipment may be exceeded. Measured vibration data obtained at the college indicates that this situation may already exist for very sensitive instruments, but to a lower extent.

It is not immediately clear that blasts similar to that reported here and on buildings or other structures at the top of Smokey Mountain are compatible at the distances currently envisioned. Therefore, as investigation and planning for Wabush 3 continues, consideration of different blast designs will need to be made; blasts at Wabush 3 may need to be of a different design from blasts at the Luce Pit, using considerably smaller total weights of explosive per delay. A greater setback between Wabush 3 and the ski equipment may also need to be considered, and great care will need to be taken in the design of new ski lift equipment. Access to the area near the top of the mountain will need to be controlled during blasting.

The measurements described here have attempted to capture data from a blast in the Luce Pit at distances similar to the future distances from key receptors to the proposed Wabush 3 Pit. However, the geology and topography is not the same, and ideally, test blasts will be undertaken in the Wabush 3 area with low explosive weights. As more data becomes available, the information can be used to make more realistic predictions of blast noise and vibration from the proposed pit.

The preliminary calculations which are based on the initial existing monitor data suggest that vibration at the upper ski lift equipment will be beyond typical blast vibration criteria. A detailed assessment of allowable vibration on the equipment has not been undertaken, but it is clear that

careful consideration will need to be given to the design of blasts near to the lift equipment, and to the design of any future lift equipment which may be considered for the area.

Additional blast vibration and overpressure measurements are required in order to collect a body of information about the impact of blasts at IOC. IOC is in the process of refining such a program at this time. We recommend that the program make use of at least one location relatively distant from the blasts, but having a direct line-of-site.

7 REFERENCES

1. USBM report RI 8507, *Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting*, 1980.
2. Ontario Ministry of the Environment Guideline NPC-119, *Blasting.*
3. 1989 version of ISO standard 2631-2, *Evaluation of human exposure to whole-body vibration – Part 2: continuous and shock-induced vibration in buildings (1 to 80 Hz)*, 1989.
4. ISO standard 10137, *Bases for design of structures – Serviceability of buildings and walkways against vibrations*, 2007.
5. 2007 guide IEST-RP-CC012.2, *Considerations of Cleanroom Design*, published by the Institute of Environmental Sciences and Technology (IEST).

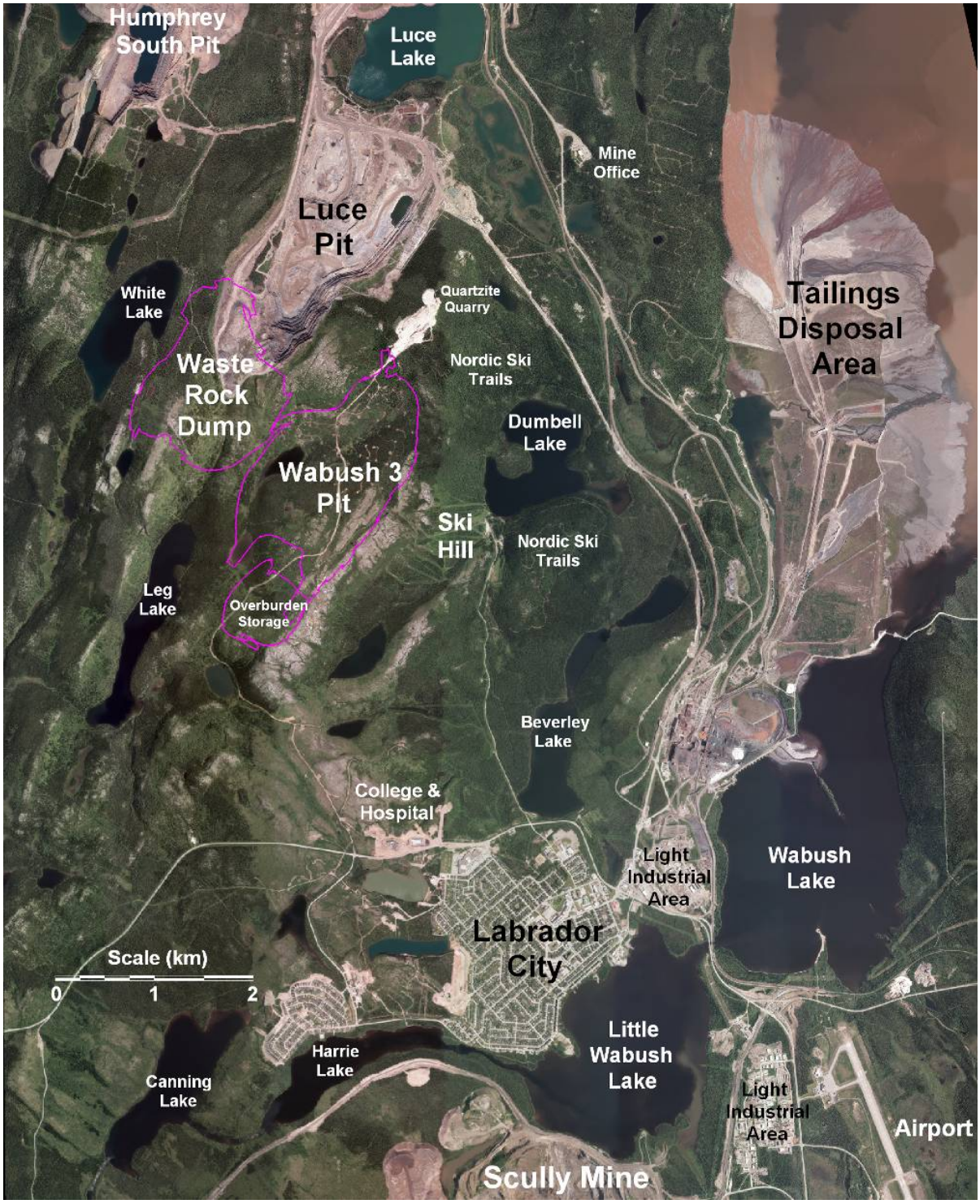


Figure 1: Key Plan

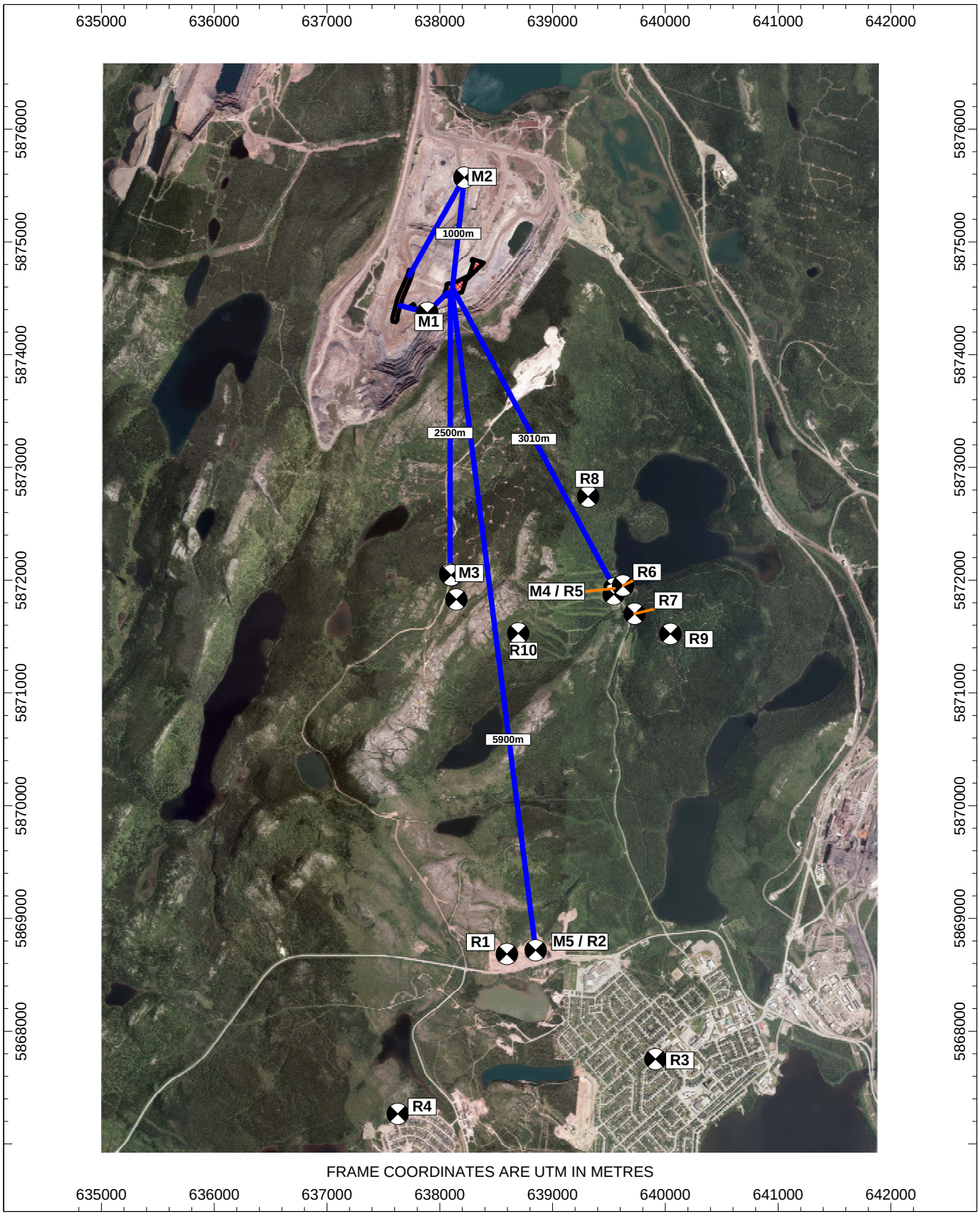


Figure 2: Area and Measurement/Receptor Locations
IOC, Proposed Wabush 3 Pit

Figure 3: Various Vibration Velocity Criteria for Blasting Operations

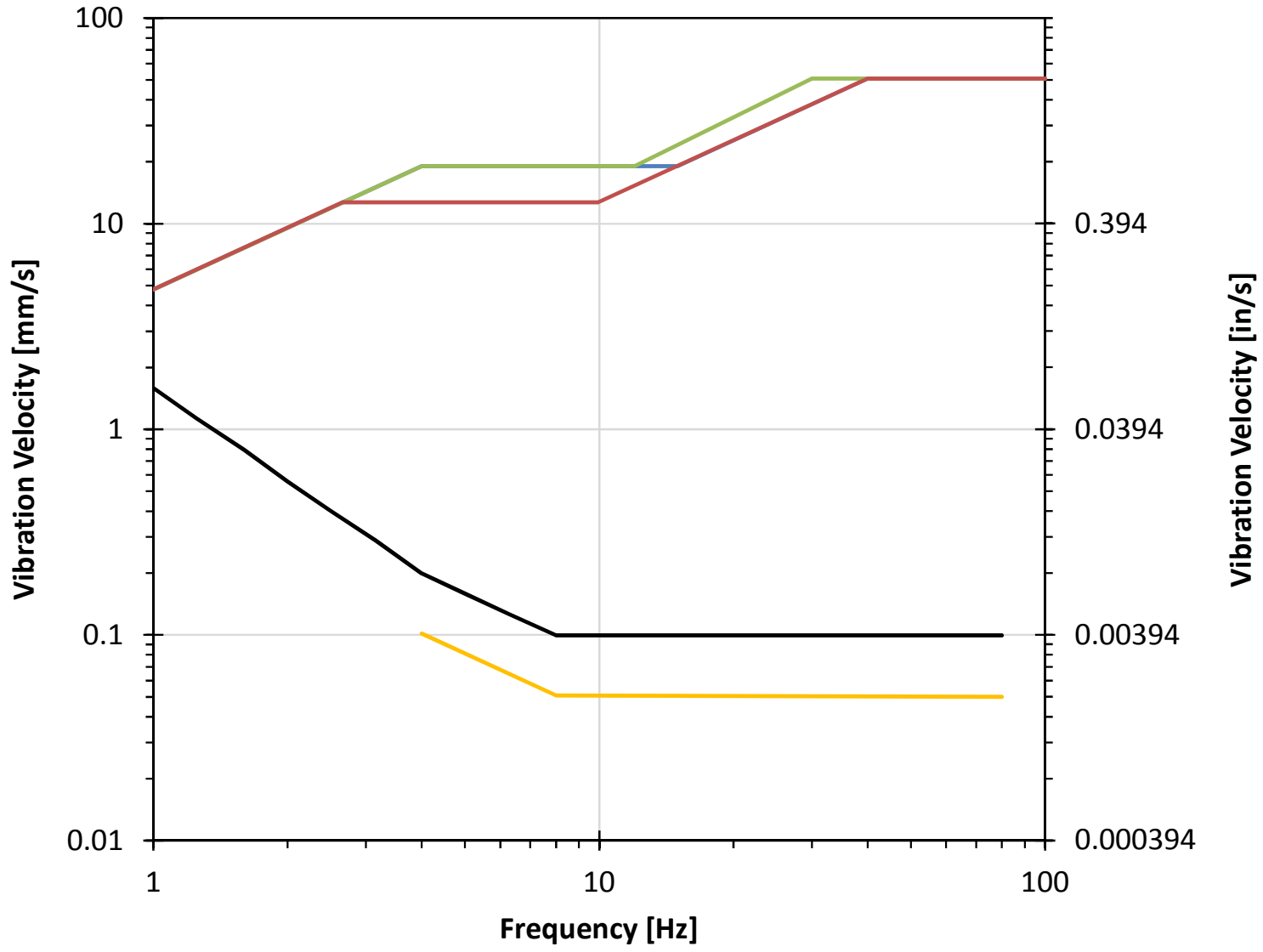
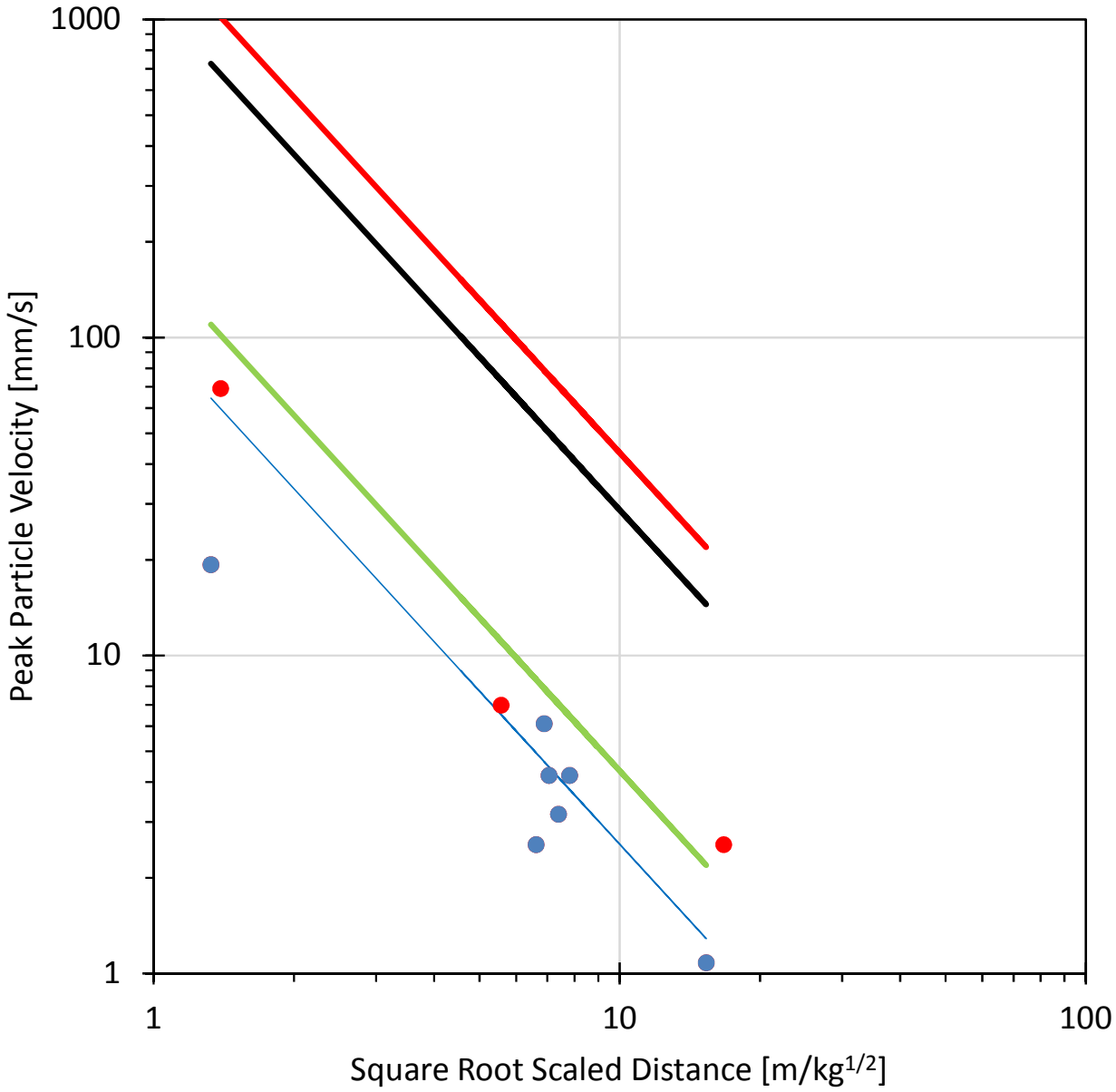
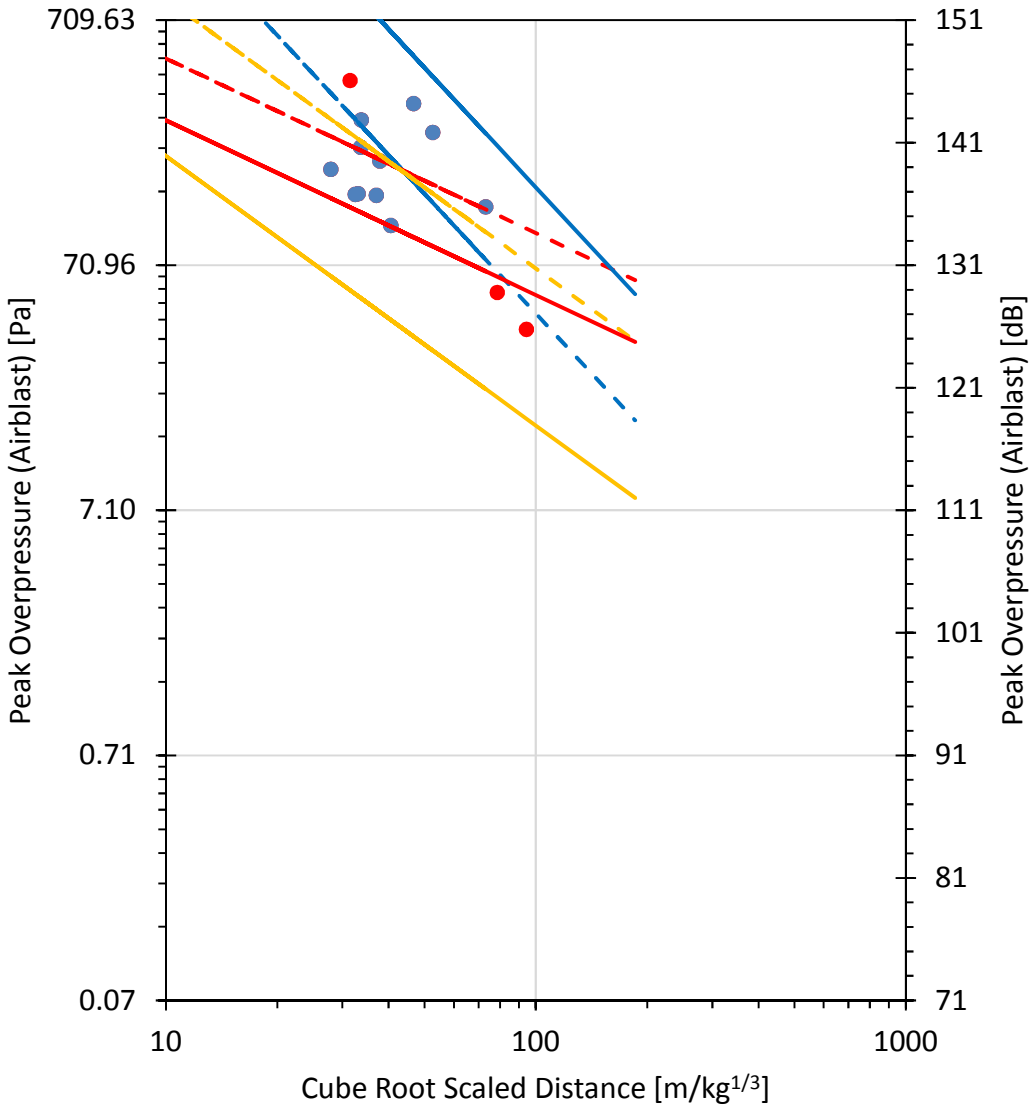


Figure 4: Predicted and Measured Peak Particle Velocity Data



HGC Measurement Data
IOC Measurement Data
Oriard Lower Bound
Oriard Average
Oriard Upper (90%) bound

Figure 5: Predicted and Measured Airblast Data



APPENDIX 1: Overpressure and Vibration Measured by HGC Engineering at Location M1

Event Report

Date/Time Vert at 13:40:26 September 23, 2014
Trigger Source Geo: 3.00 mm/s
Range Geo: 254 mm/s
Record Time 15.0 sec at 1024 sps
Job Number: 1
Notes
Location: Luce Pit, 250m, HGC-01
Client: IOC, Wabush 3
User Name:
General:

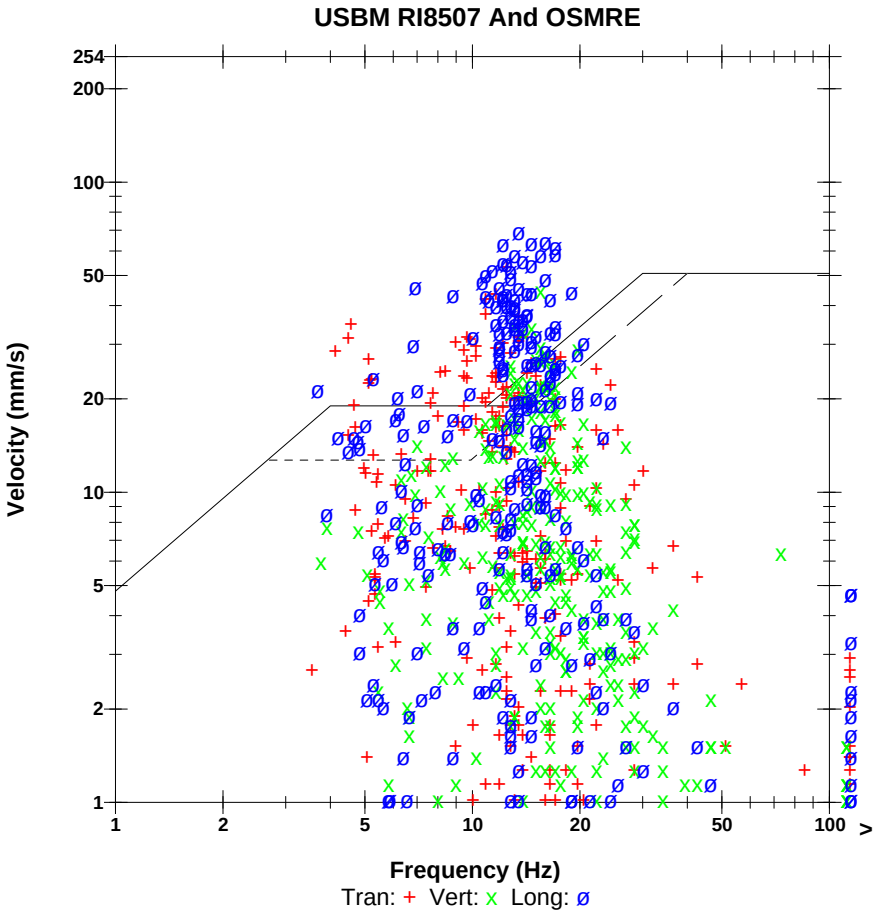
Serial Number BE14603 V 10.72-8.17 MiniMate Plus
Battery Level 6.9 Volts
Unit Calibration September 9, 2014 by Instantel
File Name P603FIIL.ZE0

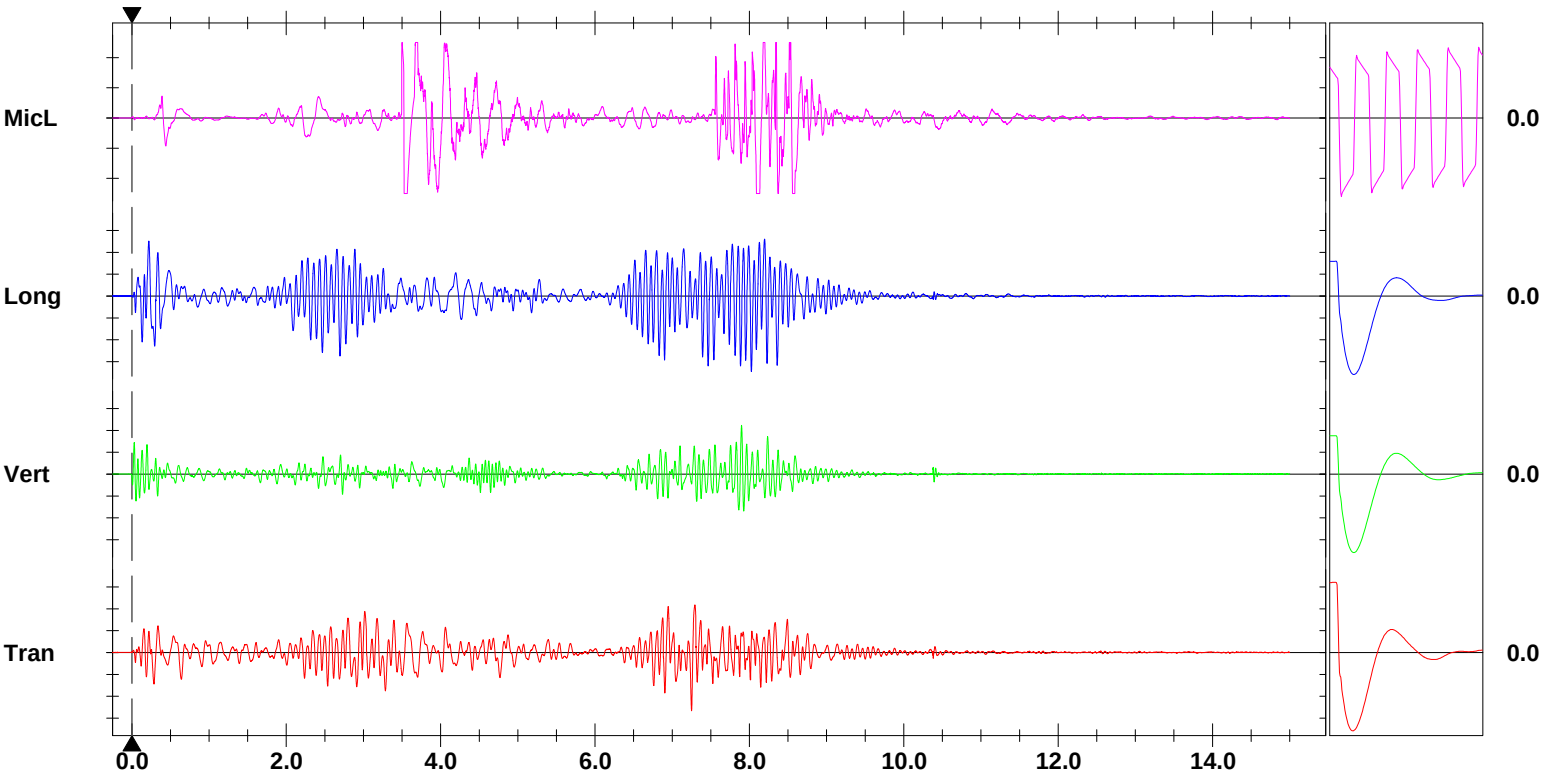
Extended Notes
Located on south side of access road
Adjacent structure (pit wall)

Microphone Linear Weighting
PSPL *** pa.(L) at 3.497 sec
ZC Freq 11 Hz
Channel Test Passed (Freq = 20.5 Hz Amp = 740 mv)

	Tran	Vert	Long	
PPV	53.2	44.6	69.1	mm/s
ZC Freq	12	16	13	Hz
Time (Rel. to Trig)	7.251	7.898	8.025	sec
Peak Acceleration	1.51	0.490	1.52	g
Peak Displacement	0.872	0.465	1.03	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.9	7.4	7.3	Hz
Overswing Ratio	3.4	3.8	4.3	

Peak Vector Sum 70.7 mm/s at 8.026 sec
***** : Out of Range**





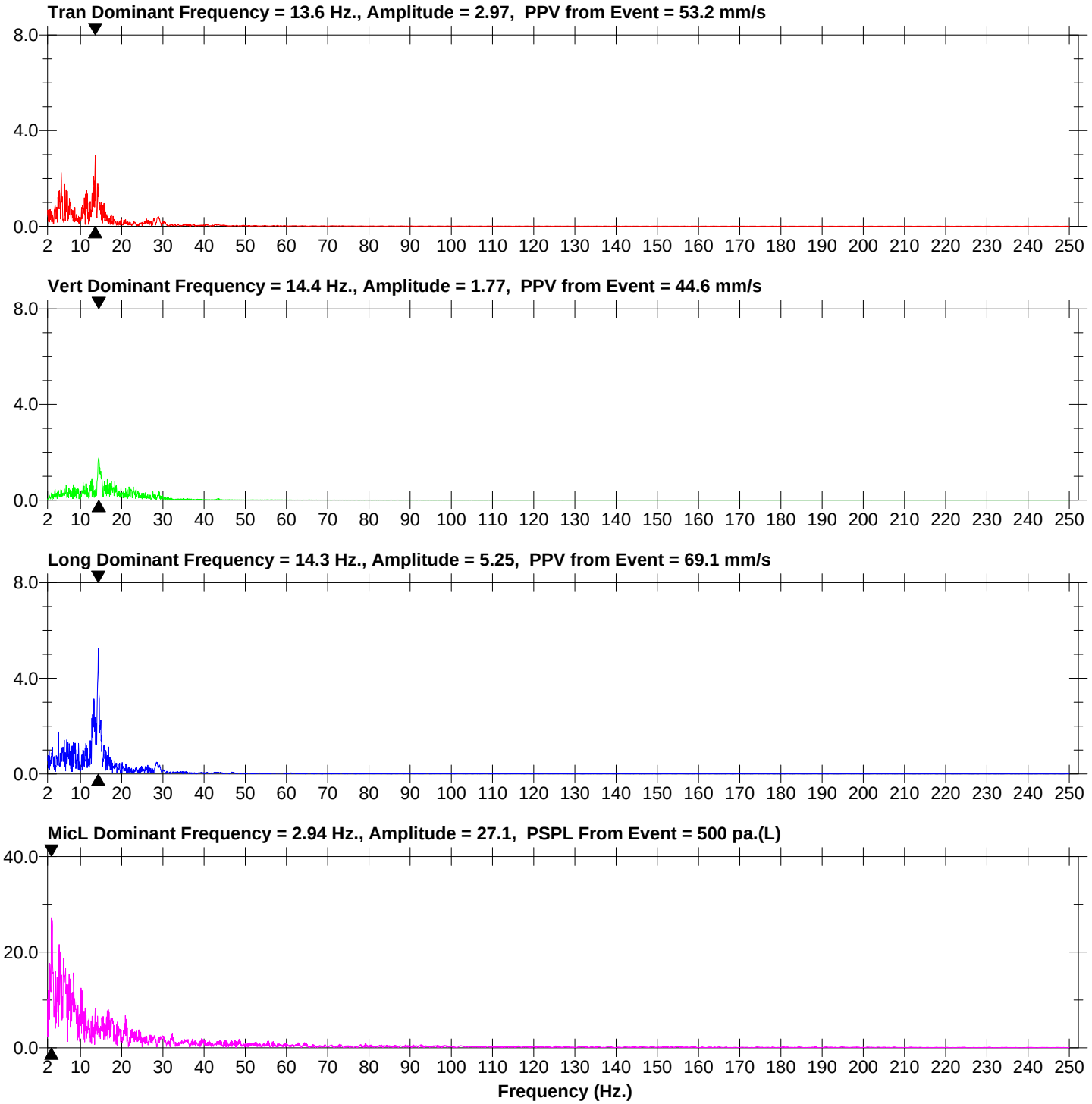
Time Scale: 0.50 sec/div **Amplitude Scale:** Geo: 20.0 mm/s/div Mic: 200 pa.(L)/div Sensor Check
Trigger =

FFT Report

Date/Time	Vert at 13:40:26 September 23, 2014
Trigger Source	Geo: 3.00 mm/s
Range	Geo: 254 mm/s
Record Time	15.0 sec at 1024 sps
Job Number:	1
Serial Number	BE14603 V 10.72-8.17 MiniMate Plus
Battery Level	6.9 Volts
Unit Calibration	September 9, 2014 by Instantel
File Name	P603FIIL.ZE0

Notes
Location: Luce Pit, 250m, HGC-01
Client: IOC, Wabush 3
User Name:
General:

Extended Notes
Located on south side of access road
Adjacent structure (pit wall)



APPENDIX 2: Overpressure and Vibration Measured by HGC Engineering and IOC at Location M2

Event Report

Date/Time Vert at 13:40:20 September 23, 2014
Trigger Source Geo: 2.00 mm/s
Range Geo: 254 mm/s
Record Time 20.0 sec at 1024 sps
Notes
Location: Luce Pit, 1000m, HGC-02
Client: IOC
User Name: HGC Engineering
General: HGC Minimate Plus #6

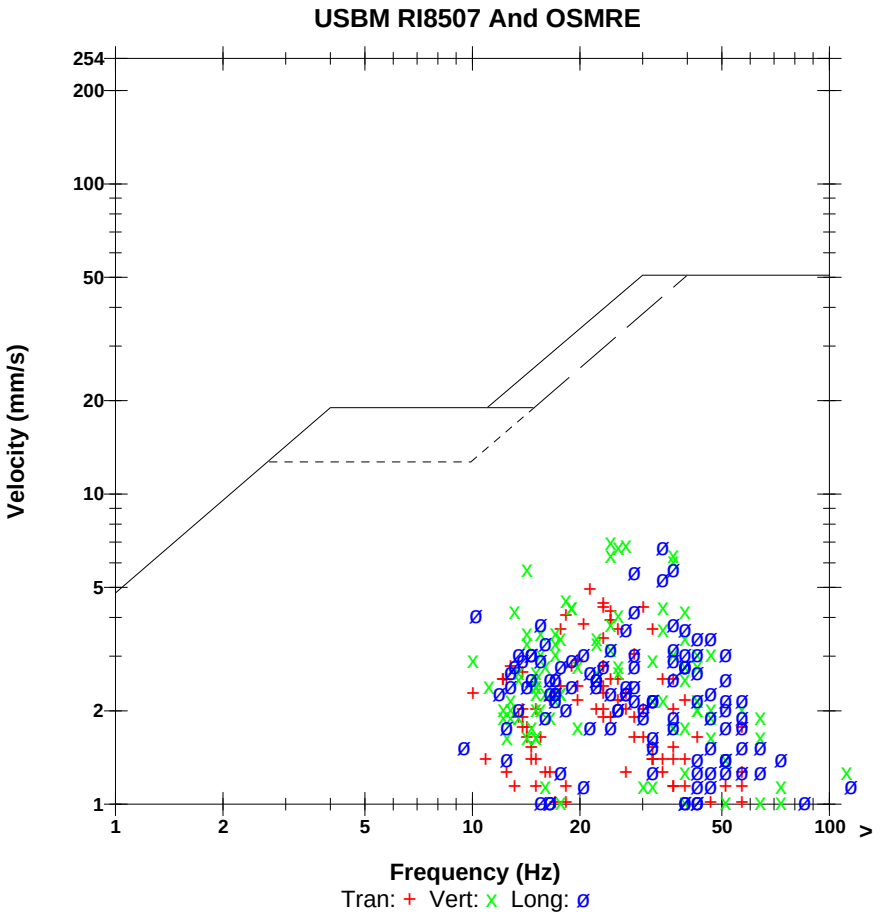
Extended Notes
Approximately 1000m from blast in Luce Pit
WP 358

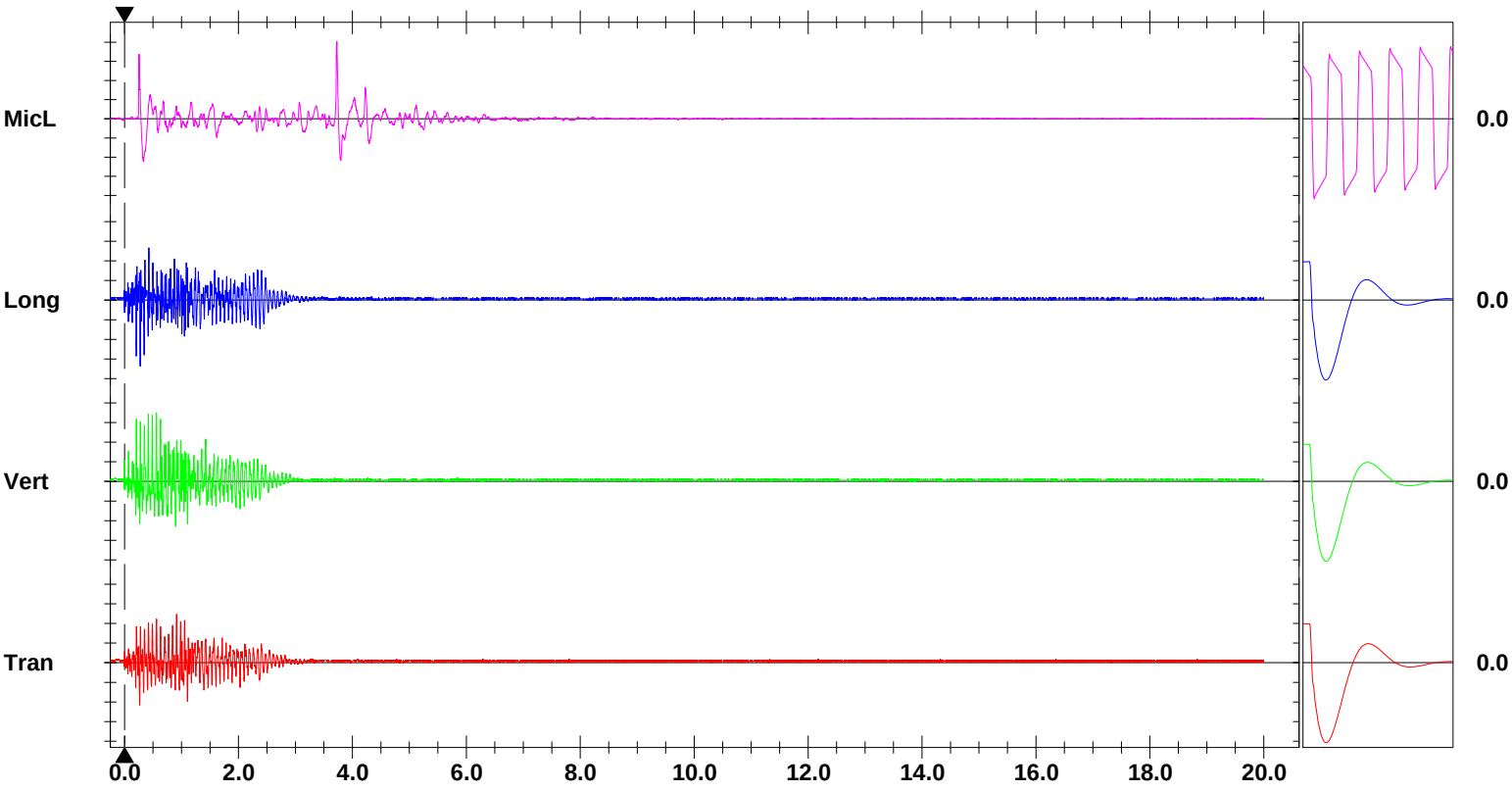
Microphone Linear Weighting
PSPL 403 pa.(L) at 3.728 sec
ZC Freq 7.8 Hz
Channel Test Passed (Freq = 20.1 Hz Amp = 720 mv)

	Tran	Vert	Long	
PPV	4.95	6.98	6.73	mm/s
ZC Freq	21	24	34	Hz
Time (Rel. to Trig)	0.913	0.561	0.274	sec
Peak Acceleration	0.0928	0.159	0.146	g
Peak Displacement	0.0301	0.0426	0.0339	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.4	7.4	7.6	Hz
Overswing Ratio	4.3	4.2	3.9	

Peak Vector Sum 9.06 mm/s at 0.276 sec

Serial Number BE7574 V 10.72-8.17 MiniMate Plus
Battery Level 6.9 Volts
Unit Calibration September 9, 2014 by Instantel
File Name I574FIIL.Z80





Time Scale: 0.50 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 100.0 pa.(L)/div Sensor Check
Trigger =

FFT Report

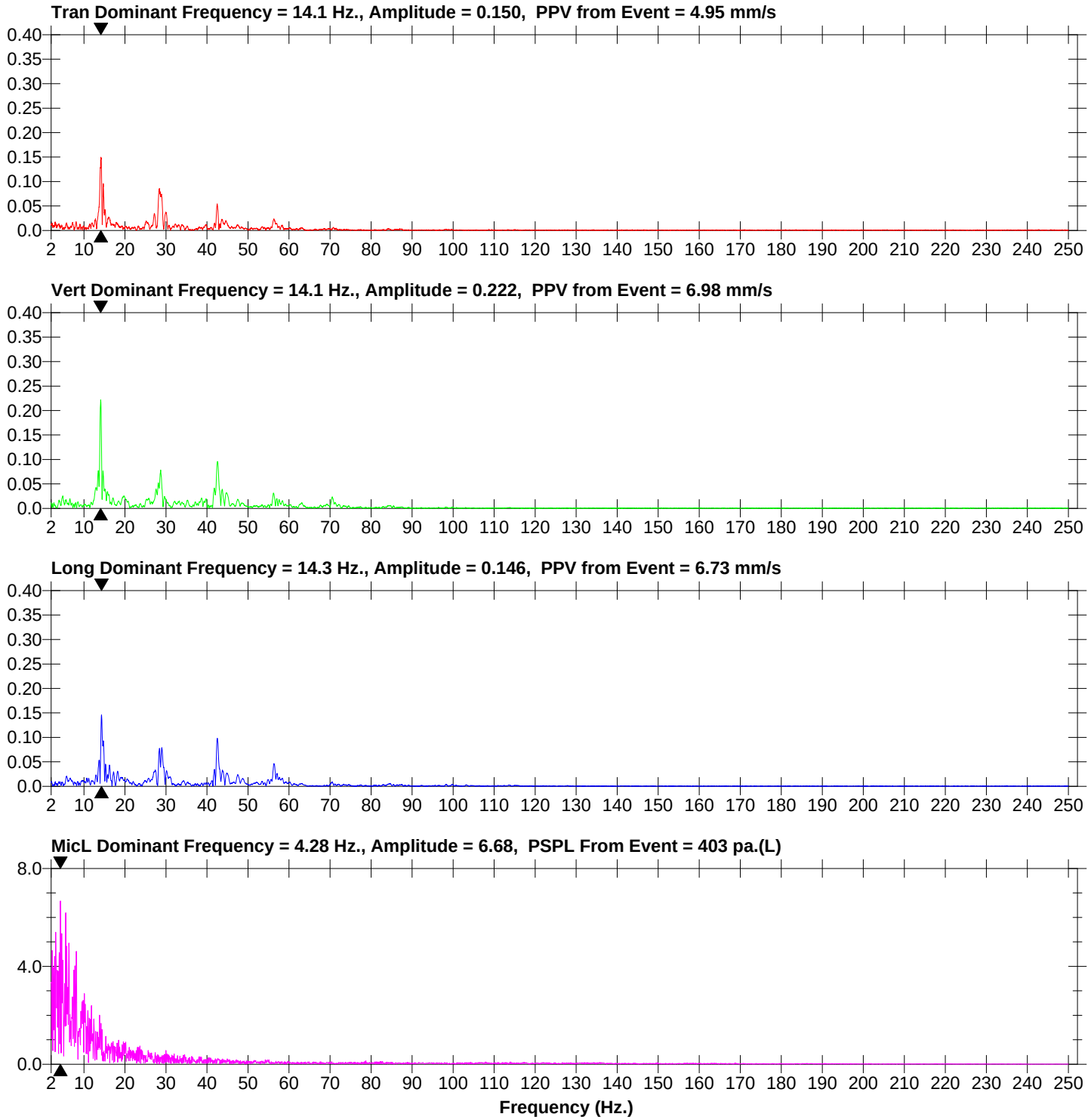
Date/Time	Vert at 13:40:20 September 23, 2014
Trigger Source	Geo: 2.00 mm/s
Range	Geo: 254 mm/s
Record Time	20.0 sec at 1024 sps
Serial Number	BE7574 V 10.72-8.17 MiniMate Plus
Battery Level	6.9 Volts
Unit Calibration	September 9, 2014 by Instantel
File Name	I574FIIL.Z80

Notes

Location: Luce Pit, 1000m, HGC-02
Client: IOC
User Name: HGC Engineering
General: HGC Minimate Plus #6

Extended Notes

Approximately 1000m from blast in Luce Pit
WP 358



Event Report

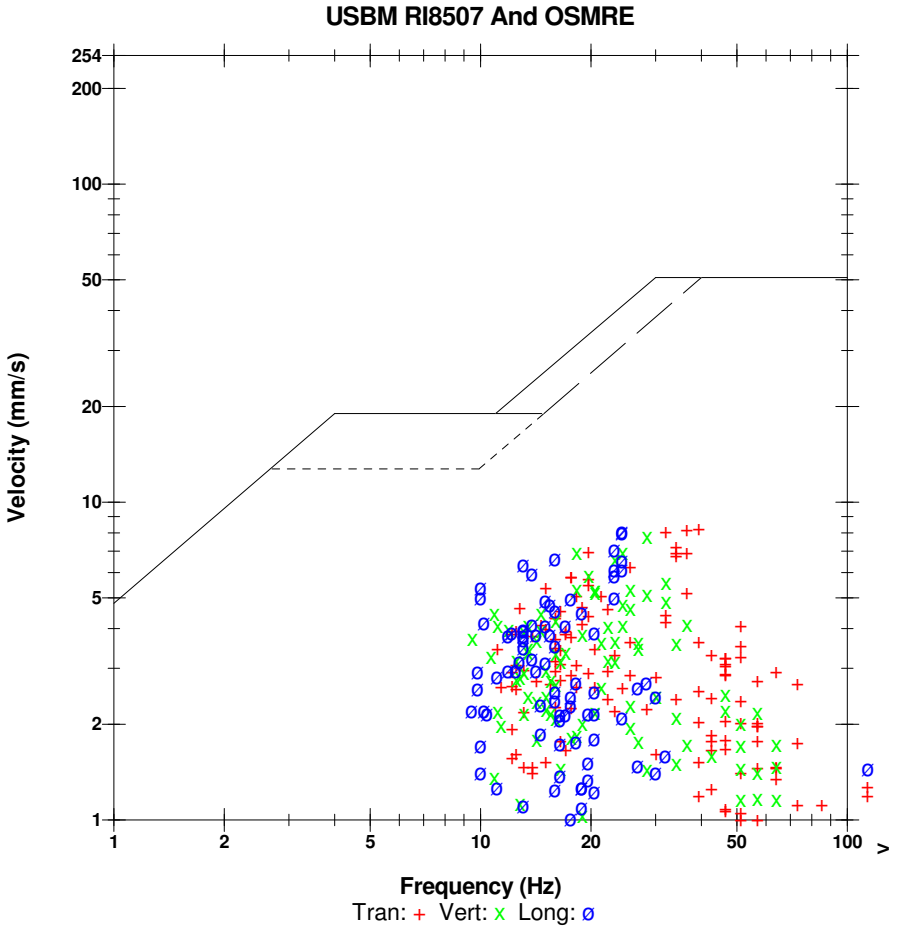
Date/Time	Vert at 13:24:57 September 23, 2014
Trigger Source	Geo: 5.00 mm/s
Range	Geo: 31.7 mm/s
Record Time	6.0 sec at 1024 sps
Job Number:	1
Notes	

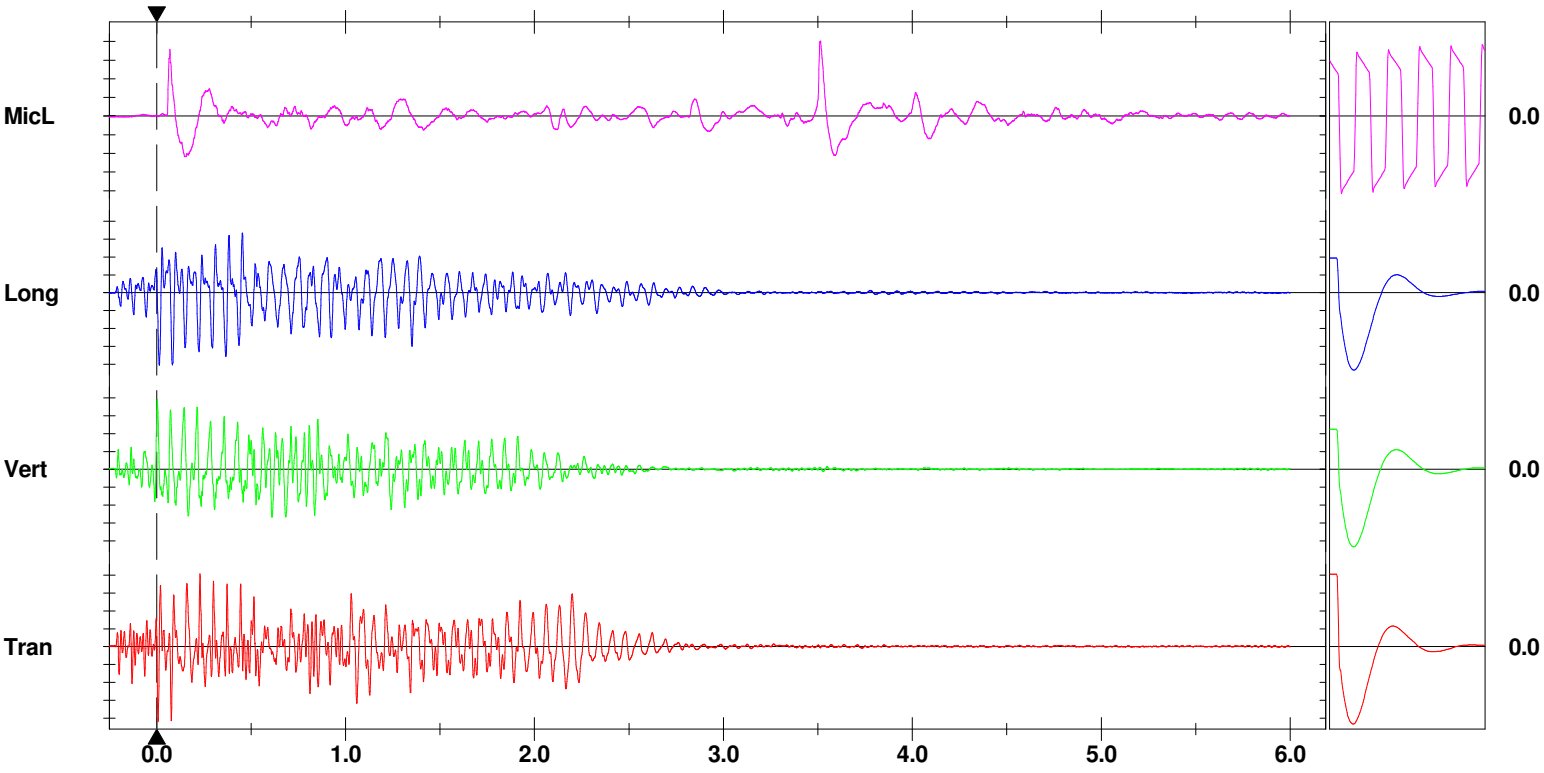
Serial Number	BA15184 V 10.31-8.17 BlastMate III
Battery Level	6.1 Volts
Unit Calibration	June 15, 2012 by Instantel
File Name	Q184FIIL.9L0

Microphone	Linear Weighting
PSPL	146.1 dB(L) at 3.515 sec
ZC Freq	7.3 Hz
Channel Test	Passed (Freq = 20.5 Hz Amp = 704 mv)

	Tran	Vert	Long	
PPV	8.38	7.81	8.11	mm/s
ZC Freq	39	28	24	Hz
Time (Rel. to Trig)	0.008	0.004	0.015	sec
Peak Acceleration	0.245	0.147	0.171	g
Peak Displacement	0.0521	0.0552	0.0602	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.9	7.5	7.3	Hz
Overswing Ratio	3.8	4.0	4.4	

Peak Vector Sum 11.0 mm/s at 0.008 sec





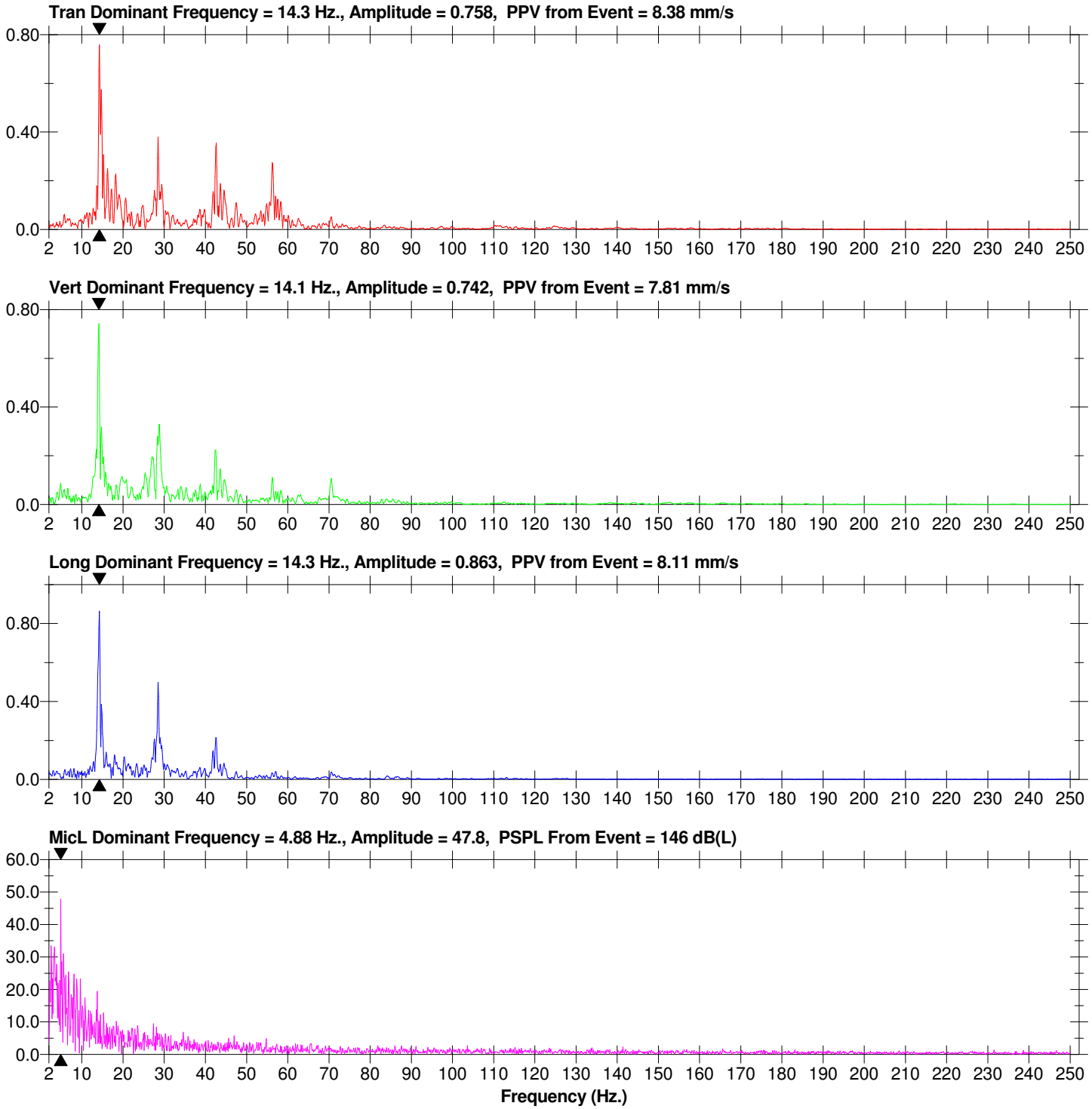
Time Scale: 0.50 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 100.0 pa.(L)/div Sensor Check

Trigger = ▶——— ———◀

FFT Report

Date/Time	Vert at 13:24:57 September 23, 2014	**Serial Number**	BA15184 V 10.31-8.17 BlastMate III
Trigger Source	Geo: 5.00 mm/s	**Battery Level**	6.1 Volts
Range	Geo: 31.7 mm/s	**Unit Calibration**	June 15, 2012 by Instantel
Record Time	6.0 sec at 1024 sps	**File Name**	Q184FIIL.9L0
Job Number:	1		

Notes



Event Report

Date/Time	Vert at 13:23:08 September 23, 2014
Trigger Source	Geo: 3.00 mm/s
Range	Geo: 254 mm/s
Record Time	5.75 sec (Auto=3Sec) at 1024 sps
Job Number:	1
Notes	
Location:	
Client:	
User Name:	
General:	

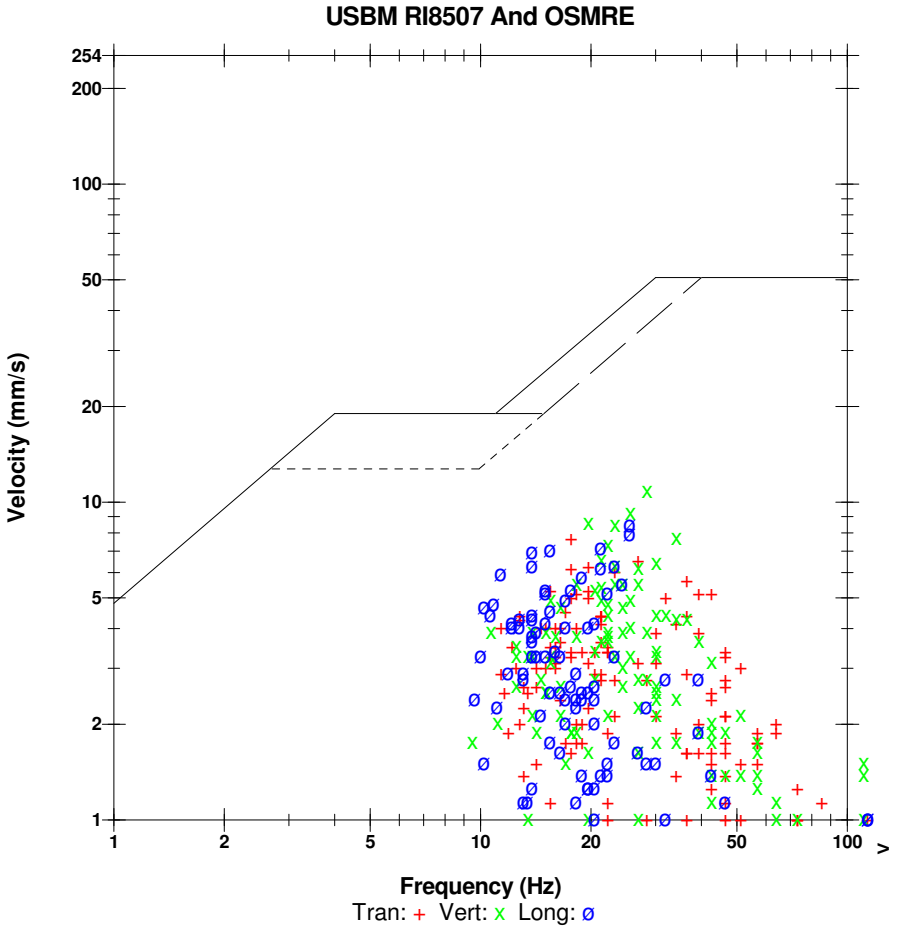
Serial Number	BA17303 V 10.31-8.17 BlastMate III
Battery Level	6.3 Volts
Unit Calibration	June 18, 2012 by Instantel
File Name	S303FIIL.6K0

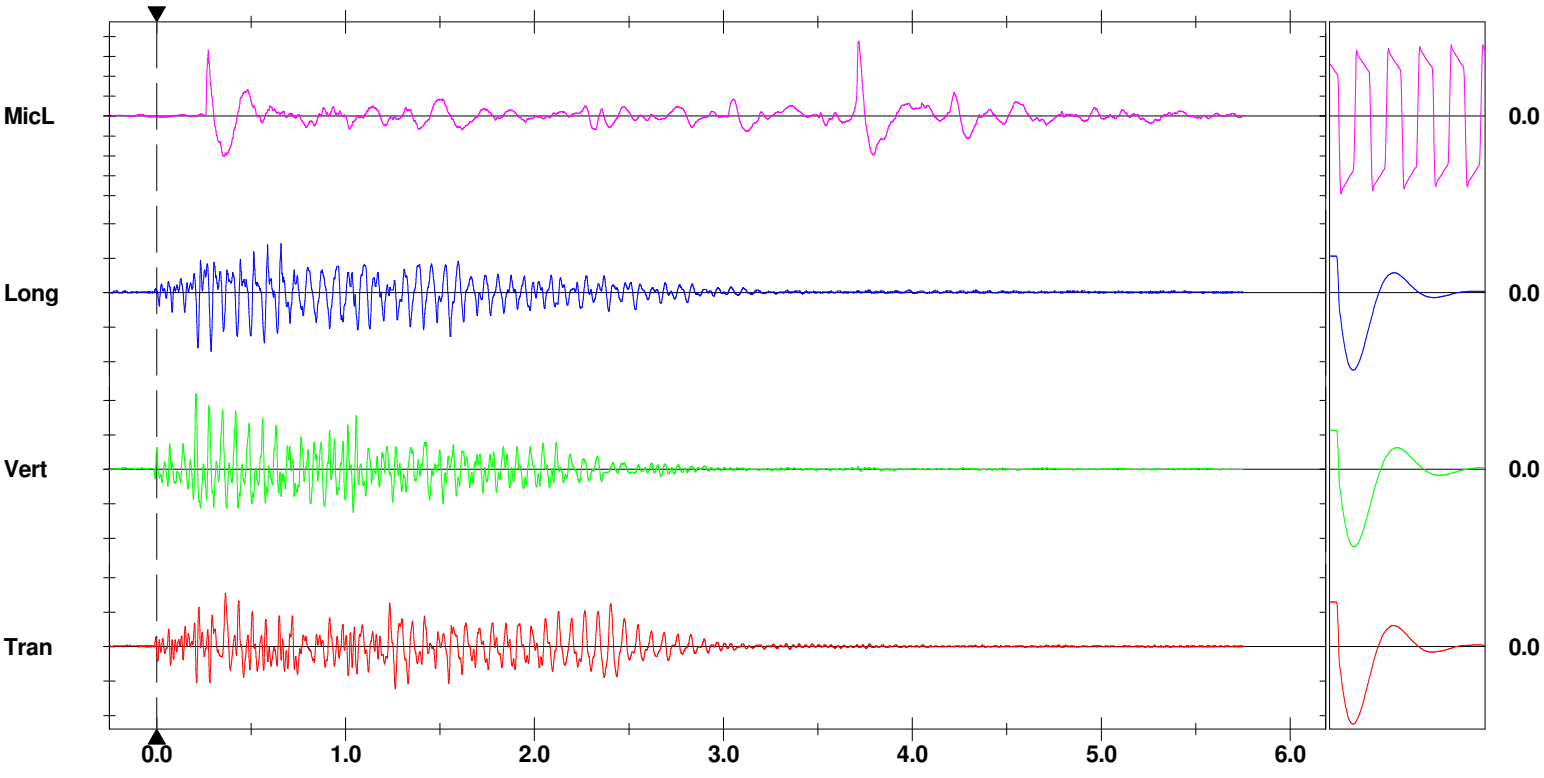
Extended Notes

Microphone	Linear Weighting
PSPL	145.5 dB(L) at 3.718 sec
ZC Freq	7.3 Hz
Channel Test	Passed (Freq = 20.1 Hz Amp = 717 mv)

	Tran	Vert	Long	
PPV	7.75	10.9	8.51	mm/s
ZC Freq	18	28	26	Hz
Time (Rel. to Trig)	0.364	0.208	0.288	sec
Peak Acceleration	0.159	0.199	0.159	g
Peak Displacement	0.0594	0.0636	0.0630	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.9	7.5	7.8	Hz
Overswing Ratio	3.7	3.6	4.0	

Peak Vector Sum 12.0 mm/s at 0.210 sec





Time Scale: 0.50 sec/div **Amplitude Scale:** Geo: 5.00 mm/s/div Mic: 100.0 pa.(L)/div Sensor Check

Trigger = ▶——— ———◀

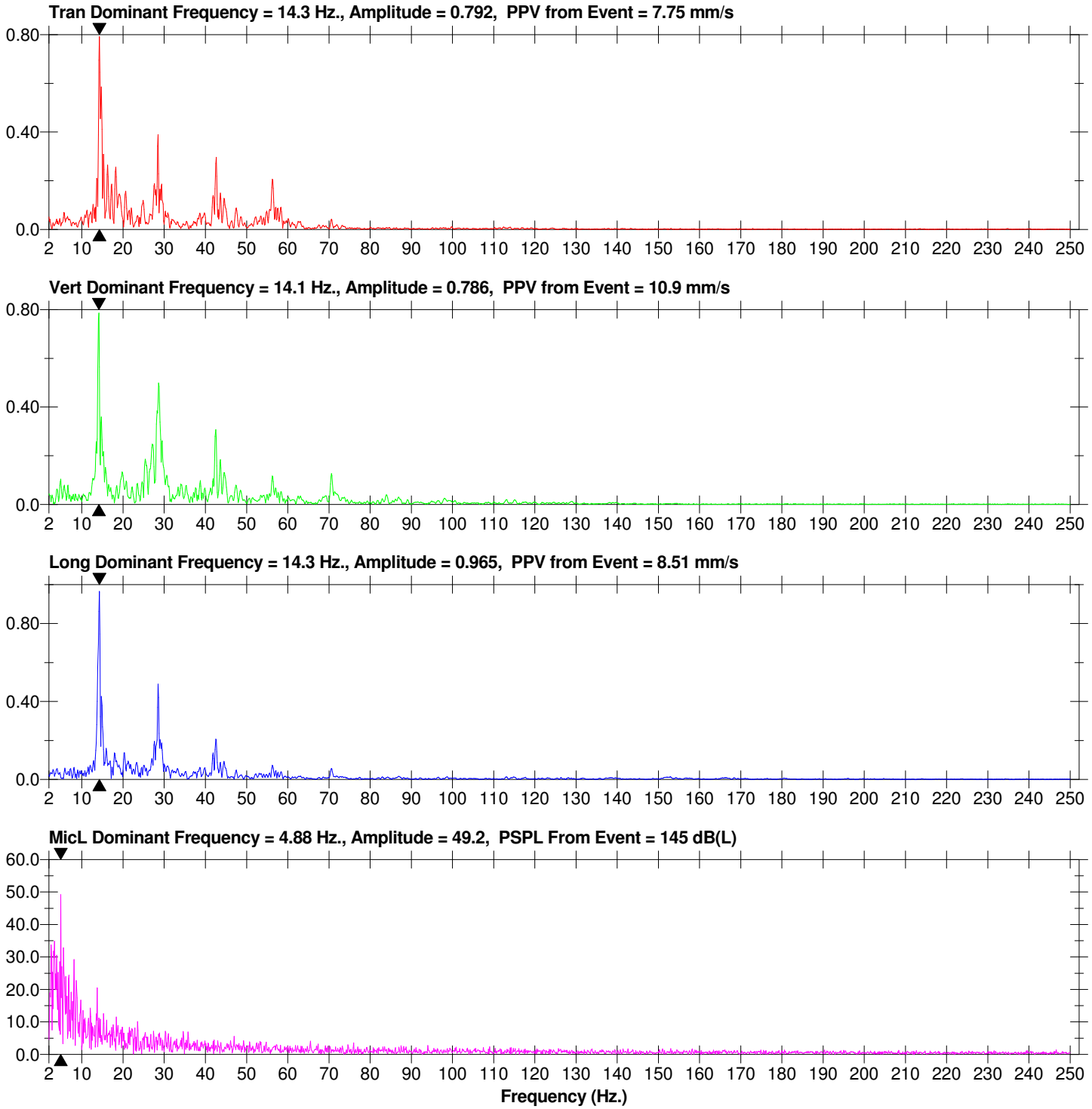
FFT Report

Date/Time	Vert at 13:23:08 September 23, 2014
Trigger Source	Geo: 3.00 mm/s
Range	Geo: 254 mm/s
Record Time	5.75 sec (Auto=3Sec) at 1024 sps
Job Number:	1

Serial Number	BA17303 V 10.31-8.17 BlastMate III
Battery Level	6.3 Volts
Unit Calibration	June 18, 2012 by Instantel
File Name	S303FIIL.6K0

Notes
Location:
Client:
User Name:
General:

Extended Notes



APPENDIX 3: Overpressure and Vibration Measured by HGC Engineering at Location M3

Event Report

Date/Time Manual at 13:40:11 September 23, 2014
Range Geo: 254 mm/s
Record Time 35.0 sec at 1024 sps
Job Number: 1
Notes
Location: 2400m from Luce Blast
Client: IOC
User Name: HGC Engineering
General: Minimate #11

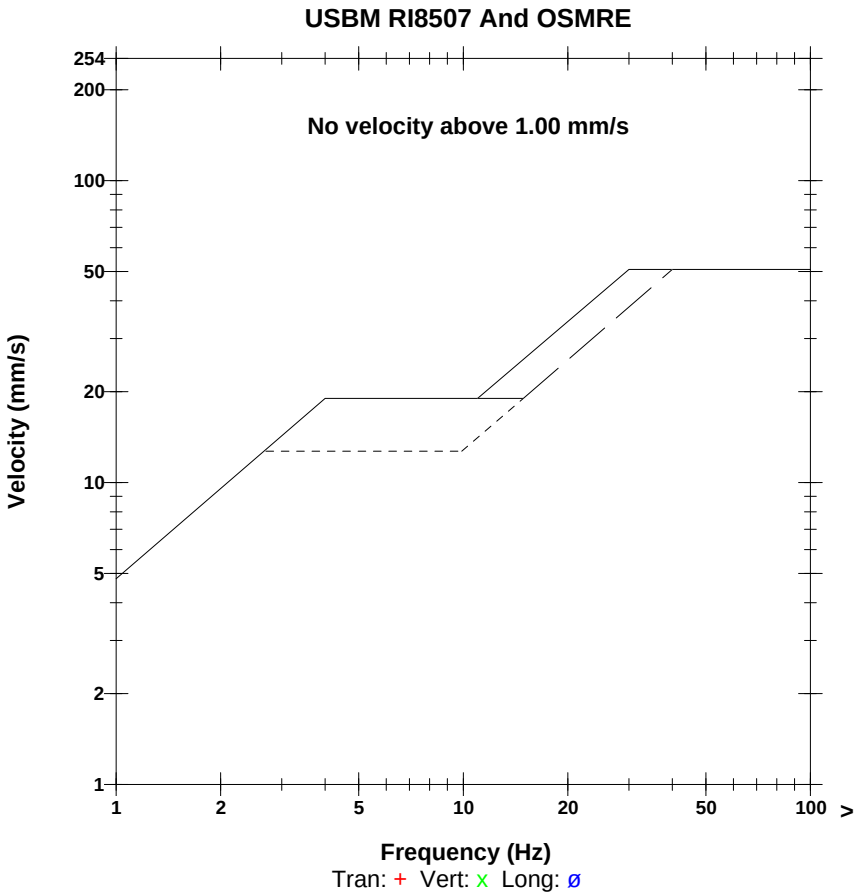
Extended Notes
approximately 2400m from Luce Blast along SE access road. WP 360.

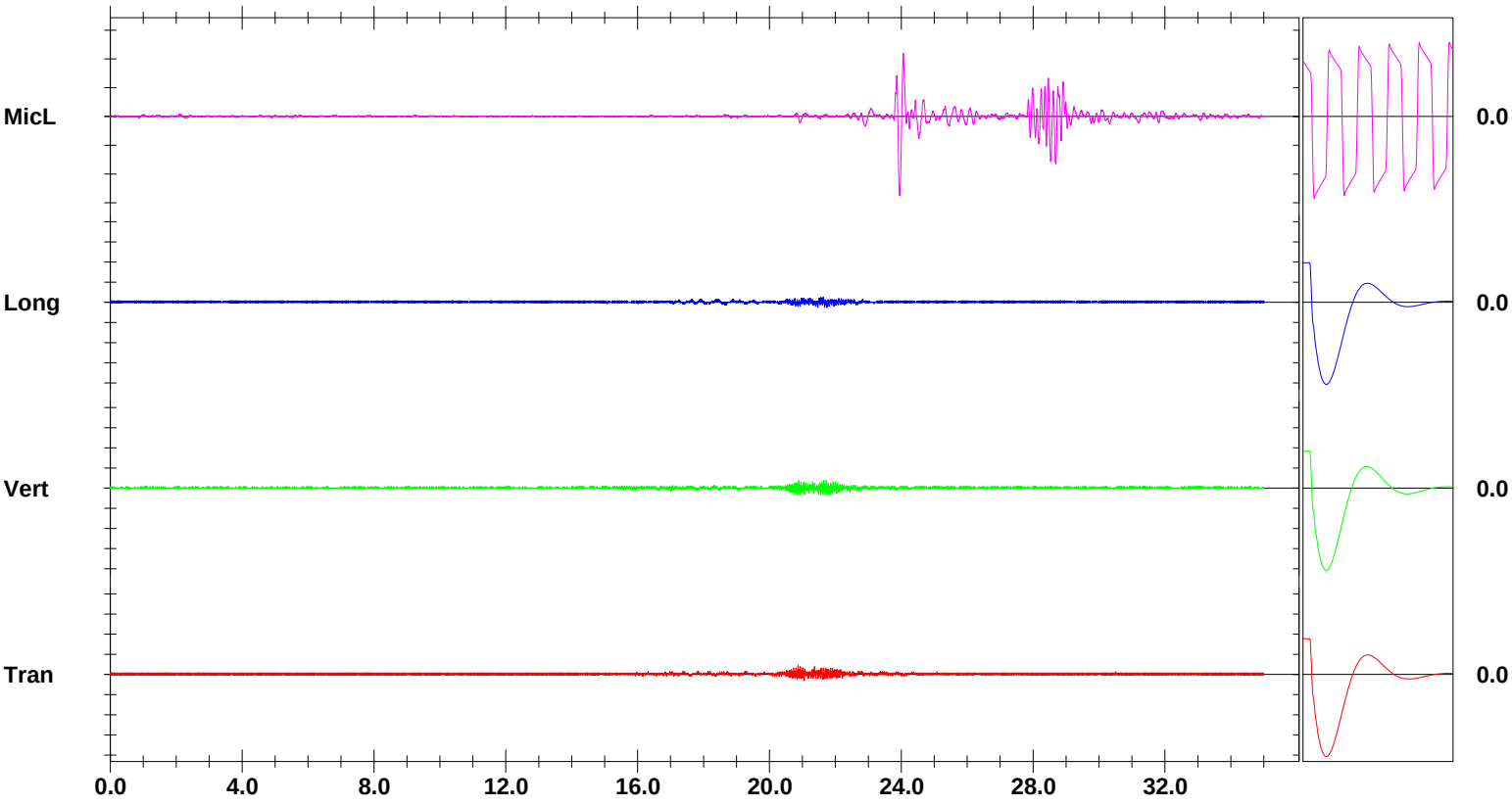
Microphone Linear Weighting
PSPL 55.0 pa.(L) at 23.949 sec
ZC Freq 4.2 Hz
Channel Test Passed (Freq = 20.5 Hz Amp = 740 mv)

	Tran	Vert	Long	
PPV	0.889	0.762	0.508	mm/s
ZC Freq	47	51	26	Hz
Time (Rel. to Trig)	20.869	20.887	21.467	sec
Peak Acceleration	0.0265	0.0265	0.0265	g
Peak Displacement	0.00595	0.00446	0.00372	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.4	7.6	7.4	Hz
Overswing Ratio	4.2	3.9	4.4	

Peak Vector Sum 0.976 mm/s at 21.583 sec

Serial Number BE20182 V 10.72-8.17 MiniMate Plus
Battery Level 7.0 Volts
Unit Calibration September 10, 2014 by Instantel
File Name V182FIIL.YZ0





Time Scale: 1.00 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 20.0 pa.(L)/div Sensor Check

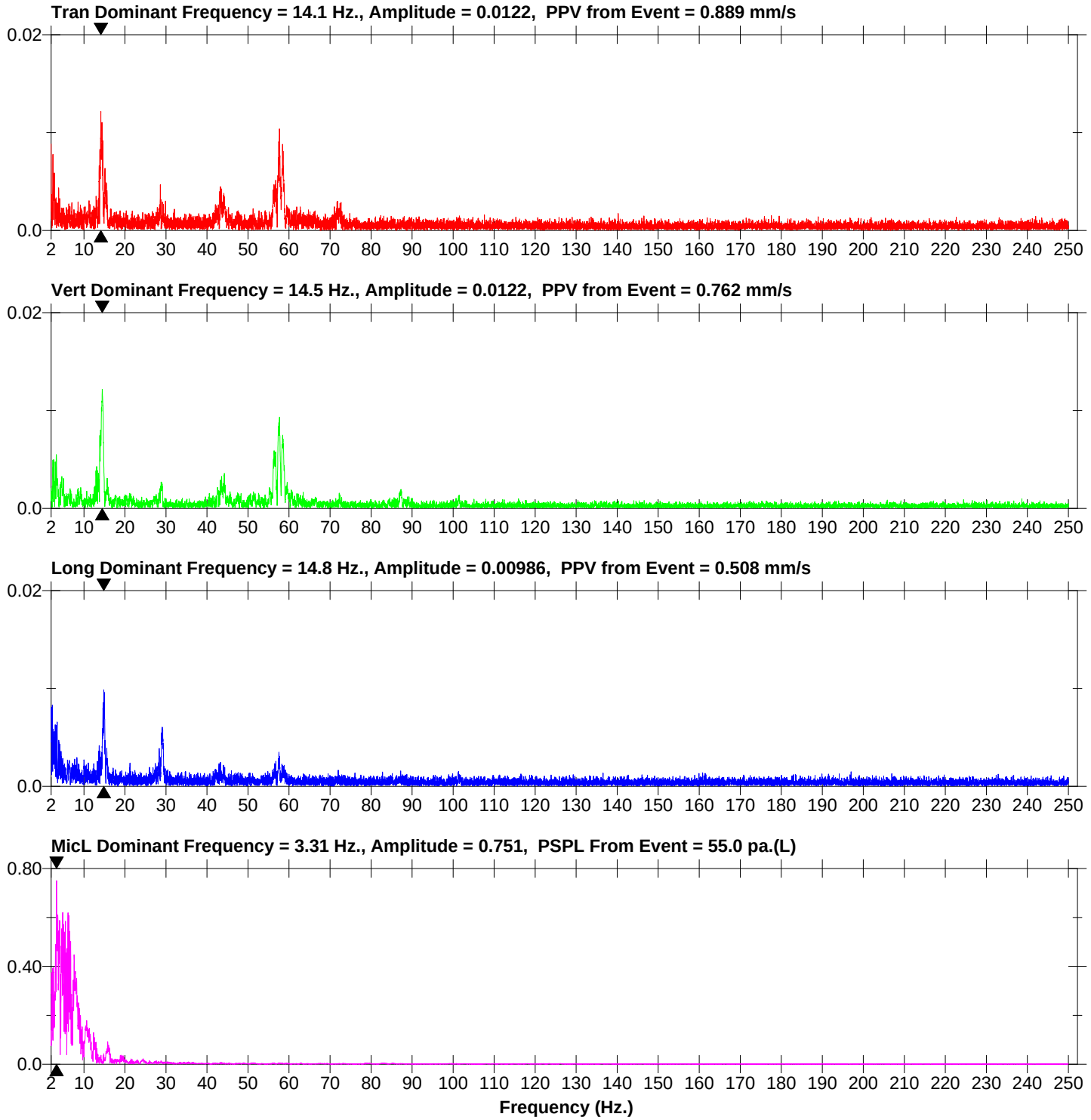
FFT Report

Date/Time Manual at 13:40:11 September 23, 2014
Range Geo: 254 mm/s
Record Time 35.0 sec at 1024 sps
Job Number: 1

Serial Number BE20182 V 10.72-8.17 MiniMate Plus
Battery Level 7.0 Volts
Unit Calibration September 10, 2014 by Instantel
File Name V182FIIL.YZ0

Notes
Location: 2400m from Luce Blast
Client: IOC
User Name: HGC Engineering
General: Minimate #11

Extended Notes
approximately 2400m from Luce Blast along SE access road.
WP 360.



APPENDIX 4: Overpressure and Vibration Measured by HGC Engineering at Location M4

Event Report

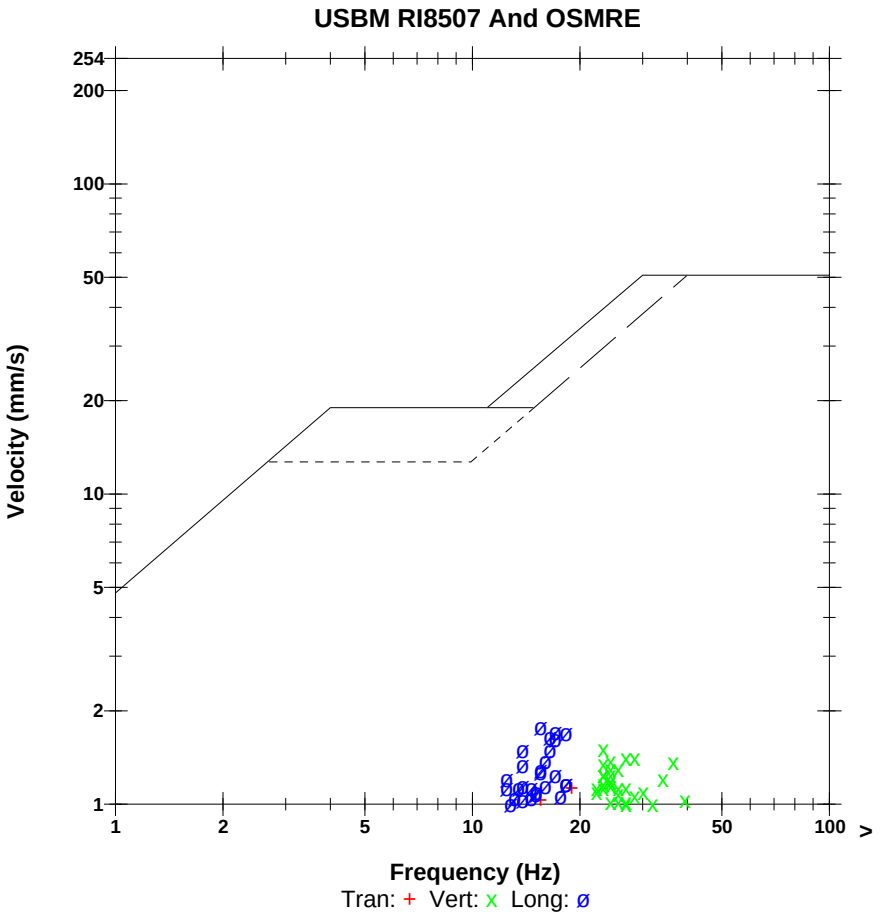
Date/Time Tran at 13:40:28 September 23, 2014
Trigger Source Geo: 0.250 mm/s
Range Geo: 31.7 mm/s
Record Time 20.0 sec at 1024 sps
Notes
Location: Smokey Mountain Lodge
Client: IOC
User Name: HGC Engineering
General: Minimate #2

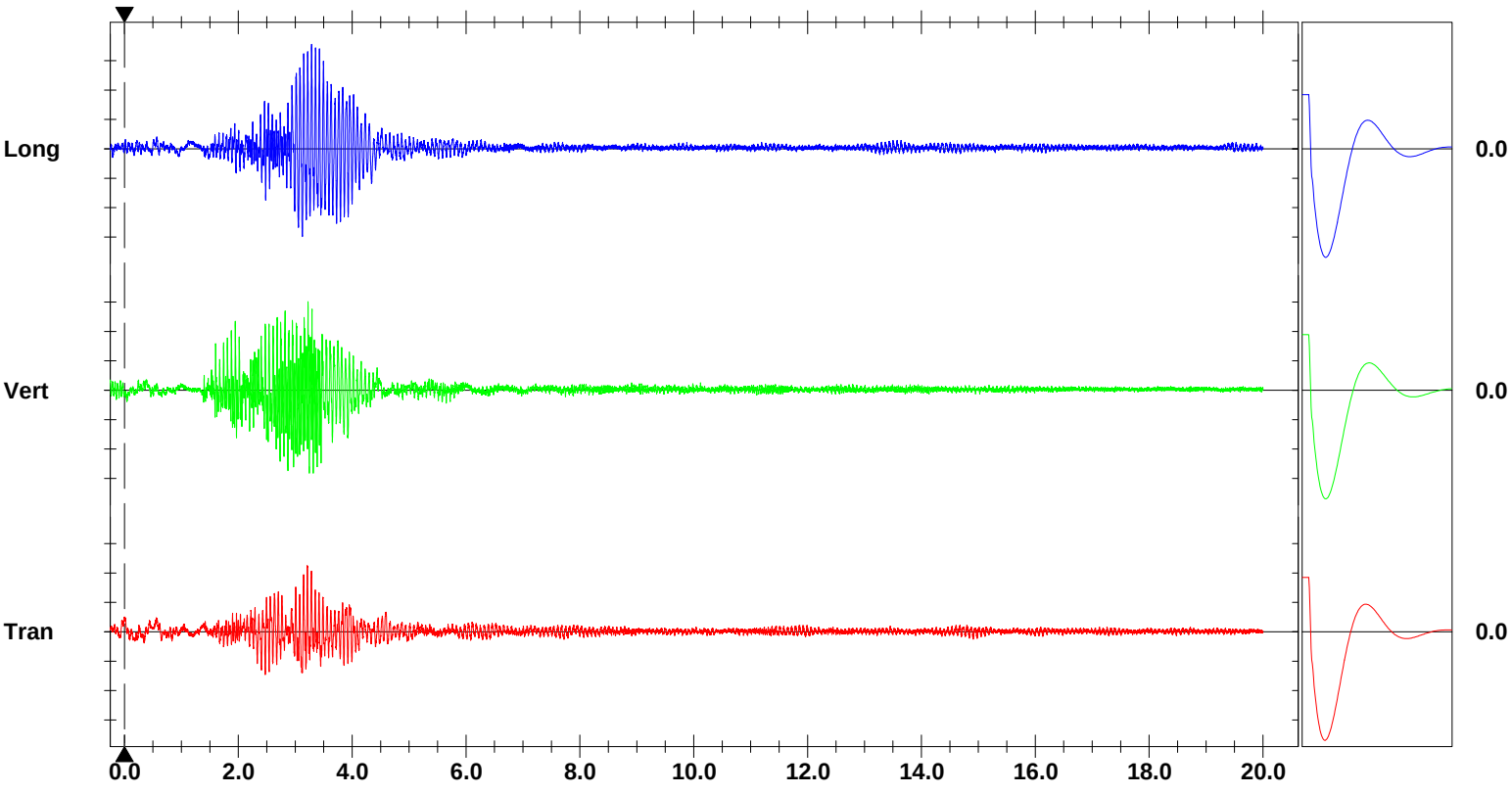
Extended Notes
In Smokey Mountain Lodge basement

Serial Number BE10744 V 10.72-8.17 MiniMate Plus
Battery Level 6.8 Volts
Unit Calibration September 9, 2014 by Instantel
File Name L744FIIL.ZG0

	Tran	Vert	Long	
PPV	1.13	1.51	1.78	mm/s
ZC Freq	19	23	16	Hz
Time (Rel. to Trig)	3.211	3.225	3.287	sec
Peak Acceleration	0.0182	0.0414	0.0265	g
Peak Displacement	0.0114	0.0103	0.0164	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.6	7.2	7.3	Hz
Overswing Ratio	4.0	4.0	3.8	

Peak Vector Sum 2.15 mm/s at 3.285 sec





Time Scale: 0.50 sec/div **Amplitude Scale:** Geo: 0.500 mm/s/div
Trigger = ▶——

Sensor Check

FFT Report

Date/Time	Tran at 13:40:28 September 23, 2014
Trigger Source	Geo: 0.250 mm/s
Range	Geo: 31.7 mm/s
Record Time	20.0 sec at 1024 sps

Serial Number	BE10744 V 10.72-8.17 MiniMate Plus
Battery Level	6.8 Volts
Unit Calibration	September 9, 2014 by Instantel
File Name	L744FIIL.ZG0

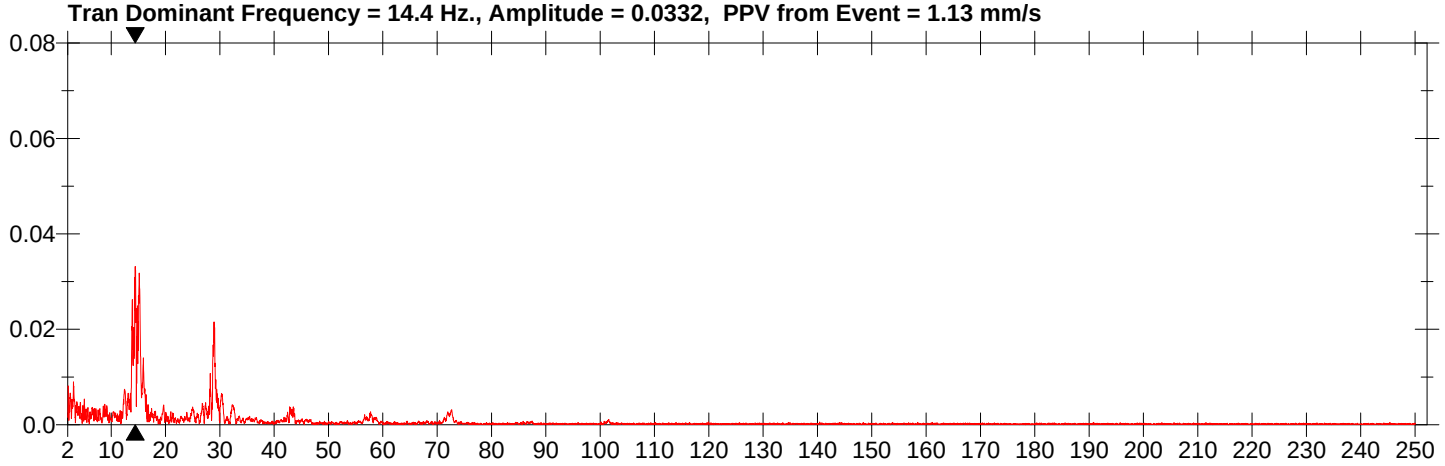
Notes

Location: Smokey Mountain Lodge
Client: IOC
User Name: HGC Engineering
General: Minimate #2

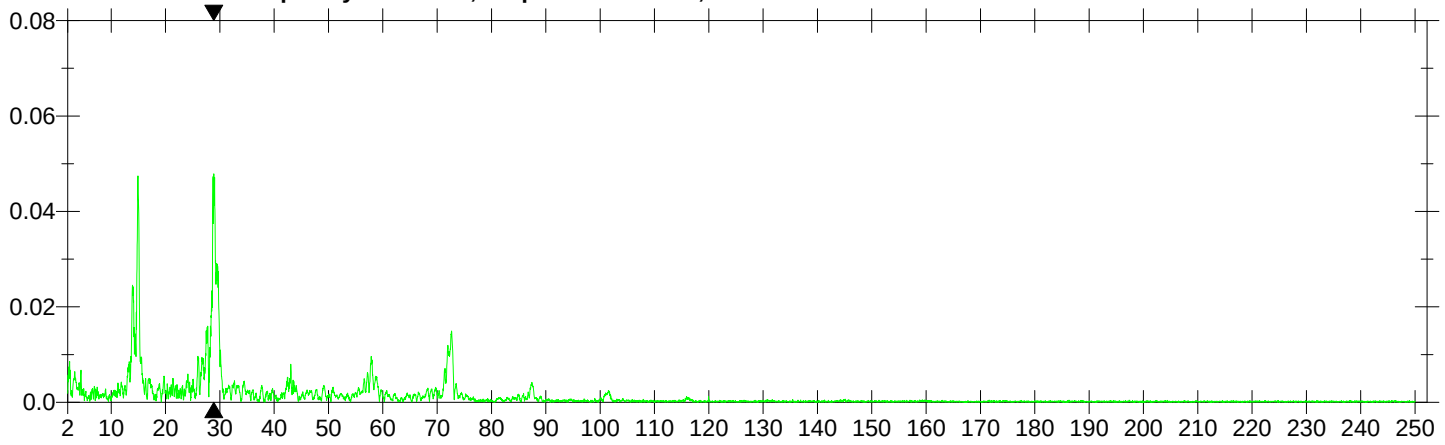
Extended Notes

In Smokey Mountain Lodge basement

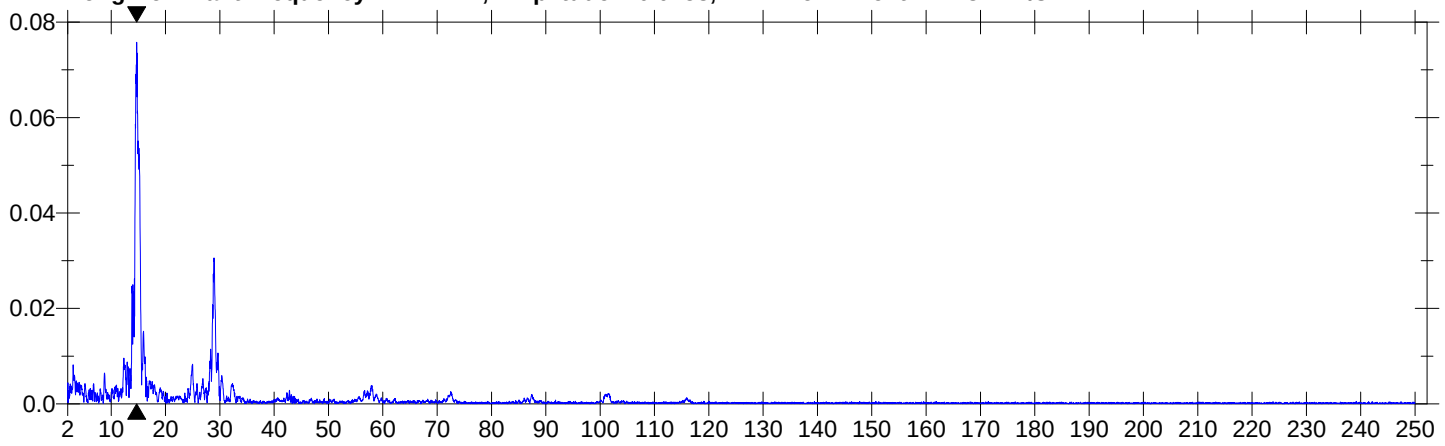
Tran Dominant Frequency = 14.4 Hz., Amplitude = 0.0332, PPV from Event = 1.13 mm/s



Vert Dominant Frequency = 28.9 Hz., Amplitude = 0.0479, PPV from Event = 1.51 mm/s



Long Dominant Frequency = 14.7 Hz., Amplitude = 0.0758, PPV from Event = 1.78 mm/s



Event Report

Date/Time Vert at 13:40:31 September 23, 2014
Trigger Source Geo: 0.510 mm/s
Range Geo: 254 mm/s
Record Time 39.0 sec at 1024 sps
Notes
Location: Smokey Mtn, Beside bldg, HGC-04b
Client: MRC
User Name: HGC Engineering
General: MRC BRT Phase 2

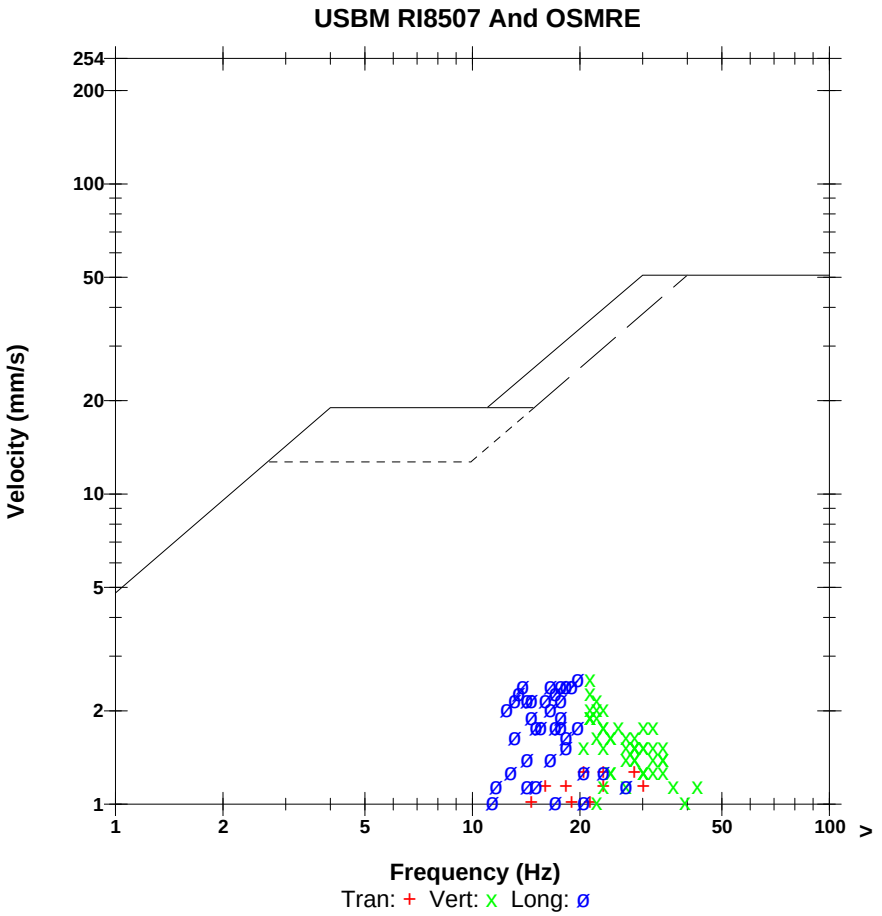
Extended Notes
Outside Smokey Mountain Lodge,

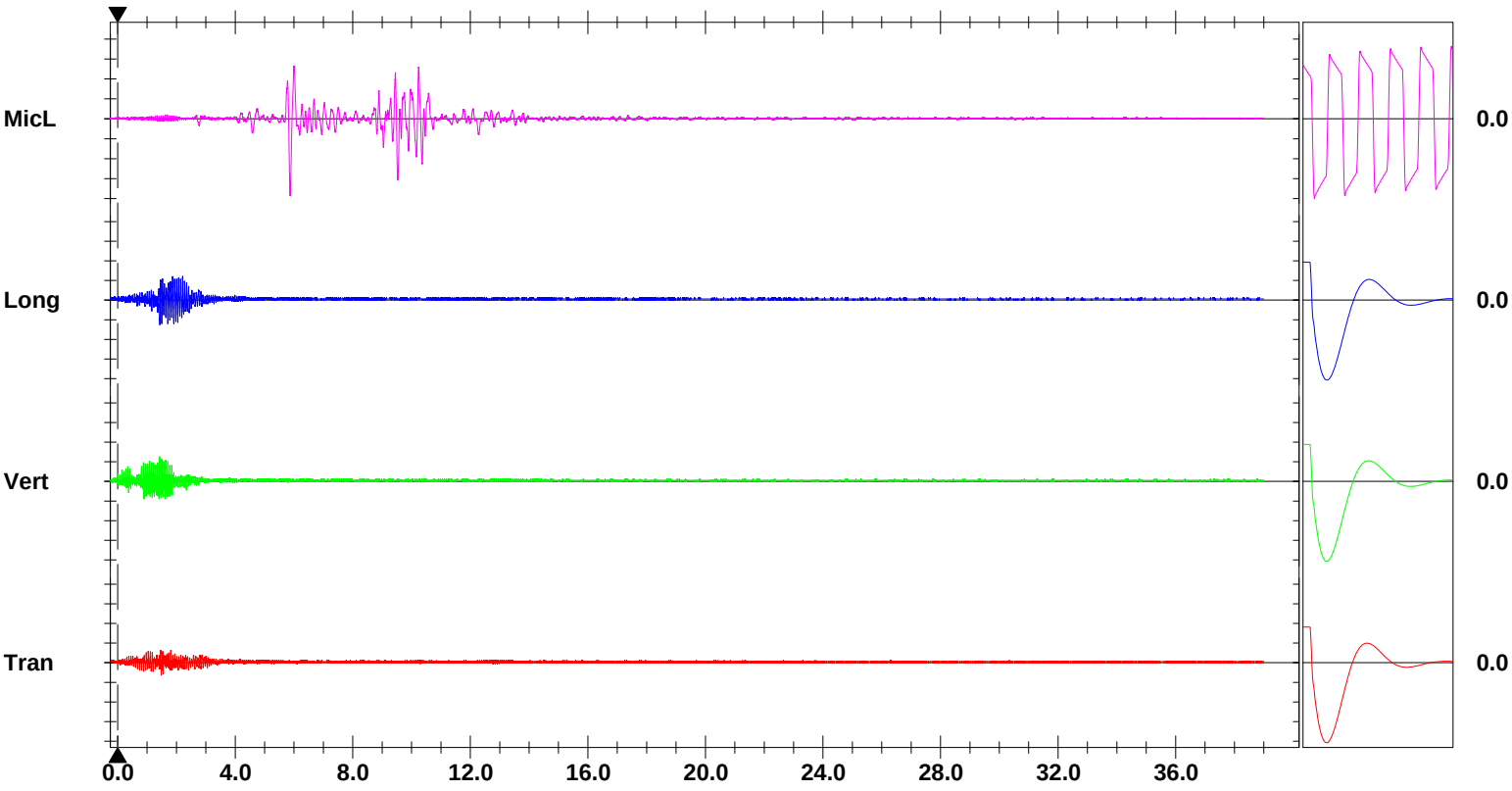
Microphone Linear Weighting
PSPL 38.8 pa.(L) at 5.867 sec
ZC Freq 4.3 Hz
Channel Test Passed (Freq = 20.1 Hz Amp = 670 mv)

	Tran	Vert	Long	
PPV	1.27	2.54	2.54	mm/s
ZC Freq	23	21	20	Hz
Time (Rel. to Trig)	1.463	1.428	1.432	sec
Peak Acceleration	0.0265	0.0530	0.0398	g
Peak Displacement	0.0110	0.0190	0.0266	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.5	7.4	7.3	Hz
Overswing Ratio	4.1	3.9	3.9	

Peak Vector Sum 3.36 mm/s at 1.430 sec

Serial Number BE11784 V 10.72-8.17 MiniMate Plus
Battery Level 7.0 Volts
Unit Calibration September 10, 2014 by Instantel
File Name M784FIIL.ZJ0





Time Scale: 1.00 sec/div **Amplitude Scale:** Geo: 2.00 mm/s/div Mic: 10.00 pa.(L)/div Sensor Check
Trigger =

FFT Report

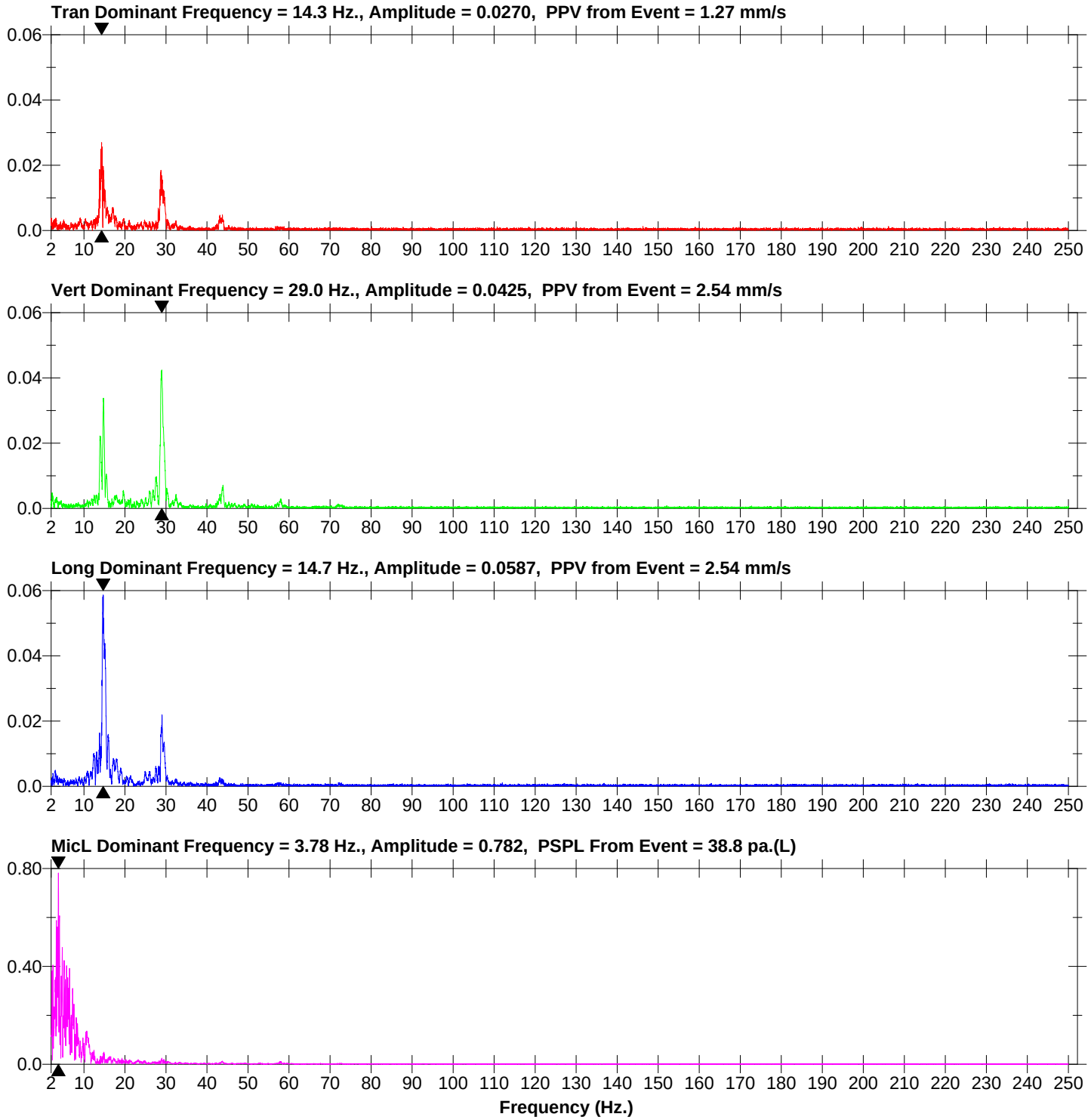
Date/Time	Vert at 13:40:31 September 23, 2014
Trigger Source	Geo: 0.510 mm/s
Range	Geo: 254 mm/s
Record Time	39.0 sec at 1024 sps
Serial Number	BE11784 V 10.72-8.17 MiniMate Plus
Battery Level	7.0 Volts
Unit Calibration	September 10, 2014 by Instantel
File Name	M784FIIL.ZJ0

Notes

Location: Smokey Mtn, Beside bldg, HGC-04b
Client: MRC
User Name: HGC Engineering
General: MRC BRT Phase 2

Extended Notes

Outside Smokey Mountain Lodge,



APPENDIX 5: Overpressure and Vibration Measured by HGC Engineering at Location M5

Event Report

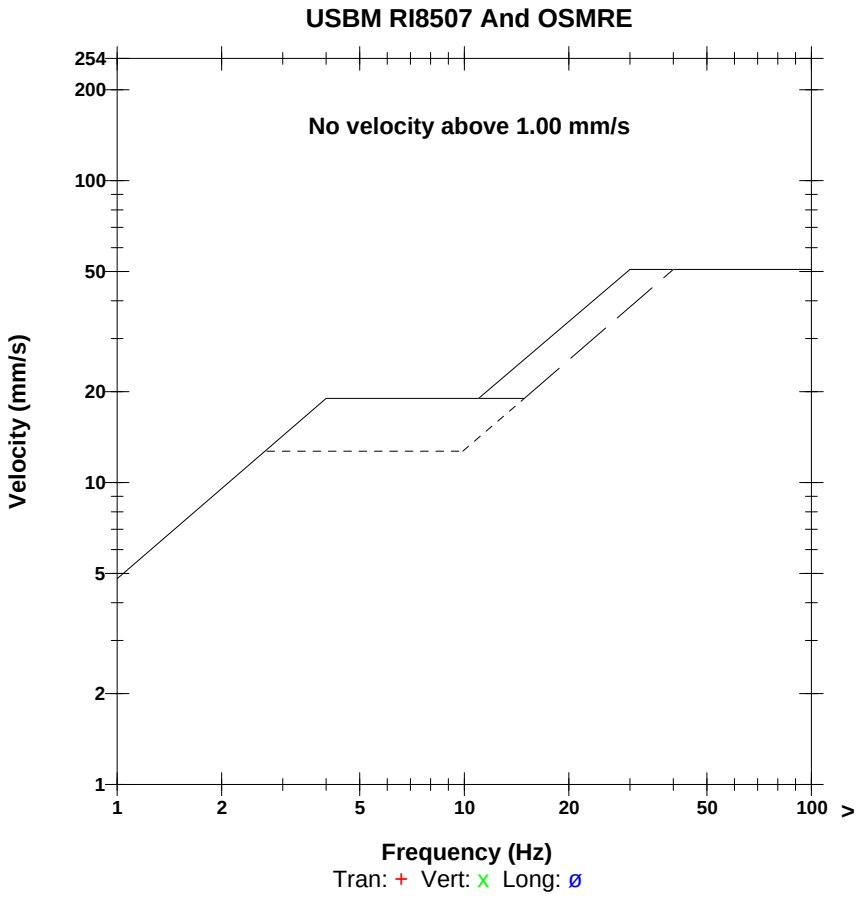
Date/Time Tran at 13:40:34 September 23, 2014
Trigger Source Geo: 0.400 mm/s
Range Geo: 31.7 mm/s
Record Time 30.0 sec at 1024 sps
Notes
Location: College approximately 6000m, HGC-05
Client: IOC
User Name: HGC Engineering
General: Minimate #10

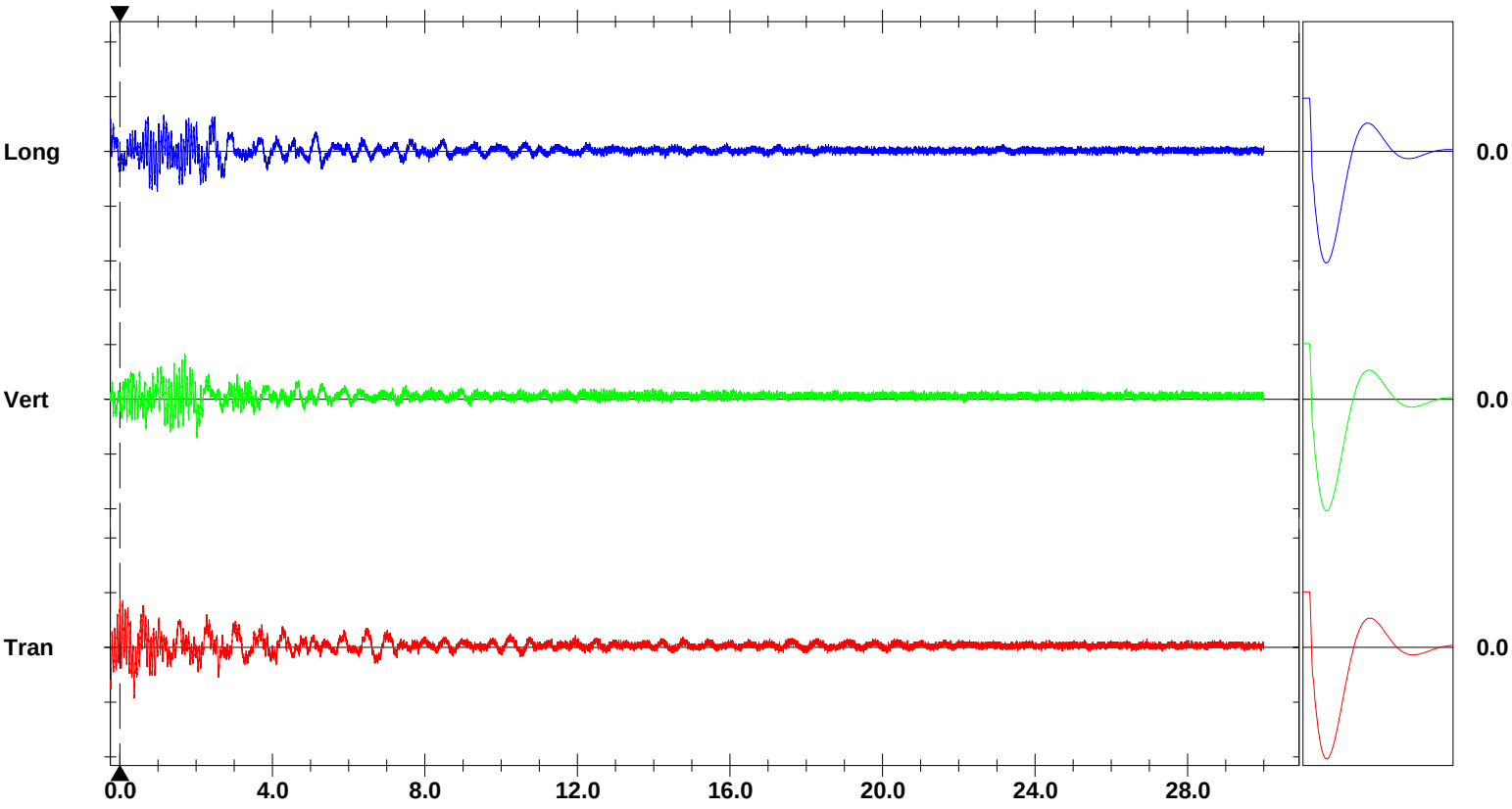
Serial Number BE18123 V 10.72-8.17 MiniMate Plus
Battery Level 6.8 Volts
Unit Calibration June 12, 2014 by Instantel
File Name T123FIIL.ZM0

Extended Notes
At College, approximately 6000m from blast
Located indoors in science lab.

	Tran	Vert	Long	
PPV	0.460	0.413	0.365	mm/s
ZC Freq	7.3	11	12	Hz
Time (Rel. to Trig)	0.377	1.704	0.980	sec
Peak Acceleration	0.00663	0.00829	0.00829	g
Peak Displacement	0.0174	0.0111	0.0164	mm
Sensor Check	Passed	Passed	Passed	
Frequency	7.2	7.3	7.5	Hz
Overswing Ratio	3.8	3.8	4.0	

Peak Vector Sum 0.478 mm/s at 0.377 sec





Time Scale: 1.00 sec/div **Amplitude Scale:** Geo: 0.500 mm/s/div
Trigger =

Sensor Check

FFT Report

Date/Time	Tran at 13:40:34 September 23, 2014
Trigger Source	Geo: 0.400 mm/s
Range	Geo: 31.7 mm/s
Record Time	30.0 sec at 1024 sps

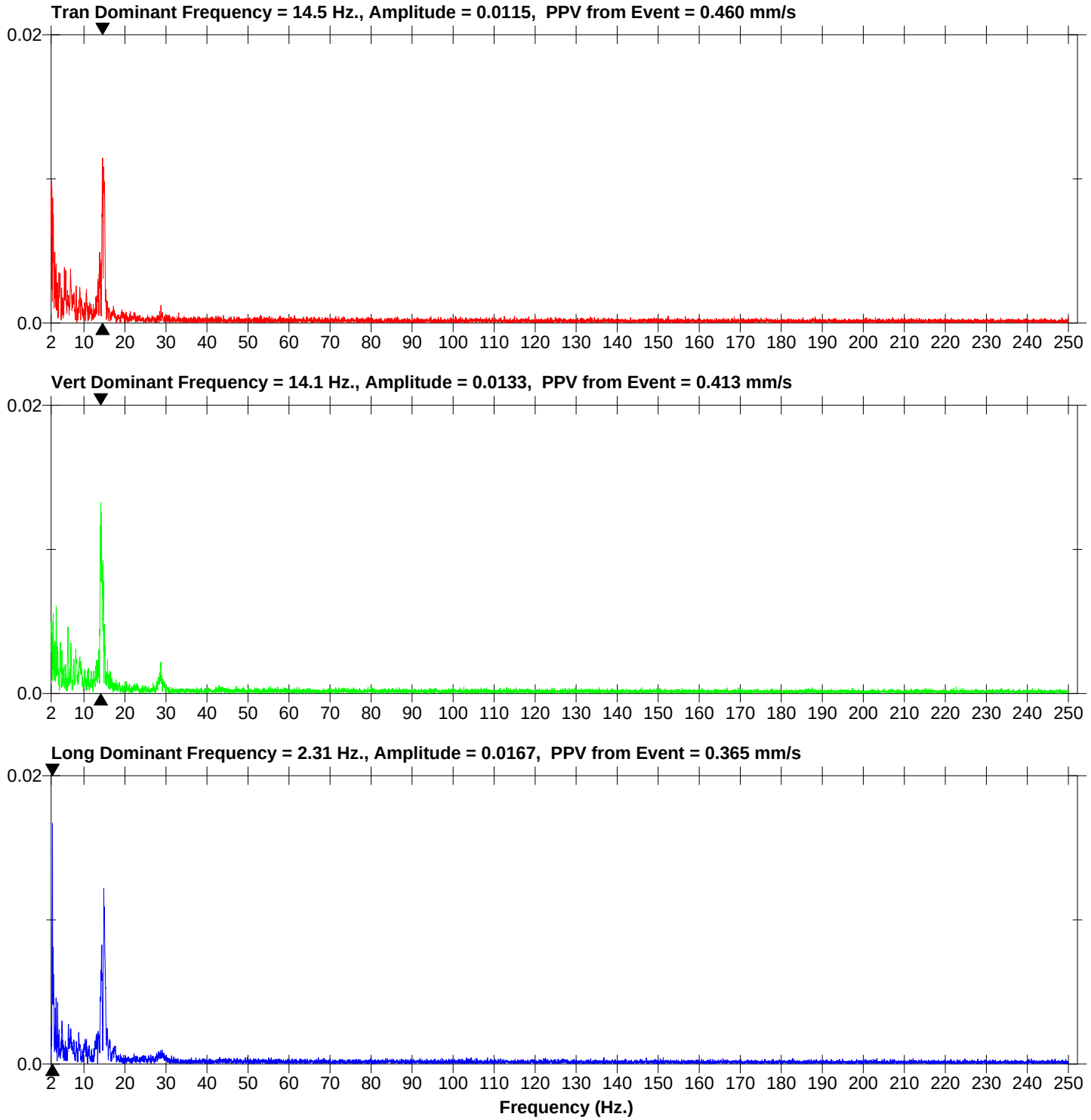
Serial Number	BE18123 V 10.72-8.17 MiniMate Plus
Battery Level	6.8 Volts
Unit Calibration	June 12, 2014 by Instantel
File Name	T123FIIL.ZM0

Notes

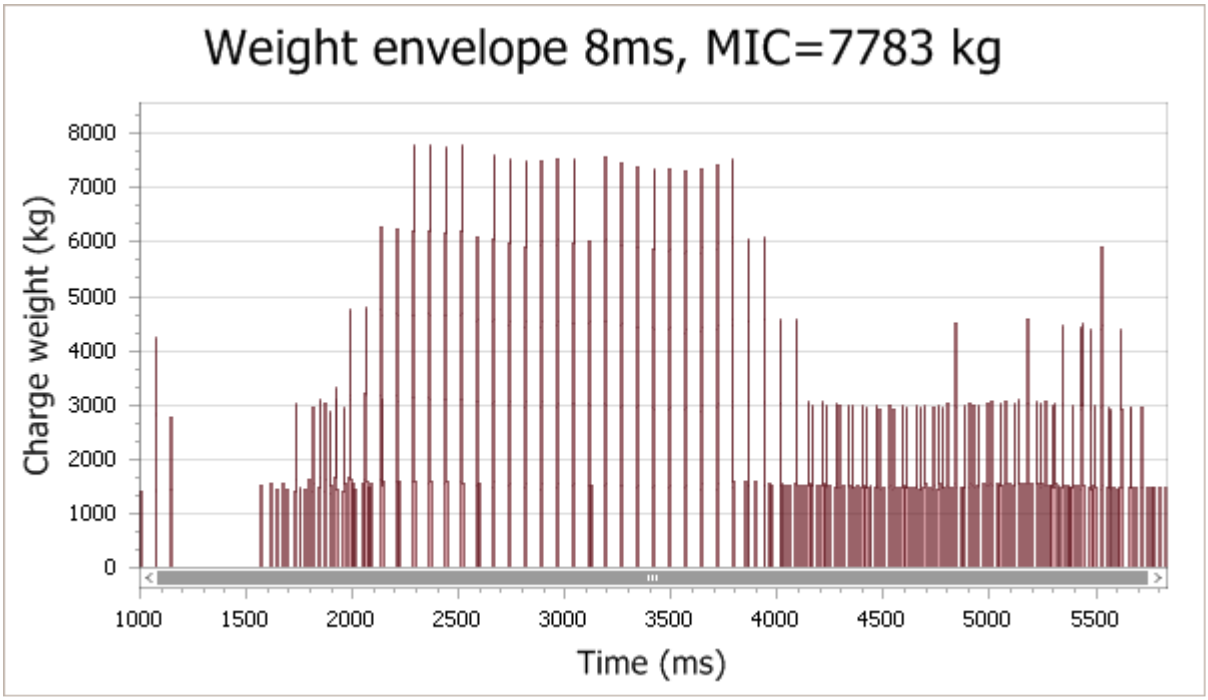
Location:	College approximately 6000m, HGC-05
Client:	IOC
User Name:	HGC Engineering
General:	Minimate #10

Extended Notes

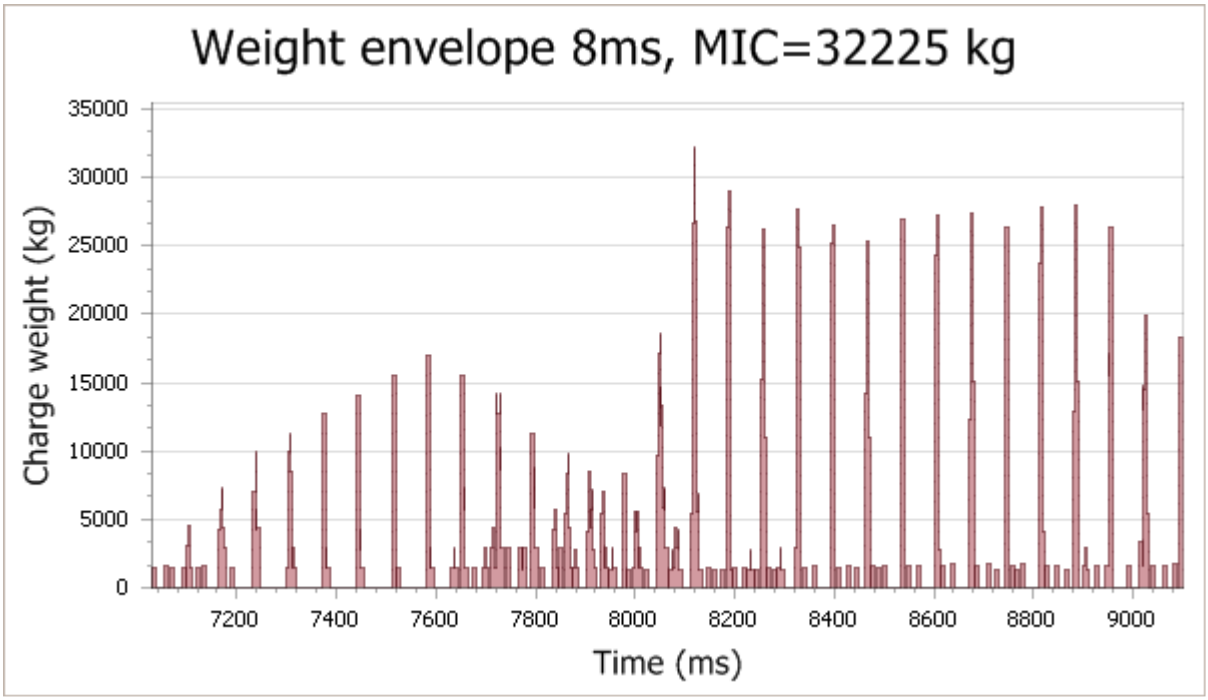
At College, approximately 6000m from blast
Located indoors in science lab.



APPENDIX 6: Blast Weight Envelope



ShotPlus5 5.2.7.0		02-10-2014
Mine	Iron Ore Company of Canada	
Location	Labrador City	
Title/author	Justin Hardy	
Filename	LU36-13&LU37-02.spf	



ShotPlus5 5.2.7.0		02-10-2014
Mine		
Location		
Title/author	LU34-44	
Filename	LU34-44.spf	