46.4883.R22A:MCC

21st April, 2016

Office of Sport
Asset Management & Procurement
Locked Bag 1422
SILVERWATER NSW 2128

Attention: Ms V. Haddock

500 METRE RANGE TESTING - COMPLIANCE TEST
SOUTHERN HIGHLANDS REGIONAL SHOOTING CENTRE
WATTLE RIDGE ROAD, HILL TOP

The purpose of this report is to present the results of acoustic testing carried out in relation to shooting from the 500 metre firing position, on the 500 metre range at the Southern Highlands Regional Shooting Centre.

The design of the 500 metre range requires an acoustic shelter over the 500 metre firing position.

The construction of the 500 metre range resulted in an elevated firing position (the as-built firing position) that gave rise to issues of non-compliance with the use of an absolute noise limit.

Acoustic testing for a firing position at ground level (in front of the covered firing benches) found acoustic compliance. However, that firing position did not satisfy the operational requirements for the 500 metre range.

A revised firing position 1.3 metres above natural ground level, but below the as-built firing position, has been determined and will apply to the 500 metre range. This new position was the subject of the latest acoustic testing.

To achieve the revised firing position, the shooter was firing whilst standing on the flatbed of a truck which was 1.3 metres above the natural ground level. A temporary acoustic shelter was placed above the shooter.

The testing to evaluate the revised firing position was conducted using the same protocols as for previous noise control tests using factory ammunition with the known noisiest firearm.

20-22 FRED STREET, LILYFIELD, 2040, NSW, AUSTRALIA A.B.N. 73 082 704 701
ph: (612) 9555 4444 fx: (612) 9555 4442 voip: (612) 8208 8881 tag1@acoustics.com.au

Testing was undertaken during the late morning of Friday 11th March 2016 for a period of approximately 45 minutes in the cul-de-sac at the end of Rocky Waterhole Road (Location A1), as used by the EPA on the previous testing program.

No resident observers were present during monitoring at Rocky Waterholes Road. However, there were intermittent interferences to the measurement results from wind gusts and planes passing over the monitoring location.

Consistent with previous testing the Peak Hold measurement results are presented as arithmetic levels and as an absolute level for the monitoring locations.

Due to the characteristics of a pressure wave from an explosion, noise measurements of rifle shooting use the "Linear Peak Hold" or the Z-weighted Peak Hold measurement. This descriptor indicates the absolute maximum level measured for each shot using a Linear (no weighting) frequency response. Originally for shooting assessments the State Pollution Control Commission (the "**SPCC**") used the logarithmic average of the shots for the determination of compliance with criteria – being based on the procedure used by the National Acoustics Laboratories for their investigation of the Hornsby Rifle Range and the Holsworthy Military Range.

Issues as to the methodology of determining the measured level for compliance purposes of the subject range (absolute level, logarithmic average or arithmetic average) and separation of wind have been raised previously. The EPA have now issued the document *Target Shooting Ranges: Application Note for Assessing Noise Compliance* which identifies the use of arithmetic average.

The presence of calm wind conditions during the monitoring permitted observation of the influence of occasional wind gusts and other extraneous noises on the measurement results.

Measurement Instrumentation

For the purpose of compliance testing, measurements were conducted as attended measurements, with unattended measurements at Location A1 for backup/supplementary analysis.

Attended sound level measurements at residence identified in Appendix A as A1 were carried out using a Bruel & Kjaer Modular Sound Level Meter Type 2260 (S/N 1772289).

Additional unattended measurements at this location were conducted as a backup using a Bruel and Kjaer Sound Level Meter Type 2250 (S/N 3004338).

Unattended measurements to the rear of the firing position on the 500 metre range were conducted using a Bruel & Kjaer Modular Sound Level Meter Type 2260 (S/N 1824813) and for backup, a SVAN 979 Sound Level Meter (S/N 35804).

All sound level meters are classified as Class 1 meters, incorporate Z-weighting filters and set to record/display the peak hold level. All sound level meters are calibrated to manufacturer's standards traceable (externally or internally) to the National Measurement Institute (NATA Registered Laboratory No. 1).

The reference calibration level of each meter was checked prior to and after measurements with a Bruel & Kjaer Sound Level Calibrator Type 4231 or Type 4230.

Measurement Procedures

Previous measurements related to the subject shooting range have involved different locations for assessing the noise.

For the March 2016 testing, monitoring was undertaken at Location A1 which is adjacent to the boundary of the residential property.

Appendix A identifies the residential measurement location used for this compliance test as well as measurement locations in residential areas used in previous tests.

The program for the revised firing position test at the 500 metre range nominated 60 shots from a standing position (on a 1.3 metre high platform) at 30 second intervals and utilised the fabricated temporary acoustic shelter above the firing position.

Due to the presence of occasional wind gusts and planes flying above affecting some of the measurement result, a further 20 shots were conducted for the test.

For all of the shots in relation to testing of the 500 metre range, noise levels were monitored at a position to the rear and side of the firing positions on the elevated platform (outside the existing structure) so as to identify consistency in the noise levels generated during shooting.

In general environmental acoustics, the dB(A) value is the normal acoustic parameter. dB(A) is the decibel value using the A-weighted filter curve, which approximates the response of the human ear to level around 40 dB(A).

The A-weighting filter (being an electronic RC equivalent circuit) has a response curve that is too low for shot duration peak pulses such as for shooting. As the use of dB(A) underestimates the total energy generated by shooting, the use of Linear Peak Hold measurements address the problem with dB(A) FAST Response measurements.

Whereas Peak Hold measurements were originally defined as a Linear Peak Hold, instrumentation today refers to the Z-weighted levels that may approximate the Linear Peak Hold result for frequencies above 10 Hz. The EPA's Application Note (*Target Shooting Ranges: Application Note for Assessing Noise Compliance*) refers to the level to be recorded as the Z-weighted Peak Hold level ("LZpeak").

In view of the need to obtain Peak Hold measurements each sound level meter was set to measure and display the Z-weighted Peak Hold value with the TAG monitoring personnel at the Rocky Waterholes Road monitoring location manually writing down the results (including any extraneous noise or wind) when a shot was audible. The instrumentation used for measurement has a designated time delay for showing the peak level that generally would include the peak pressure level from the shot as well as the peak pressure level from wind if present at the same time of the shot or shortly thereafter.

In the case of impulsive noise from rifle shots the maximum overpressure of the sound wave (the linear or Z-weighted peak hold pressure level) is commonly used to measure the absolute pressure.

Because the peak pressure hold level is a measurement parameter that has no frequency weighting, and has no relationship to the A-weighted rms level used for environmental assessments, there is an entirely different relationship between measured levels and audibility.

For A-weighted levels one can hear a noise at levels 10 dB or more below the background level. For measurements when a noise is 10 dB below the background there will be no measureable increase above the background level (for either a linear level or an A-weighted level).

On previous tests a proportion of the shots have been found to be inaudible or not measureable at residential receivers leading to the compliance testing including a meter behind the firing position to identify the occurrence of shots.

In using the peak hold level a shot may be audible but show no measureable increase above the ambient background level on the meter, due to the relationship of the actual level versus the ambient/background level. At other times a shot may be audible and give rise to a measurable increase above the ambient background level, but the measured level may be the result of the shot, or wind, or extraneous noise. Hence the desire to have supplementary back-ups of the measurements for post processing and determination if the wind or extraneous noise affected the results.

In view of the variability in measured noise levels both during shooting and without shooting occurring, it is necessary to undertake attended measurements to identify the occurrence of distinct shots and then undertake post-processing analysis (where possible) to verify the shots in the environment in which they occur.

In the first instance an evaluation is able to be undertaken using the observed measured levels to indicate the range of levels occurring during the testing. The second step utilises the post-processing analysis discussed in the following section.

As experienced in previous testing at Hill Top it was found at the residential receiver, that apart from shots that are inaudible or not measureable in the ambient noise, the presence of a variable wind may provide limitations in obtaining valid measurements.

Measurement Results

Appendix B1 presents a table of the measurement results recorded at the rear of the firing position (at 500 metres) on the 500 metre range. The table is followed by graphical presentation in Appendix B2 showing the levels recorded over time.

The results in Appendix B reveal, as expected, consistent high peak levels in proximity to the firing position.

The results in Appendix B2 show that the firing of individual rifles followed the planned 30 second time sequence so as to assist in the identification of shots at Location A1. In order to undertake the analysis of the peak pressure levels obtained at the residential location, all of the individual shots were tabled with respect to the time of the shot occurring on the range.

Due to the distance between the range and the receiver location, and that sound travels at approximately 320 metres per second, then for a distance of 4 kilometres one can expect the shot to be detected at Location A1 approximately 12 seconds after the time the shot is recorded at the on-site measurement location.

The procedure of using the on-site material is required to be undertaken for the subject residential monitoring location because in relative terms the shots from the rifle range are at, below or slightly above the ambient peak levels. Extraneous noises such as birds and planes can generate levels significantly greater than that of the shots. The analysis identifies that a number of the levels recorded by the TAG monitoring personnel at Rocky Waterholes Road were as a result of extraneous noise.

Appendix C1 provides a table of the measurement results for Location A1 incorporating the observations noted by the TAG monitoring personnel during the compliance test which includes a coding that identifies the presence of wind ("XW") and extraneous noise ("XR") that impacted upon the individual shot or inability to record a measureable increase ("X").

Supplementing the post-processed results are the measurement results that were noted by the TAG monitoring personnel from observations of the sound level meter during the compliance test which include a coding to a number of the shots that identify the presence of wind and extraneous noise that impacted upon the observed value.

From the material in Appendix B2 and utilising the timing for recorded measurements at the residential location, adjustments for the difference between the on-site shot time and the recorded time at the residential receiver can be determined. For the post-process analysis, the recorded measurements at Location A1 are in Appendix C2 superimposed on the graphical results from Appendix B2 with the appropriate timing correction to permit synchonisation of the actual shot and identification of extraneous noise that is not associated with the shot.

Comparisons between the field observations and the post-processed results reveal general agreement.

The occurrence of a shot can easily be identified in the time spice graph of the on-range site measurement due to the peak level (LZpeak) of the shot being, on average, 132 dB and much greater than the ambient level.

The red graph in Appendix C2 is the Z-weighted peak hold level recorded at Location A1. As a result of distance attenuation to the residential receiver, the noise level of the shots do not give rise to distinct peaks because they are, at times, in the same order of magnitude or lower than the ambient Z-weighted peak hold level. The fluctuations in the average minimum level in the red graph identify the presence of extraneous noise.

The green graph in Appendix C2 is the A-weighted Sound Exposure Level ("SEL") at 1 second increments. The green graph is able to show audible noise events associated with extraneous noise sources such as planes. The A-weighted SEL is a 1 second energy average of the A-weighted level and identifies a noise over a longer period than just a shot that as such displays the general trend in the ambient (or extraneous) noise.

As the influence of ambient/extraneous noise can greatly affect the peak level (LZpeak) so as to be greater than the noise level of gunshots at times, it becomes a difficult (and time consuming) exercise in differentiating peaks in the time splice graph relating to gunshots and peaks from extraneous/ambient noise.

The LZpeak levels of gunshots at the residential monitoring locations were determined with assistance from the attended measurement notes as well as the accurate timing of shots from the on-site measurement results.

Post-Processing – EPA Method

Appendix C1 provide a table of the measurement results for the compliance test.

From observations of the sound level meter during testing, it has been found that shots can be audible but cause no measureable increase above the ambient level at the residential locations as a result of the distance to the shooting range as well as extraneous noise at the residential receivers elevating the ambient level.

Utilising a post-processing method to determine the noise level of shots, there is difficulty in identifying shots from observation of the LZpeak time splice as the shots are around the same level to that of the ambient background noise. We have used the results from a sound level meter located on the shooting range to identify the occurrence of shots for comparison with the residential results, which is a method approved by the EPA. This method involves time synchronising the measurement results at the residential locations to the results from the shooting range to account for the sound delay due to the speed of sound and the distance between the shooting range and the residential locations.

With respect to the post-processing undertaken for Location A1, NSW EPA document *Target Shooting Ranges: Application Note for assessing Noise Compliance* ("Application Note") provides guidance on compliance assessment of shooting noise at shooting ranges. The preparation of the Application Note had the benefit of testing undertaken by the EPA in 2014 at Hill Top.

The methodology provided by the document seeks to characterise audible shots as "Category A" or "Category B".

A "Category A" shot represents an accurate measurement of the noise contribution from the shot and is categorised as having a distinct peak level noticeably higher than the peak level immediately before the shot which is not attributed to wind gusts or other extraneous noise.

A "Category B" shot represents an upper estimate of the contribution from the shot and is defined as a shot which has a peak level that may have been elevated by wind gusts or other extraneous noise.

Section 4.3 of the Application Note requires the post-processing method of measuring shot noise to categorise shots into "Category A" and "Category B" by comparison of the shot peak level to the peak level immediately prior to the shot. Shots 5 dB greater than the immediately preceding level are categorised as "Category A" whilst shots less than 5 dB above the preceding level are categorised as "Category B". An identified shot having a peak noise level that is less than the peak level immediately prior to the shot is considered invalid and discarded from the analysis.

Under the Application Note, calculation of the final noise level is determined by whether the number of "Category A" shots measured is less than or greater than 50. For the scenario of greater than 50 "Category A" shots measured, then the final noise level will be the arithmetic average of all "Category A" shots within one hour of commencing measurement. If the number of "Category A" shots is less than 50, then the final noise level will be the arithmetic average of all shots ("Category A" and "Category B").

Appendices B and C present the measurement results in terms of the post-processed results following the EPA method, with the addition of superimposing the on-site shots with the shots received in the residential area.

In undertaking the EPA post-processing method, the measurement results from Location A1 have been utilised to present an example of the application of the EPA post-processing method.

The time splice graph in Appendix D1 is set out in the same format as the example in the EPA's Application Note and shows the results obtained at Location A1 for the first 5 minutes of the 500 metre range compliance test at the revised firing position. An expanded view of the measurement results is required so as to clearly show the timing of the shots and the relevant peak levels that cannot be derived from the graph in Appendix C1 that covers the entire period.

The blue line of the time splice graph in Appendix D1 represents the LZpeak levels recorded at Location A1 with green markers superimposed onto the graph to identify the occurrence of a shot. The EPA procedure requires that where a marker immediately precedes/succeeds a peak in the time splice graph, then the marker is re-assigned to align with the peak (illustrated by a red marker). This is because the clock time displayed on the meter is running in seconds (and used manual notations) and therefore not as precise as the time splice output.

Appendix D2 provides a table of the measurement results from Appendix D1 (5 minute sample) in the format provided in the EPA's Application Note.

Appendix D3 provides the measurement results from the same time and location period as the graph in Appendix D1 but with the addition of the shots recorded on-site (shown as a green graph) with an alignment for the speed of sound over the distance from the range o Location A1. The addition of the on-site shots permits one to align the individual shots detected at Location A1.

An additional tool that assists in post-processing to eliminate general extraneous noise is the addition of the purple trace which is the running A-weighted SEL level at the residential monitoring location.

The analysis of the 5 minute sample in Appendix D confirms the validity of the observations and results in Appendix C1.

Analysis

At Location A1, a number of planes were observed flying above the monitoring location during the compliance test of the elevated firing position on the 500 metre range which resulted in some of the measurement results being affected. There were a few occasions during the course of the monitoring where wind gusts were present and influenced the measurement results. In accordance with the EPA procedure, measurement results that were affected by wind or extraneous noise have been excluded from the analysis.

From the measurement results in Appendix C, the arithmetic average and the absolute peak of the unaffected individual peak hold results have been provided in Table 1 below. The results reveal a significant number of shots could not be measured.

Table 1: Summary of Results

Location	Measured Shooting Levels (Peak Hold dB)			
	Min	Max	Arithmetic Average	No of Shots Measured
On Range	129	134	132	80
A1	55	71	64	Category A: 11 Category B: 43

The arithmetic average peak level of shots at Location A1 for the revised firing position was determined to be 64 dB. As expected, the slightly higher elevation of the firing position resulted in slightly louder levels than for previous tests, that were conducted at ground level.

In terms of the measurement results as an absolute maximum peak hold level, the operation of firing from the 500 metre position (with the shooter standing on a 1.3 metre high platform) at the 500 metre range did not exceed 71 dB for Location A1.

The results of compliance testing for shooting at the 500 metre position (whilst standing on a 1.3 m high platform) at the 500 metre range of Southern Highlands Regional Shooting Centre carried out on Saturday 11th March, 2016 revealed the noise level of the shots to be less than the target of 75 dB as both an arithmetic and an absolute peak level.

With the removal of the bulk structure (the as-built firing station) behind the revised firing position and the construction of a noise barrier on the eastern side of the revised firing position, it is expected that the peak hold levels at Location A1 would be lower than that shown in Table 1.

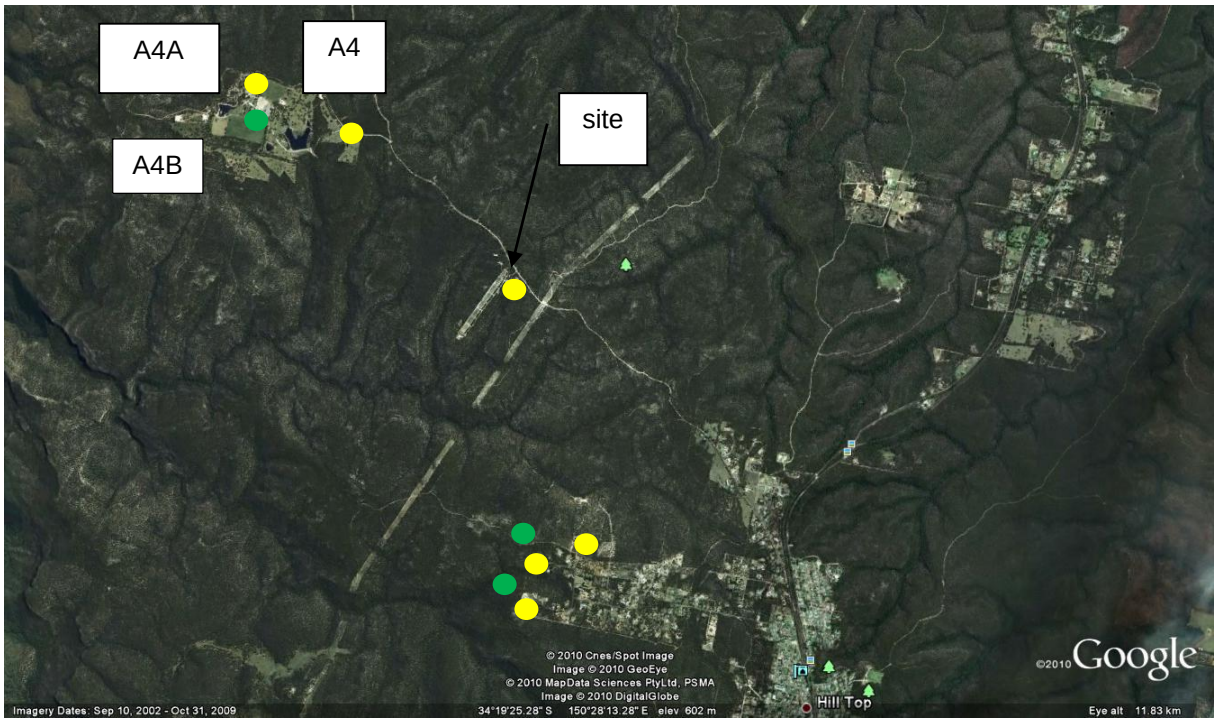
We trust the above satisfies your immediate requirements.

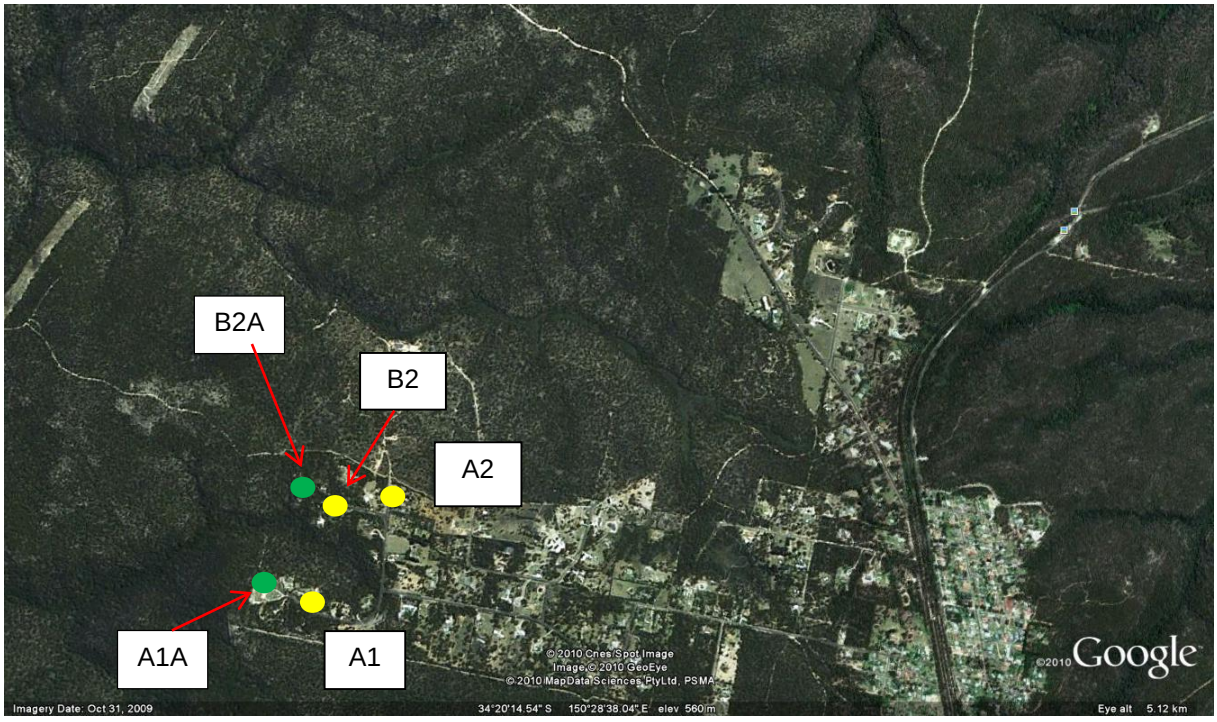
Yours faithfully,

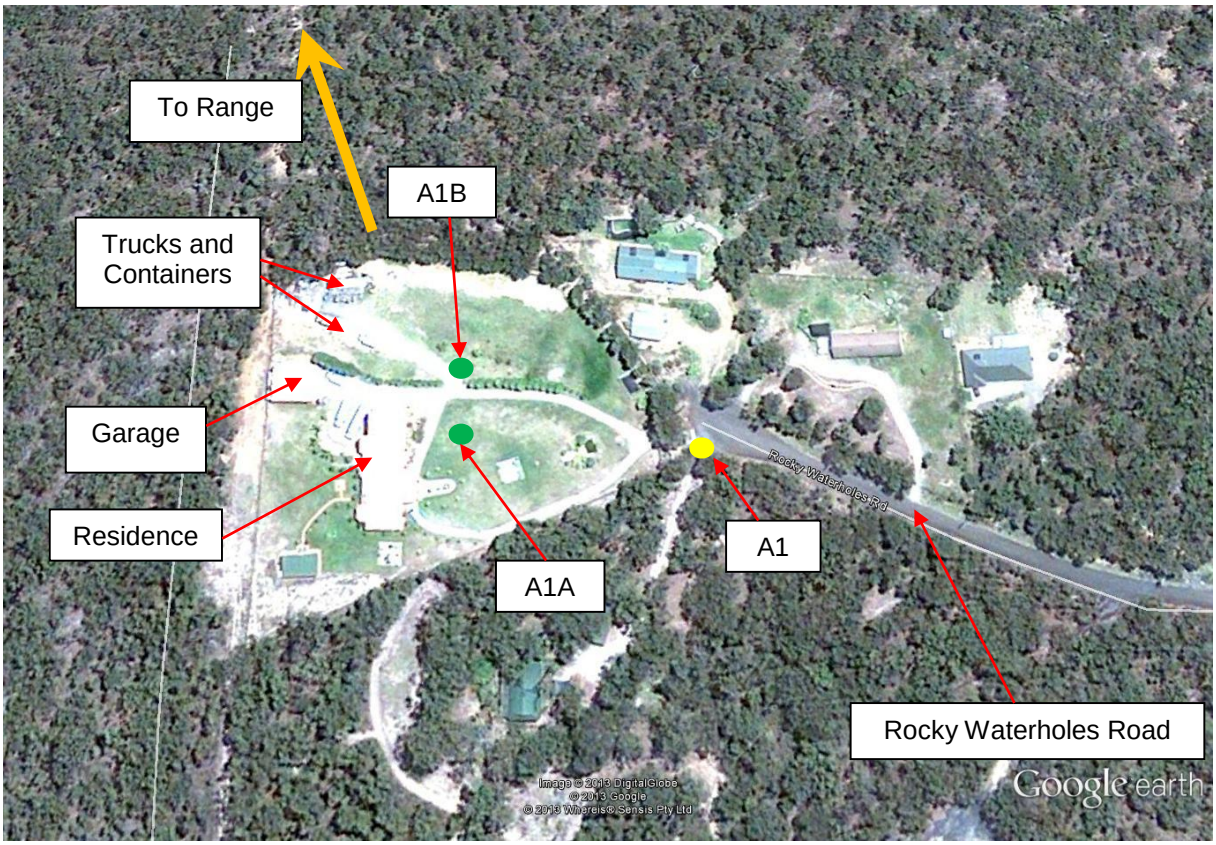
THE ACOUSTIC GROUP PTY LTD

CHRISTOPHER Y. H. CHAN

APPENDIX A: Measurement Locations



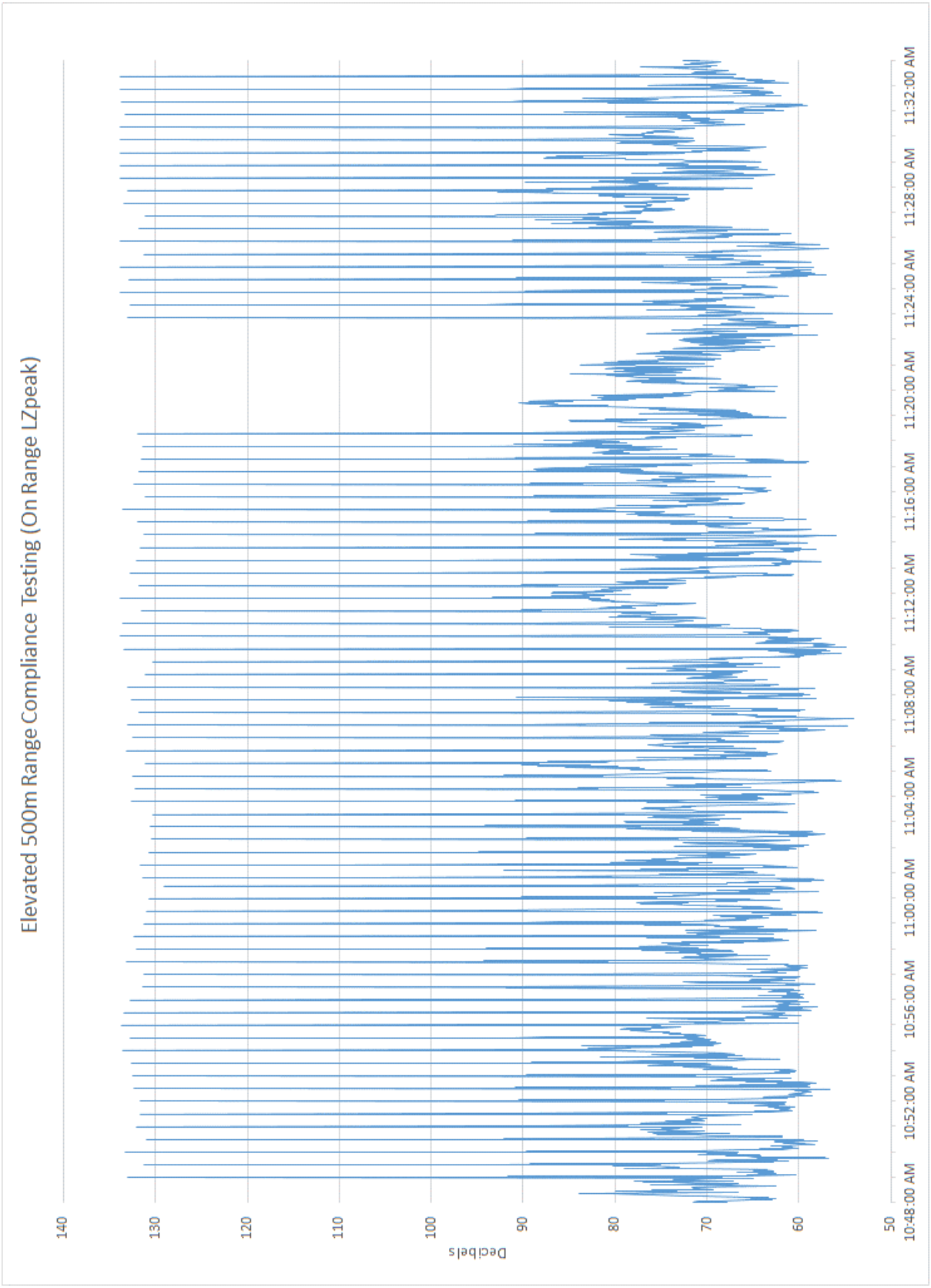

B2A
B2
A2
A1A
A1
© 2010 Cnes / Spot Image
Image © 2010 GeoEye
© 2010 MapData Sciences Pty Ltd, PSMA
©2010 Google
Imagery Date: Oct 31, 2009
34°20'14.54" S 150°28'38.04" E elev 560 m
Eye alt 5.12 km


To Range
A1B
Trucks and Containers
Garage
Residence
A1A
A1
Rocky Waterholes Rd
Rocky Waterholes Road
Image © 2013 DigitalGlobe
© 2013 Google
© 2013 Whereis® Sensis Pty Ltd
Google earth

APPENDIX B: Measurement Results – On Range

Measurement Location - Shooting Range (Onsite). Friday 11/03/2016

133	131	133	131	132	132	132	132	133	133
134	133	134	133	133	131	131	133	132	132
131	131	131	129	132	132	131	130	131	130
133	132	133	131	133	133	133	132	133	133
131	130	134	134	134	132	134	132	133	132
132	131	132	134	131	132	132	132	131	132
133	133	134	133	134	131	134	132	131	133
133	134	134	134	134	134	133	134	134	134

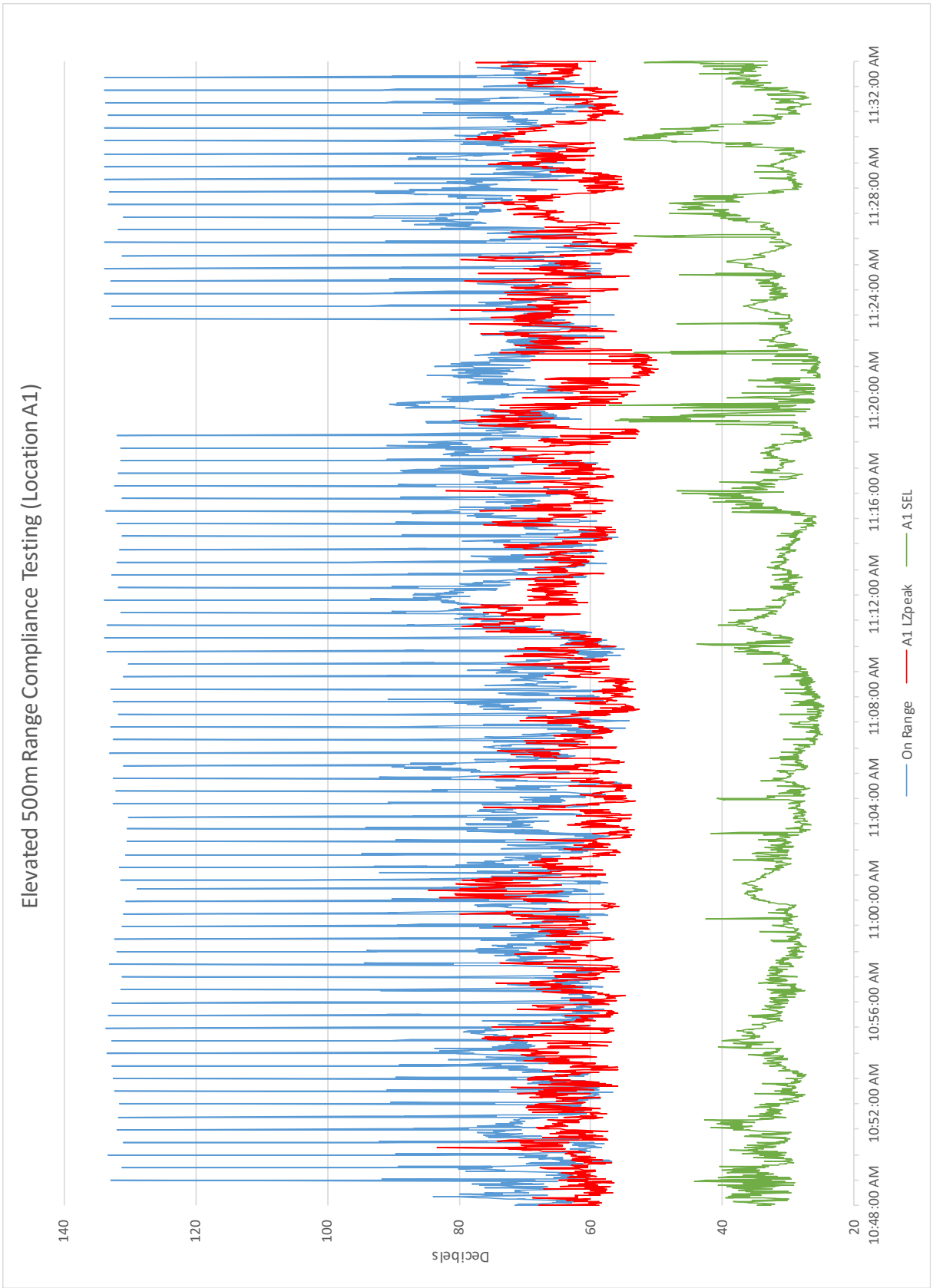

Elevated 500m Range Compliance Testing (On Range LZpeak)
Decibels
140
130
120
110
100
90
80
70
60
50
10:48:00 AM
10:52:00 AM
10:56:00 AM
11:00:00 AM
11:04:00 AM
11:08:00 AM
11:12:00 AM
11:16:00 AM
11:20:00 AM
11:24:00 AM
11:28:00 AM
11:32:00 AM

APPENDIX C: Measurement Results – Location A1

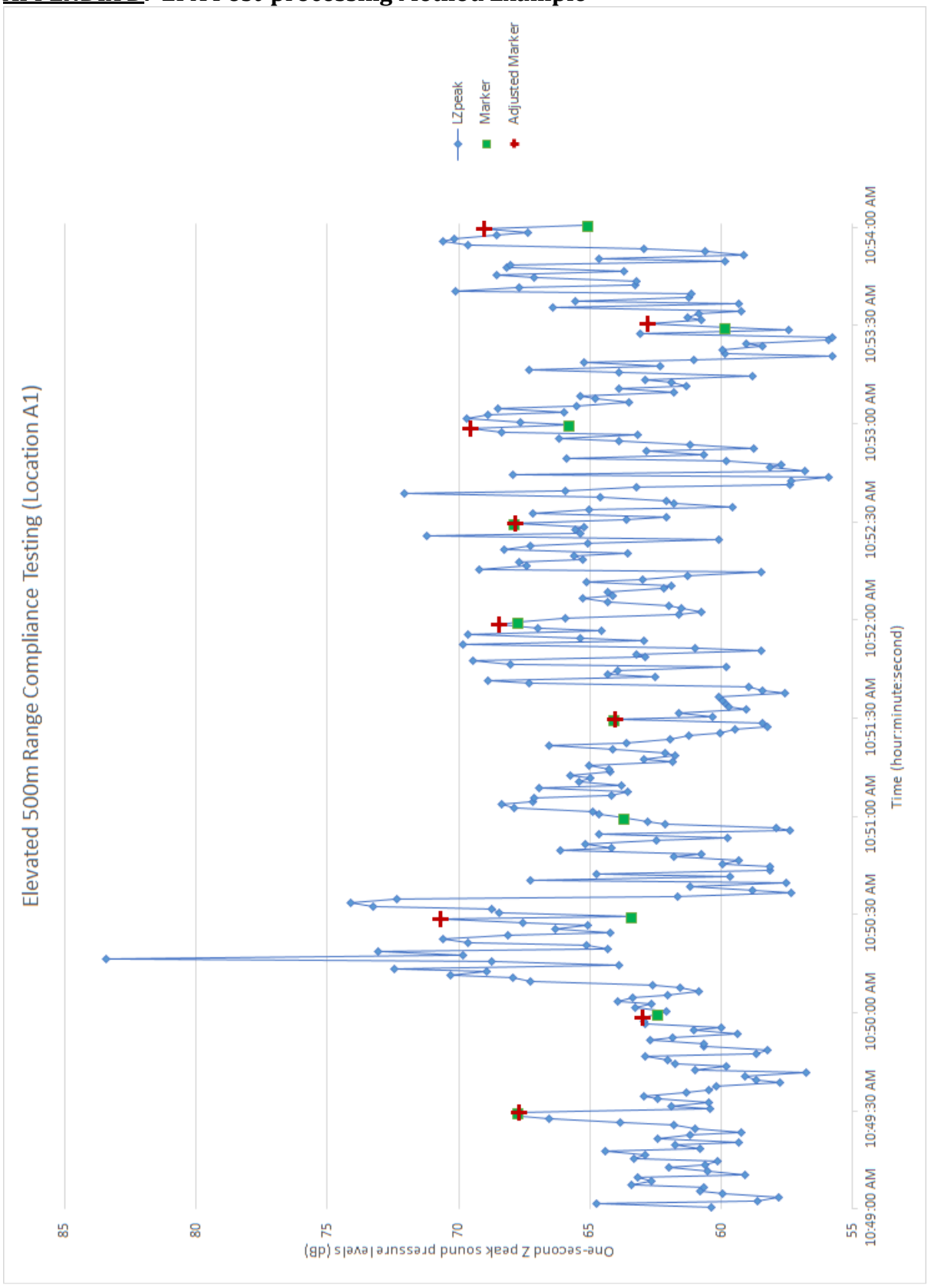
Measurement Location A1 – Rocky Waterholes Road. Friday 11/03/2016

64	68	63	71	XR	64	68	68	70	63
69	X	X	64	60	X	65	XW (70)	X	58
69	XW (80)	XW	XW (80)	XW (80)	67	60	60	52	58
62	59	61	62	69	64	61	63	60	58
64	69	XW (68)	X	XR (80)	XR (76)	X	69	63	65
X	65	XW	XR	60	59	XR (71)	67	XW (74)	65
70	68	XR (73)	XR (79)	70	64	58	68	67	XR
60	61	67	X	XR (72)	XR (71)	61	62	60	70

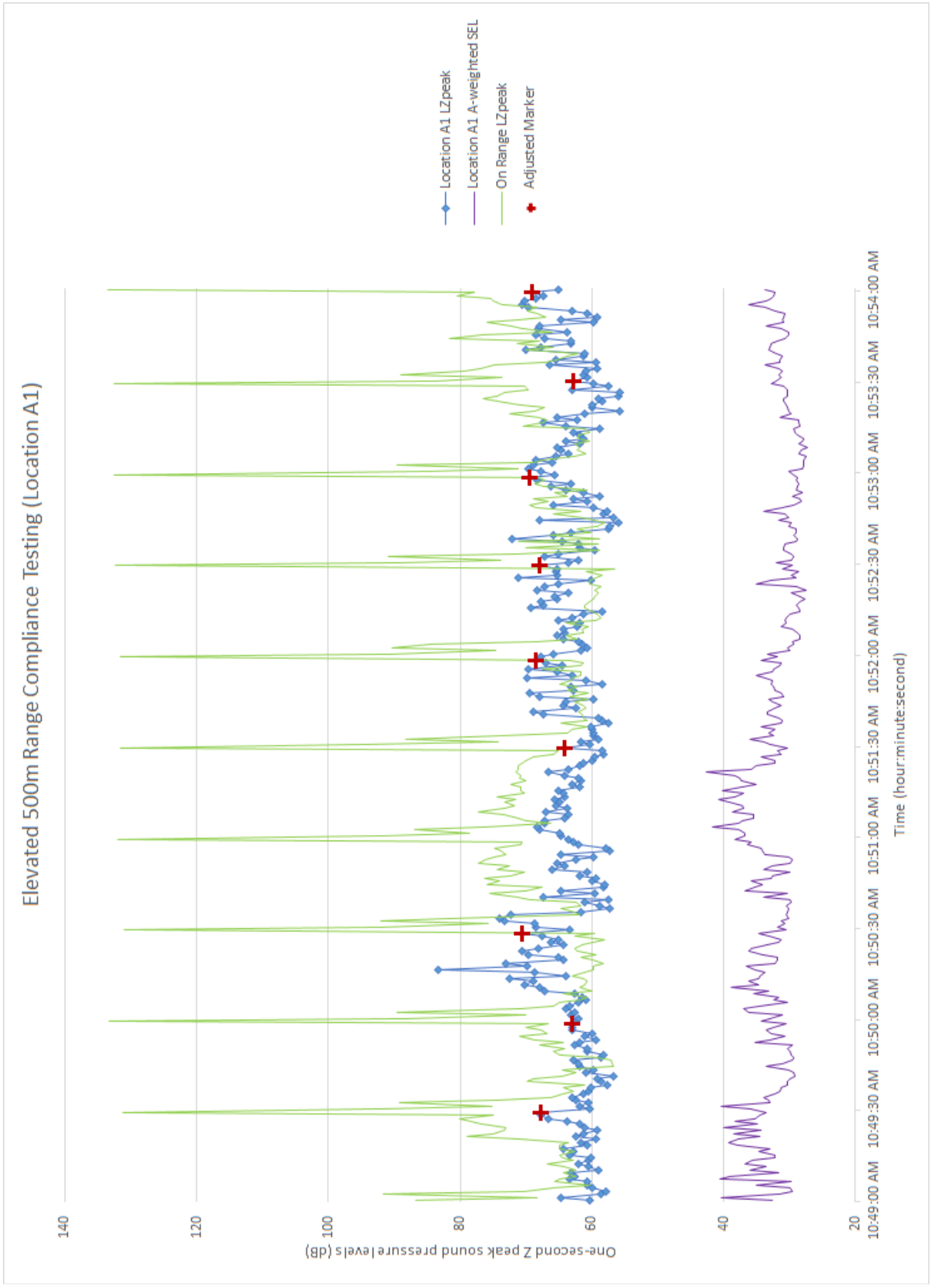
X = Audible but not measureable in ambient (background noise level or birds)
XW = Audible but not measureable due to wind at time of shot
XR = Not measureable due to extraneous noise from vehicle or plane
( ) = Extraneous peak level
\- = No measurement
NA = Not audible


Elevated 500m Range Compliance Testing (Location A1)
Decibels
140
120
100
80
60
40
20
10:48:00 AM
10:52:00 AM
10:56:00 AM
11:00:00 AM
11:04:00 AM
11:08:00 AM
11:12:00 AM
11:16:00 AM
11:20:00 AM
11:24:00 AM
11:28:00 AM
11:32:00 AM
On Range
A1 LZpeak
A1 SEL

APPENDIX D: EPA Post-processing Method Example



Measurement	Pre-shot LZpeak	Shot LZpeak	Shot/pre-shot difference	Shot category
2	67.69	67.72	0.03	B
3	62.97	62.99	0.02	B
4	67.58	70.71	3.13	B
5	62.83	63.67	0.84	Not valid (extraneous noise)
6	58.42	64.06	5.64	A
7	66.98	68.44	1.46	B
8	65.25	67.86	2.61	B
9	68.36	69.54	1.18	B
10	59.83	62.79	2.96	B
11	67.39	69.02	1.63	B


Elevated 500m Range Compliance Testing (Location A1)
Location A1 LZpeak
Location A1 A-weighted SEL
On Range LZpeak
Adjusted Marker
One-second Z peak sound pressure levels (dB)
140
120
100
80
60
40
20
10:49:00 AM
10:49:30 AM
10:50:00 AM
10:50:30 AM
10:51:00 AM
10:51:30 AM
10:52:00 AM
10:52:30 AM
10:53:00 AM
10:53:30 AM
10:54:00 AM
Time (hour:minute:second)