

MTR Corporation Limited

HONG KONG SECTION OF GUANGZHOU –
SHENZHEN – HONG KONG EXPRESS RAIL LINK
(No. EP-349/2009/B)

Performance Test Plan
(Revision C)

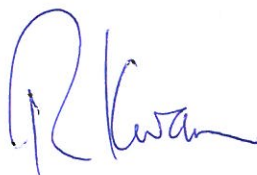
Verified by:	 _____
Position:	<u>Independent Environmental Checker</u>
Date:	<u>21 October 2011</u>

MTR Corporation Limited

HONG KONG SECTION OF GUANGZHOU –
SHENZHEN – HONG KONG EXPRESS RAIL LINK
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Certified by:



Position:

Environmental Team Leader

Date:

20 OCT 2011

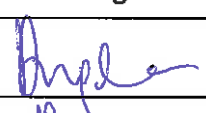
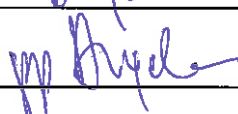
MTR Corporation Limited

Consultancy Agreement No. C8016

**Environmental Term Consultancy
for Express Rail Link**

Performance Test Plan

October 2011

	Name	Signature
Prepared & Checked:	Angela Tong	
Reviewed & Approved:	Josh Lam	

Version: C Date: 20 October 2011

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Table of Content

	Page
1 INTRODUCTION	1
1.1 Background	1
1.2 Purpose of This Test Plan.....	1
1.3 Report Structure	1
2 VIBRATION BOREHOLE TESTING	2
2.1 Testing Locations	2
2.2 Instrumentations.....	2
2.3 Measurement Procedures.....	3
2.4 Geological Conditions.....	5
2.5 Prediction of Line Source Response	5
3 LINE SOURCE RESPONSE ANALYSIS.....	6
3.1 LSR Adopted in the Approved EIA Report.....	6
3.2 Verification of LSR.....	6
4 CONCLUSION.....	8

List of Tables

Table 2.1	Vibration Borehole Testing Locations
Table 2.2	Instruments Used in the Vibration Borehole Impact Test
Table 2.3	Details of Vibration Borehole Impact Test

List of Figures

C8016/C/XRL/ENS/M53/005	Locations of Vibration Borehole Test at Kwai Chung
C8016/C/XRL/ENS/M53/006	Locations of Vibration Borehole Test at Shek Kong

List of Appendices

Appendix A	Photographic Record of VBT
Appendix B	Drillhole Records
Appendix C	Measured Point Source Responses
Appendix D	Determined Line Source Responses
Appendix E	XRL EIA Assumed Line Source Responses
Appendix F	Comparison of Measured and EIA Line Source Responses
Appendix G	Calibration Records of Measurement Equipment
Appendix H	Latest Geological Profiles at Measurement Locations

1 INTRODUCTION

1.1 Background

- 1.1.1 The “Hong Kong Section of Guangzhou-Shenzhen-Hong Kong Express Rail Link” Project (hereinafter known as “the Project”) covers a 26km long underground rail line on a dedicated track that runs from the terminus in West Kowloon to the boundary at Huanggang, where is connect with the XRL Mainland section. XRL Project also covers ventilation buildings, emergency access points, stabling sidings and maintenance facilities and an emergency rescue siding (formerly known as rescue emergency station).
- 1.1.2 An Environmental Impact Assessment (EIA) study for the Project was conducted in accordance with the EIA Study Brief No. ESB-197/2008. The EIA study concluded that the Project would be environmentally acceptable with the implementation of mitigation measures.
- 1.1.3 The EIA Report (Register No.: AEIA-143/2009) was approved on 28th September 2009 by the Director of Environmental Protection (DEP) under the Environmental Impact Assessment Ordinance (EIAO). Following the approval of the EIA Report, an environmental permit (EP) was granted on 16th October 2009 (EP No: EP-349/2009) for the construction and operation of the Project. A variation of environmental permit was approved with an Environmental Permit (EP No: EP-349/2009/A) issued by Director of Environmental Protection (DEP) on 27 September 2010.
- 1.1.4 Pursuant to EP Condition 2.23, the Permit Holder, MTR Corporation Ltd (MTR), should deposit with the Director a Performance Test Plan (PTP) for the verification of the Line Source Response (LSR) assumed in the EIA Report. The PTP should include the result of the vibration borehole testing (VBT) to be carried out at two carefully selected locations along the tunnel alignment before the commencement of the construction of the Project and the knowledge of the ground vibration conditions to be obtained during the construction stage of the Project.
- 1.1.5 AECOM Asia Co. Ltd has been commissioned by the MTR to conduct the VBT and prepare the PTP for the verification of the LSR assumed in the EIA Report.

1.2 Purpose of This Test Plan

- 1.2.1 This PTP presents the LSR analysis based on the results of the VBT conducted at two selected locations for verification of the LSR assumed in the EIA Report.

1.3 Report Structure

- 1.3.1 This PTP comprises the following sections:
- Section 1 presents the background information of the PTP.
 - Section 2 presents the details of the VBT and the prediction of LSR based on results of the VBT.
 - Section 3 presents the LSR analysis to verify the LSR assumptions in the EIA study.
 - Section 4 presents the conclusion of verification.

2 VIBRATION BOREHOLE TESTING

2.1 Testing Locations

2.1.1 Appropriate testing locations were selected to obtain representative LSR information in northern and southern sections of alignment respectively. The following considerations were taken into account during the selection of testing locations:

- Safety issue - The borehole locations should be located at least 5m away from tunnel alignment in order to avoid construction risk during tunnelling works.
- Relative high ground-borne noise levels predicted – The VBT is recommended to be conducted at critical sensitive locations closest to the XRL tunnel. Based on EIA findings, relatively high L_{max} levels ranging from 38 to 43dB(A) and 34 to 45dB(A) were predicted in Kwai Chung (area near Kwai Ying Building and Ming Tak Building) and Shek Kong (area near Wang Toi Shan Tsuen) respectively.
- Ground condition - The XRL tunnel will pass through mostly highly decomposed granite rock with alluvium/marine deposit on top. The tests are therefore proposed to be conducted at this type of ground condition. Kwai Ying Building and Ming Tak Building are relatively larger buildings supported by piles on rock and the tunnel in this area will be in rock, one of typical conditions in southern section. Village houses in Shek Kong are low-rise buildings without piles set on completely/highly decomposed (CD/HD) rock and the tunnel in this area will be in rock with overlying highly decomposed rock above, which is a typical condition in northern section. In conclusion, the ground conditions are typical for the general areas where high levels are predicted.
- Accessibility and appropriateness of site condition – Locations should be allowed for fairly easy access for drilling equipment and for testing, and there are good positions suitable for fixing the vibration transducers. Approval of site access by the land owner should also be sought.

2.1.2 With the above considerations, site visits were conducted in Kwai Chung, Shek Kong to identify two representative locations for VBT and liaisons with land owners were also conducted to obtain approval on access. The testing sites are given in **Table 2.1** with the locations of borehole and accelerometer shown in **Figures C8016/C/XRL/ENS/M53/005 &006**. A photographic record of VBT is presented in **Appendix A**.

Table 2.1 Vibration Borehole Testing Locations

Section	Testing Location
Southern Section	Parking bay at Tai Loong Street, Kwai Chung
Northern Section	Open storage area near Kam Tai Road, Shek Kong

2.2 Instrumentations

2.2.1 The VBT was conducted using the instruments as listed in **Table 2.2**.

Table 2.2 Instruments Used in the Vibration Borehole Impact Test

Instrument	Manufacturer / Model No.	Purpose
Pneumatic Hammer	Wilkinson Murray (WM) model 3.5	Connection to compressor to induce force (impact)
Impact Controller	WM type 1	Connection to pneumatic hammer to control impact on/ off
Analyzer Platform	Bruel & Kjaer PULSE /	Spectrum analyzer for data

Instrument	Manufacturer / Model No.	Purpose
	Sinus Harmonie with Samurai software	acquisition
Accelerometer	Brüel & Kjær type 4370V / PCB type 353B33	Vibration receiver instrument to measure vibration, bonded in place
Force transducer	PCB 200M200	Fitted to pneumatic hammer to measure impact force

2.3 Measurement Procedures

2.3.1 The ground investigation (GI) contractor (Gammon Construction Limited) conducted borehole drilling works with the following setup at the borehole:

- a straight hole of minimum clear internal diameter 130mm to a depth of ranging from 17m to 30m with installation of PVC pipe for avoiding water flowing into testing location; and
- 500mm concrete plug at the base of the hole.

2.3.2 Vibration borehole testing was conducted according to measurement procedures provided below:

- Fix a force transducer to the bottom of the pneumatic hammer and connect this transducer to the PULSE or Harmonie measurement instrumentation;
- Connect the accelerometers to the PULSE or Harmonie (set for 10 – 5000 Hz analysis, Gaussian window) and place the accelerometers with bees wax onto the ground and foundation of nearby Noise Sensitive Receivers (NSRs);
- Remove excess water from the drillhole immediately before the test;
- Lower the pneumatic hammer with force transducer attached to the base of the hole;
- Activate the pneumatic hammer to apply an impact at base of the hole;
- Record the impact force and the vibration levels at the surface locations. Measurement was conducted in narrow frequency bands;
- Impacts force and vibration measurements were repeated (at least 20 times) to obtain adequate data for prediction of LSR.

2.3.3 Vibration borehole testing was conducted in September and December 2010 with details presented in **Table 2.3**.

Table 2.3 Details of Vibration Borehole Impact Test

Borehole No.	Location	Impact Depth ⁽¹⁾	Measurement Date	Sensor No.	Slant Distance from Borehole
B01	Parking bay at Tai Loong Street, Kwai Chung	30m	6 September 2010	S1 – Foundation of Kwai Chung Building	31m
				S2 – Foundation of Kwai Ying Building	39m
				S3 – Foundation of Kam Pui Building	44m
B02	Open storage area near Kam Tai Road, Shek Kong	17m	29 December 2010	S1 – On small piece of concrete on ground at 7m setback from the hole	18m
				S2 – On small piece of concrete on ground at 14m setback from the hole	22m
				S3 – On concrete ground at 17m setback from the hole	24m
				S4 – On concrete ground at 25m setback from the hole	30m
				S5 – On small piece of concrete on ground at 27m setback from the hole	32m
				S6 – On small piece of concrete on ground at 34m setback from the hole	38m

Remark:

(1) As it is not possible to measure the PSR over large distances since the background vibration levels will affect the measurements, the depth of borehole was therefore set to 30m and 17m instead of exact tunnel depth to allow practical measurements.

2.4 Geological Conditions

- 2.4.1 At Kwai Chung slightly decomposed granite rock exists from approximately 2m below the surface. The hole was drilled into this rock and the impact was applied at a depth of 30m within the rock. All buildings on which vibration testing was conducted were constructed on the rock so that the path of vibration transmission from the impact point to the building is via rock. Drillhole record is given in **Appendix B**.
- 2.4.2 At Shek Kong, the impact was applied in slightly decomposed coarse ash Lapilli Tuff rock and there was slightly silty fine to coarse sand above this. Nearby buildings were located on the sand. Drillhole record is given in **Appendix B**. Given that the measurement locations were on small pieces of concrete (approximately 1m in dimension) it has been assumed that no coupling loss and no amplification were included in the results.

2.5 Prediction of Line Source Response

- 2.5.1 The measurement data was organised so that the differing geological conditions at receivers along the alignment, namely, the setback of the receiver from the alignment, the depth of the tunnel, and the depth of the receiver-building basement can be input. For the given input conditions, the overall PSR is extrapolated from the borehole impact database with respect to the setback, and source and receiver depth. The LSR was then determined by (numerical) incoherent integration of the Point Source Response (PSR) along the length of the train centred on the receiver, while PSR was determined from impacting in a borehole (i.e. VBT).
- 2.5.2 The calculation of LSR followed the calculation outlined in High-Speed Ground Transportation Noise and Vibration Impact Assessment (FRA High-Speed Guidance Manual). Firstly, the narrow band frequency PSR results were converted to one third octave band results over the frequency range 12.5 to 500 Hz. For each one third octave band, the regression line of best fit was established through the results and this allowed extrapolation of the results to positions beyond the measurement locations. Using the extrapolated PSR results, the LSR values were determined.
- 2.5.3 At these sites, the results below 12.5Hz could not be obtained with the test equipment used at the time of measurement, but this will have an insignificant effect on the prediction of A-weighted ground-borne noise which is dominated by frequencies around 100 Hz. This is because frequencies below 10Hz are not included in the internationally defined A-weighting curve and, even at 10Hz the weighting is a very negative -70 dB.
- 2.5.4 The numerical integration to determine LSR was carried out by assuming a train length consisted of a series of point sources h metres (10m) apart and the PSR from each point source to the receiver location was established from the measured PSR, using interpolation where necessary. LSR was then calculated as follows:

$$LSR = 10 \log [h \times (10^{PSR1/10}/2 + 10^{PSR2/10} + \dots + 10^{PSRn/10}/2)]$$

Where h = point source interval
 PSR_i = point source response of the i th point source
 n = last point source

- 2.5.5 The PSR for various impact boreholes used to calculate LSR and the LSR obtained by extrapolating the PSR are presented in **Appendices C** and **D** respectively. The results for Shek Kong are, to some degree, affected by background vibration levels on site but the results are adequate for verification of LSR assumptions.

3 LINE SOURCE RESPONSE ANALYSIS

3.1 LSR Adopted in the Approved EIA Report

- 3.1.1 The LSR determines the vibration levels or attenuation in the ground as a function of distance caused by an incoherent line source of unit force point impacts.
- 3.1.2 The LSR values adopted in ground-borne noise assessment were referenced from the data West Island Line (WIL) EIA Study (EIA Register No. AEIAR-126/2008).
- 3.1.3 The LSR for WIL EIA Study were determined based on the results of borehole impact tests performed in rock, soil and close to the rock head both on the soil side and the rock side, with receiver vibration data taken at many setback distances. Appropriate LSR was selected accordingly with consideration of geological characteristics along alignment. Where the tunnel will pass through rock, the rock is granite with highly decomposed granite and alluvium on top, and the LSR values used from WIL are those obtained by testing in the same rock and ground material. Where the tunnel will pass through soft ground, the soft ground is mostly decomposed granite and sandstone.
- 3.1.4 The test carried out at Kwai Chung was specifically aimed at determining the LSR values for vibration propagating only through rock, while test was conducted at Shek Kong was aimed at determining propagation through soft ground, taking consideration of relative higher ground-borne noise predictions in these areas.

3.2 Verification of LSR

- 3.2.1 The LSR values determined at Kwai Chung and Shek Kong may be compared with those used in the EIA for the same area and the same ground conditions (WIL D064-54.6m and D018-39.8m respectively). The EIA LSR values are now shown in **Appendix E**. To allow a better comparison, **Appendix F** shows the LSR value determined at Kwai Chung at a distance of 60m and the EIA assumed LSR at a distance of 61m, and the LSR values determined at Shek Kong and in the EIA at 40m.
- 3.2.2 It can be seen that the measured Kwai Chung LSR values are lower than the EIA LSR values over a large part of the frequency range but are slightly higher than the EIA values at the high frequencies. At Shek Kong, the measured values are higher than the assumed EIA values except for at the high frequencies. Different in ground condition information for EIA stage and recent stage may be accounted for the differences in LSR values. Based on latest geological profile obtained from recent site investigation works (**Appendix H**), it is indicated the geological profile adopted in EIA prediction is similar to the latest profile in Kwai Chung area but is a bit different from those recorded in Shek Kong. The LSR values measured in Shek Kong is therefore different from those adopted in EIA.
- 3.2.3 Given that tunnelling works are yet to commence, and thus the knowledge of the ground vibration conditions obtained during tunnelling works is not available during the preparation of PTP. However, ground-borne noise impact monitoring will be conducted at designated monitoring locations when the TBM head is operating underneath the monitoring locations, according to the EM&A Manual. The monitoring results will be reviewed to reconfirm the EIA predictions. Investigation will be conducted in the event of exceedances recorded and follow-up actions will be proposed as necessary.
- 3.2.4 A review of LSR values adopted in EIA has been conducted. Based on the same assumption of Force Density Level (FDL) adopted in EIA Report for China Railway High-speed (CRH) trains, higher LSR values at most frequencies and lower at high frequencies would result in higher ground-borne noise levels. However, it should be noted that the FDL of CRH trains is yet to be obtained and thus the dominant frequencies and actual levels are unknown at this moment. The compliance of noise limits would therefore be checked upon available of measured FDL values. Pursuant to EP Condition 2.25, ground-borne noise prediction will be

conducted based on the measured LSR values and FDL of the trains for updating the mitigation proposal as necessary.

4 CONCLUSION

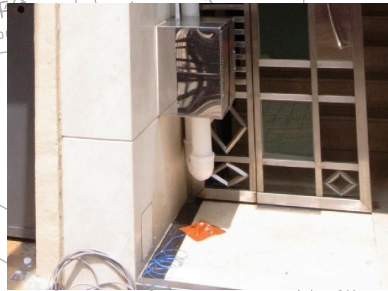
- 4.1.1 The measurement of ground LSR values at two carefully selected locations along the route of the proposed XRL will allow a check of the suitability of the LSR assumptions adopted in the EIA for the two relevant ground types.
- 4.1.2 The LSR values measured at Kwai Chung apply to those conditions where the tunnel is proposed to be in rock and the NSRs are supported on rock. The LSR values measured at Shek Kong apply to those locations where the tunnel is in rock, but the NSRs are supported on the overlying soft ground.
- 4.1.3 The measured Kwai Chung LSR values are lower than the EIA LSR values over a large part of the frequency range but are slightly higher than the EIA values at the high frequencies. At Shek Kong, the LSR values are higher than the EIA assumption at most frequencies, but lower at the high frequencies. Upon the available of FDL values, ground-borne noise prediction will be conducted based on the measured LSR values and FDL of the trains for updating the mitigation proposal as necessary.

Figures

Plot Drw: \\mtr\mtr\p1\DRIVER\WINDOWS\X3\COLOUR\p1\140838
Model Name: C8016
File Name: C8016_C_XRL_ENS_M53_005A.dgn

LOCATION	DESCRIPTION
BOREHOLE 01	BOREHOLE NEAR KWAI CHUNG BUILDING (IMPACT DEPTH: 30m)
S1	SENSOR 1 ON GROUND FLOOR OF KWAI CHUNG BUILDING
S2	SENSOR 2 ON GROUND FLOOR OF KWAI YING BUILDING
S3	SENSOR 3 ON GROUND FLOOR OF KAM PUI BUILDING

REV	DESCRIPTION	BY	DATE	APPROVED	REV	DESCRIPTION	BY	DATE	APPROVED



LEGEND:

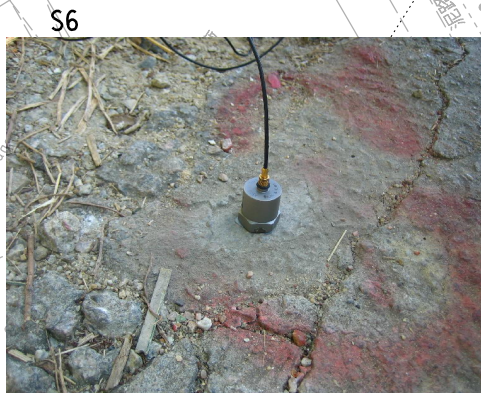
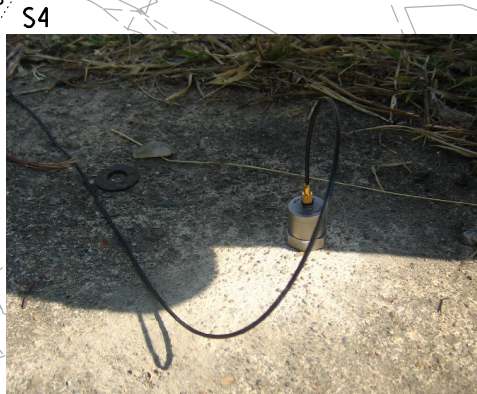
- XRL ALIGNMENT
- UNDERGROUND FACILITIES
- BOREHOLE LOCATION
- ACCELEROMETER LOCATION
- GROUND-BORNE NOISE SENSITIVE RECEIVERS ASSESSED IN XRL EIA

DRAWN	ZRH
DESIGNED	--
CHECKED	--
APPROVED	--
DATE	29/OCT/2010
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EXPRESS RAIL LINK
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AECOM
CADD REF.

C8016_C_XRL_ENS_M53_005A.dgn

TITLE	C8016 ENVIRONMENTAL TERM CONSULTANCY FOR XRL LOCATIONS OF VIBRATION BOREHOLE TEST AT KWAI CHUNG
SCALE	1 : 1000 (A3)
FIGURE NO.	C8016/C/XRL/ENS/M53/005
REV.	A



LOCATION	DESCRIPTION
BOREHOLE 02	BOREHOLE AT OPEN STORAGE AREA NEAR KAM TAI ROAD, SHEK KONG (IMPACT DEPTH: 17m)
S1	SENSOR 1 ON CONCRETE GROUND AT 7m SETBACK FROM THE BOREHOLE
S2	SENSOR 2 ON CONCRETE GROUND AT 14m SETBACK FROM THE BOREHOLE
S3	SENSOR 3 ON CONCRETE GROUND AT 17m SETBACK FROM THE BOREHOLE
S4	SENSOR 4 ON CONCRETE GROUND AT 25m SETBACK FROM THE BOREHOLE
S5	SENSOR 5 ON CONCRETE GROUND AT 27m SETBACK FROM THE BOREHOLE
S6	SENSOR 6 ON CONCRETE GROUND AT 34m SETBACK FROM THE BOREHOLE

REV	DESCRIPTION	BY	DATE	APPROVED	REV	DESC

DRAWN	ZRH
DESIGNED	--
CHECKED	--
APPROVED	--
DATE	18/JAN/2011

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TITLE		
C8016 ENVIRONMENTAL TERM CONSULTANCY FOR XRL LOCATIONS OF VIBRATION BOREHOLE TEST AT SHEK KONG		
SCALE	FIGURE NO.	REV.
1 : 1000 (A3)	C8016/C/XRL/ENS/M53/006	A

LEGEND:

- | | |
|---|--|
|  | XRL ALIGNMENT |
|  | PERMANENT ABOVEGROUND FACILITIES |
|  | UNDERGROUND FACILITIES |
|  | BOREHOLE LOCATION |
|  | ACCELEROMETER LOCATION |
|  | GROUND-BORNE NOISE SENSITIVE RECEIVERS ASSESSED IN XRL EIA |

C8016
ENVIRONMENTAL TERM CONSULTANCY FOR XRL
LOCATIONS OF VIBRATION BOREHOLE TEST AT SHEK KONG

SCALE 1 : 1000 (A3)	FIGURE NO. C8016/C/XRL/ENS/M53/006	REV. A
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APPENDIX A

Photographic Record of VBT

Appendix A Photographic Record of VBT

VBT at Kwai Chung



Pneumatic Hammer



Force Transducer



Impact Controller



Analyzer Platform

VBT at Shek Kong



Pneumatic Hammer



Impact Controller and Analyzer Platform

APPENDIX B

Drillhole Records

PRELIMINARY



Gammon Construction Limited

Ground Engineering Department

HOLE No.
B01

SHEET **4** of **4**

DRILLHOLE RECORD

Project Title Express Rail Link (XRL) Consultancy Agreement No C8016 Environmental Term Consultancy for XRL Drilling Works for Vibration Borehole Test

METHOD Rotary

CO-ORDINATES

PROJECT No. J3347

MACHINE & No. 20-110

E
N

DATE from 19/08/2010 **to** 28/08/2010

FLUSHING MEDIUM WATER

ORIENTATION Vertical

GROUND LEVEL mPD

Drilling Progress	Casing depth/size	Water Depth (m)	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples			Reduced Level	Depth (m)	Legend	Grade	Description
									No.	Type	Depth					
28/08/2010		3.20m at 18.00	80	100	100	100							30.00	+	III	As sheet 2 of 4.
													30.32	+		End of hole at 30.32m depth.
													40.00			

●

Small disturbed sample

▨

SPT liner sample

▩

U76 undisturbed sample

■

U100 undisturbed sample

▨

Mazier sample

▩

Piston sample

↓

Standard penetration test

⬇

Vibrocore sample

▲

Water sample

⚙

Piezometer / Standpipe tip

⬆

Permeability test

⊥

Packer (Water Absorption) test

⊥

Impression packer test

⊥

Acoustic Televiwer Survey Test

∨

In-situ vane shear test

⊥

Pressuremeter Test

LOGGED

W K SIU

DATE

30/08/2010

CHECKED

KEN MA

DATE

31/08/2010

REMARKS

PRELIMINARY

t:\gintw\library\1july2009.glb\drillhole (1 sep 2010)

DRILLHOLE RECORD

Project Title Express Rail Link (XRL) Consultancy Agreement No C8016 Environmental Term Consultancy for XRL Drilling Works for Vibration Borehole Test

METHOD Rotary

CO-ORDINATES

PROJECT No. J3347

MACHINE & No. 20-110

E	826742.69
N	833709.31

DATE from 22/12/2010 to 24/12/2010

FLUSHING MEDIUM WATER

ORIENTATION **Vertical**

GROUND LEVEL + 13.75 mPD

Drilling Progress	Casing depth/size	Water Depth (m)	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples			Reduced Level	Depth (m)	Legend	Grade	Description	
									No.	Type	Depth						
22/12/2010	SX	08:00									13.75	0.00			Brown, slightly silty fine to coarse SAND with occasional angular to subangular fine to medium gravel sized rock fragments. (FILL)		
22/12/2010 23/12/2010									A	•	0.45 0.50						
									B	•	0.95 1.00						
									C	•	1.45 1.50						
									D	•	1.95 2.00	11.75	2.00				
		Dry at 18:00 Dry at 08:00														Wash boring, no sample recovered, assumed to be soil.	
											3.75	10.00					

•

Small disturbed sample

SPT liner sample

U76 undisturbed sample

U100 undisturbed sample

Mazier sample

Piston sample

Standard penetration test

Vibrocore sample

▲

Water sample

Piezometer / Standpipe tip

Permeability test

Packer (Water Absorption) test

Impression packer test

Acoustic Televiwer Survey Test

In-situ vane shear test

Pressuremeter Test

LOGGED

W K SIU

DATE

28/12/2010

CHECKED

KEN MA

DATE

29/12/2010

REMARKS

1. Inspection pit was dug to 2.00m depth.
2. UPVC pipe (140mm dia.) was installed at the bottom of drillhole for Noise Impact Test.

PRELIMINARY

DRILLHOLE RECORD

Project Title Express Rail Link (XRL) Consultancy Agreement No C8016 Environmental Term Consultancy for XRL Drilling Works for Vibration Borehole Test

METHOD Rotary	CO-ORDINATES	PROJECT No. J3347
MACHINE & No. 20-110	E 826742.69 N 833709.31	DATE from 22/12/2010 to 24/12/2010
FLUSHING MEDIUM WATER	ORIENTATION Vertical	GROUND LEVEL + 13.75 mPD

Drilling Progress	Casing depth/size	Water Depth (m)	Water Recovery %	Total core Recovery %	Solid core Recovery %	R.Q.D.	Fracture Index	Tests	Samples			Reduced Level	Depth (m)	Legend	Grade	Description
									No.	Type	Depth					
	SX 12.20			100	62	55	>20				12.20	1.55	12.20	III		As sheet 1 of 2. <

- | | | | |
|---|---------------------------|---|---------------------------------|
| ● | Small disturbed sample | ▲ | Water sample |
| □ | SPT liner sample | ⬆ | Piezometer / Standpipe tip |
| ▨ | U76 undisturbed sample | ⬆ | Permeability test |
| ■ | U100 undisturbed sample | ↕ | Packer (Water Absorption) test |
| ▤ | Mazier sample | ↕ | Impression packer test |
| ▥ | Piston sample | ⬆ | Acoustic Televiewer Survey Test |
| ↓ | Standard penetration test | ∇ | In-situ vane shear test |
| ▩ | Vibrocore sample | ⊥ | Pressuremeter Test |

LOGGED W K SIU

DATE 28/12/2010

CHECKED KEN MA

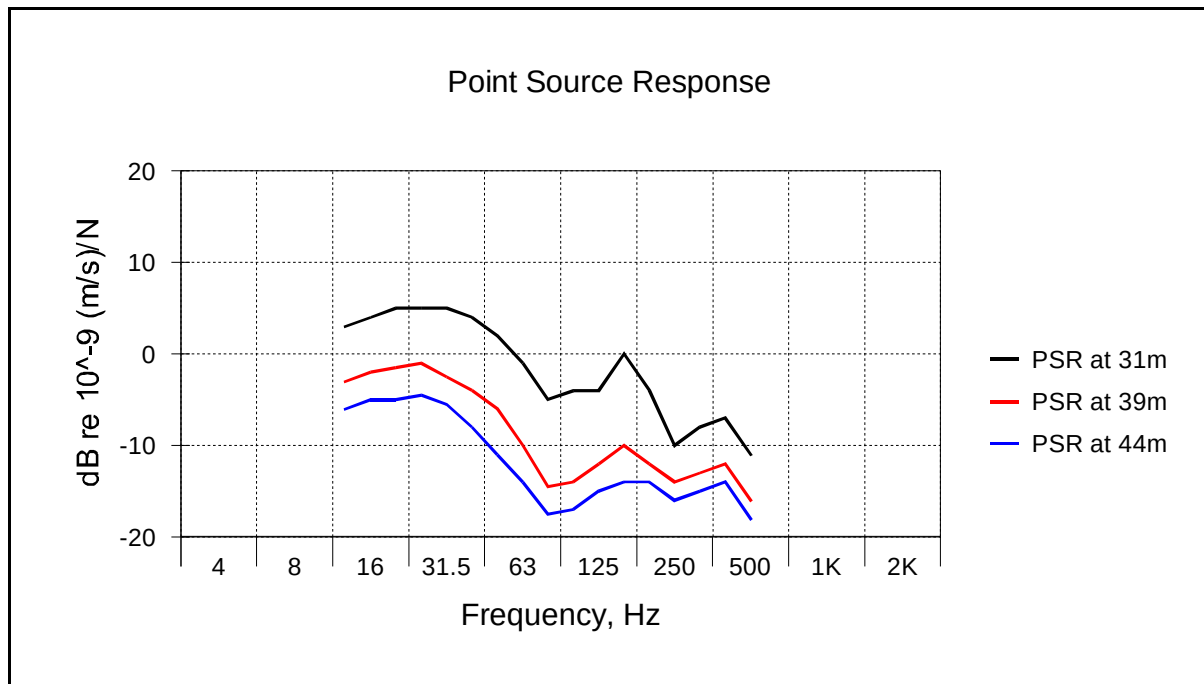
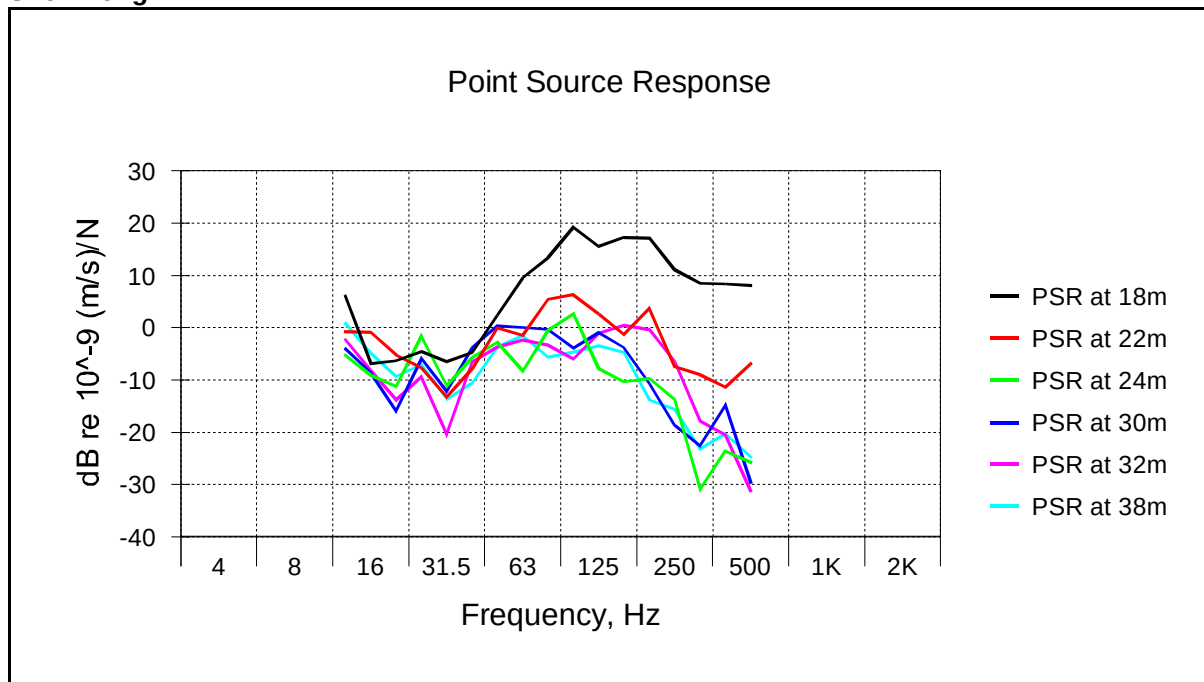
DATE 29/12/2010

REMARKS

PRELIMINARY

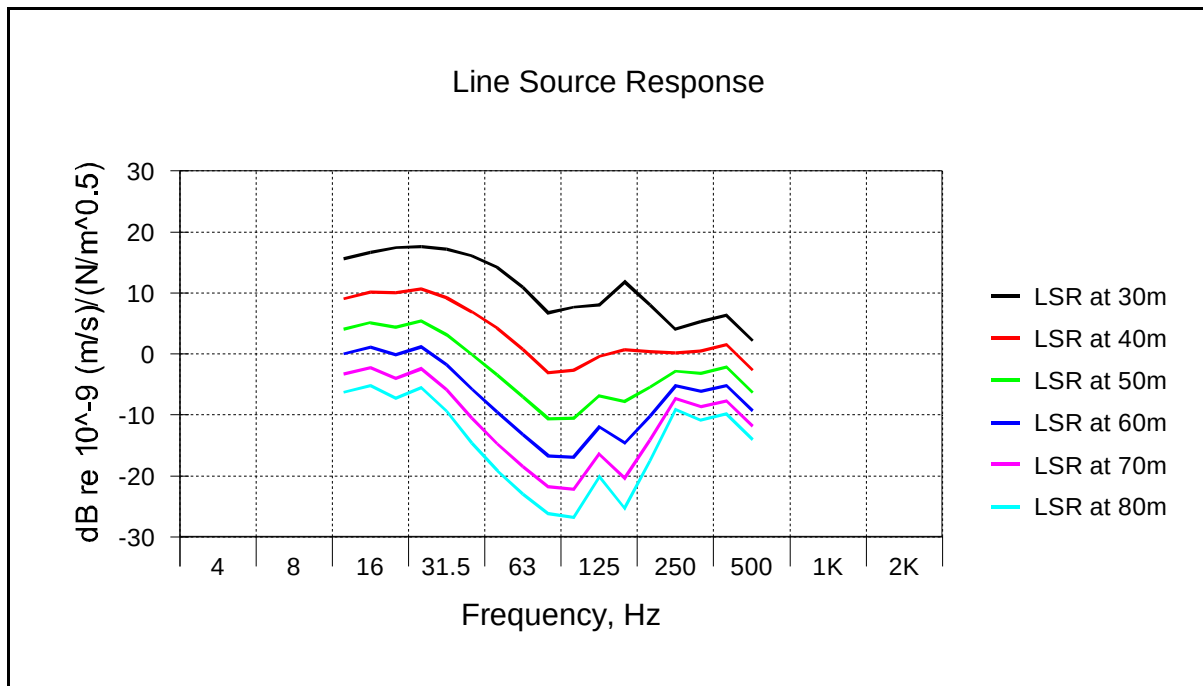
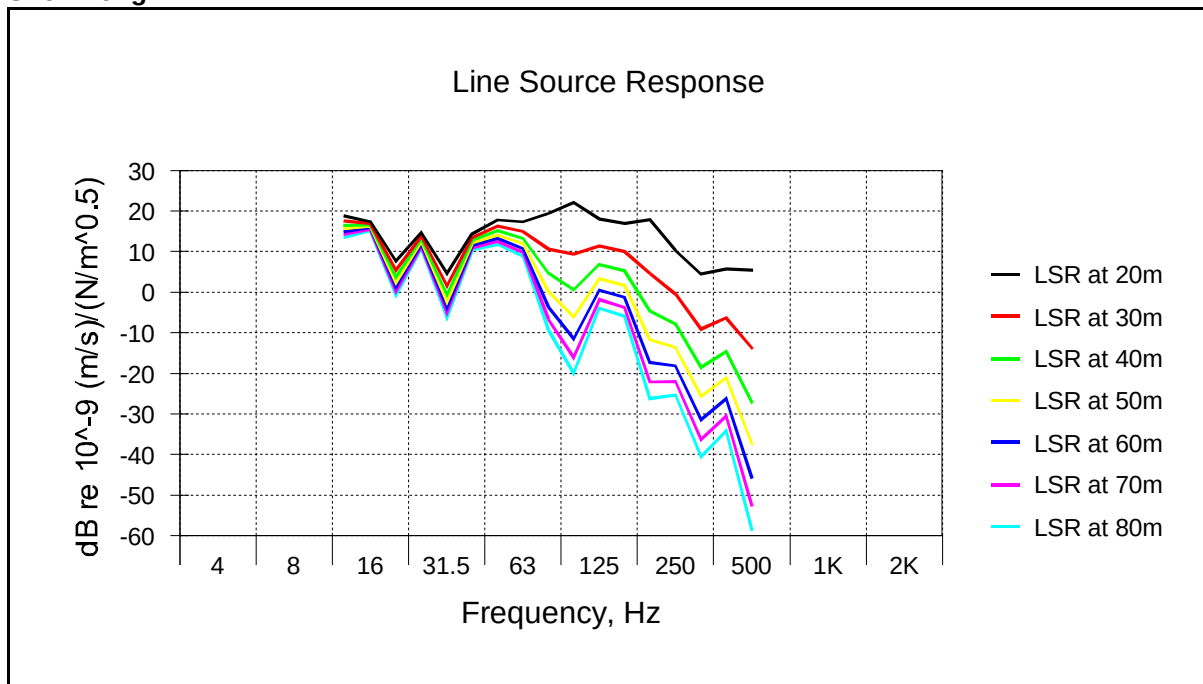
APPENDIX C

Measured Point Source Responses

Appendix C Measured Point Source Responses**Kwai Chung****Shek Kong**

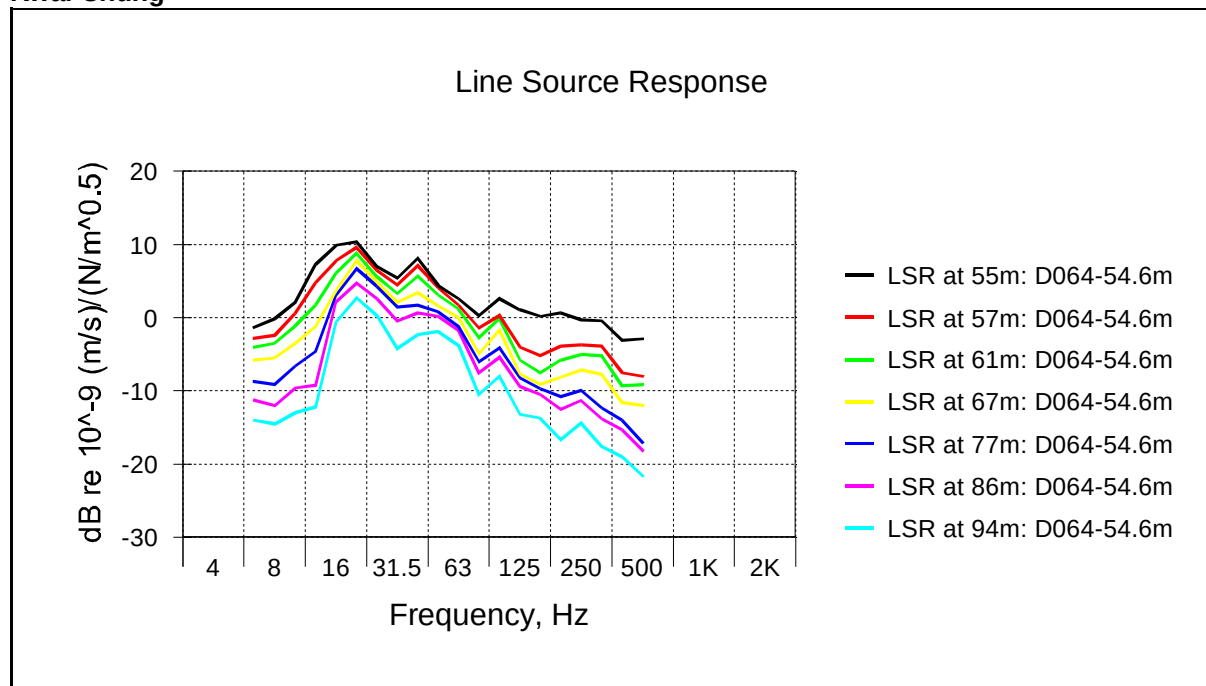
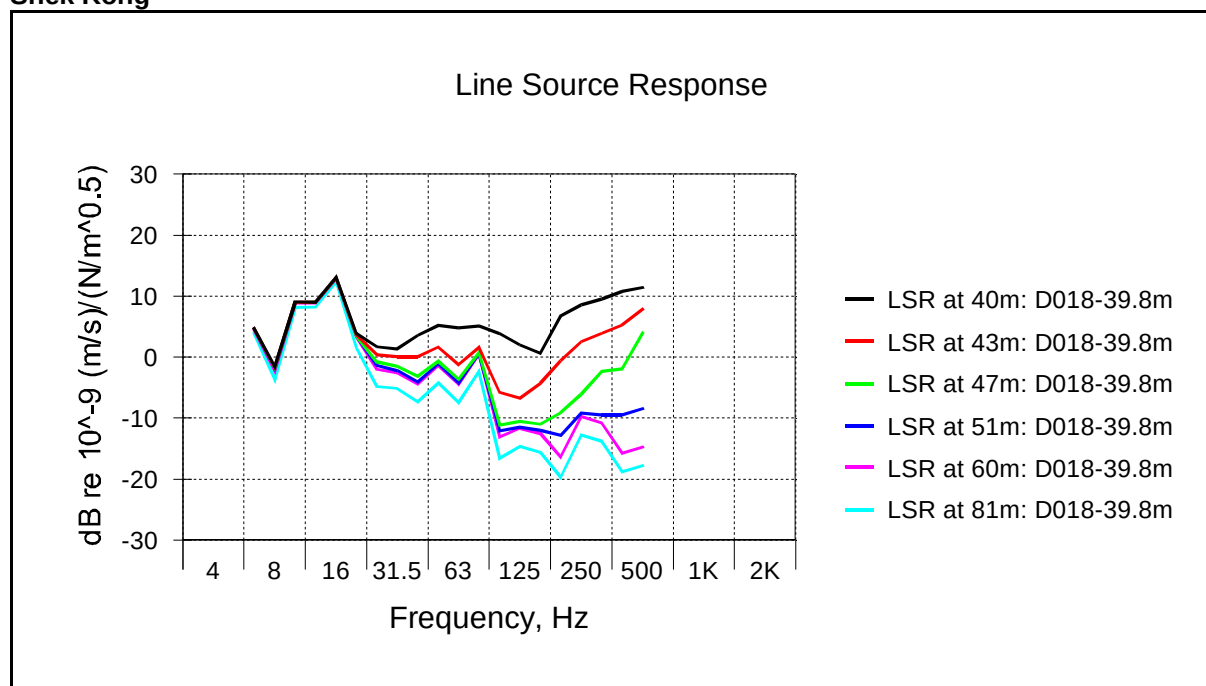
APPENDIX D

Determined Line Source Responses

Appendix D Determined Line Source Responses**Kwai Chung****Shek Kong**

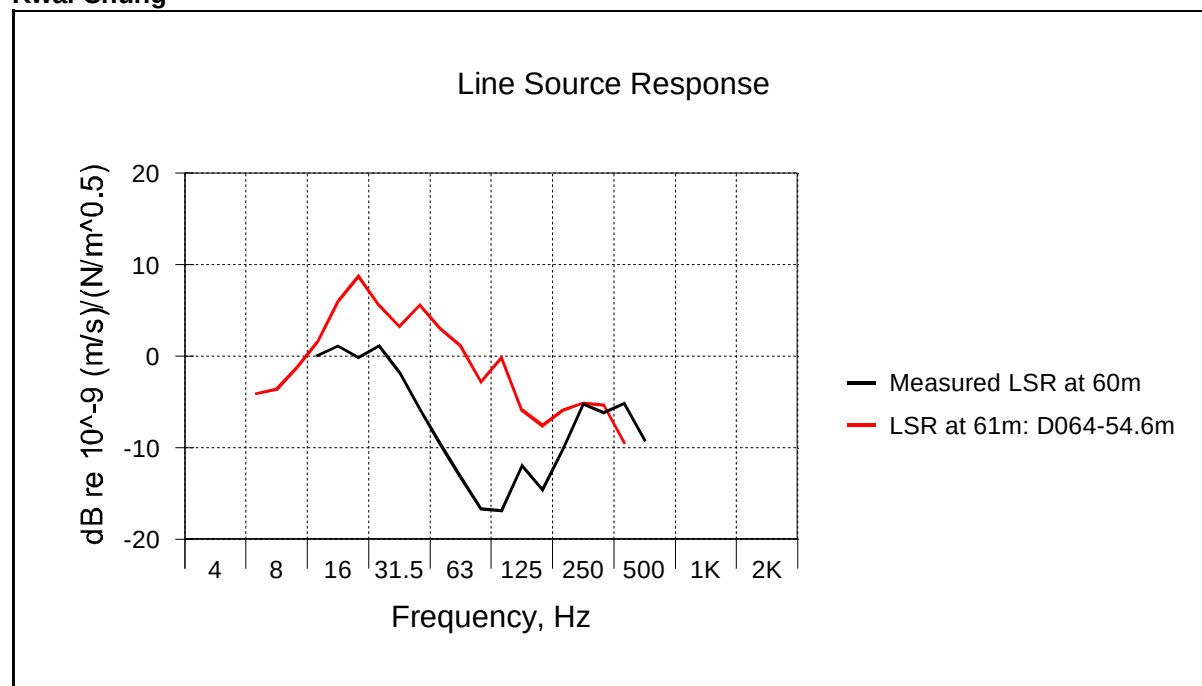
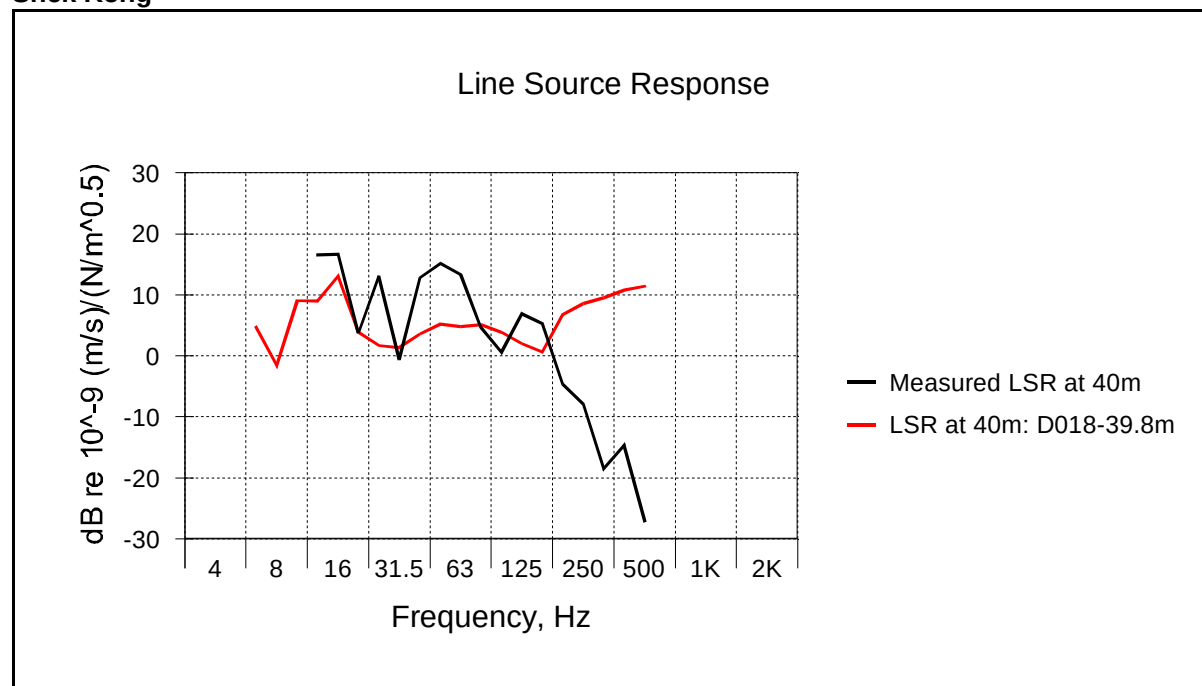
APPENDIX E

XRL EIA Assumed Line Source Responses

Appendix E XRL EIA Assumed Line Source Responses**Kwai Chung****Shek Kong**

APPENDIX F

Comparison of Measured and EIA Line Source Responses

Appendix F Comparison of XRL EIA and Measured Line Source Responses**Kwai Chung****Shek Kong**

APPENDIX G

Calibration Records of Measurement Equipment

Appendix G Calibration Record of Measurement Equipment

CALIBRATION CERTIFICATE

Model: 200M200
Serial #: 4967
Description: Force Sensor
Type: ICP

Date: 8/26/2004
By: James Weselak, Cal. Tech. *W*
Station: 0-100,000 lb Load Cell (Test Procedure AT501-2)

Sensitivity*: 0.2555 mV/LBF
 0.0574 mV/V

Temp: 71 deg F [22deg C]
Humidity: 62 %

Linearity*: 0.8% FS
Uncertainty:** +/- 1 %

Cert #: 177535

Bias: 11.23 VDC
 * Zero based, least-squares straight line.
 ** Measurement uncertainty represented using a coverage factor of k=2 which provides a level of confidence of approximately 95 %.

Condition of Unit:
As Found: Not applicable
As Left: In tolerance, new unit

INPUT - LBF

(N)

89000

14.8F = 4.45N

TEST DATA

INPUT (LBF)	OUTPUT (mV)
4000	980
8000	2020
12000	3058
16000	4095
20000	5127

Notes:

- 1 Calibration is traceable to NIST and is accredited to ISO 17025 and ANSI/NCCL Z540-1-1994.
- 2 NIST traceability through PCB control # KE051.
- 3 This certificate may not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.

PCB PIEZOTRONICS™

Tel: 716-684-0001 Fax: 716-684-0987 Email: sales@pcb.com
 3425 Walden Avenue, Depew NY 14043

ISO 9001 CERTIFIED

Page 1 of 1

Cert. No. 1882.01

~ Calibration Certificate ~
Per ISO 15063-21

Model Number: 353B33

Serial Number: 141499

Description: ICP® Accelerometer Method: Back-to-Back Comparison (AT401-3)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz **100.7 mV/g** Output Bias **10.0 VDC**
(10.27 mV/m/s²) Transverse Sensitivity **0.6 %**

Discharge Time Constant **0.6 seconds** Resonant Frequency **25.9 kHz**

Sensitivity Plot

Temperature: 70 °F (21 °C) Relative Humidity: 43 %

Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	-0.2	300.0	0.0
15.0	0.0	500.0	0.0
30.0	-0.0	1000.0	0.2
50.0	0.0	3000.0	1.7
REF. FREQ.	0.0	4000.0	2.9

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Steel Mount
 Acceleration Level (ms⁻²): 10.0 g (98.1 ms⁻²)
 *The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude: Acceleration Level (g) = 0.009 s (10ms)².
 *The gravitational constant used for calculations by the calibration system is: 1 g = 9.80665 ms⁻².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 822/277342 and PTB Traceable thru Project 1254.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Tim Greene Date: 05/07/10

PCB PIEZOTRONICS
VIBRATION DIVISION
Headquarters: 3425 Walden Avenue, Depew, NY 14043
Calibration Performed at: 10869 Highway 903, Halifax, NC 27839
TEL: 888-684-0013 FAX: 716-685-3886 www.pcb.com

ACCREDITED
CALIBRATION CERT #1862.02
PAGE 1 of 1

cal48 - 3356051156 78

~ Calibration Certificate ~
Per ISO 18003-21

Model Number: 353B33

Serial Number: 141500

Description: ICP® Accelerometer **Method:** Back-to-Back Comparison (AT401-3)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	99.8 mV/g	Output Bias	9.8 VDC
	(10.18 mV/m/s²)	Transverse Sensitivity	0.4 %
Discharge Time Constant	0.6 seconds	Resonant Frequency	25.8 kHz

Sensitivity Plot

Temperature: 70 °F (21 °C) Relative Humidity: 43 %

Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	0.1	300.0	0.1
15.0	0.0	500.0	0.1
30.0	-0.0	1000.0	0.2
50.0	0.1	3000.0	1.8
REF. FREQ.	0.0	4000.0	2.9

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Steel Hexnut Fixture Orientation: Vertical
Acceleration Level (msl): 10.0 g (98.1 m/s²)
*The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be achieved, the calibration system uses the following formula to set the vibration amplitude: Acceleration Level (g) = 0.0125 (50g)².
*The gravitational constant used for calculations by the calibration system is: 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

- Calibration is NIST Traceable thru Project 822/277342 and PTB Traceable thru Project 1254.
- This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
- Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
- See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
- Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Tim Greene **Date:** 05/07/10

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CALIBRATION CERT 81862.02
PAGE 1 of 1

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 353B33

Serial Number: 141502

Description: ICP® Accelerometer

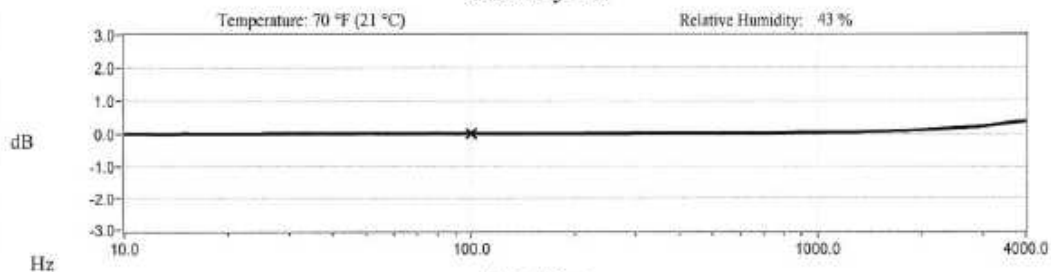
Method: Back-to-Back Comparison (AT401-3)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	99.0 mV/g	Output Bias	9.9 VDC
	(10.09 mV/m/s ²)	Transverse Sensitivity	1.0 %
Discharge Time Constant	0.6 seconds	Resonant Frequency	25.7 kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	-0.2	300.0	0.0
15.0	-0.1	500.0	0.1
30.0	-0.1	1000.0	0.4
50.0	0.0	3000.0	2.6
REF. FREQ.	0.0	4000.0	4.4

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Steel Nipple
Acceleration Level (max): 0.5 g (281 m/s²)

Fishnet Orientation: Vertical

Acceleration Level (ms)[†]: 01.0 g (38.1 rad/s²)

The acceleration level may be limited by shaker displacement at low frequencies. If the Rated level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude: Acceleration Level (g) = $0.010 \times (\text{Hz})^1$. The gravitational constant used for calculations by the calibration system is: $1 g = 9.80665 \text{ m/s}^2$.

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 822/277342 and PTB Traceable thru Project 1254.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz: +/- 2.0%, 10-99 Hz: +/- 1.5%, 100-1999 Hz: +/- 1.0%, 2-10 kHz: +/- 2.5%.

Technician:

Tim Greene

Date: 05/07/10



CALIBRATION CERT #1862.02

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APPENDIX H

Latest Geological Profiles at Measurement Locations

