

HOCHTIEF Solutions American Bridge International DRAGADOS Morrison Construction

Project

Contractor

FORTH REPLACEMENT CROSSING

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VIBRATION MONITORING REPORT FEBRUARY 2012 TO APRIL 2012

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INTRODUCTION

- **1.1.** In accordance with the Code of Construction Practice (CoCP) and Noise and Vibration Management Plan, FCBC have risk assessed all construction activities through the PCNV process.
- **1.2.** During the preparation of the PCNVs, assessment/prediction of vibration levels showed that no plant or equipment used, or construction activity carried out was envisaged to induce any level of vibration at receptors that would exceed threshold levels of vibration in the CoCP. This assessment/prediction was confirmed by means of permanent vibration monitoring.



2. MONITORING SUMMARY

- **2.1.** Due to the location and sensitivity of vibration monitoring equipment, the exceedances presented in the graphs included in the appendices of this report do not represent levels generated by construction, but rather show local interference around the monitoring equipment. This can include doors being slammed or movement close to the location of the Vibrock causing elevated vibration levels.
- **2.2.** According to the BS5228-2 (2009) there is hardly any documented proof of actual damage to structures or their finishes, and damage resulting solely from well-controlled construction and demolition vibrations is rare. There are many other mechanisms which cause damage, especially in decorative finishes, and it is often incorrectly concluded that vibrations from construction and demolition sites are to blame. It is not possible to ascertain the exact cause of vibration, though it is possible to rule out construction as a cause on an activity basis.
- **2.3.** The works carried out in each construction area as well as vibration assessments of the works are summarised in Appendix A.
- **2.4.** Due to the distance between the works and the receptors and the methods of working the risk of damage to structures or nuisance to the residents due to vibration is highly unlikely.
- **2.5.** The number of exceedances during construction are shown in Table 1 below.



Table 1- Exceedances of thresholds set out in the COCP

February

	PPV Exc	eedance	VDV Exceedance	
Location	Continuous (5 mm.s ⁻¹)	Intermittent (10 mm.s ⁻¹)	Day (0.4 m.s ^{-1.75})	Night (0.2 m.s ^{-1.75})
Clufflat Brae	1	8	0	0
5 Linn Mill	3	6	1	2
Barracks East	0	0	0	0
Barracks West	0	0	0	0
Butlaw Fisheries	1	0	0	0
Dundas Home Farm	1	0	1	2
Echline	0	1	0	0
Inchgarvie Lodge	0	0	0	0
Springfield	0	1	4	26
Tigh ni Grian	2	2	0	0
Whinnyhill	1	10	0	0

March

	PPV Exc	eedance	VDV Exceedance	
Location	Continuous (5 mm.s ⁻¹)	Intermittent (10 mm.s ⁻¹)	Day (0.4 m.s ^{-1.75})	Night (0.2 m.s ^{-1.75})
Clufflat Brae	4	22	0	0
5 Linn Mill	4	9	3	20
Butlaw Fisheries	0	0	0	0
Dundas Home Farm	0	0	0	1
Echline	0	1	0	0
Inchgarvie Lodge	1	2	1	0
Springfield	2	2	3	28
Tigh ni Grian	4	4	0	0
Newton	0	12	6	13
Scotstoun	0	1	0	0
Whinnyhill	0	12	0	0

April

	PPV Exc	eedance	VDV Exceedance	
Location	Continuous (5 mm.s ⁻¹)	Intermittent (10 mm.s ⁻¹)	Day (0.4 m.s ^{-1.75})	Night (0.2 m.s ^{-1.75})
Clufflat Brae	3	19	0	15
5 Linn Mill	2	7	0	0
Barracks West	0	0	0	0
Butlaw Fisheries	0	0	0	0
Dundas Home Farm	1	0	0	1
Echline	0	1	0	0
Inchgarvie Lodge	1	1	0	0
Springfield	0	0	0	0
Tigh ni Grian	8	5	0	0
Newton	0	21	12	19
Scotstoun	1	1	1	0
Whinnyhill	5	12	0	0

Forth Crossing Bridge Constructors - A Joint Venture of Hochtief Solutions AG, American Bridge International, Dragados, S.A. and Galliford Try Infrastructure Limited (Trading as Morrison Construction)



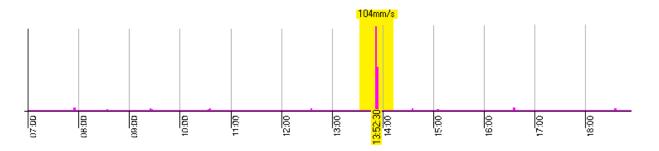
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- 2.6. Peak Particle Velocity (PPV) is used to measure vibration through a solid surface. When a vibration is measured, the point at which the measurement takes place can be considered to have a particle velocity. This particle vibration will take place in three dimensions (x, y and z).
- **2.7.** The Peak Particle Velocity is the highest velocity that is recorded during a particular event, and as such is appropriate for the measurement of activities such as blasting and piling. The thresholds for the Forth Replacement Crossing are 5 mm.s⁻¹ for continuous construction (e.g. piling) and 10 mm.s⁻¹ for intermittent construction (i.e. blasting).
- **2.8.** These thresholds are set to protect against building damage. For this monitoring period, all the exceedances have been investigated thoroughly and seem to be generated due to standalone, instantaneous events most probably as a result of unknown local interferences. There was no construction activity within 300m of the receptors which could cause such exceedances.
- **2.9.** Vibration Dose Value (VDV) is a metric used in vibration monitoring. It is calculated by taking the fourth root of the integral of the fourth power of acceleration after it has been frequency-weighted. The frequency-weighted acceleration is measured in m.s⁻² and the time period over which the VDV is measured is in seconds. This yields VDVs in m.s^{-1.75}
- 2.10. During the monitoring period, vibratory rollers were used intermittently at several locations around the site in the construction of haul roads. Due to the distances of the rollers away from any receptors none of the exceedances in VDV levels can be associated with the use of vibratory rollers.
- 2.11. In addition, detailed investigation of all exceedances (i.e. review of PPV levels over 30 seconds periods) has shown that each resulted from isolated, non-construction related events, which occurred adjacent to the transducer. Below is an example of one of such investigation, an exceedance of 104



mm.s⁻¹, which occurred on 23/11/11. As can be seen, this was an isolated event which appears to be due to sources other than construction activities.

	Calibrate by: SEP 12						
Ev 011				-			
Cont	Max	Time	Date				
Event	104mm/s	13:52:30	23/11/11				
Hour 1	.725mm/s	07:54:10	23/11/11]			
Hour 2	.275mm/s	08:34:10	23/11/11				
Hour 3	.400mm/s	09:25:10	23/11/11				
Hour 4	.425mm/s	10:34:50	23/11/11				
Hour 5	.175mm/s	11:00:10	23/11/11				
Hour 6	.600mm/s	12:35:00	23/11/11				
Hour 7	104mm/s	13:52:30	23/11/11				
Hour 8	.475mm/s	14:35:10	23/11/11				
Hour 9	.325mm/s	15:05:30	23/11/11	-			
•			► I				



- **2.12.** Within the Appendix B, there are short gaps of missing data in the PPV and VDV graphs. These occurred as a result of:
 - The occasional relocation of Vibrocks for rock blasts; or
 - Short power cuts, causing the Vibrock to power down until manually reset; or
 - Vibrocks being sent back to the supplier for emergency maintenance, as data could not be retrieved.



3. Conclusion

- **3.1.** Considering the distance between construction works and the above receptors, and the methods of working utilised, the risk of damage to structures or nuisance to residents resulting from vibration is highly unlikely.
- **3.2.** Due to the location and sensitivity of vibration monitoring equipment, the exceedances presented in the graphs included in the appendices of this report do not represent levels generated by construction, but rather show local interference around the monitoring equipment. This may include, for example, the slamming of doors or other movements nearby the monitoring equipment location, which result in elevated vibration levels.

APPENDIX A – VIBRATION ASSESSMENTS OF RELEVANT PCNVs



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0002	Feb 12 to Apr 12	Marine- based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	 Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0011	Feb 12 to Apr 12	Main Crossing- Bridge Works Area	 S7 Foundation – Construction of S7 foundation S8 Foundation – Construction of S8 foundation N2 Foundation – Construction of N2 foundation including drilling shot holes for blasting. Construction of Working Platform at S6 as well as Construction of S6 foundation. 	 PPV: Nearest property to the works is Inchgarvie House which is an average 64m from foundation S8. All other works are or average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibratior assessment has been carried out.
PCNV0019	Feb 12 to Apr 12	Beamer Rock blast & excavation	 Blasting works Excavation and disposal of loosened rock 	Butlaw Fisheries - 0.2mm.s ⁻¹ Tigh-na-Grian - 0.4mm.s ⁻¹ Port Edgar Barracks - 0.2mm.s ⁻¹ Forth Rd Bridge North Tower - 0.8mm.s ⁻¹



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0002	Feb 12 to Apr 12	Marine- based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	 Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0011	Feb 12 to Apr 12	Main Crossing- Bridge Works Area	 S7 Foundation – Construction of S7 foundation S8 Foundation – Construction of S8 foundation N2 Foundation – Construction of N2 foundation including drilling shot holes for blasting. Construction of Working Platform at S6 as well as Construction of S6 foundation. 	 PPV: Nearest property to the works is Inchgarvie House which is an average 64m from foundation S8. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0019	Feb 12 to Apr 12	Beamer Rock blast & excavation	 Blasting works Excavation and disposal of loosened rock 	Butlaw Fisheries - 0.2mm.s ⁻¹ Tigh-na-Grian - 0.4mm.s ⁻¹ Port Edgar Barracks - 0.2mm.s ⁻¹ Forth Rd Bridge North Tower - 0.8mm.s ⁻¹



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0002	Feb 12 to Apr 12	Marine- based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	 Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.



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PCNV0011	Feb 12 to Apr 12	Main Crossing- Bridge Works Area	 S7 Foundation – Construction of S7 foundation S8 Foundation – Construction of S8 foundation N2 Foundation – Construction of N2 foundation including drilling shot holes for blasting. Construction of Working Platform at S6 as well as Construction of S6 foundation. 	 PPV: Nearest property to the works is Inchgarvie House which is an average 64m from foundation S8. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the hard-standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is on average 64m from foundation S8. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.



Barracks East				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0011	Feb 12 to Apr 12	Main Crossing- Bridge Works	 1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation 2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation 3. N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting. 	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard- standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0019	Feb 12 to Apr 12	Beamer Rock blast & excavation	 Blasting works Excavation and disposal of loosened rock 	Butlaw Fisheries - 0.2mm.s ⁻¹ Tigh-na-Grian - 0.4mm.s ⁻¹ Port Edgar Barracks - 0.2mm.s ⁻¹ Forth Rd Bridge North Tower - 0.8mm.s ⁻¹



Inchgarvie Ho	Inchgarvie House					
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment		
PCNV0002	Feb 12 to Apr 12	Marine- based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data exists for 182m but the vibration levels based on the historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum duration to reduce any exposure.		
PCNV0011	Feb 12 to Apr 12	Main Crossing- Bridge Works	 S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting. 	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard- standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.		



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
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PCNV0021	Feb 12 to Apr 12	Earthworks	 Earthworks – cut and fill operations including excavation and deposition of rock Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway Road work operations Utility diversions – electric, water, sewerage, gas, BT Site Clearance 	 PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibrator roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used i all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property ha been assessed as it will be the most likely to have an effect



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
				on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

Linn Mill				
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Linn Mill Relevant PCNV	Relevant		[
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Linn Mill					
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PCNV0021	Feb 12 to Apr 12	Earthworks	 Earthworks – cut and fill operations including excavation and deposition of rock Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway Road work operations Utility diversions – electric, water, sewerage, gas, BT Site Clearance 	 PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment. 	



Clufflat Brae				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0011	Feb 12 to Apr 12	Main Crossing- Bridge Works	 1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation 2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation 3. N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting. 	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard- standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0021	Feb 12 to Apr 12	Earthworks	 Earthworks – cut and fill operations including excavation and deposition of rock Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway Road work operations 	PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest



Clufflat Brae				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
			4. Utility diversions – electric, water, sewerage, gas, BT 5. Site Clearance	 levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement. Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.



Springfield				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0011	Jan 12	Main Crossing- Bridge Works	 1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation 2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation 3. N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting. 	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard- standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0021	Feb 12 to Apr 12	Earthworks	 Earthworks – cut and fill operations including excavation and deposition of rock Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway Road work operations Utility diversions – electric, water, sewerage, gas, BT Site Clearance 	PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibrator roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used i all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect



Springfield				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
				on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.

Echline				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0011	Jan 12	Main Crossing- Bridge Works	1.S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation2. S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation3. N2 Foundation – Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting.	Nearest property to the works is Inchgarvie House which is 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are likely to be generated by the vibratory roller during the hard- standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0021	Feb 12 to Apr 12	Earthworks	1. Earthworks – cut and fill operations including excavation and deposition of rock	PPV: Nearest property to the works is Inchgarvie House which is



Echline				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
			 Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway Road work operations Utility diversions – electric, water, sewerage, gas, BT Site Clearance 	an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used ir all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
				VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.



Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0021	Feb 12 to Apr 12	Earthworks	 Earthworks – cut and fill operations including excavation and deposition of rock Drainage – pre earthworks, temporary, outfall, attenuation, chambers, headwalls, culverts, carriageway Road work operations Utility diversions – electric, water, sewerage, gas, BT Site Clearance 	 PPV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. All other works are on average over 100m from the works. A predicted vibration level assessment is presented in Appendix 6. The highest levels of vibration are likely to be generated by the vibratory roller during the compaction of sub-base and various road layers. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used ir all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken. VDV: Nearest property to the works is Inchgarvie House which is an average 83m from work area. Therefor this property has been assessed as it will be the most likely to have an effect on the human response to vibration. An estimated VDV assessment is presented in Appendix 6. The estimated VDV are calculated using the calculation methodology provided in DMRB Stage 3 Environmental Statement Chapter 19 Section 19.6.21. Assessment Criteria as defined in British Standard 6472:2008 and Tables 19.11 and 19.12 of DMRB Stage 3 Environmental Statement. This method will over-estimate VDV and therefore represents a conservative approach. Once works start these levels will be closely monitored and actual VDV levels will be taken from monitoring equipment.



Figh-ni Grian Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
PCNV0002	Feb 12 to Apr 12	Marine- based Geotechnical	Marine drilling of exploratory boreholes and recovery of soil and geological samples	Significant levels of vibration are not anticipated. A risk assessment has gauged the risk of vibration impacts to be negligible based on the available historic evidence (presented below) that the vibration levels are expected to be very low. Only the cable percussive methods are likely to generate any perceptible vibration. The closest property to this investigation technique is Tigh-na-Grian which is approximately 182m away. Historic data from BS5228: Part 2 Table D1 Refs 1, 2, 3 & 4 indicate that the PPV vibration levels reduce to less than 1.8 mm/s at 6m from the activity of driving a casing into a variety of materials. No historic data exists for 182m but th vibration levels based on the historic data out to 6m show that vibration levels are likely to be very low at 182m and therefore the impact is negligible. Additional attended vibration monitoring will be undertaken should complaints arise and the works managed to a practical minimum
PCNV0010	Jan 12 to Jun 12	North 1 Works	Drilling Shot Holes; Removal of Blasted Rock; Structure; Filling; Removal of Blasted Rock; Soil Mixing; Piled Embankment; Sewer Diversions; Working Platform; Ground Improvement.	duration to reduce any exposure. The equipment to be used in these activities do not generate appreciable levels of vibration, also the distances to the closest occupied receptors are over 300m so therefore no assessment has been undertaken.
PCNV0011	Jan 12	Main Crossing- Bridge Works	 S7 Foundation –Construction of Working Platform at S7 as well as Construction of S7 foundation S8 Foundation –Construction of Working Platform at S8 as well as Construction of S8 foundation 	Nearest property to the works is Inchgarvie House which 39m from foundation S8. All other works are in excess of 50m for the works. The highest levels of vibration are like to be generated by the vibratory roller during the hard-

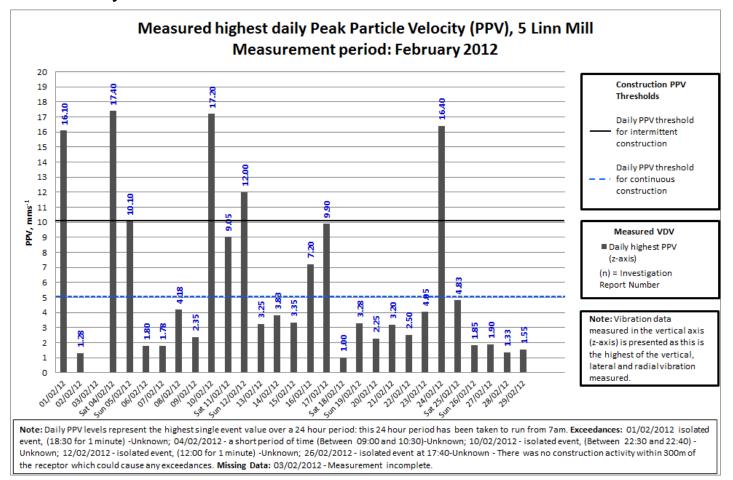


Tigh-ni Grian				
Relevant PCNV No.	Relevant Date	PCNV Name	Particulars of works to be carried out	Vibration Assessment
			3. N2 Foundation –Construction of Working Platform to N2 as well as Construction of N2 foundation including drilling shot holes for blasting.	standing preparation. Hydraulic rock breakers which would typically generate 4.5 mm/s @ 5m, 0.4 @ 20m, 0.1 @ 50m will not generated appreciable levels of vibration levels due to the distance from the closest receptor. Equipment to be used in all other activities do not generate appreciable levels of vibration and therefore no assessment has been undertaken.
PCNV0014	Feb 12 to Apr 12	Dredging Works	To enable the foundation of each bridge pier to be constructed the estuary bed will need to be dredged. It is anticipated that circa 122,000 cu m will need to be removed for the southern tower and piers S1 to S6 and 50,000 cu m from the northern tower and pier N1. The dredging will be completed by the following plant: • Spud dredger for works within the access channel. • Cable crawler excavator to remove soil from within the caissons.	Given the nature of the marine works there are no predicted vibration impacts from the proposed techniques for excavation of loosened material. Therefore no vibration assessment has been carried out.
PCNV0019	Feb 12 to Apr 12	Beamer Rock blast & excavation	 Blasting works Excavation and disposal of loosened rock 	Butlaw Fisheries - 0.2mm.s ⁻¹ Tigh-na-Grian - 0.4mm.s ⁻¹ Port Edgar Barracks - 0.2mm.s ⁻¹ Forth Rd Bridge North Tower - 0.8mm.s ⁻¹



APPENDIX B – VIBRATION GRAPHS

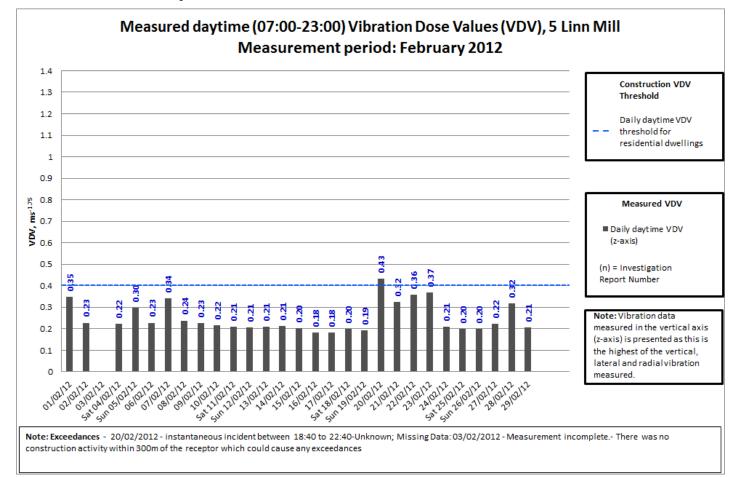




PPV at 5 Linn Mill – February 2012

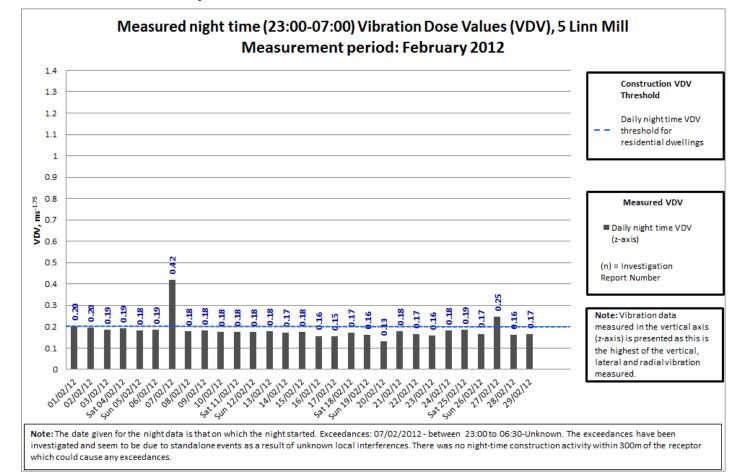
Dragados, S.A. and Galliford Try Infrastructure Limited (Trading as Morrison





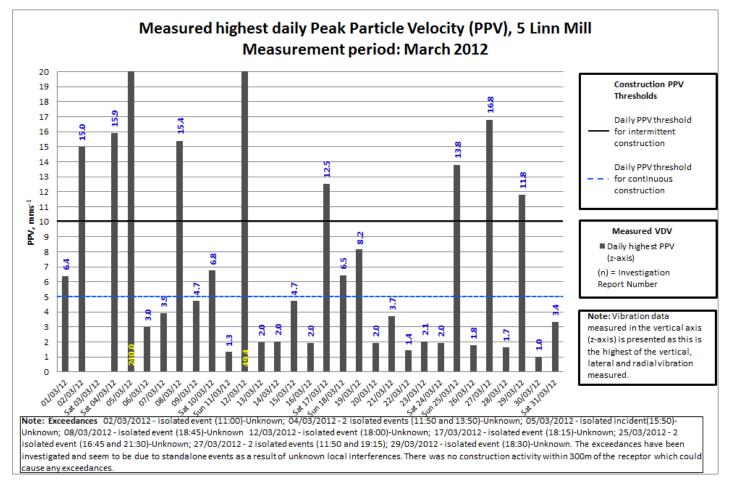
Daytime VDV at 5 Linn Mill – February 2012





Night-time VDV at 5 Linn Mill – February 2012

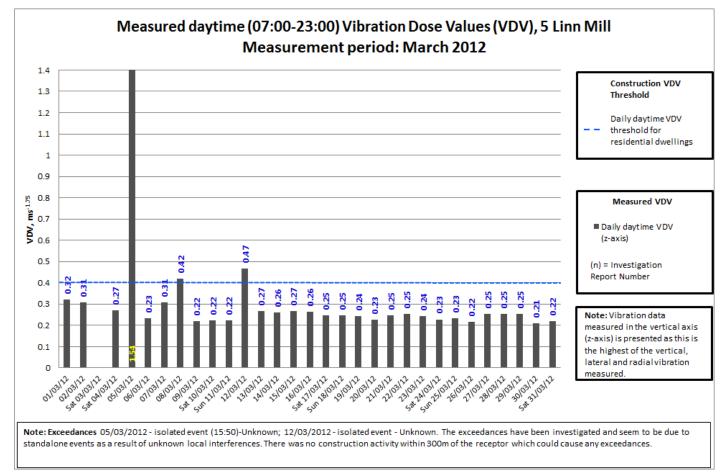




PPV at 5 Linn Mill – March 2012

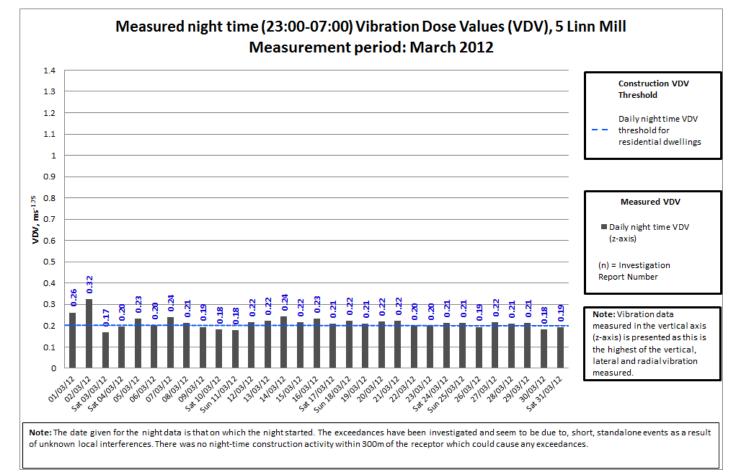
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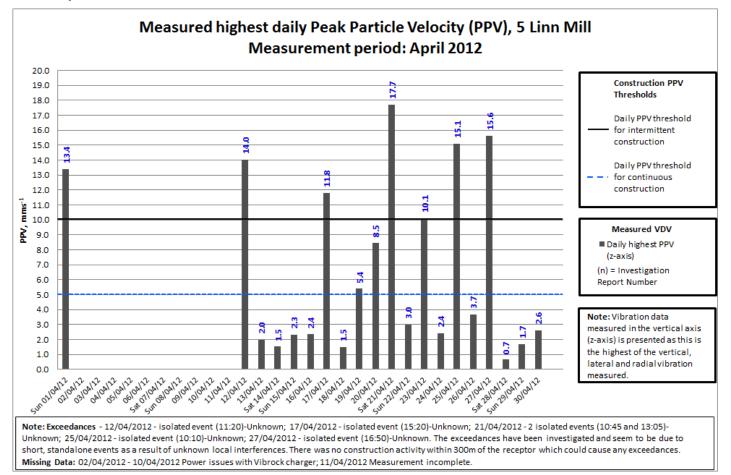
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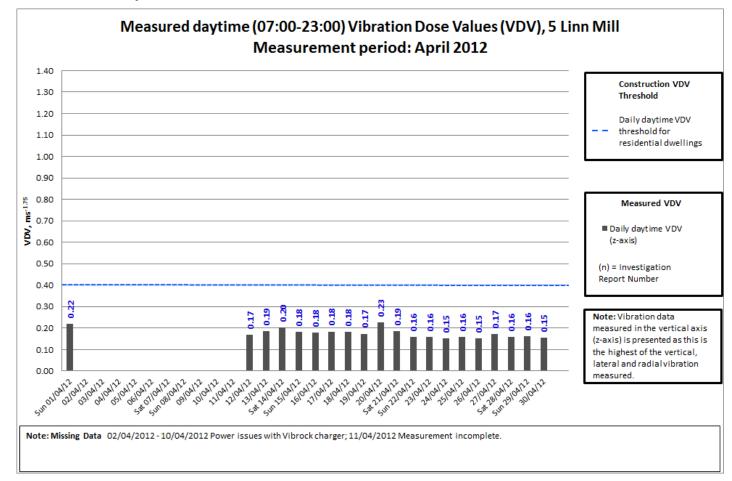
Night-time VDV at 5 Linn Mill – March 2012





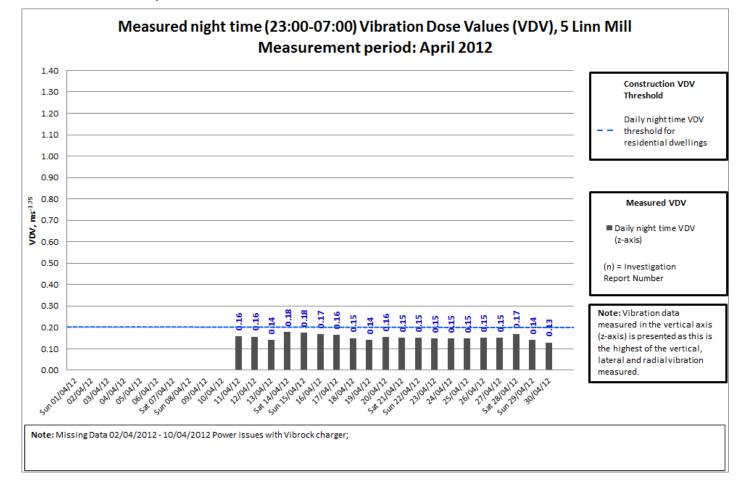
PPV at 5 Linn Mill – April 2012





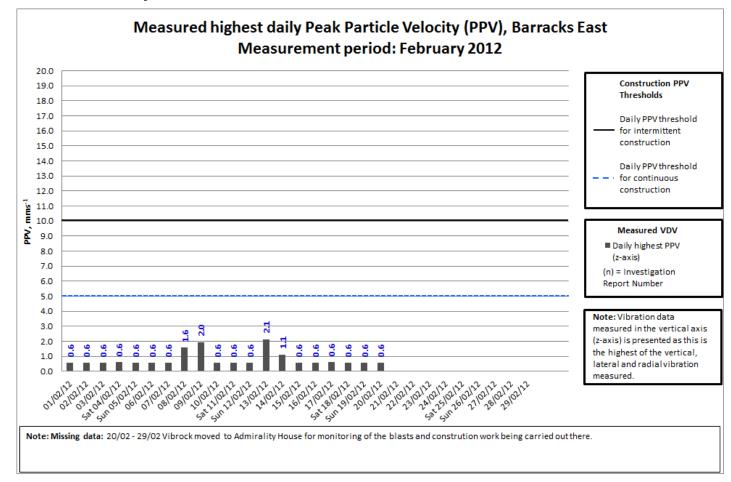
Daytime VDV at 5 Linn Mill – April 2012





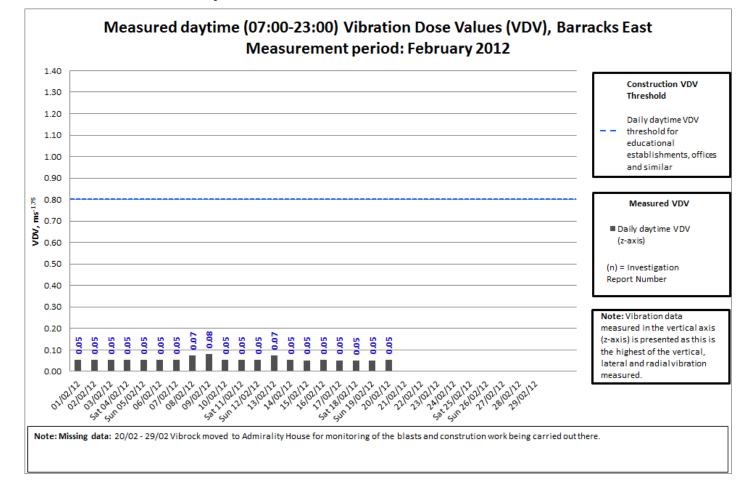
Night-time VDV at 5 Linn Mill – April 2012





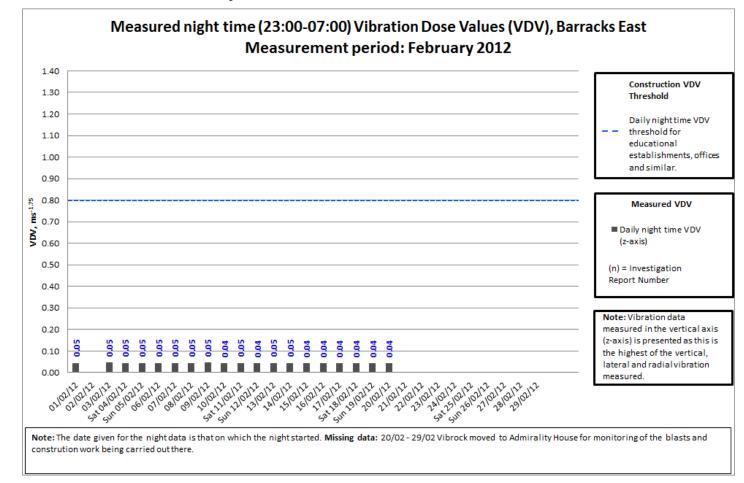
PPV at Barracks East – February 2012





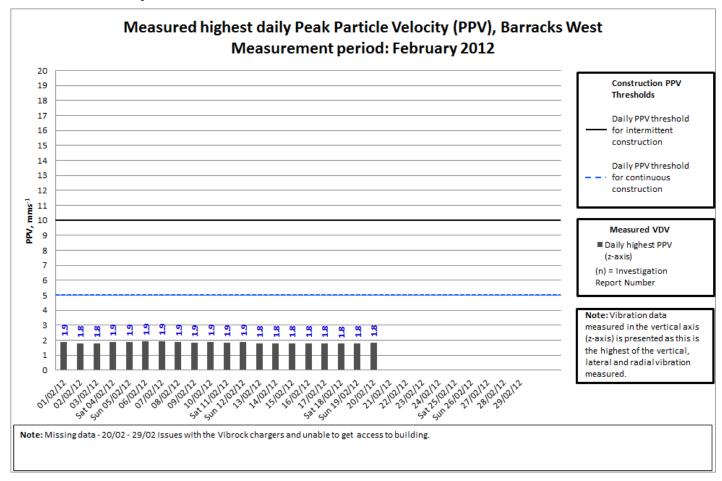
Daytime VDV at Barracks East – February 2012





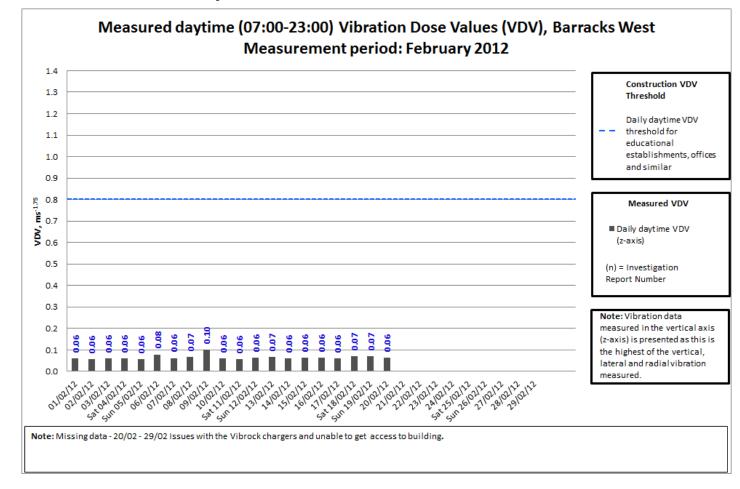
Night-time VDV at Barracks East – February 2012





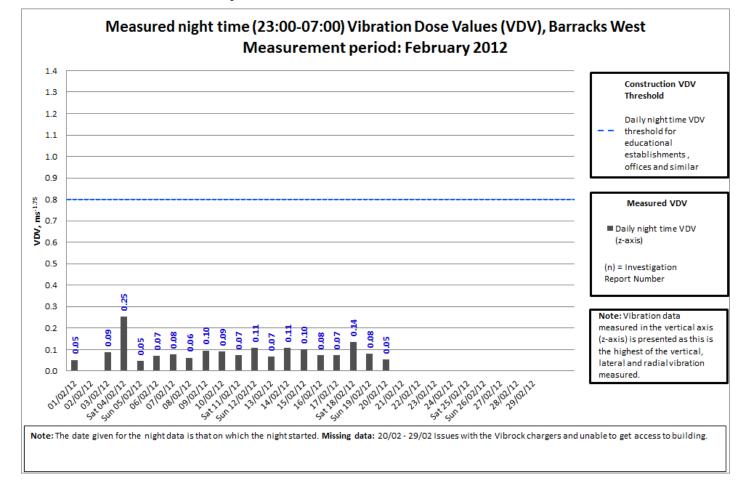
PPV at Barracks West – February 2012





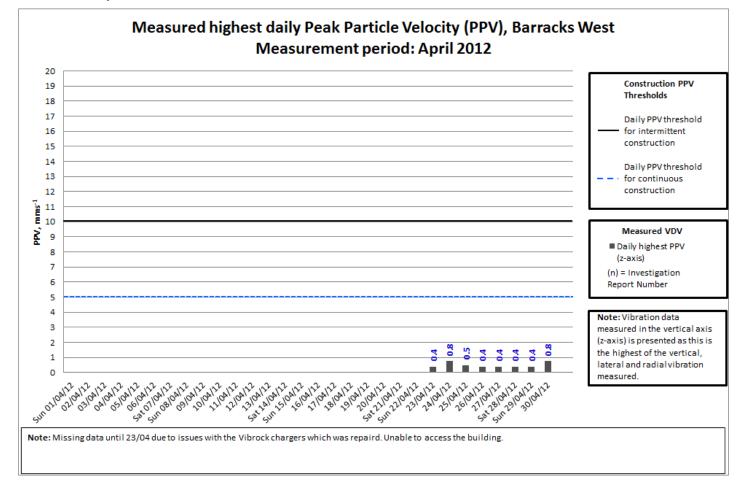
Daytime VDV at Barracks West – February 2012





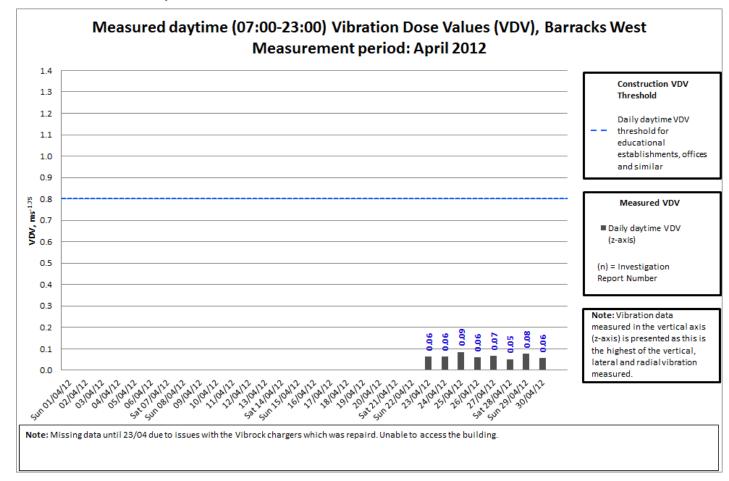
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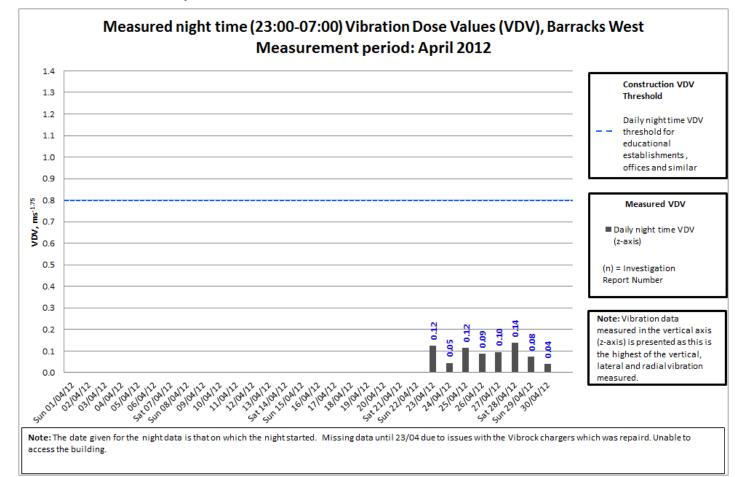
PPV at Barracks West – April 2012





Daytime VDV at Barracks West – April 2012

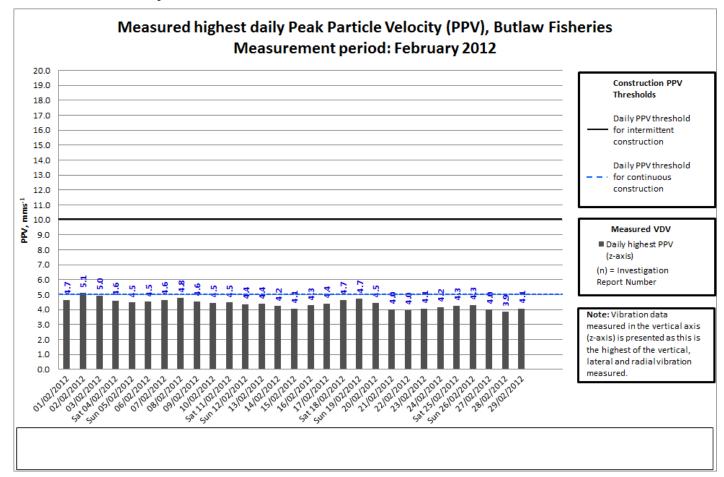




Night-time VDV at Barracks West – April 2012

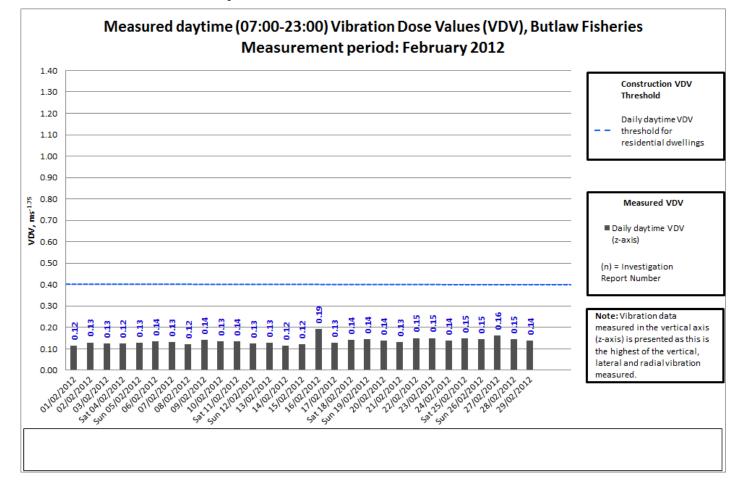
Forth Crossing Bridge Constructors - A Joint Venture of Hochtief Solutions AG, American Bridge International,





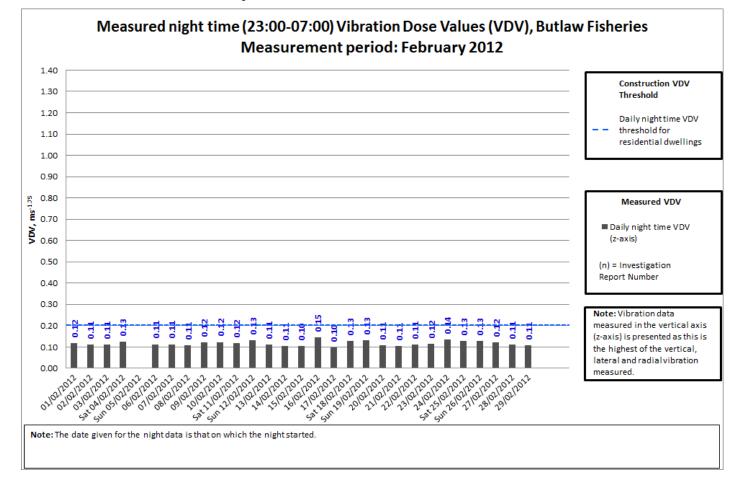
PPV at Butlaw Fisheries – February 2012





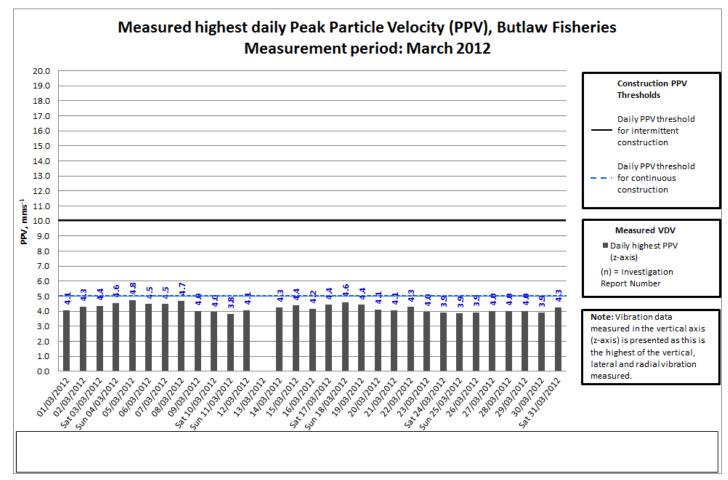
Daytime VDV at Butlaw Fisheries – February 2012





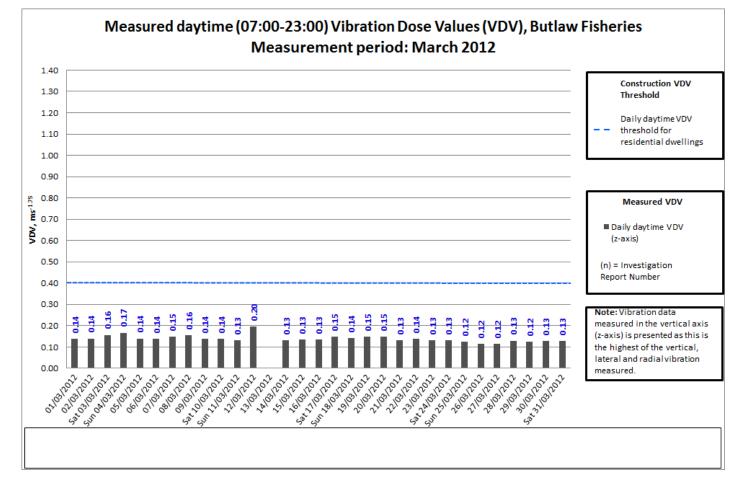
Night-time VDV at Butlaw Fisheries – February 2012





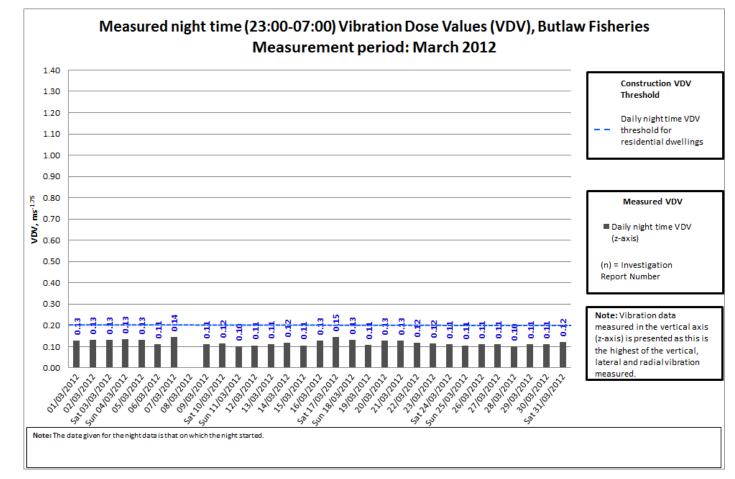
PPV at Butlaw Fisheries – March 2012





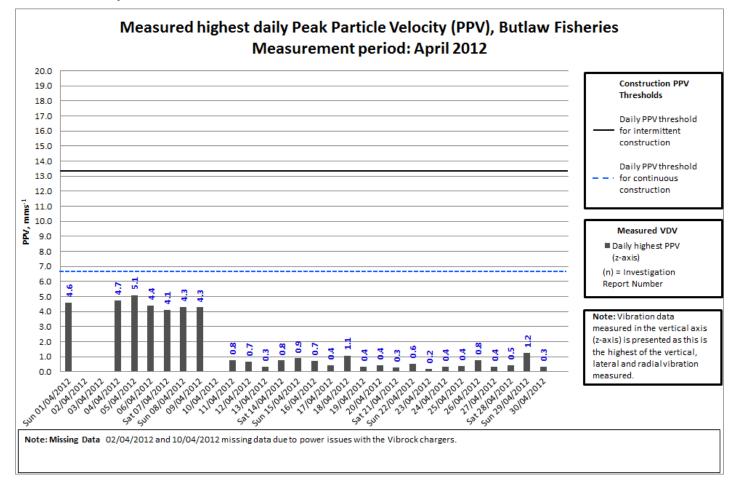
Daytime VDV at Butlaw Fisheries – March 2012





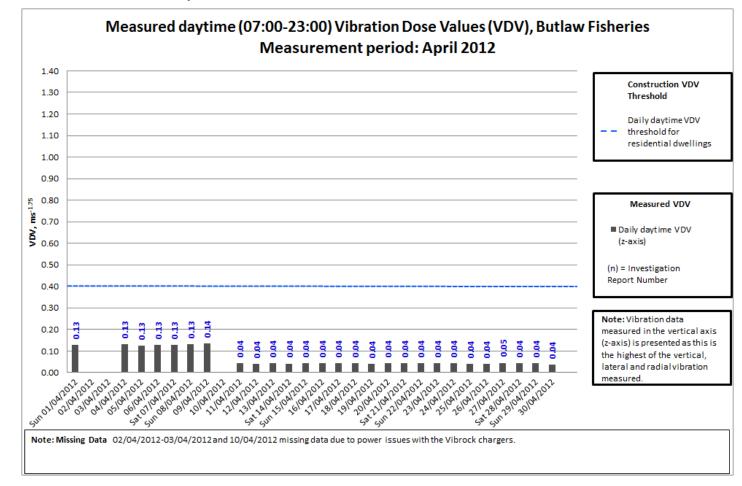
Night-time VDV at Butlaw Fisheries – March 2012





PPV at Butlaw Fisheries – April 2012





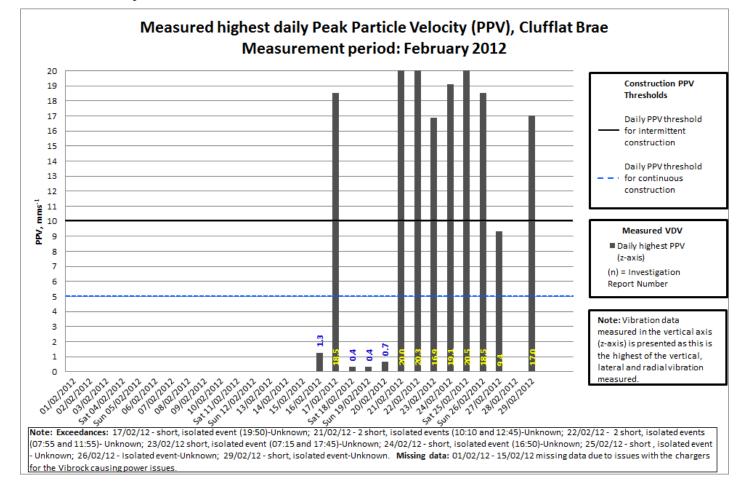
Daytime VDV at Butlaw Fisheries – April 2012



Measured night time (23:00-07:00) Vibration Dose Values (VDV), Butlaw Fisheries Measurement period: April 2012 1.40 Construction VDV 1.30 Threshold 1.20 Daily night time VDV threshold for 1.10 residential dwellings 1.00 0.90 ក្ត 0.80 Measured VDV Ë 0.70 ₹ 0.60 Daily night time VDV (z-axis) 0.50 (n) = Investigation Report Number 0.40 0.30 Note: Vibration data 0.20 measured in the vertical axis . 2 3 0 (z-axis) is presented as this is 0.10 the highest of the vertical, ä 3 ő - o ó ó 09/04/2012/2012 lateral and radial vibration Joint Carlon 2014 0.00 0210412012012012 SUNOLION/2012 04/04/2012 05/04/2012 06/04/2012 54721042022 23/04/2012/2012 30104/2012 measured. 12104/2012 20104/2012 5812110412012 531410412014 Sunspation 53128/04/2014 547291042012 13/04/2011 26/04/2014 25/04/201 27/04/201 Note: The date given for the night data is that on which the night started. Missing Data: 01/04/2012-03/04/2012 and 10/04/2012 missing data due to power issues with the Vibrock chargers.

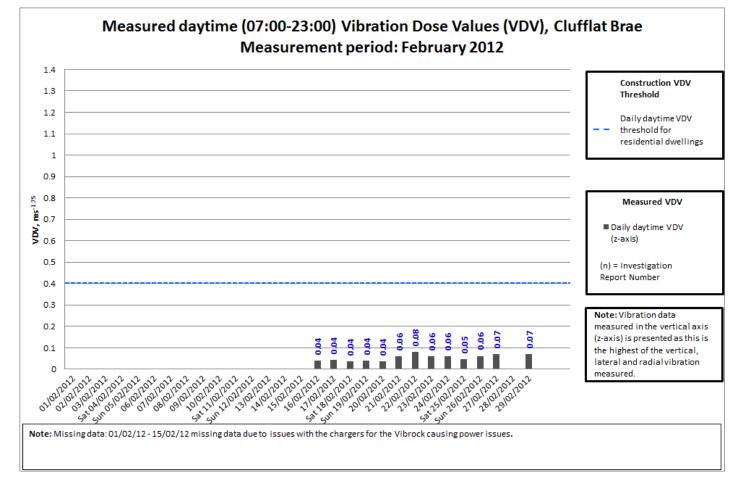
Night-time VDV at Butlaw Fisheries – April 2012





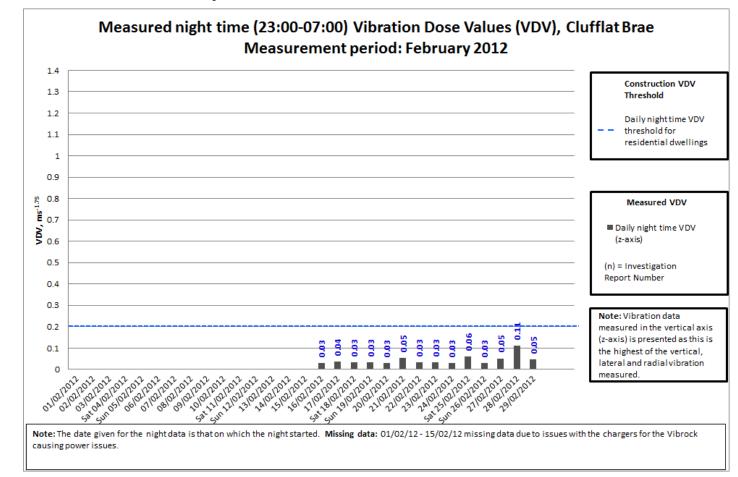
PPV at Cufflat Brae – February 2012





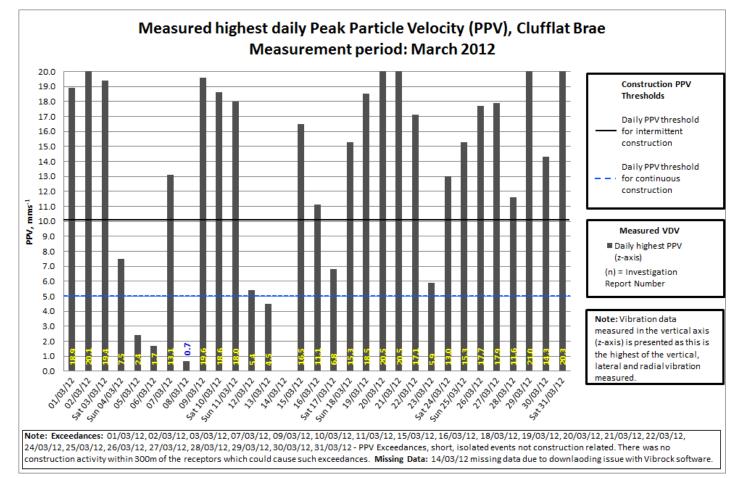
Daytime VDV at Cufflat Brae – February 2012





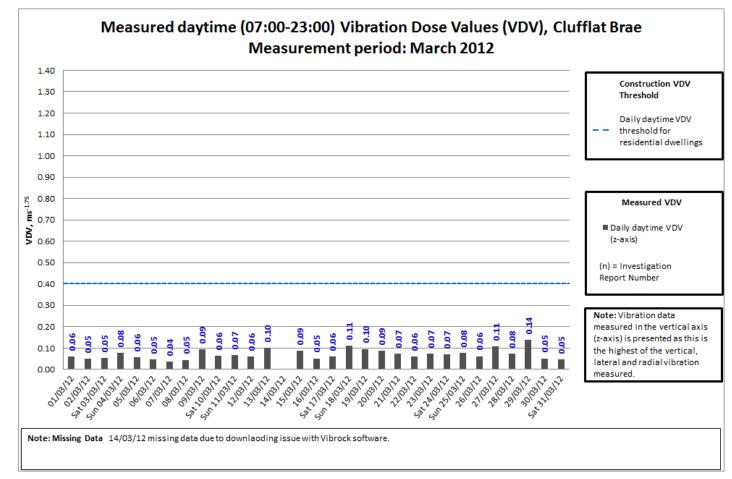
Night-time VDV at Cufflat Brae – February 2012





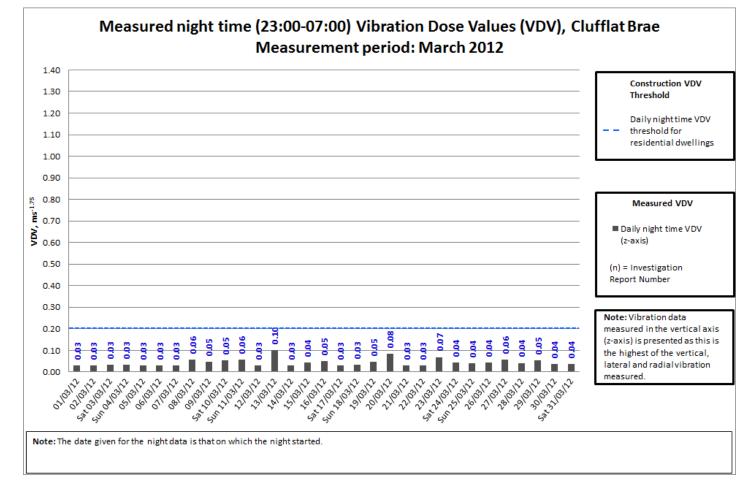
PPV at Cufflat Brae – March 2012





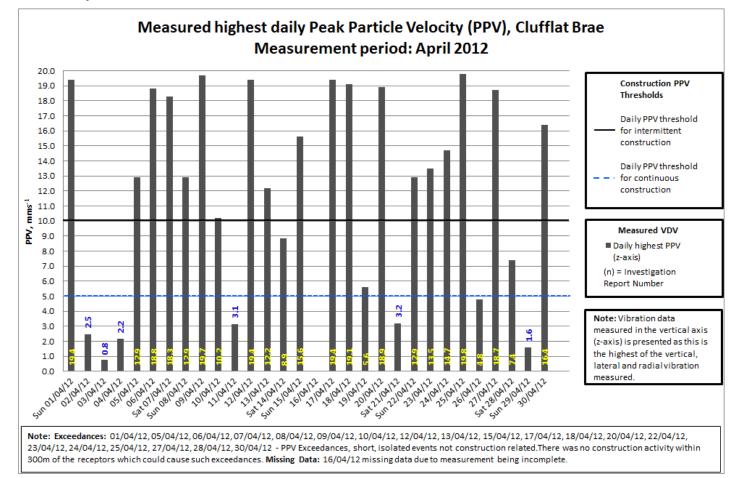
Daytime VDV at Cufflat Brae – March 2012





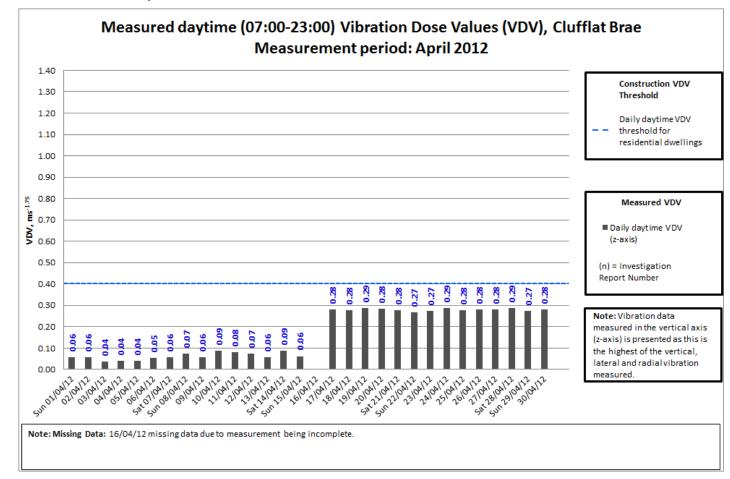
Night-time VDV at Cufflat Brae – March 2012





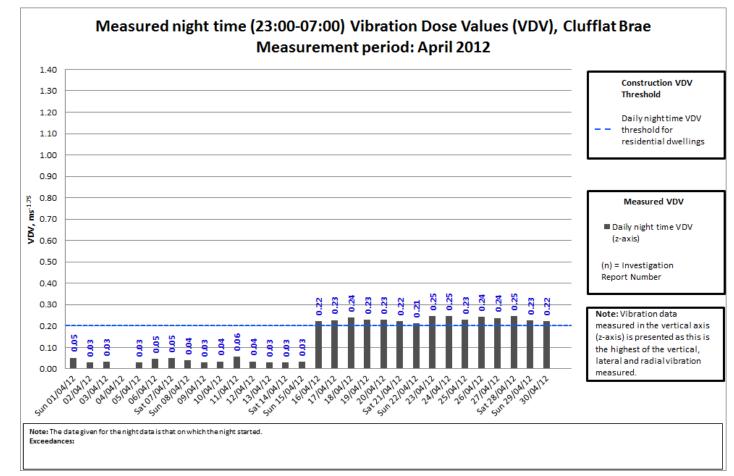
PPV at Cufflat Brae – April 2012





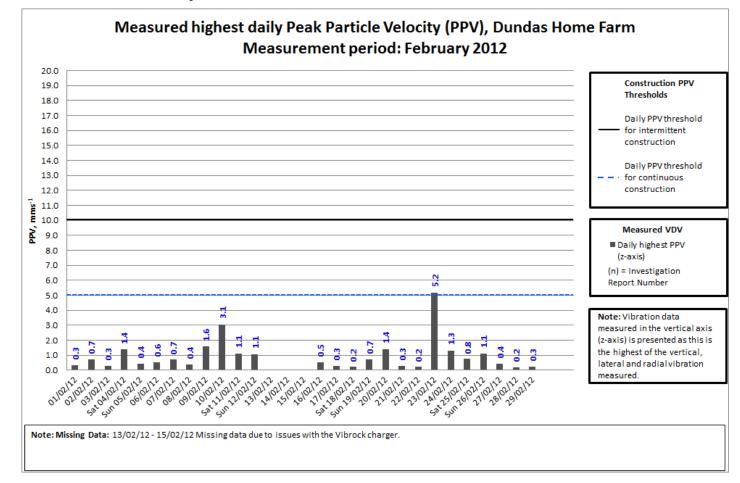
Daytime VDV at Cufflat Brae – April 2012





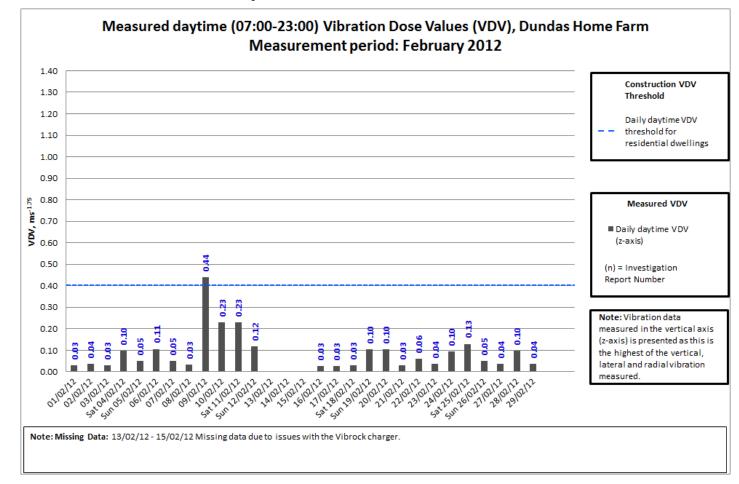
Night-time VDV at Cufflat Brae – April 2012





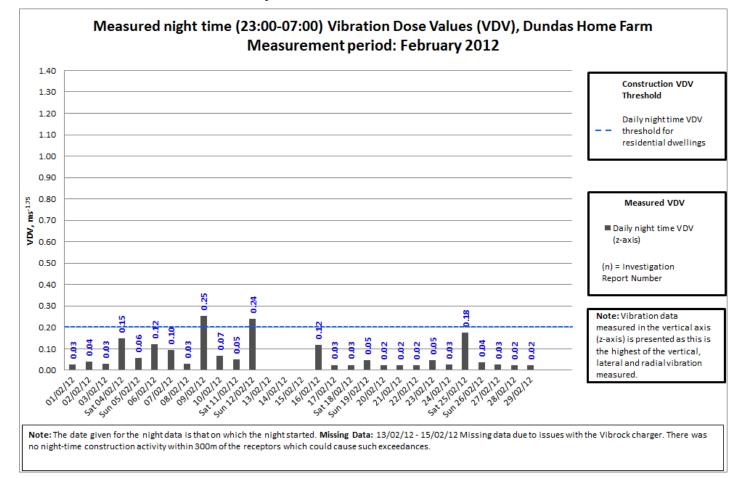
PPV at Dundas Home Farm – February 2012





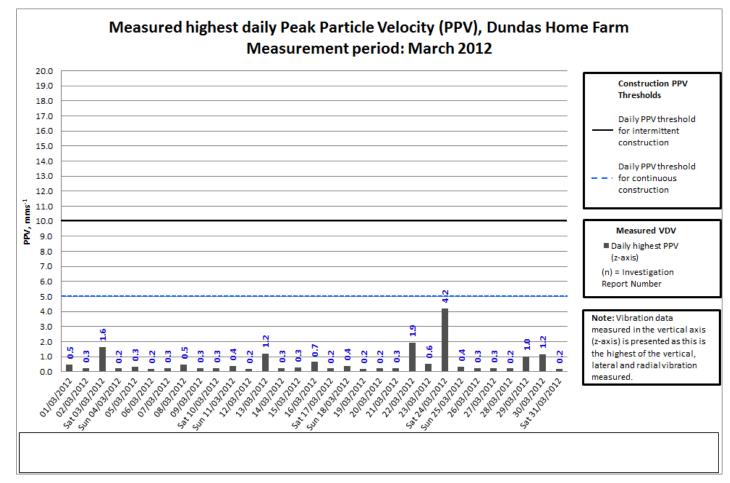
Daytime VDV at Dundas Home Farm – February 2012





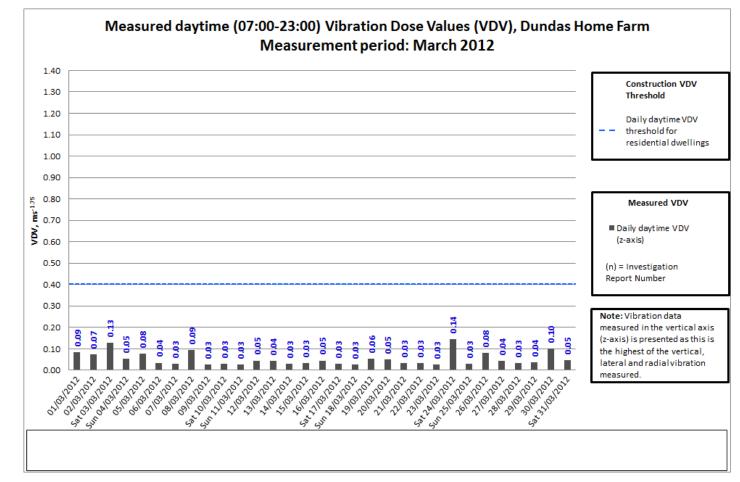
Night-time VDV at Dundas Home Farm – February 2012





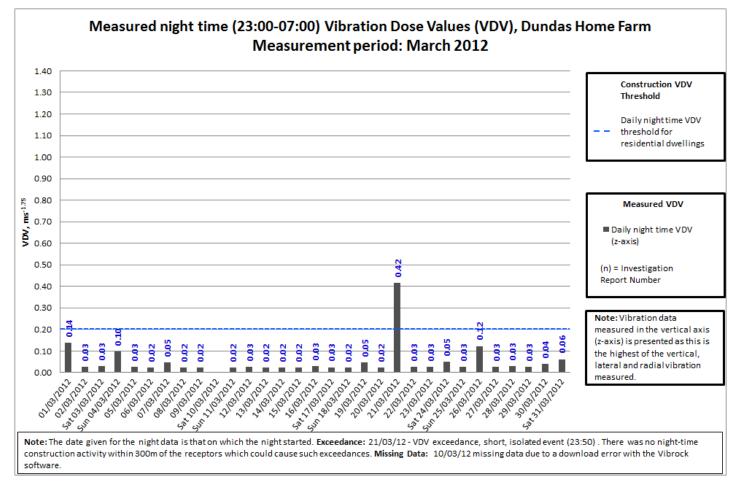
PPV at Dundas Home Farm – March 2012





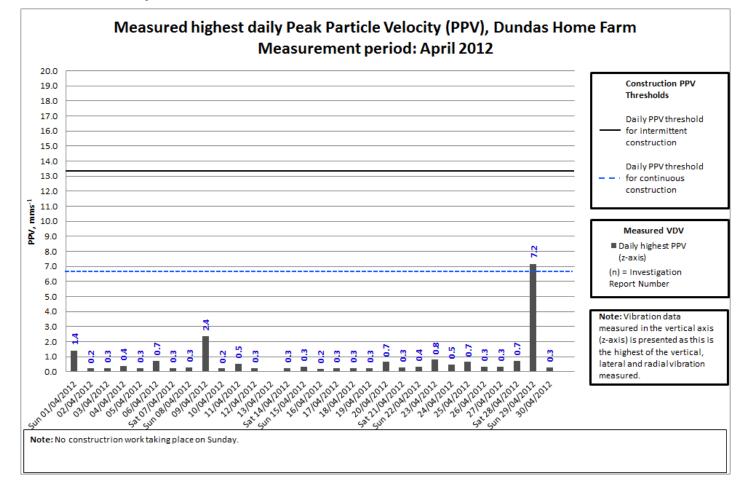
Daytime VDV at Dundas Home Farm – March 2012





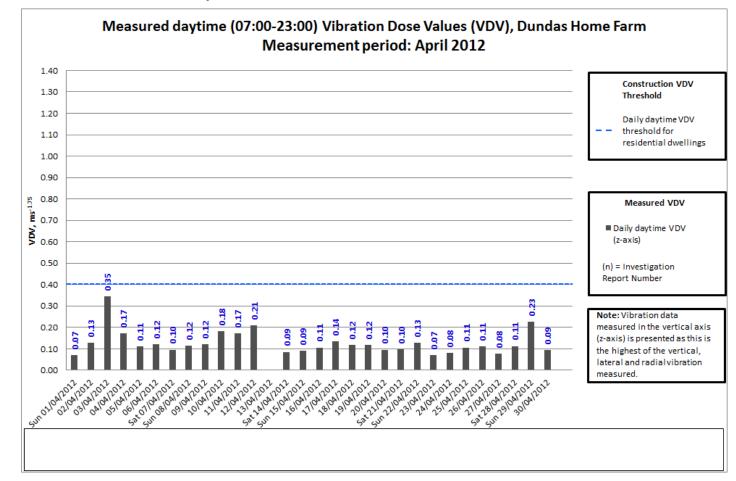
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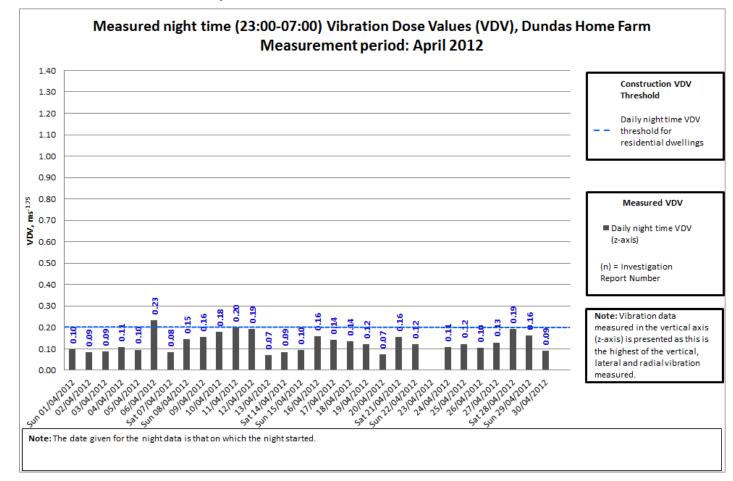
PPV at Dundas Home Farm – April 2012





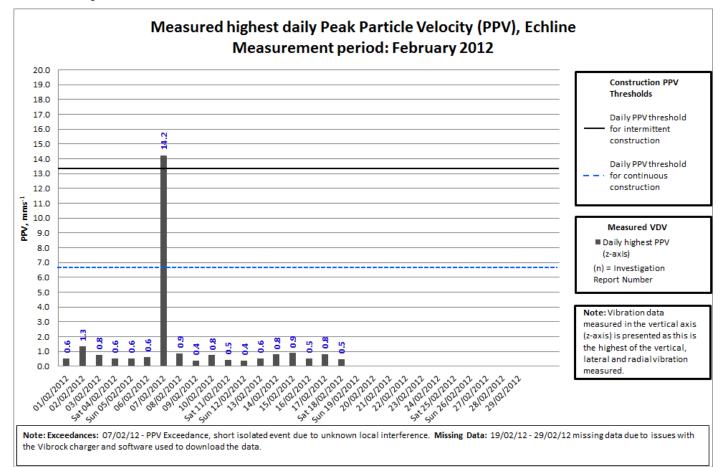
Daytime VDV at Dundas Home Farm – April 2012





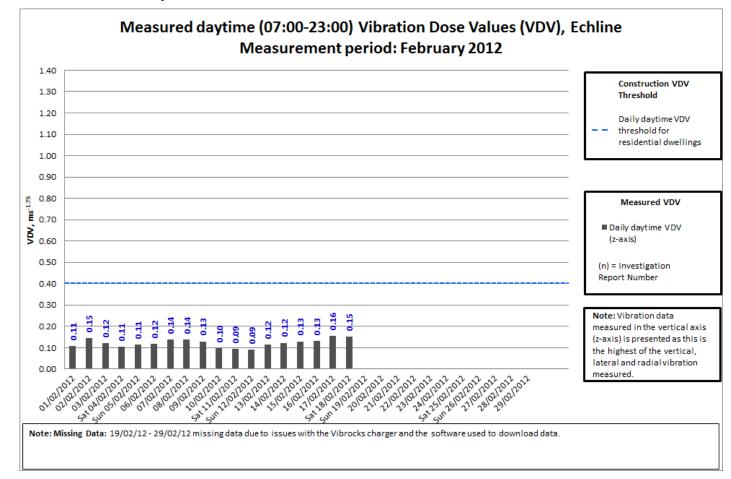
Night-time VDV at Dundas Home Farm – April 2012





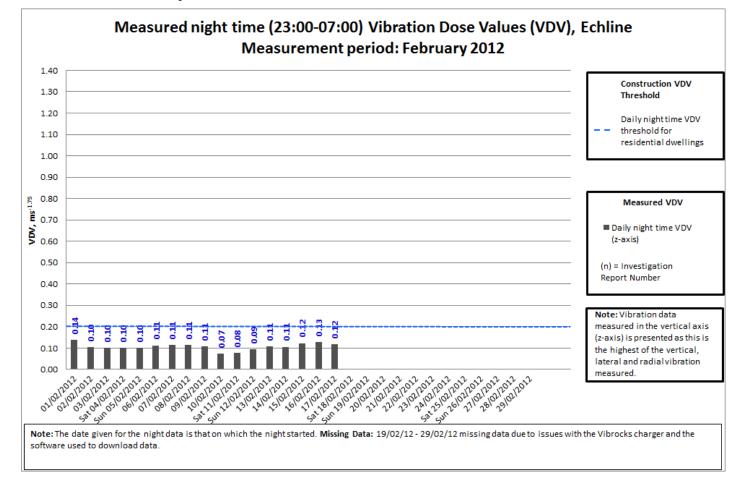
PPV at Echline – February 2012





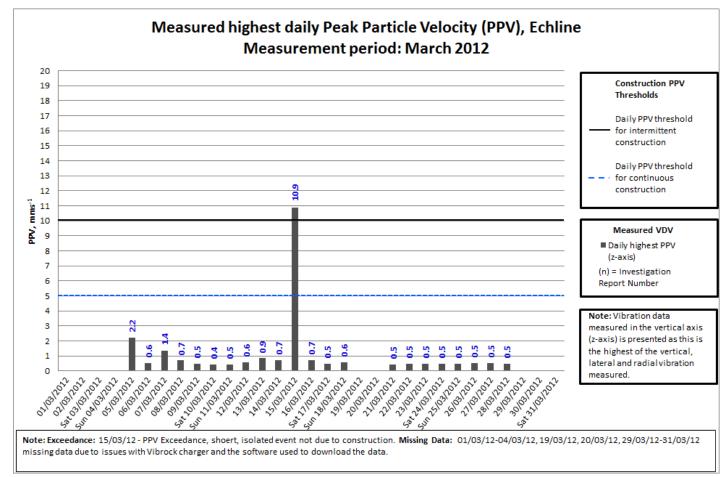
Daytime VDV at Echline – February 2012





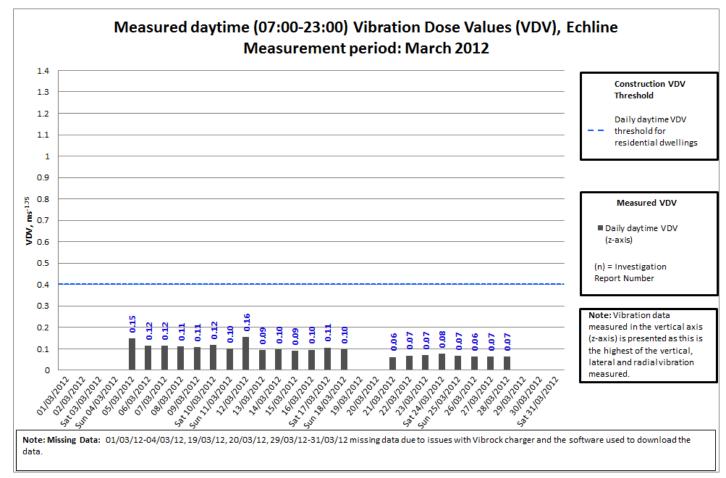
Night-time VDV at Echline – February 2012





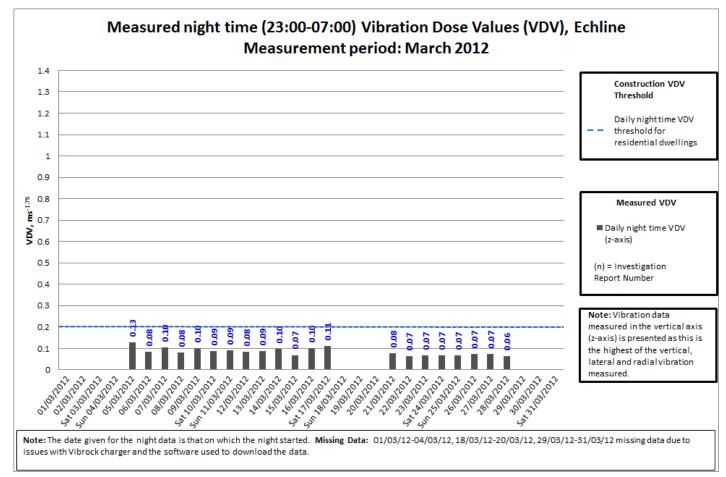
PPV at Echline – March 2012





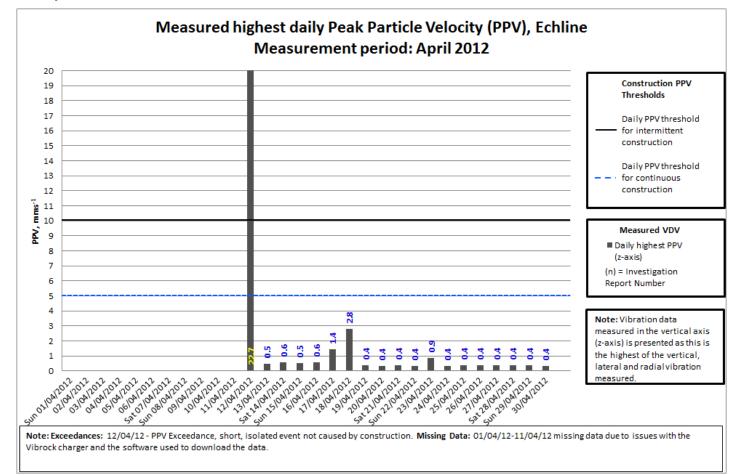
Daytime VDV at Echline – March 2012





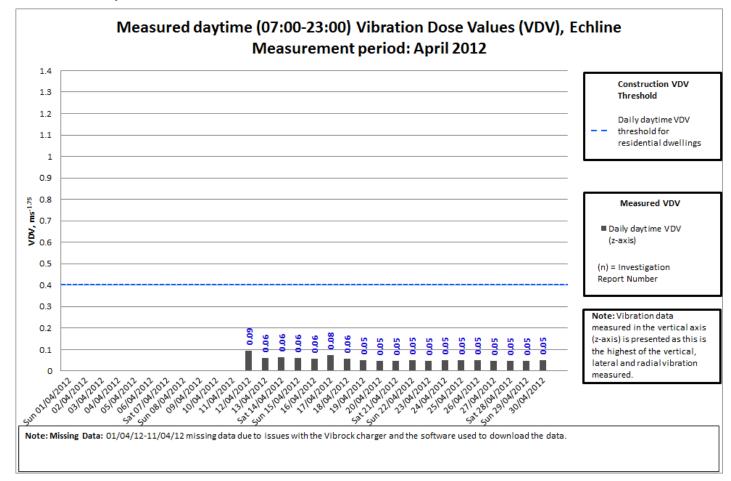
Night-time VDV at Echline – March 2012





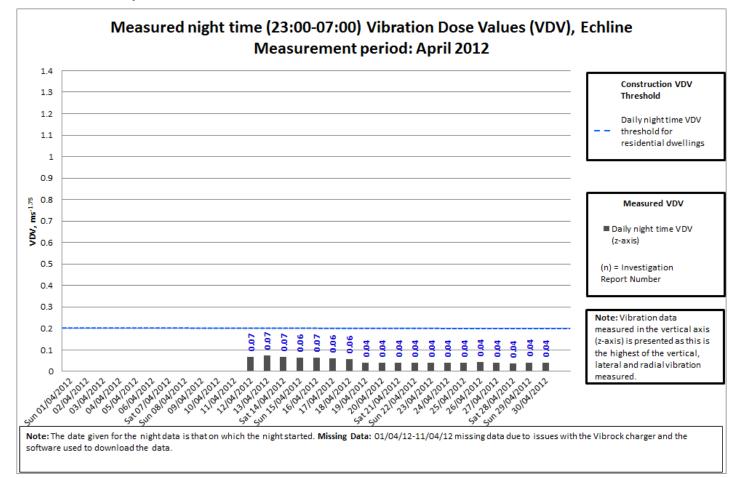
PPV at Echline – April 2012





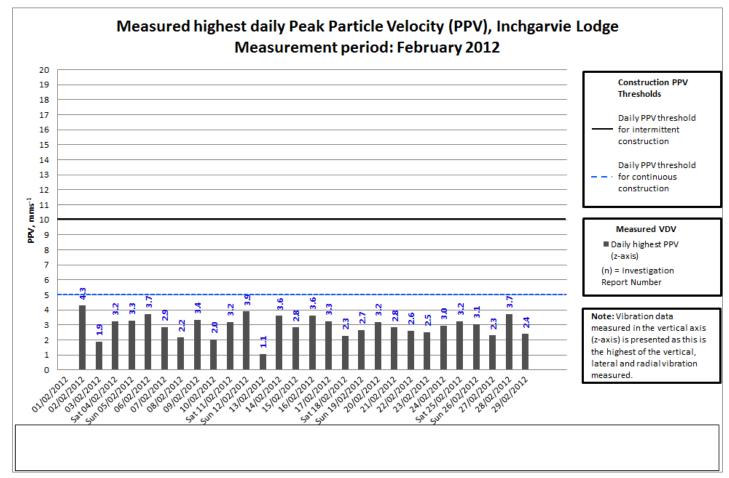
Daytime VDV at Echline – April 2012





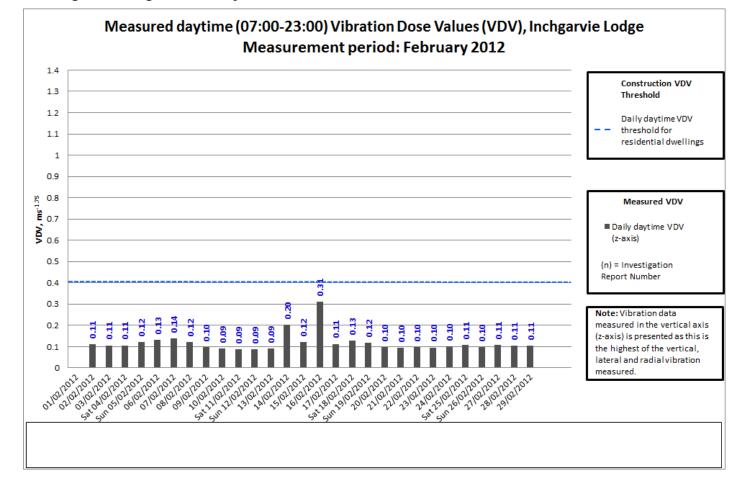
Night-time VDV at Echline – April 2012





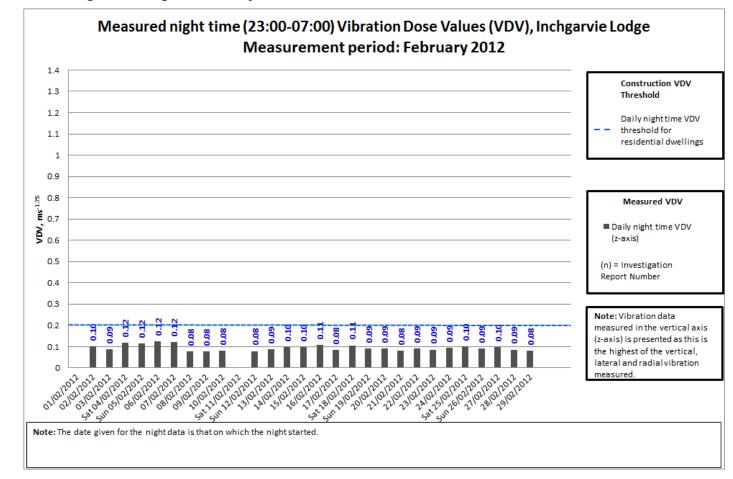
PPV at Inchgarvie Lodge – February 2012





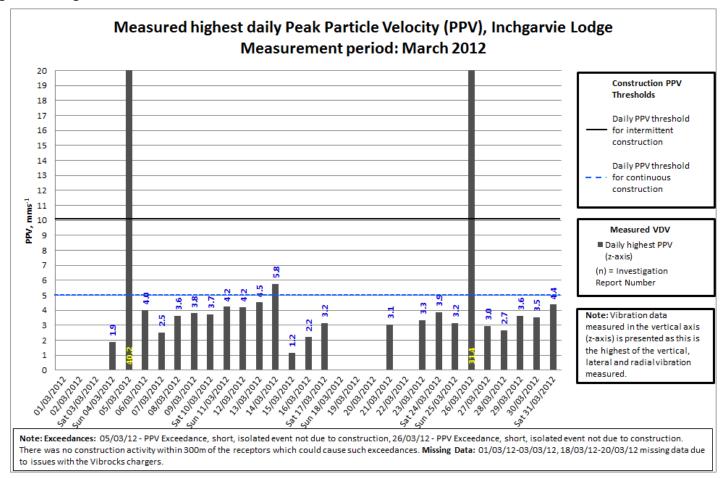
Daytime VDV at Inchgarvie Lodge – February 2012





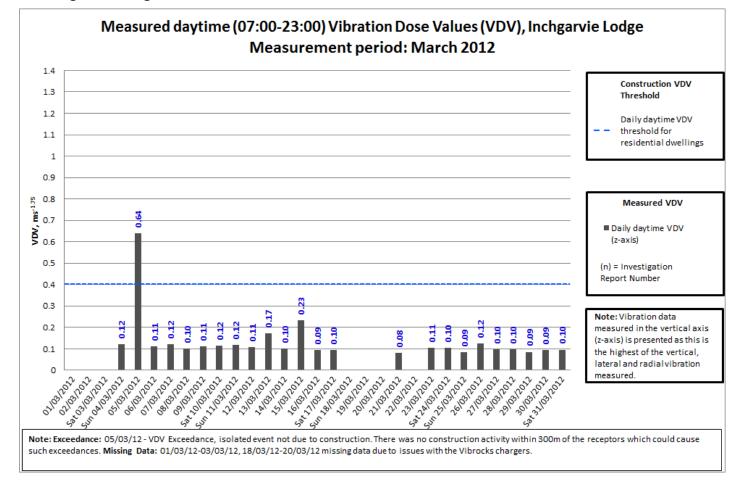
Night-time VDV at Inchgarvie Lodge – February 2012





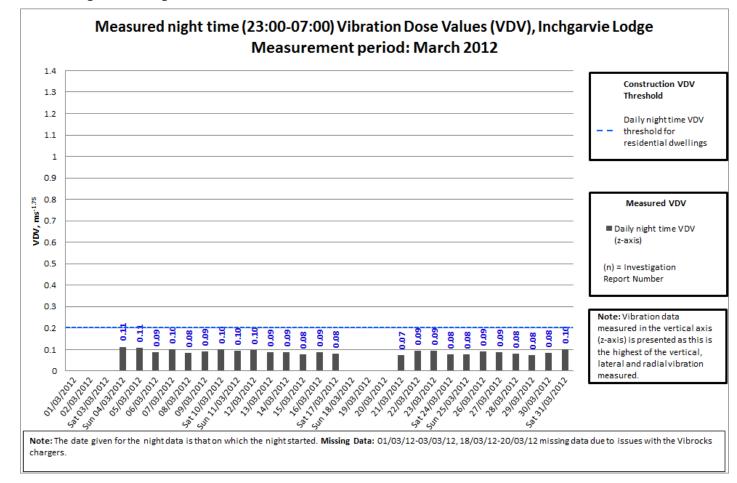
PPV at Inchgarvie Lodge – March 2012





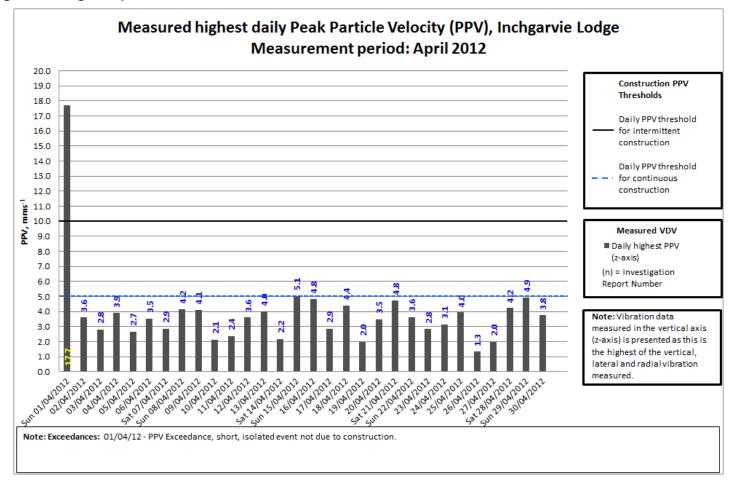
Daytime VDV at Inchgarvie Lodge – March 2012





Night-time VDV at Inchgarvie Lodge – March 2012





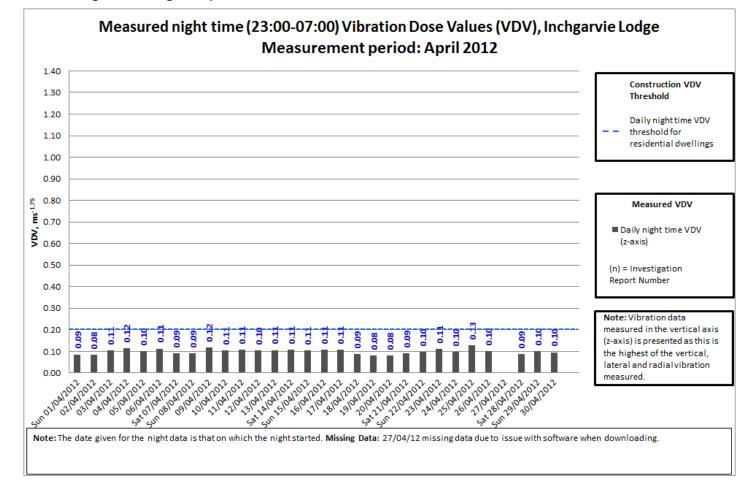
PPV at Inchgarvie Lodge – April 2012



Measured daytime (07:00-23:00) Vibration Dose Values (VDV), Inchgarvie Lodge Measurement period: April 2012 1.40 Construction VDV 1.30 Threshold 1.20 Daily daytime VDV threshold for 1.10 residential dwellings 1.00 0.90 ក្ត 0.80 Measured VDV Ê 0.70 Daily daytime VDV Å 0.60 (z-axis) 0.50 (n) = Investigation Report Number 0.40 0.30 Note: Vibration data 0.20 measured in the vertical axis 7 (z-axis) is presented as this is 0.10 the highest of the vertical, lateral and radial vibration 0.00 13/04/012/012 531-4/04/2012 54 500 2012 1012 54 500 2012 30/04/2012 05/04/2012 12/04/2012 measured. Sun OI DAI 2012 581210412012 54721042012 201041201 26/04/2011 27/04/2014 02/04/201 03/04/201 " OA104/201

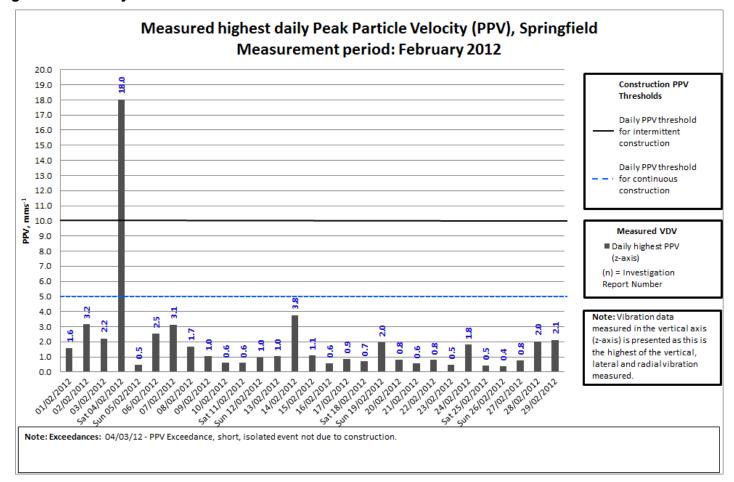
Daytime VDV at Inchgarvie Lodge – April 2012





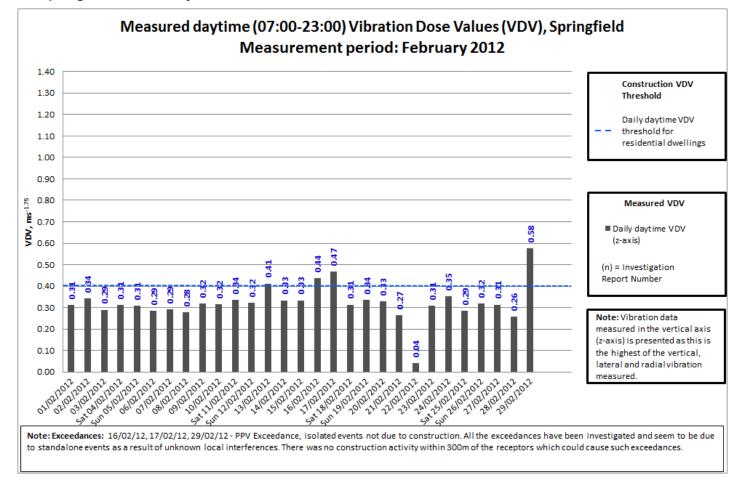
Night-time VDV at Inchgarvie Lodge – April 2012





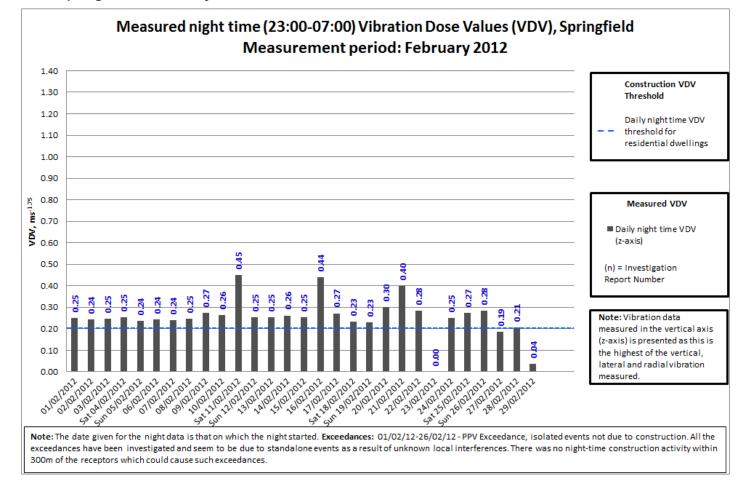
PPV at Springfield – February 2012





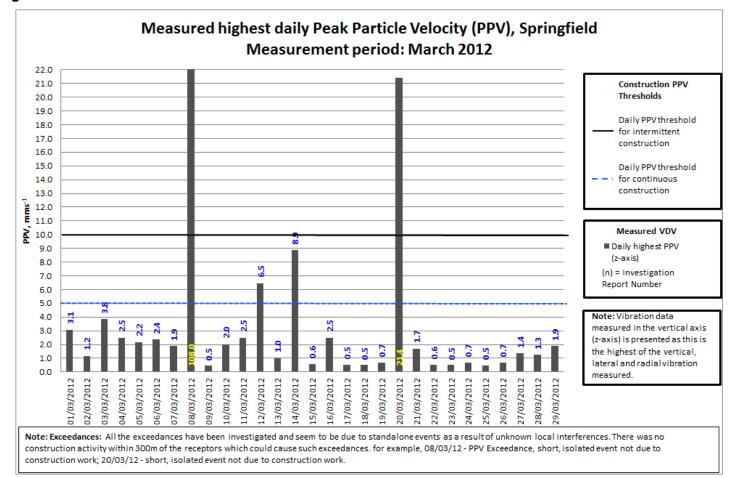
Daytime VDV at Springfield – February 2012





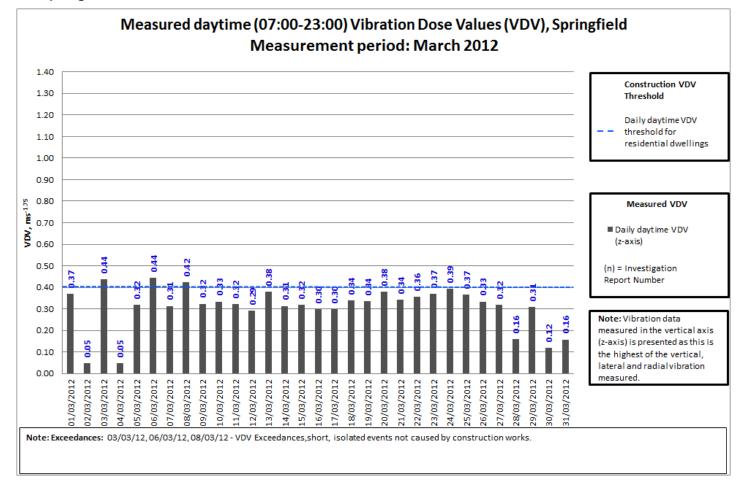
Night-time VDV at Springfield – February 2012





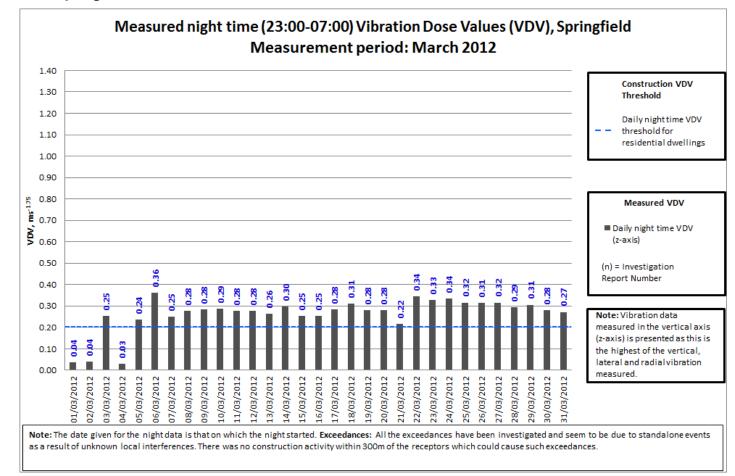
PPV at Springfield – March 2012





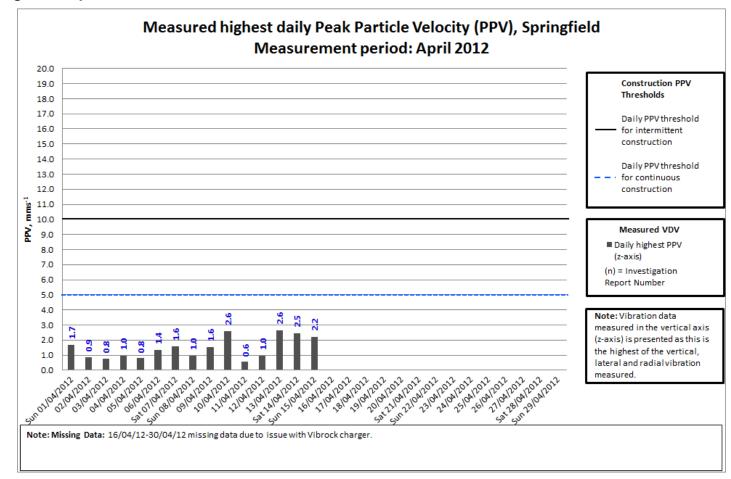
Daytime VDV at Springfield – March 2012





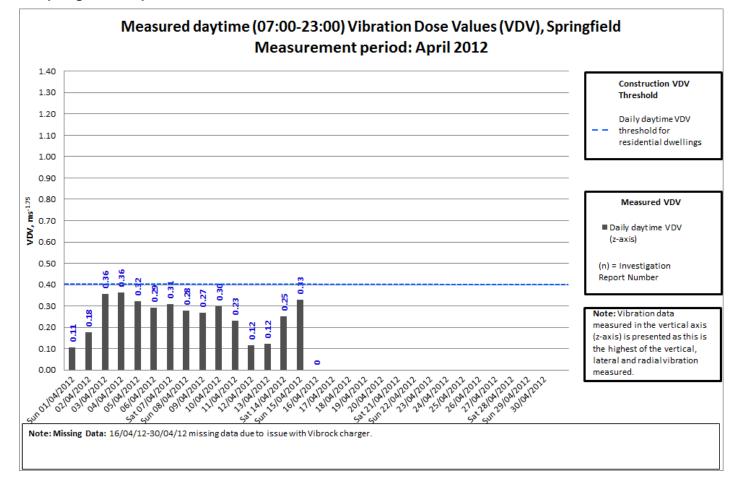
Night-time VDV at Springfield – March 2012





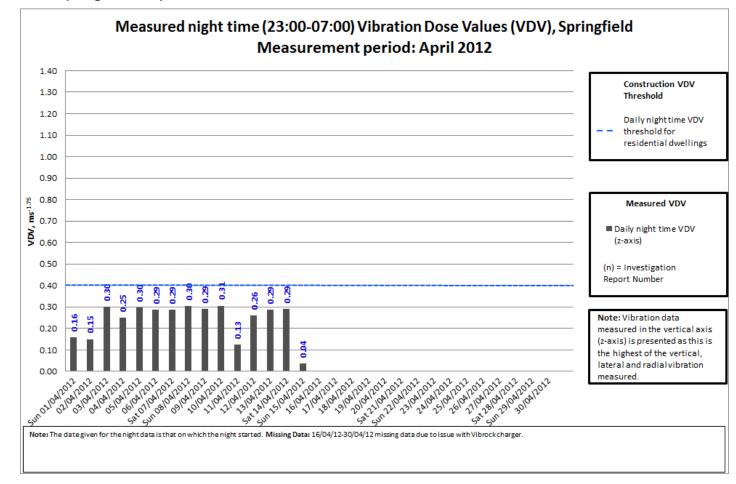
PPV at Springfield – April 2012





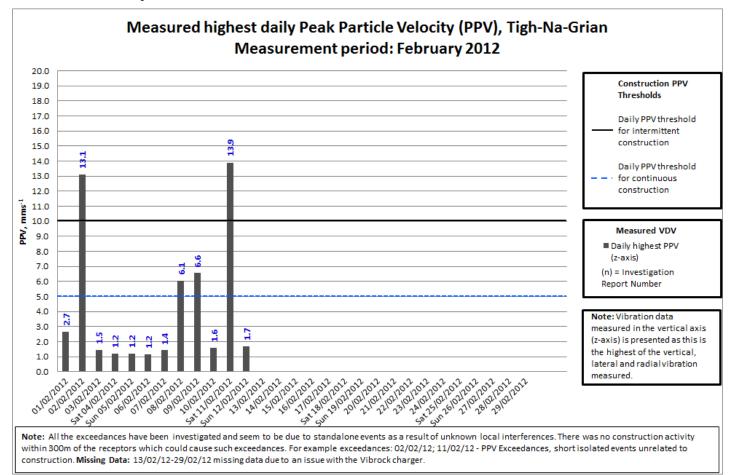
Daytime VDV at Springfield – April 2012





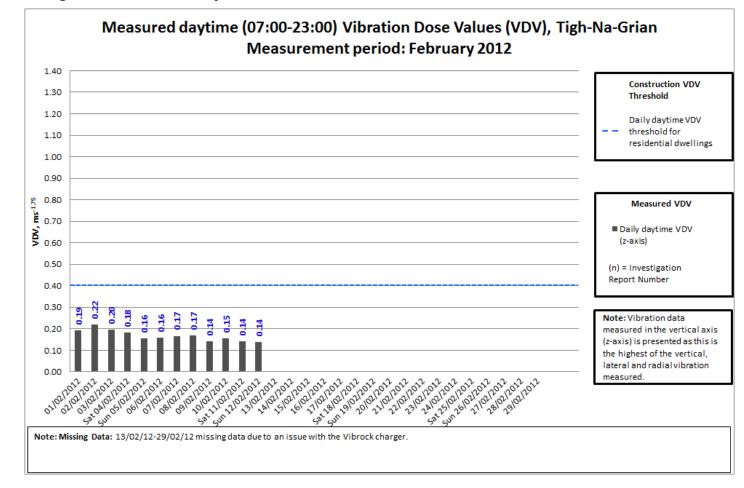
Night-time VDV at Springfield – April 2012





PPV at Tigh-Na-Grian – February 2012





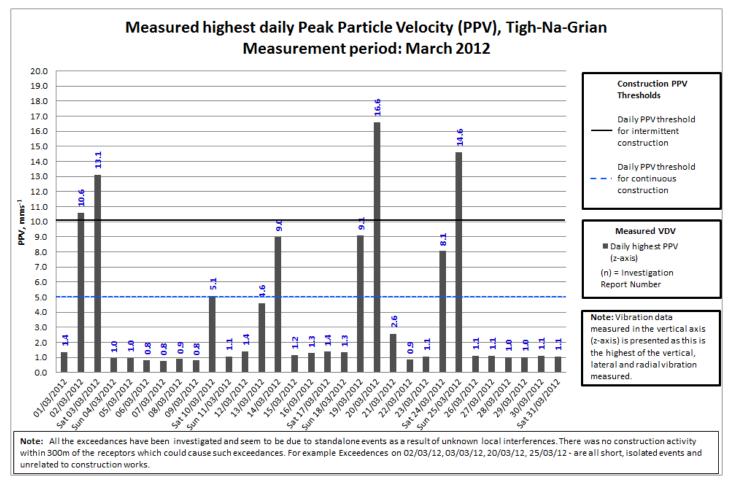
Daytime VDV at Tigh-Na-Grian – February 2012



Measured night time (23:00-07:00) Vibration Dose Values (VDV) **Tigh-Na-Grian** Measurement period: February 2012 1.4 Construction VDV Threshold 1.3 Daily night time VDV 1.2 threshold for residential dwellings 1.1 1.0 0.9 Measured VDV 8 0.8 Ë 0.7 Daily night time VDV Å 0.6 (z-axis) 0.5 (n) = Investigation Report Number 0.4 0.3 Note: Vibration data measured in the vertical axis 0.2 6 6 . (z-axis) is presented as this is -0.1 the highest of the vertical, lateral and radial vibration 1/2/18/01/01/01/01/01/01 58 501 10/01/01/01/01 Mi-24/01/012 0.0 15/02/2012 16/012012 measured. 2210212012 Sun26/02/2012 27/02/2012 28/02/2012 29/02/2012 23/02/2012 21/02/201 01/02/201 5at04/02/20 09/02/201 02102120. 03/02/20 Note: The date given for the night data is that on which the night started. Missing Data: 13/02/12-29/02/12 missing data due to an issue with the Vibrock charger.

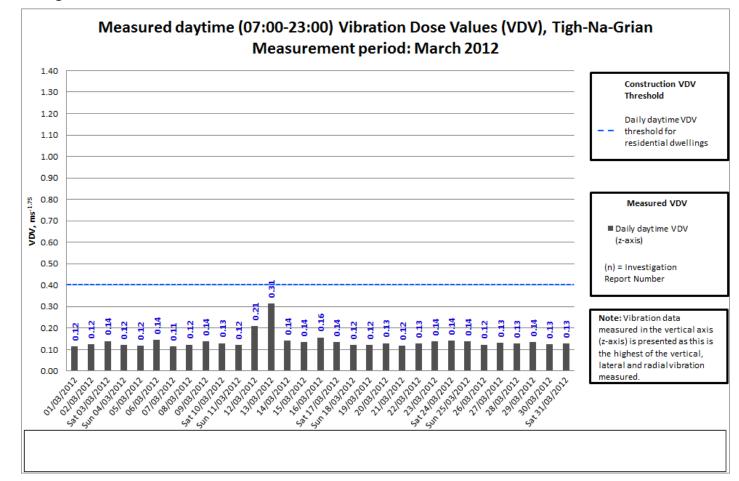
Night-time VDV at Tigh-Na-Grian – February 2012





PPV at Tigh-Na-Grian – March 2012





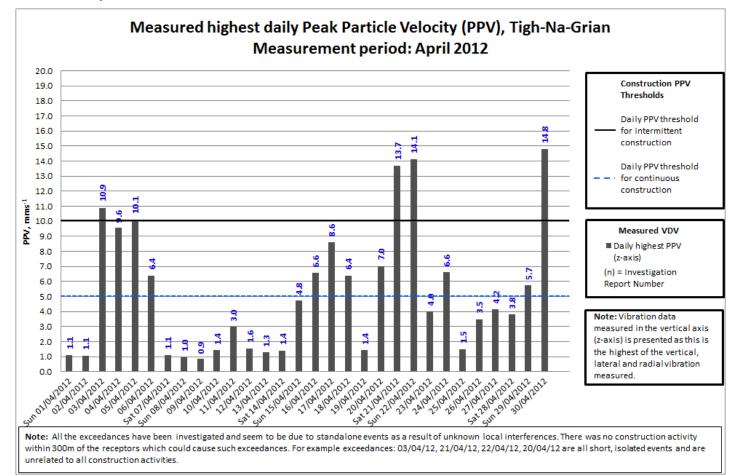
Daytime VDV at Tigh-Na-Grian – March 2012



Measured night time (23:00-07:00) Vibration Dose Values (VDV) **Tigh-Na-Grian** Measurement period: March 2012 1.4 Construction VDV Threshold 1.3 Daily night time VDV 1.2 threshold for residential dwellings 1.1 1.0 0.9 Measured VDV R 0.8 Ë 0.7 Daily night time VDV Å 0.6 (z-axis) (n) = Investigation 0.5 Report Number 0.4 0.3 Note: Vibration data 0.2 measured in the vertical axis (z-axis) is presented as this is 0.1 the highest of the vertical. lateral and radial vibration 0.0 58-31031012 5310031012 Suntility 09/03/2012 12/03/2012 13/03/2012 1410312012 15/03/2012 08/03/2012 measured. 16/03/2012 01/03/2012 5400403201 53111031011 54n 2021011 58221031201 54725103101 58103103101 21/03/201 22/03/201 23/03/201 26/03/201 29103/201 02103/201 191031201 20103/201 27103/201 81031201 301031201 22012 1012 1012 101 3201 1010 1012 101 3201 1010 1010 1010 Note: The date given for the night data is that on which the night started. No construction works conducted on Sunday. Missing Data: 31/03/12 missing data due to error when downloading dat files with Vibrock software.

Night-time VDV at Tigh-Na-Grian – March 2012





PPV at Tigh-Na-Grian – April 2012



Measured daytime (07:00-23:00) Vibration Dose Values (VDV), Tigh-Na-Grian Measurement period: April 2012 1.40 Construction VDV 1.30 Threshold 1.20 Daily daytime VDV threshold for 1.10 residential dwellings 1.00 0.90 22 0.80 Measured VDV Ê 0.70 Å 0.60 Daily daytime VDV (z-axis) 0.50 (n) = Investigation 33 Report Number 0.40 0.30 Note: Vibration data 0.20 measured in the vertical axis (z-axis) is presented as this is 0.10 the highest of the vertical, lateral and radial vibration 531-2104/2012 531-2104/2012 531-2104/2012 0.00 -1310012012012 531410012012 Sun 15/04/2012 26/04/2012 21022002002002002002002 21042042042002002002002 532500290301042002 measured. - SUNDIDARDOLZ 12/04/2012 231022012012012012 231022012012012012 231022012012012020 2010412011 02/04/201

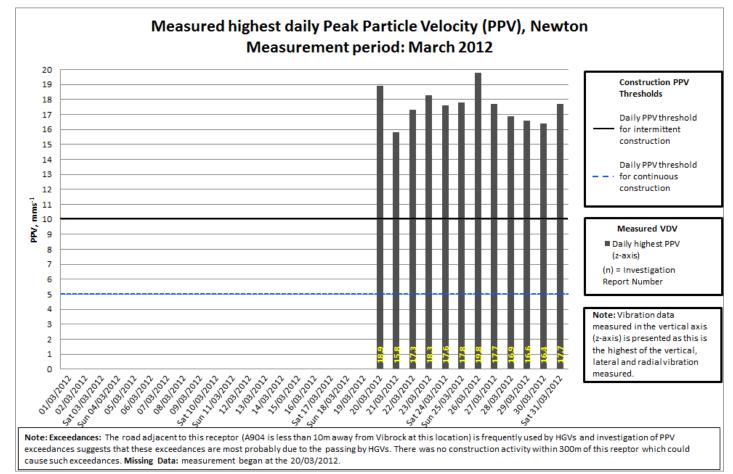
Daytime VDV at Tigh-Na-Grian – April 2012



Measured night time (23:00-07:00) Vibration Dose Values (VDV) **Tigh-Na-Grian** Measurement period: April 2012 1.4 Construction VDV Threshold 1.3 Daily night time VDV 1.2 threshold for residential dwellings 1.1 1.0 0.9 Measured VDV R 0.8 Ë 0.7 Daily night time VDV Å 0.6 (z-axis) (n) = Investigation 0.5 Report Number 0.4 0.3 Note: Vibration data measured in the vertical axis 0.2 -(z-axis) is presented as this is 0.1 the highest of the vertical, lateral and radial vibration 0.0 30/04/2012 measured. 5312104/201 5un 221041201 22/02/201 53128/04/201 54729/04/201 53124/04/201 Suntsoutor 18/04/201 01/04/201 13/04/201 16/04/202 171041201 19/04/201 23/04/201 25/04/201 26/04/201 27/04/202 06/04/20 12109/201 20104120 05/04/20 12/04/21 Satorioal2 5un08/04/2 0210412 091041 10/04/ oaloal SUL Note: The date given for the night data is that on which the night started

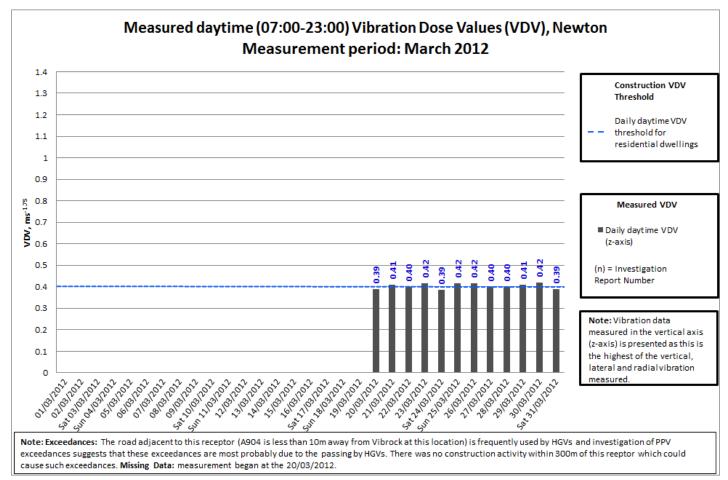
Night-time VDV at Tigh-Na-Grian – April 2012





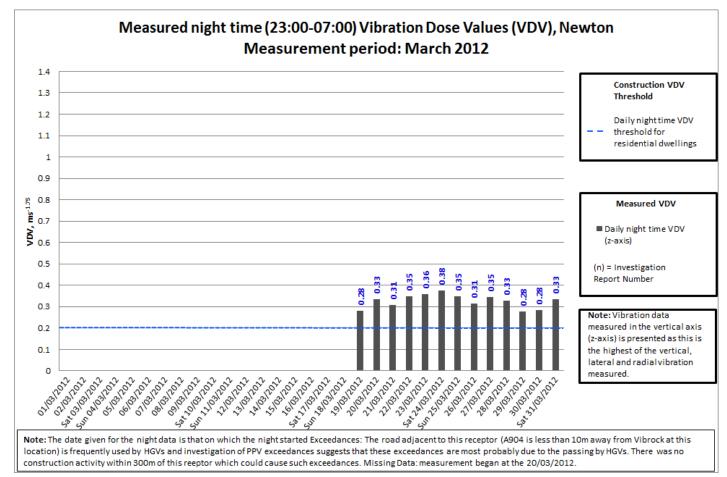
PPV at Newton – March 2012





Daytime VDV at Newton – March 2012





Night-time VDV at Newton – March 2012

Forth Crossing Bridge Constructors - A Joint Venture of Hochtief Solutions AG, American Bridge International,

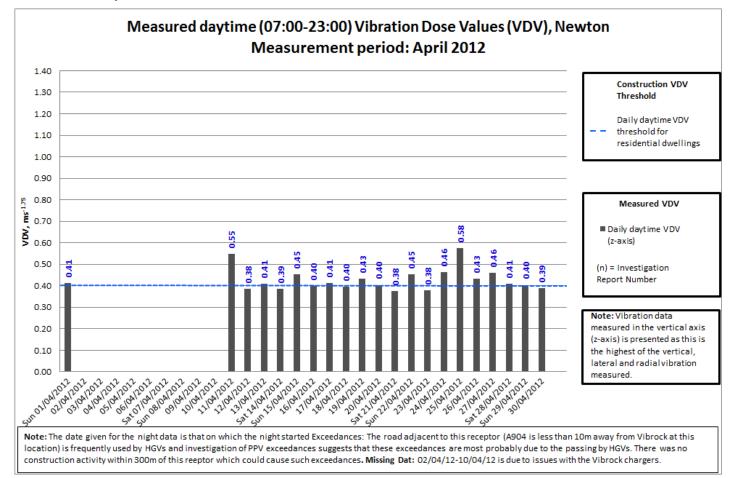


Measured highest daily Peak Particle Velocity (PPV), Newton Measurement period: April 2012 20 Construction PPV 19 Thresholds 18 17 Daily PPV threshold 16 for intermittent construction 15 14 Daily PPV threshold 13 for continuous 12 construction 11 10 10 9 Measured VDV Daily highest PPV 8 (z-axis) 7 (n) = Investigation 6 Report Number 5 4 Note: Vibration data 3 measured in the vertical axis (z-axis) is presented as this is 2 the highest of the vertical, 1 lateral and radial vibration 0 2010412012 5012110012 23/04/2012 26104/2012 54729042012 19/04/2012 un22/04/2012 24/04/2012 25/04/2012 27104/2012 58128/04/2012 30/04/2012 measured. n01/04/2012 Note: The date given for the night data is that on which the night started Exceedances: The road adjacent to this receptor (A904 is less than 10m away from Vibrock at this location) is frequently used by HGVs and investigation of PPV exceedances suggests that these exceedances are most probably due to the passing by HGVs. There was no construction activity within 300m of this reeptor which could cause such exceedances. Missing Dat: 02/04/12-10/04/12 is due to issues with the Vibrock chargers.

PPV at Newton – April 2012

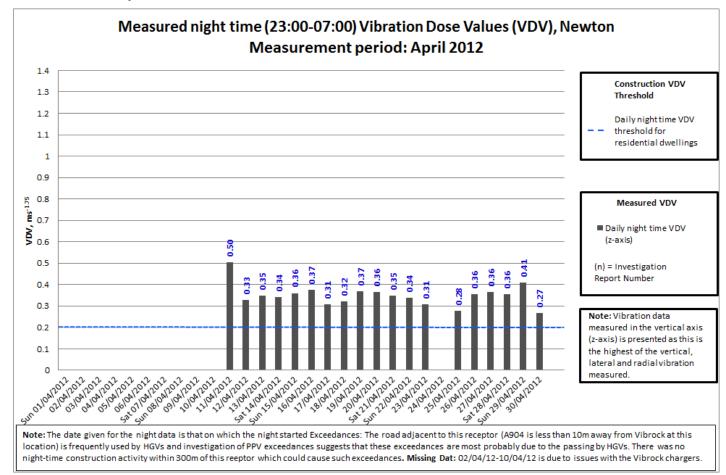
Forth Crossing Bridge Constructors - A Joint Venture of Hochtief Solutions AG, American Bridge International,





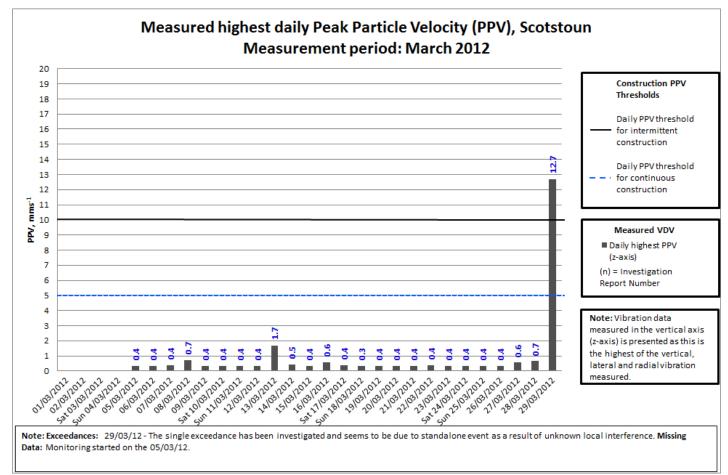
Daytime VDV at Newton – April 2012





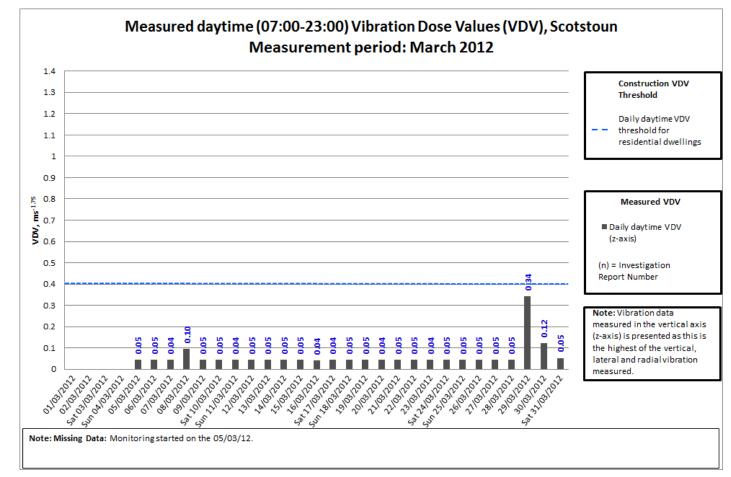
Night-time VDV at Newton – April 2012





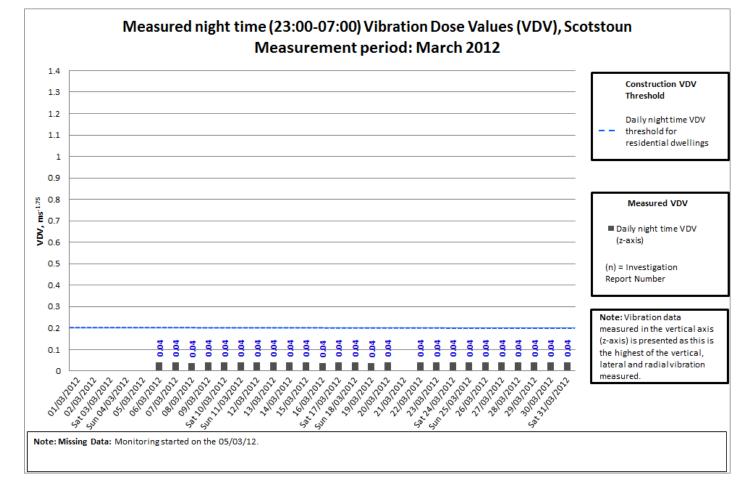
PPV at Scotstoun – March 2012





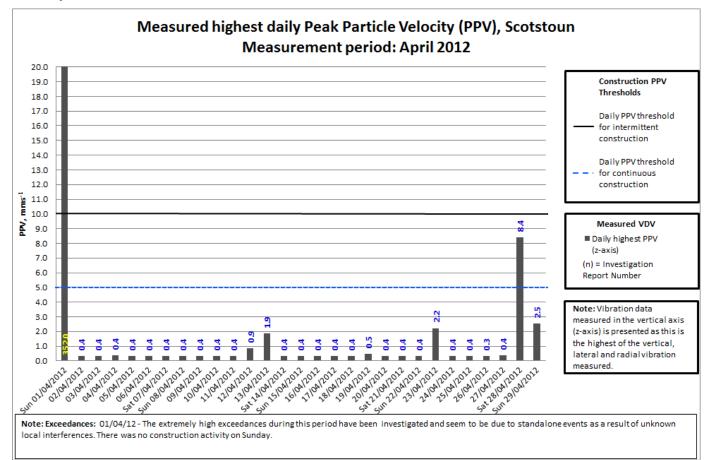
Daytime VDV at Scotstoun – March 2012





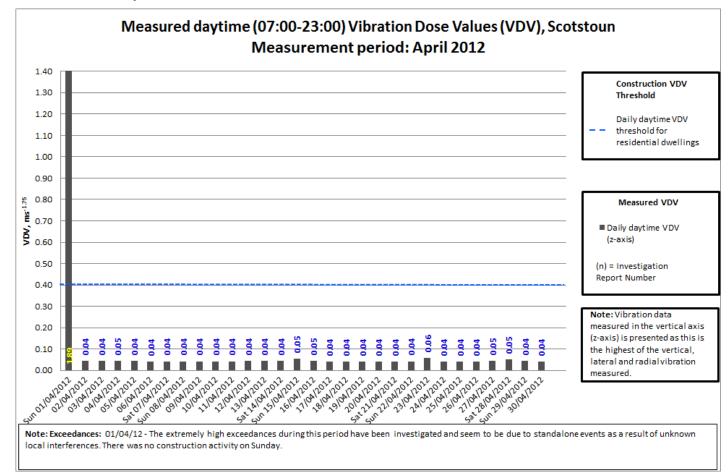
Night-time VDV at Scotstoun – March 2012





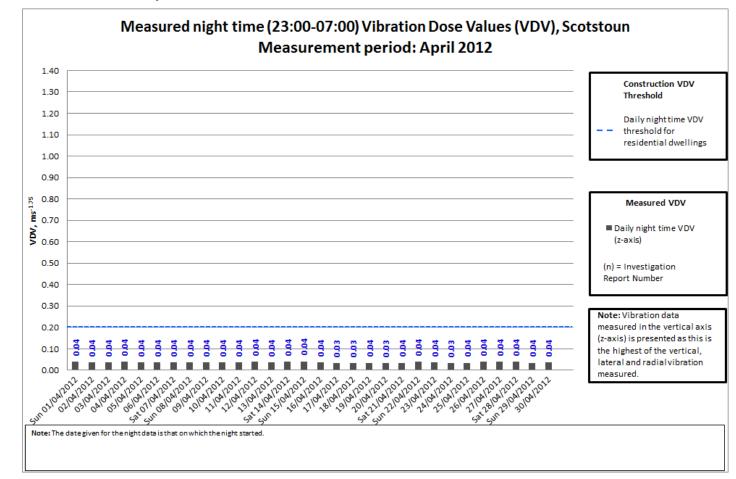
PPV at Scotstoun – April 2012





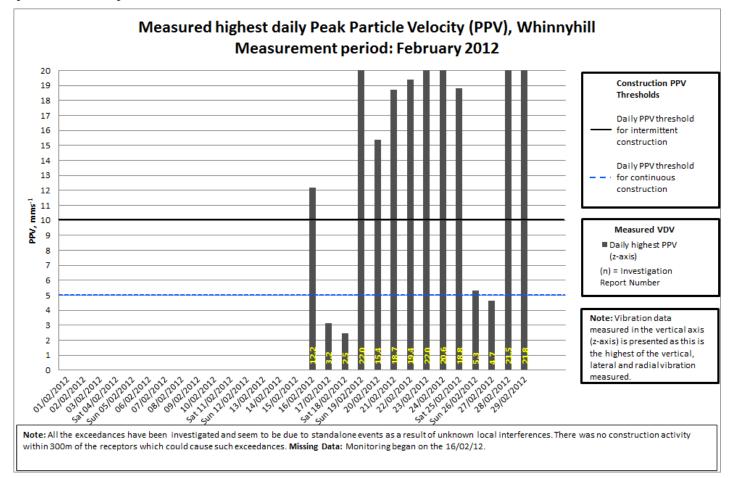
Daytime VDV at Scotstoun – April 2012





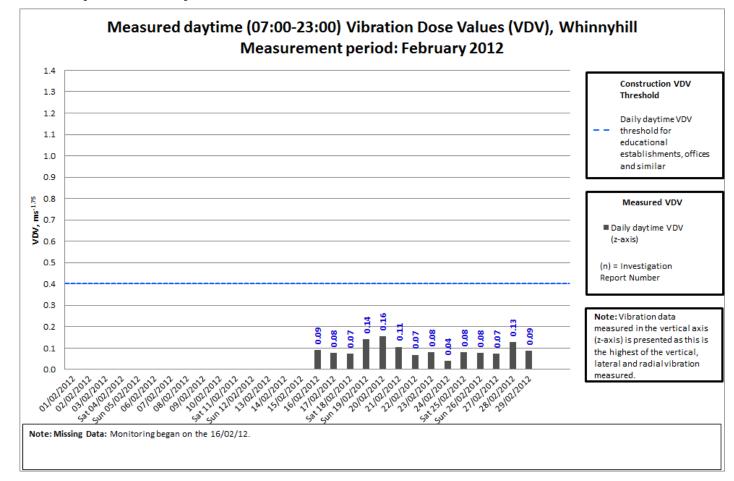
Night-time VDV at Scotstoun – April 2012





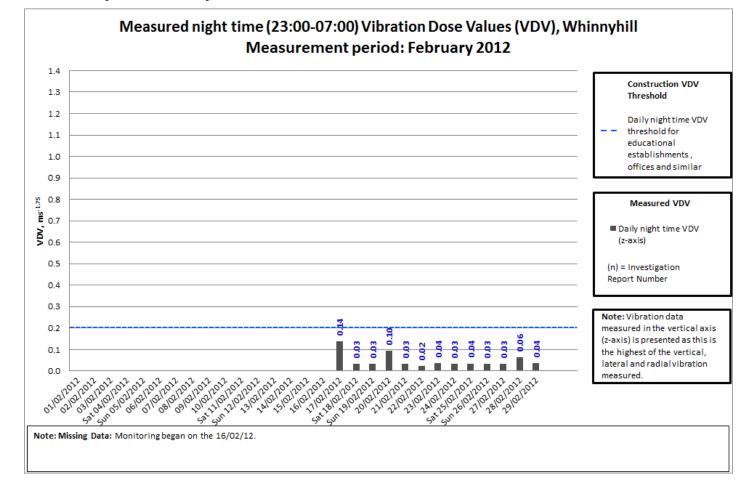
PPV at Whinnyhill – February 2012





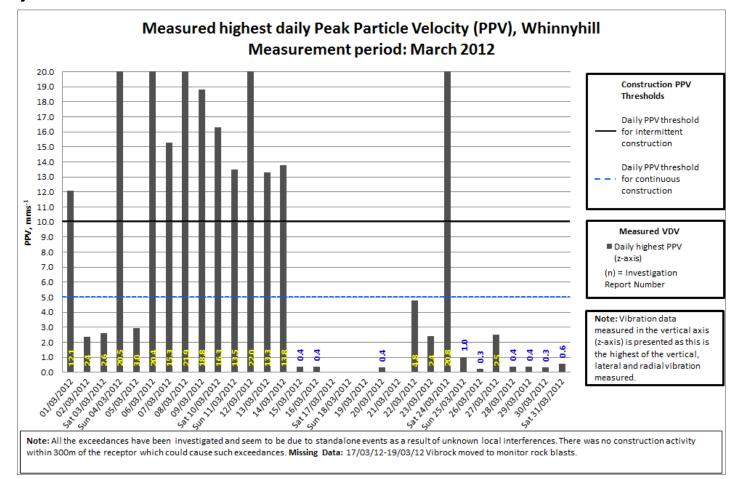
Daytime VDV at Whinnyhill – February 2012





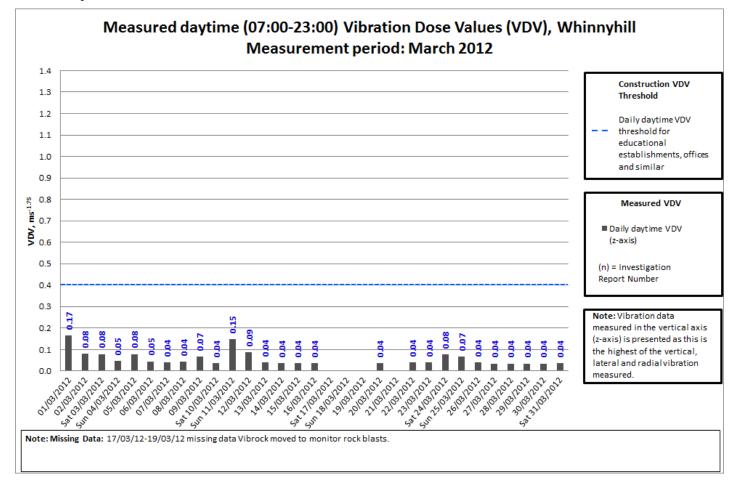
Night-time VDV at Whinnyhill – February 2012





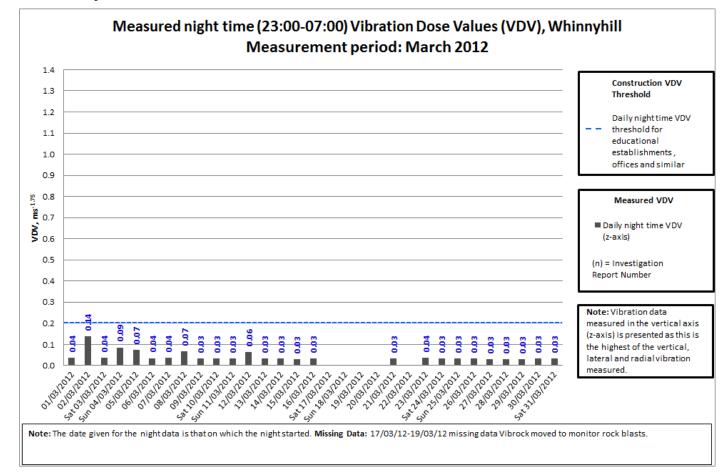
PPV at Whinnyhill – March 2012





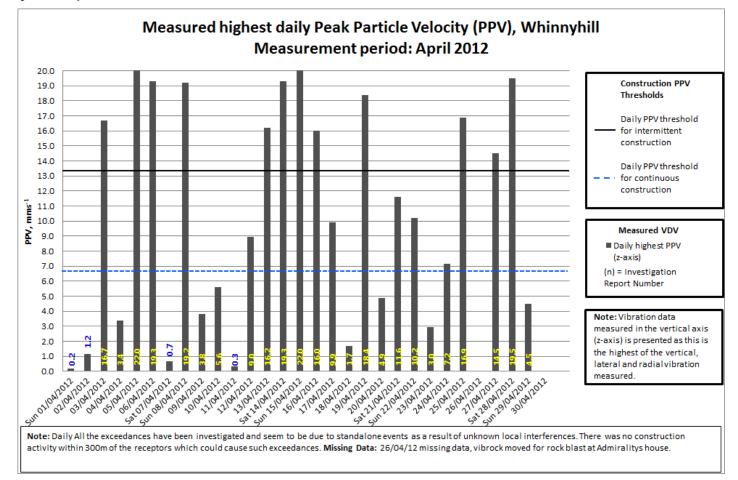
Daytime VDV at Whinnyhill – March 2012





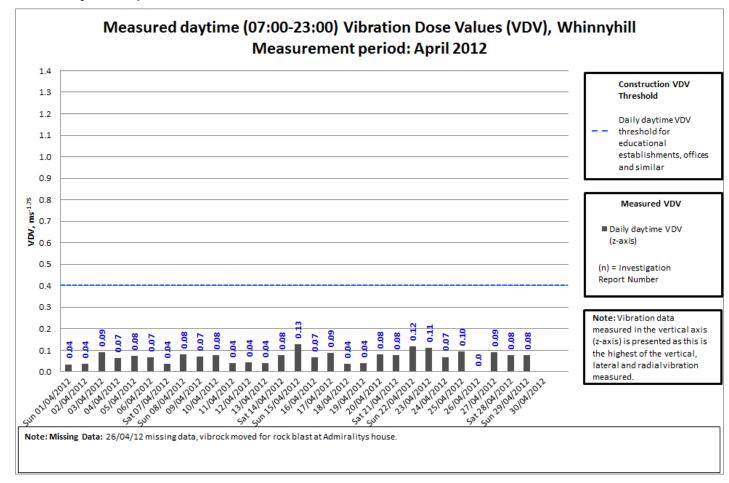
Night-time VDV at Whinnyhill – March 2012





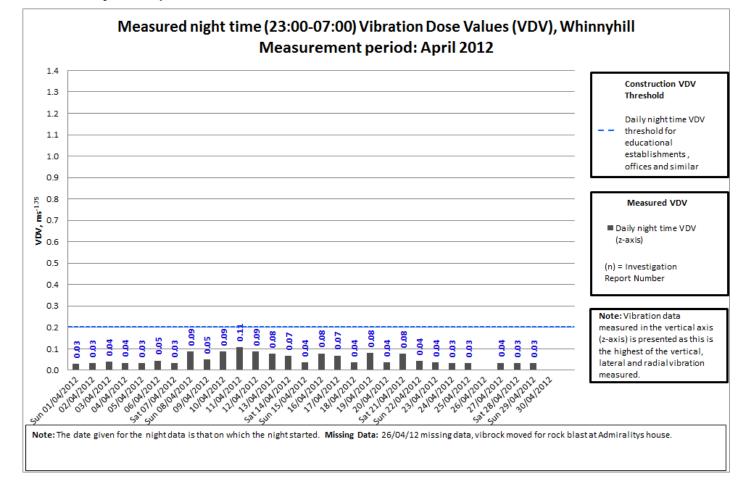
PPV at Whinnyhill – April 2012





Daytime VDV at Whinnyhill – April 2012

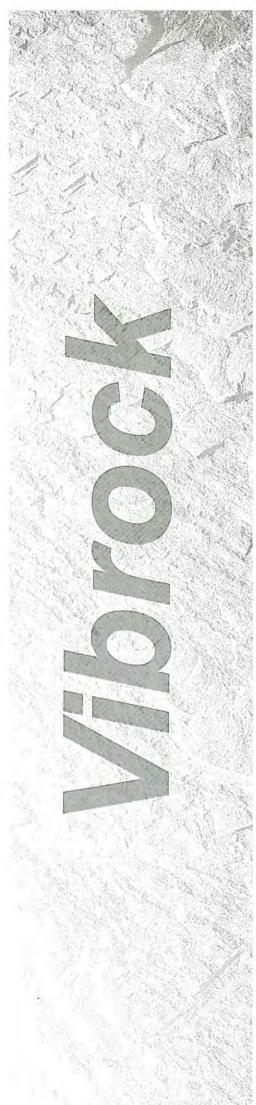




Night-time VDV at Whinnyhill – April 2012



APPENDIX C – VIBROCK CALIBRATION CERTIFICATES



CALIBRATION CERTIFICATE NO.: CLIENT: INSTRUMENT TYPE: SERIAL NUMBER: CALIBRATION DATE: CALIBRATED BY: **08121562 Forth Crossing Bridge Constructors 1901-GSM 1901-GSM 1901-GSM 1901-GSM 1901-GSM 1901-GSM 1900-GSM 190**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5_%	<u>±5</u> %	X <u>±5</u> %
Peak Particle Velocity V	<u>±5_%</u>	<u>ts</u> %	Y <u> ±</u> 5 %
Peak Particle Velocity T	±5_%	<u>+</u> 5- %	z <u>±s</u> %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted MA dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

DATE:

THIS CERTIFICATE IS VALID FOR 12 MONTHS

The above calibration was carried out using equipment calibrated as follows:-Pulsar Acoustic Calibrator 100B, serial number 60796, calibrated March 2012 ISO-TECH IFG 100 Oscillator, serial number 300351, calibrated June 2012 Monitran Vibration Meter, serial number 213608, calibrated June 2012 Precision Gold PG012 Multimeter, serial number 09000182, calibrated June 2012

THIS CALIBRATION IS TRACEABLE TO NATIONAL STANDARDS

VIBROCK LIMITED Shanakiel Ilkeston Road Heanor Derbyshire DE75 7DR Tel: 01773 711211 Fax: 01773 711311 Email: vibrock@vibrock.com Web: www.vibrock.com





CALIBRATION CERTIFICATE NO .:

CLIENT: INSTRUMENT TYPE: SERIAL NUMBER: CALIBRATION DATE: CALIBRATED BY: 08121563 Forth Crossing Bridge Constructors V901-GSM 1563 14TH AUGUST 2012

DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel	
Peak Particle Velocity L	<u>±5_%</u>	<u>±5</u> %	X <u>±5</u> %	
Peak Particle Velocity V	±5_%	<u>±</u> 5_%	Y = 1- %	
Peak Particle Velocity T	±5- %	±5_%	Z <u>±</u> 5%	

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted <u>MA</u> dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

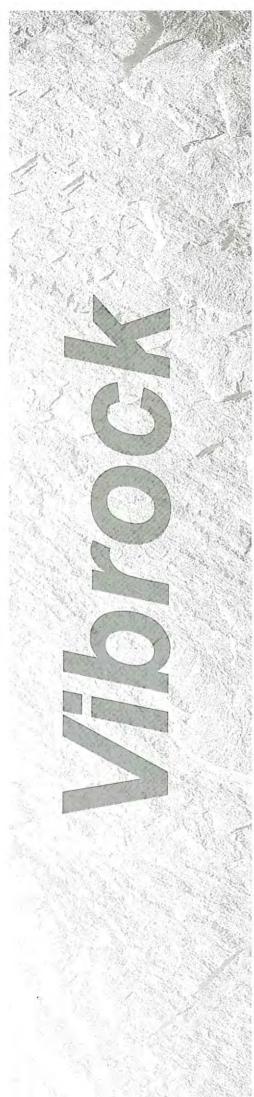
DATE:

THIS CERTIFICATE IS VALID FOR 12 MONTHS

The above calibration was carried out using equipment calibrated as follows:-Pulsar Acoustic Calibrator 100B, serial number 60796, calibrated March 2012 ISO-TECH IFG 100 Oscillator, serial number 300351, calibrated June 2012 Monitran Vibration Meter, serial number 213608, calibrated June 2012 Precision Gold PG012 Multimeter, serial number 09000182, calibrated June 2012

THIS CALIBRATION IS TRACEABLE TO NATIONAL STANDARDS

VIBROCK LIMITED Shanakiel Ilkeston Road Heanor Derbyshire DE75 7DR Tel: 01773 711211 Fax: 01773 711311 Email: vibrock@vibrock.com Web: www.vibrock.com



CALIBRATION CERTIFICATE NO .:

CLIENT: INSTRUMENT TYPE: SERIAL NUMBER: CALIBRATION DATE: CALIBRATED BY:

TE NO.	08121564
IL NO.	Forth Crossing Bridge Constructors
	V901-GSM
	1564
	14TH AUGUST 2012
	DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	<u>±5_%</u>	<u>±5</u> %	X <u>±</u> %
Peak Particle Velocity V	<u>±5_%</u>	±5_%	Y <u>+5 %</u>
Peak Particle Velocity T	±5_%	<u>±5_%</u>	z <u>*</u> 5%

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted <u>N/A</u> dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

DATE:

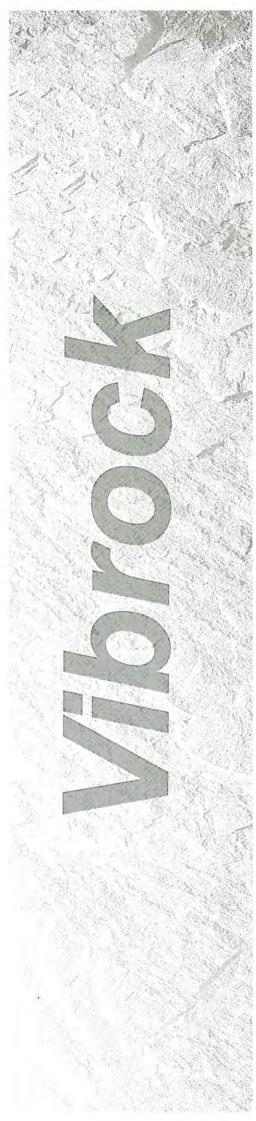
THIS CERTIFICATE IS VALID FOR 12 MONTHS

The above calibration was carried out using equipment calibrated as follows:-Pulsar Acoustic Calibrator 100B, serial number 60796, calibrated March 2012 ISO-TECH IFG 100 Oscillator, serial number 300351, calibrated June 2012 Monitran Vibration Meter, serial number 213608, calibrated June 2012 Precision Gold PG012 Multimeter, serial number 09000182, calibrated June 2012

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VIBROCK LIMITED Shanakiel Ilkeston Road Heanor Derbyshire DE75 7DR Tel: 01773 711211 Fax: 01773 711311 Email: vibrock@vibrock.com Web: www.vibrock.com





CALIBRATION CERTIFICATE NO.: CLIENT: INSTRUMENT TYPE: SERIAL NUMBER: CALIBRATION DATE: CALIBRATED BY: **08121565 Forth Crossing Bridge Constructors 1901-GSM 1965 14TH AUGUST 2012 DENNIS LORD**

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5_%	<u>±5</u> %	X <u>±5</u> %
Peak Particle Velocity V	<u>±5_%</u>	<u>±5</u> %	Y <u>+ 5 %</u>
Peak Particle Velocity T	<u>±5</u> %	<u>+j-</u> %	z <u>*</u> %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted <u>N/A</u> dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

DATE:

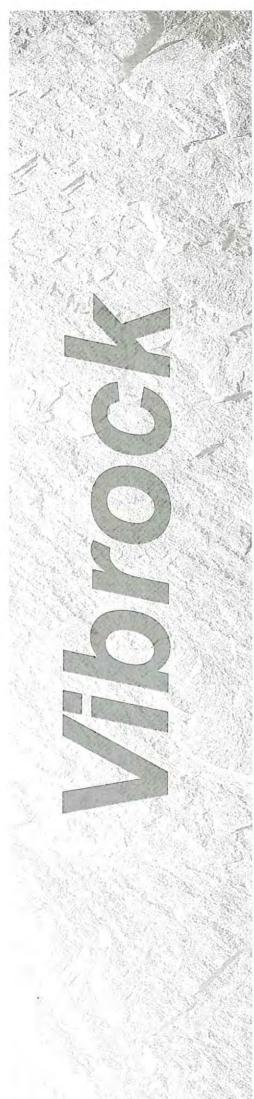
THIS CERTIFICATE IS VALID FOR 12 MONTHS

The above calibration was carried out using equipment calibrated as follows:-Pulsar Acoustic Calibrator 100B, serial number 60796, calibrated March 2012 ISO-TECH IFG 100 Oscillator, serial number 300351, calibrated June 2012 Monitran Vibration Meter, serial number 213608, calibrated June 2012 Precision Gold PG012 Multimeter, serial number 09000182, calibrated June 2012

THIS CALIBRATION IS TRACEABLE TO NATIONAL STANDARDS

VIBROCK LIMITED Shanakiel Ilkeston Road Heanor Derbyshire DE75 7DR Tel: 01773 711211 Fax: 01773 711311 Email: vibrock@vibrock.com Web: www.vibrock.com





08121567CALIBRATION CERTIFICATE NO.:CLIENT:Forth Crossing Bridge ConstructorsINSTRUMENT TYPE:V901-GSMSERIAL NUMBER:1567CALIBRATION DATE:14TH AUGUST 2012CALIBRATED BY:DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel	
Peak Particle Velocity L	<u>±5_%</u>	<u>±5 %</u>	X_ <u>ts_</u> %	
Peak Particle Velocity V	<u>±5_%</u>	<u>±5</u> %	Y <u>≠」</u> %	
Peak Particle Velocity T	<u>±5</u> %	±5_%	Z <u>≠</u> √%	

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted _//A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

DATE:

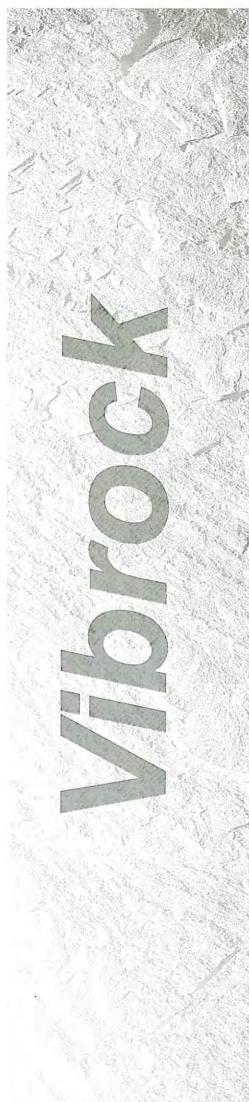
THIS CERTIFICATE IS VALID FOR 12 MONTHS

The above calibration was carried out using equipment calibrated as follows:-Pulsar Acoustic Calibrator 100B, serial number 60796, calibrated March 2012 ISO-TECH IFG 100 Oscillator, serial number 300351, calibrated June 2012 Monitran Vibration Meter, serial number 213608, calibrated June 2012 Precision Gold PG012 Multimeter, serial number 09000182, calibrated June 2012

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08121568
IO.:
Forth Crossing Bridge Constructors
V901-GSM
1568
14TH AUGUST 2012
DENNIS LORD
DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel	
Peak Particle Velocity L	<u>±</u> 5_%	<u>%</u>	X <u>ts</u> %	
Peak Particle Velocity V	±5_%	tr %	Y 15 %	
Peak Particle Velocity T	<u>±5 %</u>	±5 %	z <u>=5</u> %	

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted <u>AA</u> dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

DATE:

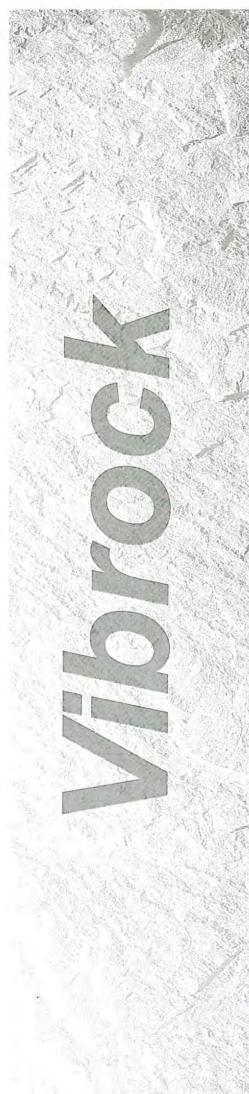
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CALIBRATION CERTIFICATE NO	08121569
CLIENT:	Forth Crossing Bridge Constructors
INSTRUMENT TYPE:	V901-GSM
SERIAL NUMBER:	1569
CALIBRATION DATE:	14TH AUGUST 2012
CALIBRATED BY:	DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	<u>ts</u> %	<u>t5</u> %	X <u>≠厂</u> %
Peak Particle Velocity V	<u>±5 %</u>	<u>±</u> 5_%	Y =5 %
Peak Particle Velocity T	±5_%	<u>±5</u> %	z <u>±s</u> %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted _N/A_dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

DATE:

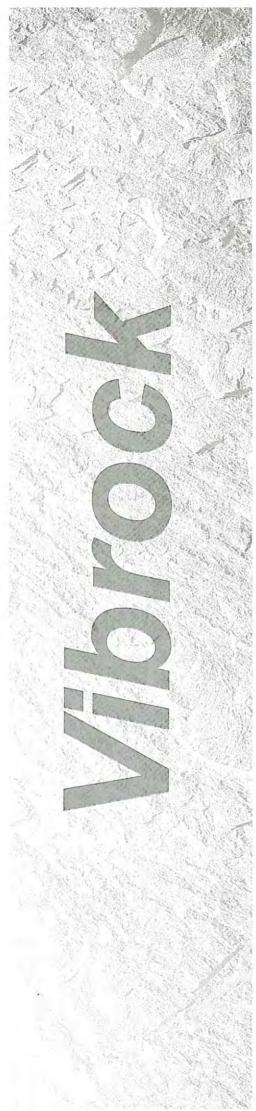
THIS CERTIFICATE IS VALID FOR 12 MONTHS

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CALIBRATION CERTIFICATE NO .:

CLIENT: INSTRUMENT TYPE: SERIAL NUMBER: CALIBRATION DATE: CALIBRATED BY: 08121570

Forth Crossing Bridge Constructors
V901-GSM
1570
14TH AUGUST 2012

DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	<u>±5</u> %	<u>±5</u> %	X <u>±5</u> %
Peak Particle Velocity V	<u>±5</u> %	<u>*</u> 5%	Y <u>*</u> 5%
Peak Particle Velocity T	<u>ts</u> %	<u>±5</u> %	Z <u>±s</u> %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted _____ dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

DATE:

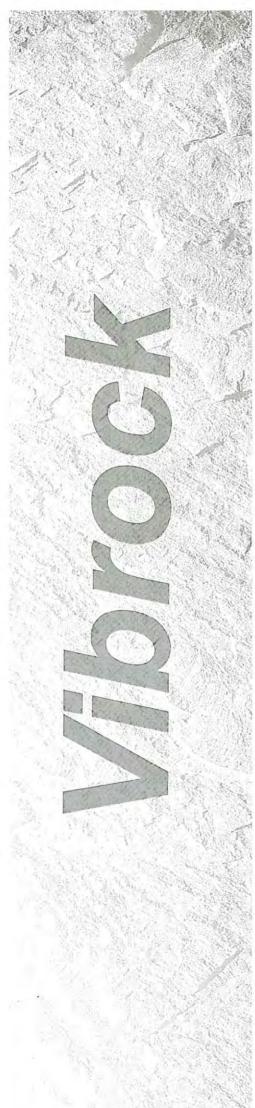
THIS CERTIFICATE IS VALID FOR 12 MONTHS

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CALIBRATION CERTIFICATE NO .:

CLIENT: INSTRUMENT TYPE: SERIAL NUMBER: CALIBRATION DATE: CALIBRATED BY:

	08121571
Forth	Crossing Bridge Constructors
-	V901-GSM
	1571
1	14TH AUGUST 2012
	DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5_%	<u>±5</u> %	X <u>≠5</u> %
Peak Particle Velocity V	±5_%	<u>±5_%</u>	Y <u> </u>
Peak Particle Velocity T	±5_%	<u>ts</u> %	<u>z_*</u> %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted <u>AA</u> dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

DATE:

14TH AUGUST 2012

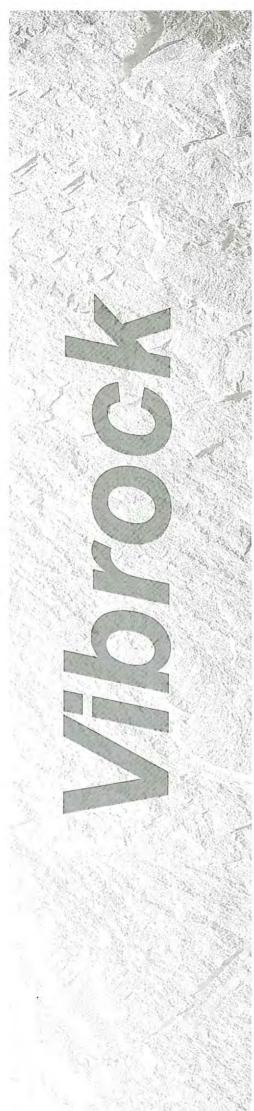
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CALIBRATION CERTIFICATE NO.: _

CLIENT: INSTRUMENT TYPE: SERIAL NUMBER: CALIBRATION DATE: CALIBRATED BY:

orth Crossing Bridge Constructo
V901-GSM
1572
14TH AUGUST 2012

DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5_%	±5 %	X <u>+5</u> %
Peak Particle Velocity V	±5 %	<u>*2*</u> %	Y%
Peak Particle Velocity T	±5_%	±5_%	z <u>+</u> 5%

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted N/A dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

DATE:

14TH AUGUST 2012

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 08121612

 CALIBRATION CERTIFICATE NO.:

 Forth Crossing Bridge Constructors

 CLIENT:

 INSTRUMENT TYPE:
 V901-GSM

 SERIAL NUMBER:
 1612

 CALIBRATION DATE:
 14TH AUGUST 2012

 CALIBRATED BY:
 DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	<u>±5_%</u>	<u>±5</u> %	x <u>±5</u> %
Peak Particle Velocity V	±5_%	<u>±5</u> %	Y <u>= 5</u> %
Peak Particle Velocity T	±5_%	±5-%	z <u>≠5</u> %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted <u>A</u> dB(Lin)

WE HEREBY CERTIFY THAT THIS SEISMOGRAPH FULLY COMPLIES WITH THE MANUFACTURERS SPECIFICATION

CERTIFIED BY:

14TH AUGUST 2012

DATE:

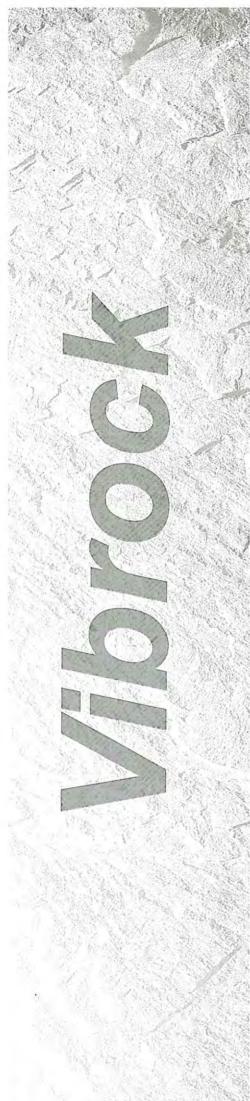
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 08121613

 CALIBRATION CERTIFICATE NO.:

 Forth Crossing Bridge Constructors

 CLIENT:

 INSTRUMENT TYPE:
 V901-GSM

 SERIAL NUMBER:
 1613

 CALIBRATION DATE:
 14TH AUGUST 2012

 CALIBRATED BY:
 DENNIS LORD

CALIBRATION ACCURACY:-

	A channel	B channel	VDV channel
Peak Particle Velocity L	±5 %	±5 %	X <u>±5</u> %
Peak Particle Velocity V	±5_%	±1_%	Y <u>±s</u> %
Peak Particle Velocity T	±5_%	<u>±5</u> %	Z <u><i>t</i></u> %

AIR OVERPRESSURE CHANNEL - Peak Level Unweighted <u>A</u> dB(Lin)

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CERTIFIED BY:

14TH AUGUST 2012

DATE:

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