Contractor

FCBC
Queensferry Crossing
DRAGADOS | AMERICAN BRIDGE INTERNATIONAL
HOCHTIEF | MORRISON CONSTRUCTION

Project

FORTH REPLACEMENT CROSSING

Document title

VIBRATION MONITORING REPORT

AUGUST 2017

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INTRODUCTION

1.1. Monitoring of construction vibration is being undertaken by FCBC during the construction of the new Forth Crossing and associated road network. This report covers the month of August 2017. The objective of this report is to detail the vibration monitoring that has been undertaken across the site during this period, which has been done so in accordance with the Code of Construction Practice (CoCP), and Noise and Vibration Management Plan (NVMP).

1.2. FCBC carefully risk assesses noise & vibration likely to result from all construction activities, through the production of Plans for Control of Noise & Vibration (PCNVs). During the preparation of PCNVs, vibration prediction assessments are made. These assessments illustrate that no construction plant, equipment or methodology to be used by FCBC are envisaged to induce any levels of vibration at sensitive receptors that would exceed the vibration threshold levels stated in the CoCP. These assessments/predictions have been validated by means of the vibration monitoring results displayed in this report.

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, for example, footsteps or doors being slammed, or indeed any significant movements occurring close to the monitoring equipment.

2.2. According to the BS5228-2 (2009) there is minimal documented proof of actual damage to structures or their finishes resulting from construction vibration, and damage resulting solely from well-controlled construction and demolition vibration is rare. There are many other mechanisms that cause damage, especially in decorative finishes, and it is often incorrectly concluded that vibrations from construction and demolition sites are to blame. In many cases it is not possible to ascertain the exact source of vibration, though it is possible to rule out construction as a source on an activity basis.

2.3. The works carried out in each of the various construction work areas as well as the related vibration assessments are summarised in Appendix A.

2.4. Considering the distances between the various construction work areas and sensitive receptors as well as working methods utilised, the risk of any damage to structures or nuisance to residents occurring as a result of FCBC construction-related vibration is highly unlikely.

2.5. The number of threshold exceedances at the various vibration monitoring stations during the relevant period are shown in Table 1 below.

Table 1: Number of exceedances of thresholds set out in the CoCP

August 2017

Location	PPV Exceedance		VDV Exceedance	
	Continuous ($5\ mm.s^{-1}$)	*Intermittent ($10\ mm.s^{-1}$)*	*Day ($0.4\ m.s^{-1.75}$)*	*Night ($0.2\ m.s^{-1.75}$)*
Linn Mill	1	1	1	0
Butlaw Fisheries	3	1	1	0
Clufflat Brae	9	2	0	0
Dundas Home Farm	0	0	0	0
Echline	0	0	0	0
Inchgarvie Lodge	6	5	0	0
Scotstoun	0	1	1	0
Springfield	10	17	0	0
Tigh-Na-Grian	0	0	0	0
Whinnyhill	11	18	0	0

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 of the 3 axis that are recorded during a particular event, and as such is appropriate for the measurement of activities such as blasting, piling and compacting. 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 (e.g. blasting).

2.8. These thresholds are set to protect against building damage. For this monitoring period, all the exceedances have been investigated thoroughly and appear to have been generated as a result of standalone, instantaneous events arising from local interferences, the exact source of which remains unknown.

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. The vibration dose value (VDV), a cumulative measurement of the vibration level received over an 8-hour (night time) or 16-hour (day time) period, is recommended in BS 6472 as the appropriate measure to evaluate human exposure to vibration in buildings in residential and other uses.

2.11. During the monitoring period, vibratory rollers and whacker plates were used intermittently at several locations around the site however no exceedances were recorded as a result of the use of this equipment.

2.12. Detailed investigation of all other exceedances (i.e. review of PPV levels over 30 seconds periods) has suggested that each resulted from isolated, non-construction related events, which occurred close to the monitoring station.

2.13. Within the Appendix B, there are gaps of missing data in the PPV and VDV at all monitoring locations. This occurred due to the annual calibration of the vibration monitors. There is also a gap of missing data at Linn Mill due to a power issue.

3. CONCLUSION

3.1. Considering the distance between FCBC construction works and sensitive 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 are unlikely to be generated by construction, but rather show local interference around the monitoring equipment.

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APPENDIX A – MONITORING LOCATIONS & VIBRATION ASSESSMENTS FROM RELEVANT PCNVs

Table 2: Monitoring Locations

Ref.	Monitoring Location	Crossing or Network	Main Construction Activities During August 2017
M1	Whinny Hill	Network	• Earth Works/Fill Placement • Main carriageway roadworks
M3	Tigh-Na-Grian	Crossing	• Central Tower stay cable installation works • North Tower stay cable installation works • Bridge Deck works
M7	Butlaw Fisheries	Crossing	• Central Tower stay cable installation works • Deck surfacing • Wind shield installation • South Tower stay cable installation works • Bridge deck works
M10	Inchgarvie Lodge	Crossing	• Minor main carriageway works • SUDS detention basin works • Waterproofing on deck • Deck surfacing • Wind shield installation • South Tower stay cable installation works • Bridge deck works • South abutment works
M11	Linn Mill	Network (close proximity to Crossing)	• Minor main carriageway works • Waterproofing on deck • Surfacing works • Wind shield installation • Scour protection • South Tower stay cable installation works • Bridge deck works • South abutment works
M13	Clufflat Brae	Crossing	• Minor main carriageway works • SUDS detention basin works • Waterproofing on deck • Deck surfacing • Wind shield installation • South Tower stay cable installation works • Bridge deck works • South abutment works • Cycle/footpath works
M14	Springfield	Network	• Minor main carriageway works • SUDS detention basin works • South abutment works
M15	Echline	Network	• South Abutment works • Cycle/footpath works
M16	Scotstoun	Network	• Main carriageway roadworks

M17	Dundas Home Farm	Network	• Main carriageway roadworks
M18	Newton	Network	• Outside Works Area

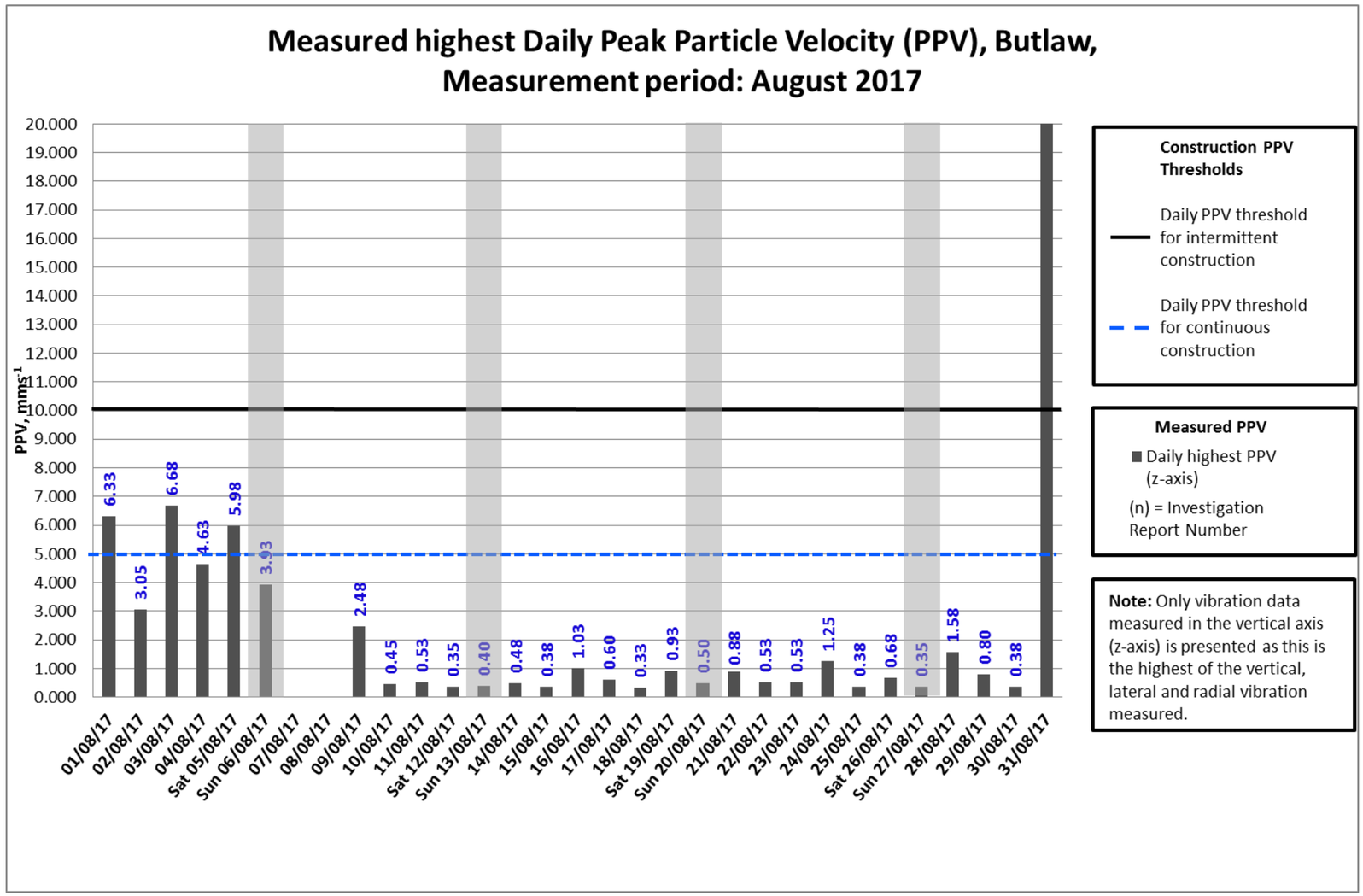
Table 3: PCNV Predicted PPV & VDV Levels

Monitor	Minimum distance from work areas (m)		Type of vibration emitting plant/activity operated at nearest work areas	Worst case predicted vibration levels	
	Day (07:00-19:00)	Night (19:00-07:00)		PPV (mm/s)	eVDV ($m.s^{-1.75}$)
Butlaw Fisheries	130	160	Roller/Whacker	0.44	0.23
Clufflat Brae	40	90	Roller/Whacker	2.44	0.37
Dundas	75	2000	Roller/Whacker	0.98	0.33
Echline	40	1000	Roller/Whacker	2.44	0.37
Inchgarvie Lodge	50	40	Roller/Whacker	1.77	0.33
Linn Mill	60	250	Roller/Whacker	1.36	0.33
Scotstoun	40	2000	Roller/Whacker	2.44	0.37
Springfield	50	300	Roller/Whacker	1.77	0.33
Tigh-Na-Grian	200	200	N/A	-	-
Whinny Hill	180	1800	Roller/Whacker	0.383	0.04

Notes on Table 3

- All plant used during construction activities has been assessed with respect to vibration. The only plant utilised considered to generate appreciable levels of vibration was a vibratory roller and a whacker plate (NOTE: Hydraulic rock breakers which typically generate 4.5mm/s @ 5m, 0.4mm/s @ 20m, 0.1mm/s @ 50m have been discounted due to the distances of use from the closest receptors).
- Vibratory rollers were not operated within 20m of any sensitive receptor.
- Whacker plates were not utilised within 40m of any occupied sensitive receptor.
- All roller eVDV values in the table above are based on the worst case scenario of a vibratory roller remaining in continuous operation for 2 hours an average distance (100m) from the nearest occupied receptors.
- All whacker plate eVDV values in the table above are based on the worst case scenario of a whacker plate remaining in continuous operation for 2 hours a minimum distance from the nearest receptor.

APPENDIX B – VIBRATION GRAPHS



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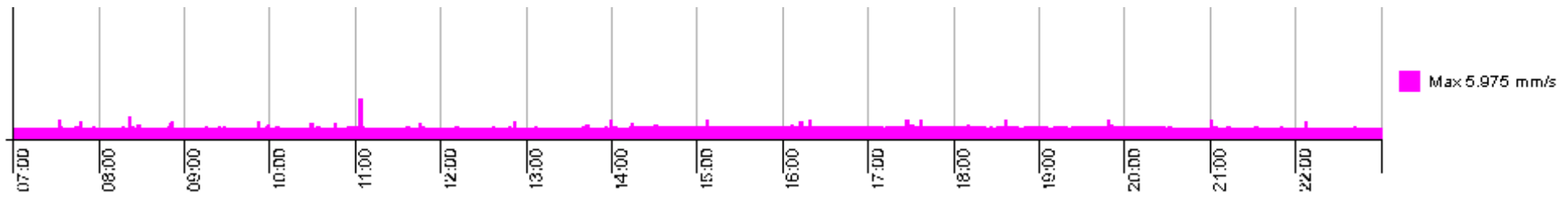
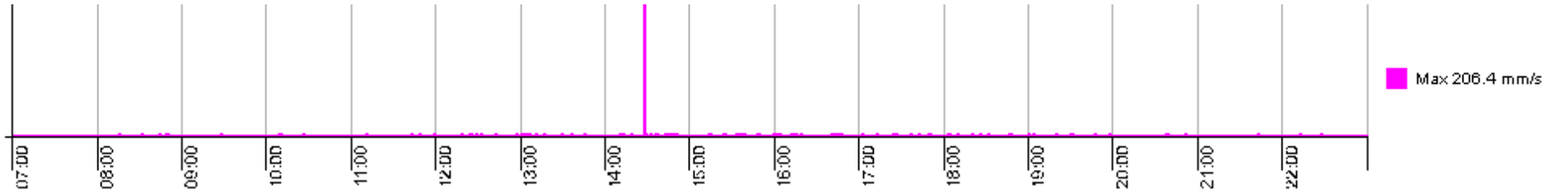
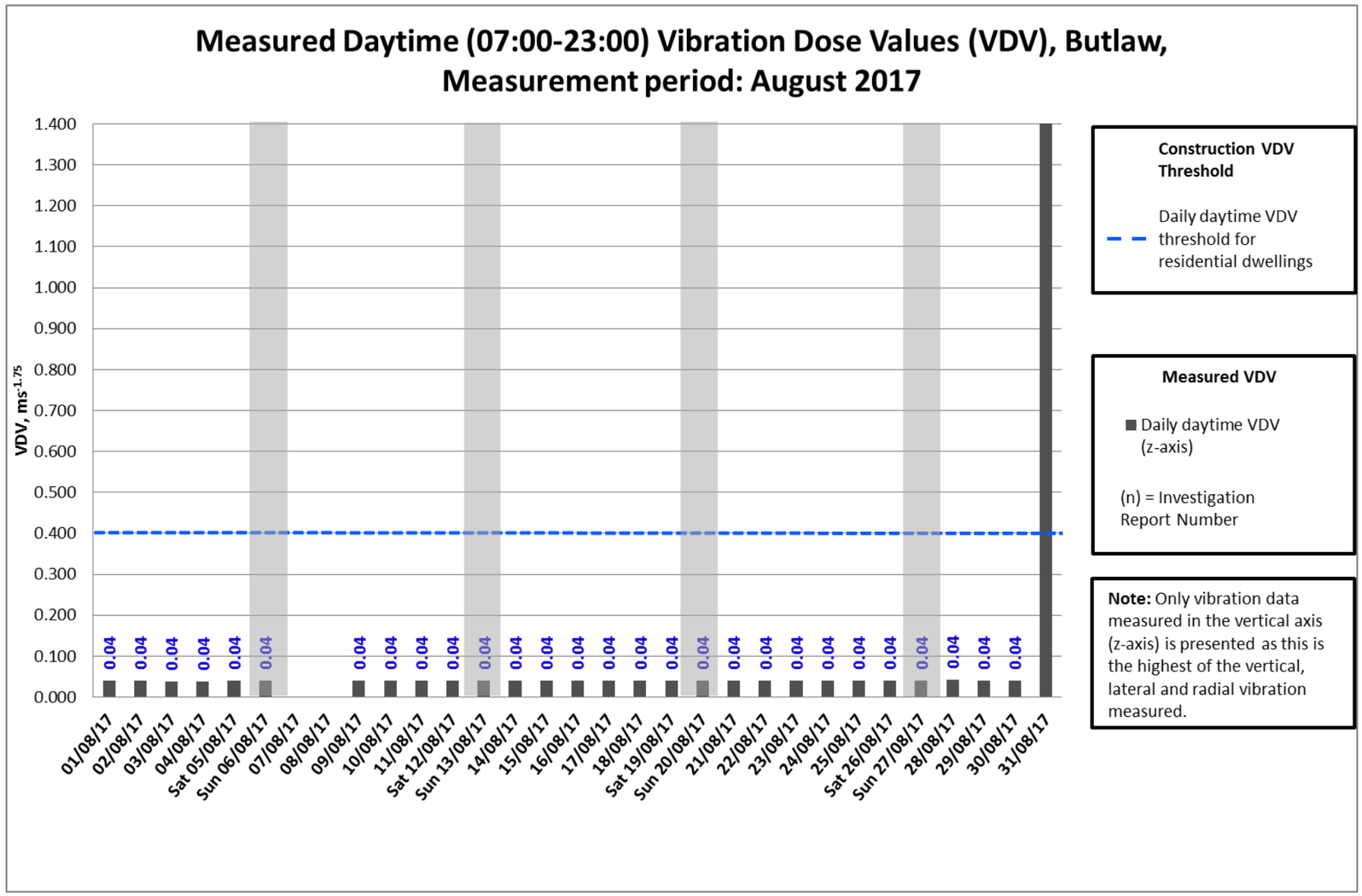


Exceedances on the 1st, 3rd and 5th of August have been investigated and found to be caused by individual isolated events that are unlikely to have been construction related activities (graph above from the 05/08/2017). The vibration monitor is located in the residents back garden, therefore resident's activity may have caused these exceedances.



Exceedance on the 31st of August has been investigated and found to be caused by the environmental team collecting data from noise monitor.



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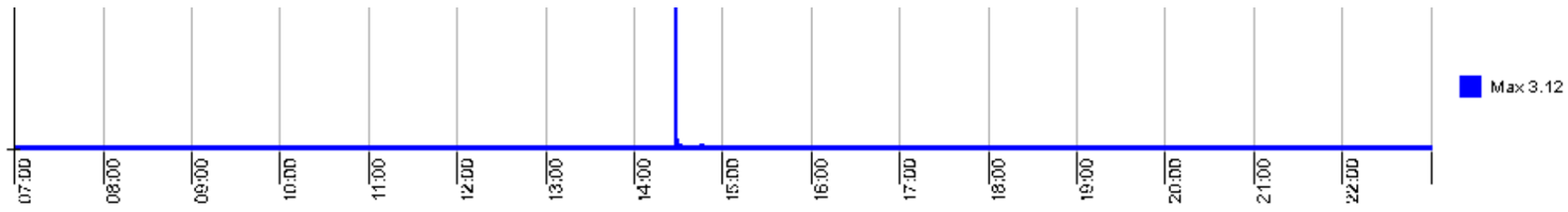

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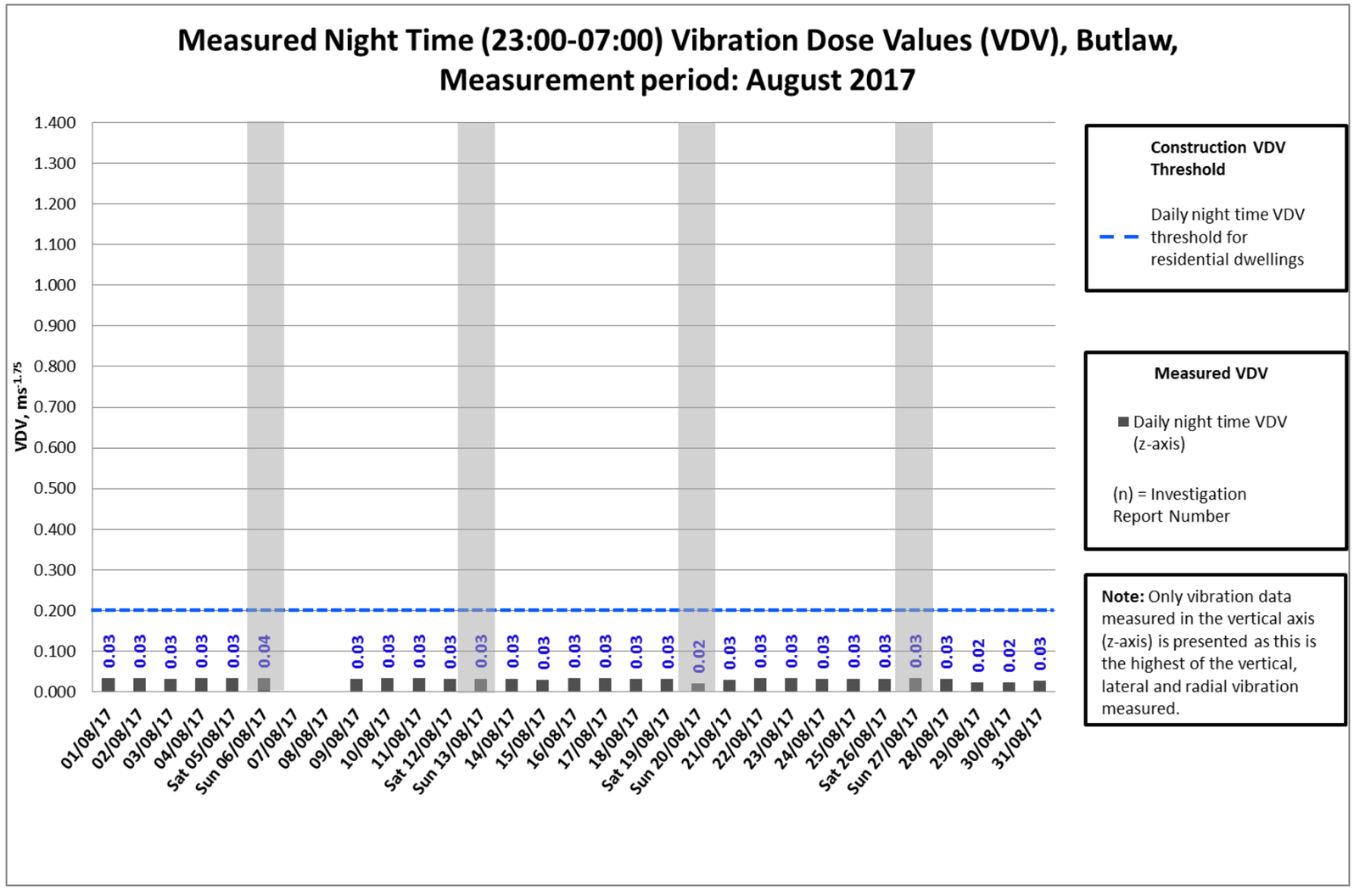

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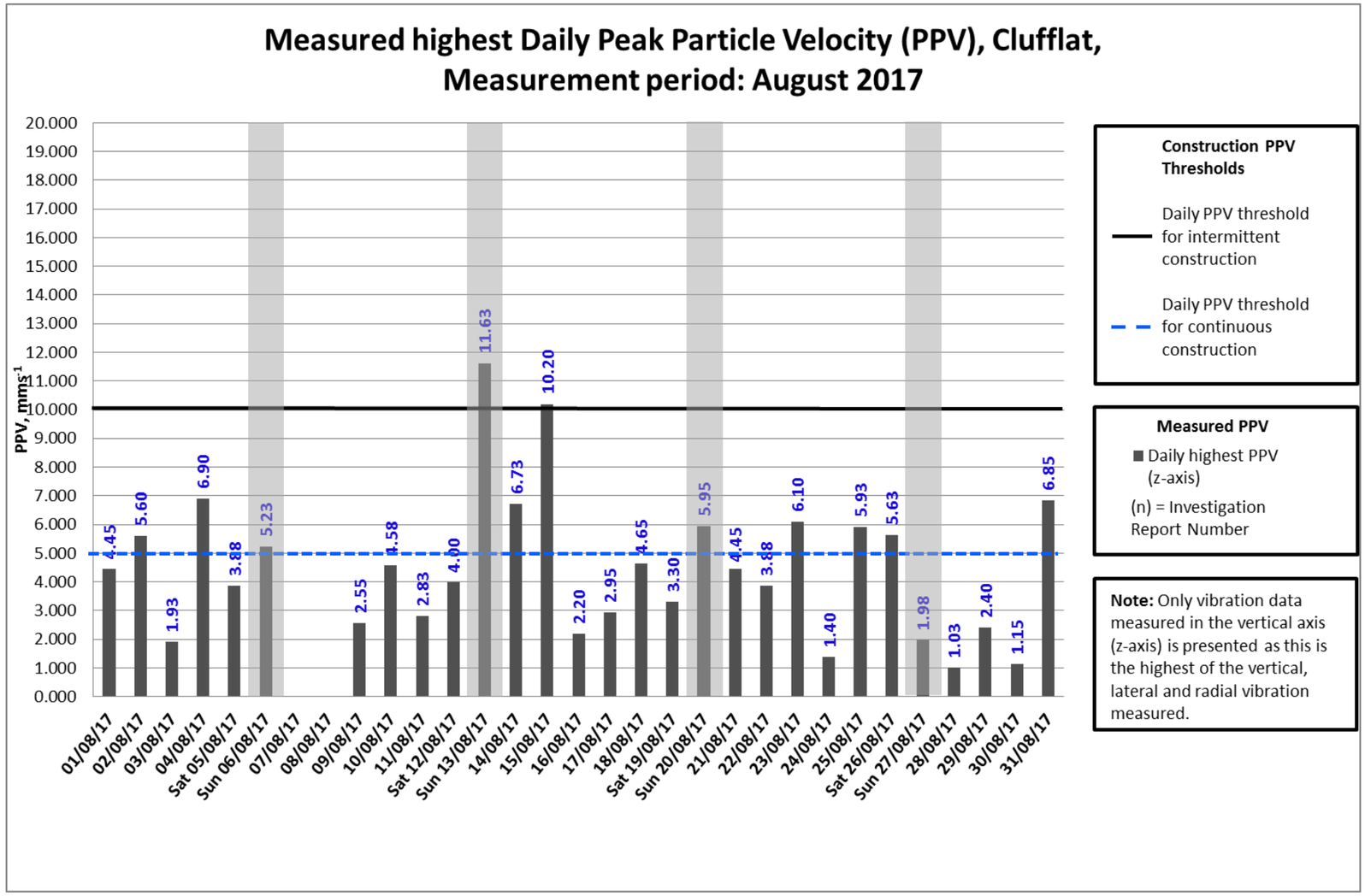

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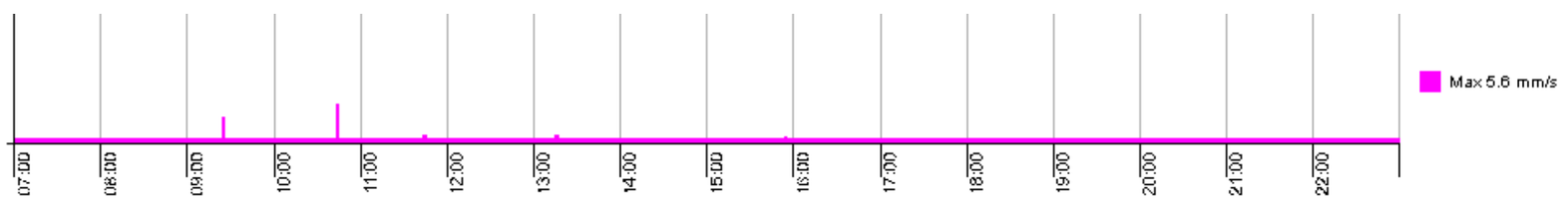
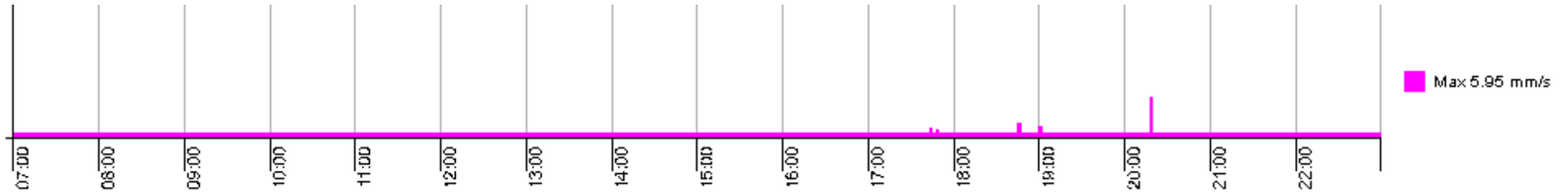
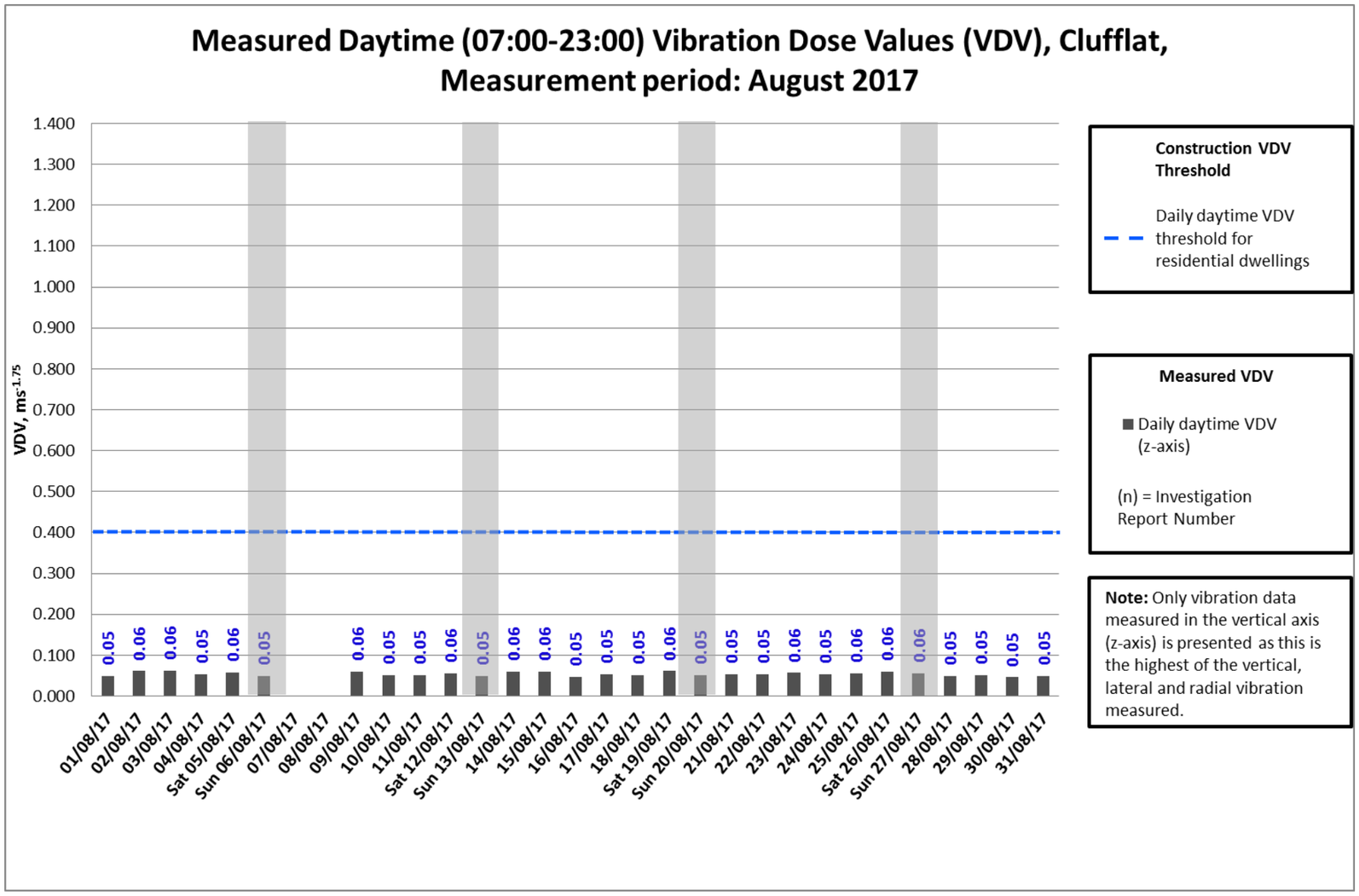


Exceedances on the 2nd, 4th, 13th, 14th, 23rd, 25th and 31st of August have been investigated and found to be caused by individual isolated events that are unlikely to have been construction related activities (graph above from the 02/08/2017). With this monitor being located in a public amenity area there is a likelihood that the exceedances seen above might have been caused by pedestrians using the area.



Exceedances on the 6th, 15th, 20th and 26th of August have been investigated and found to be caused out with construction working hours therefore it is unlikely that a construction related activity was the cause of these events (graph above from the 20/08/2017).



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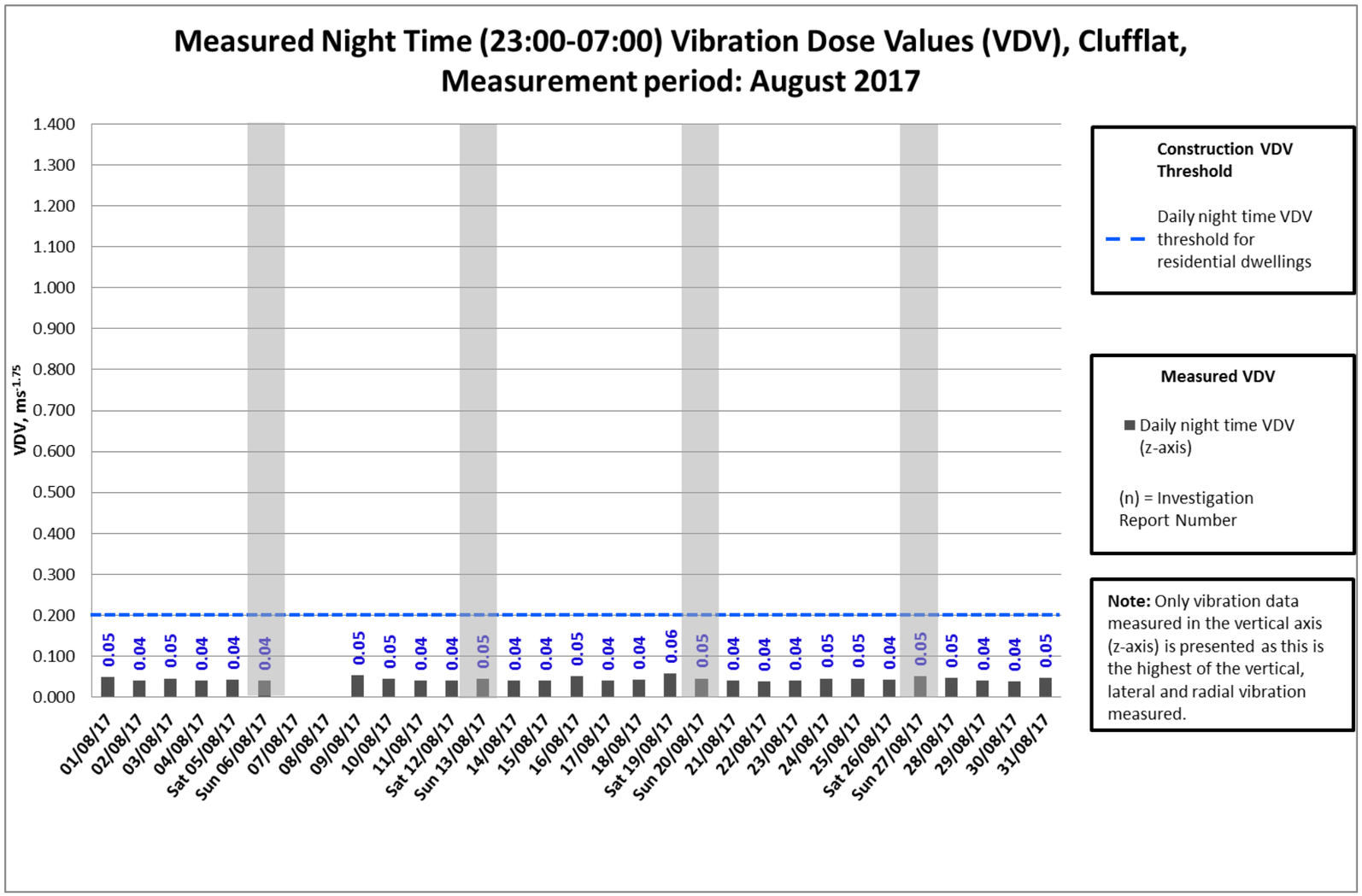

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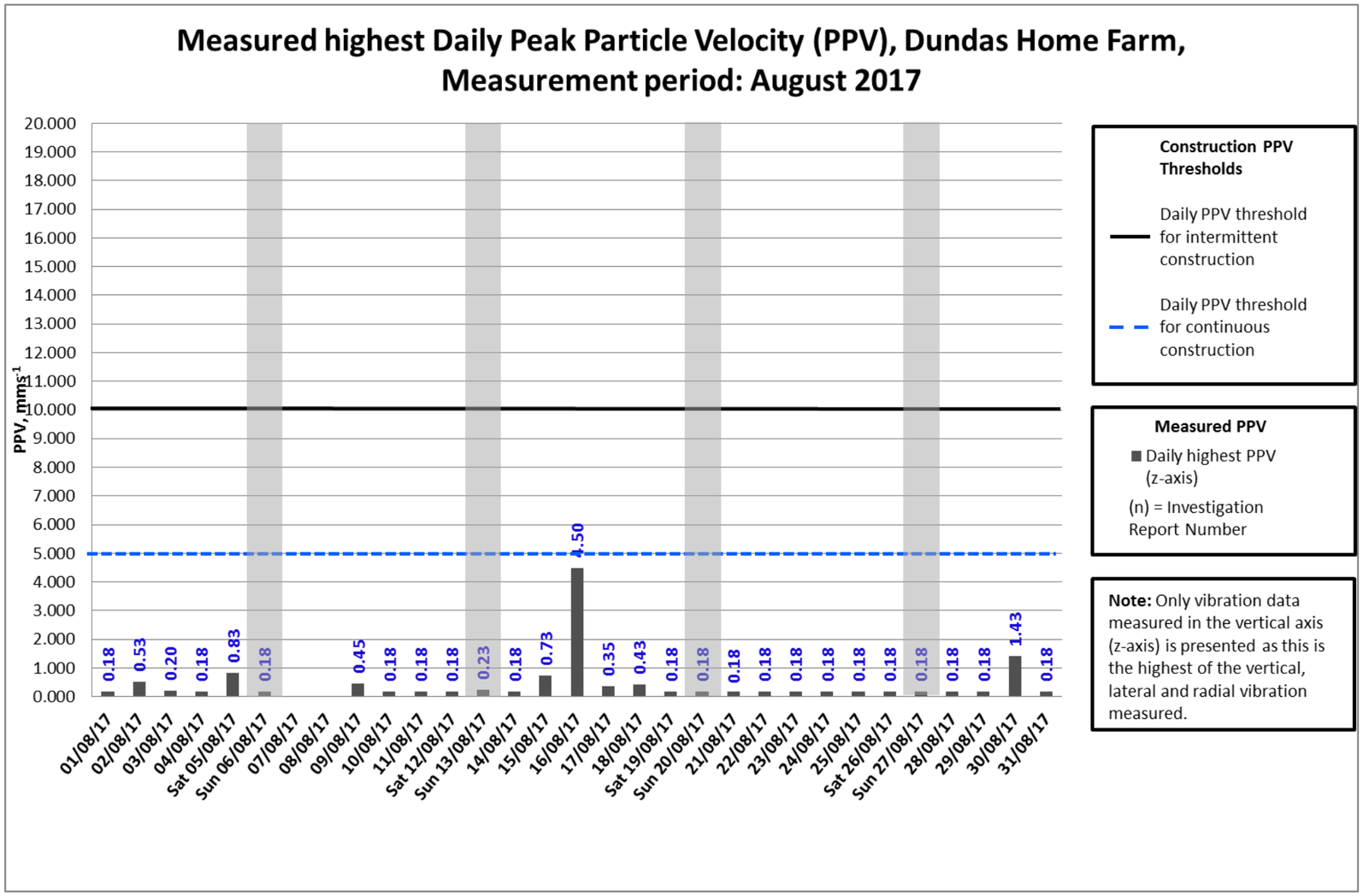

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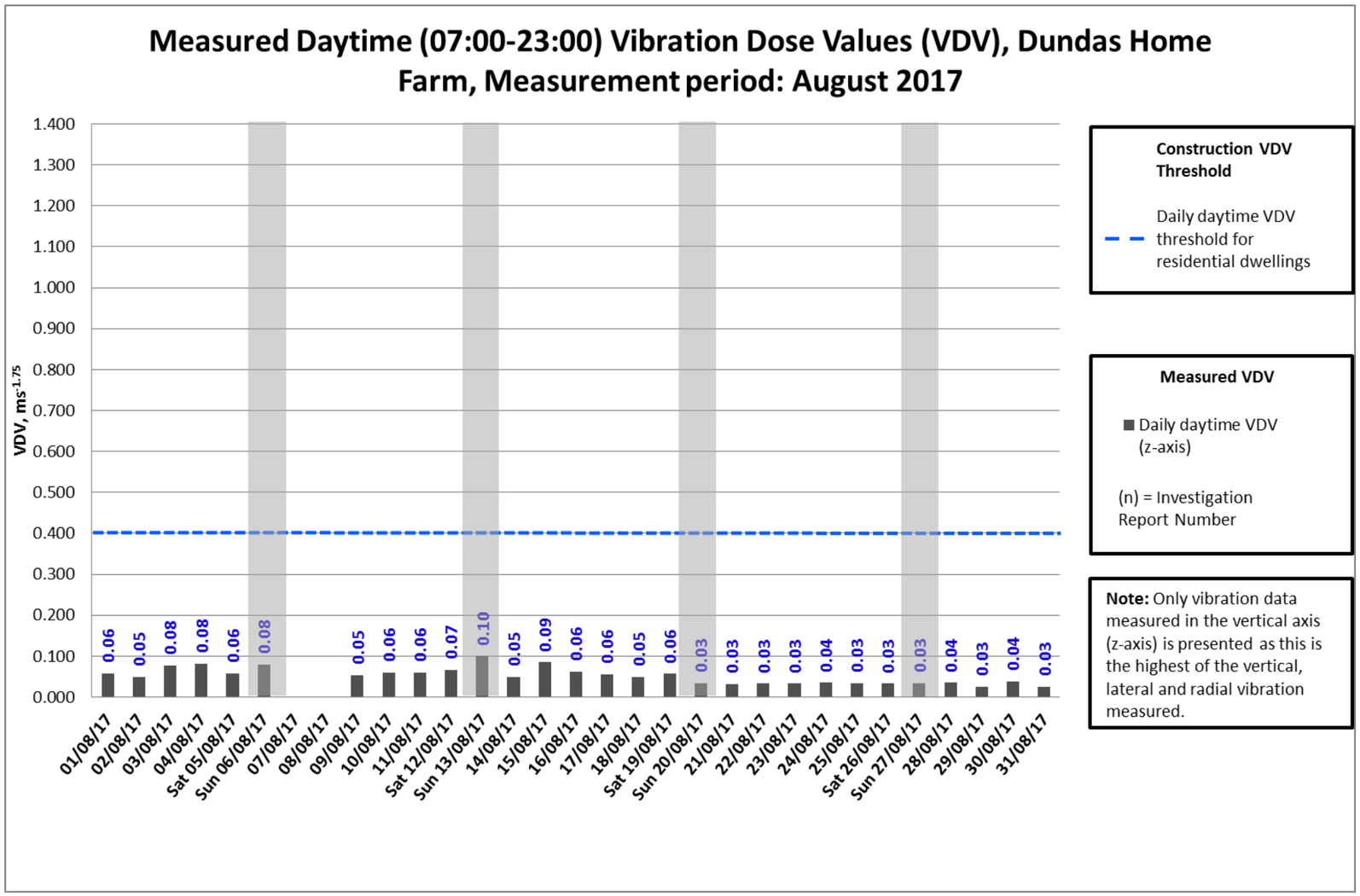

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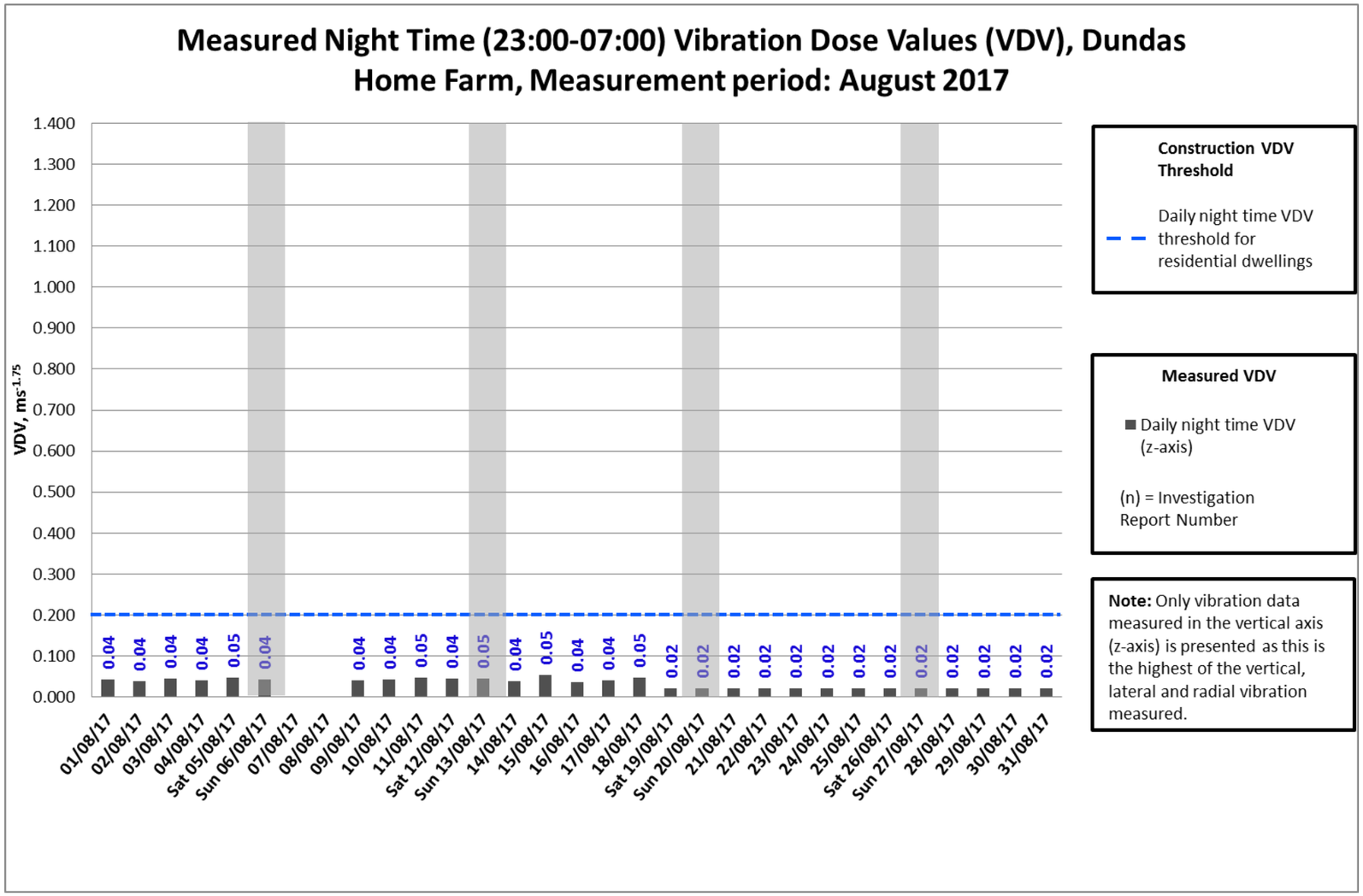

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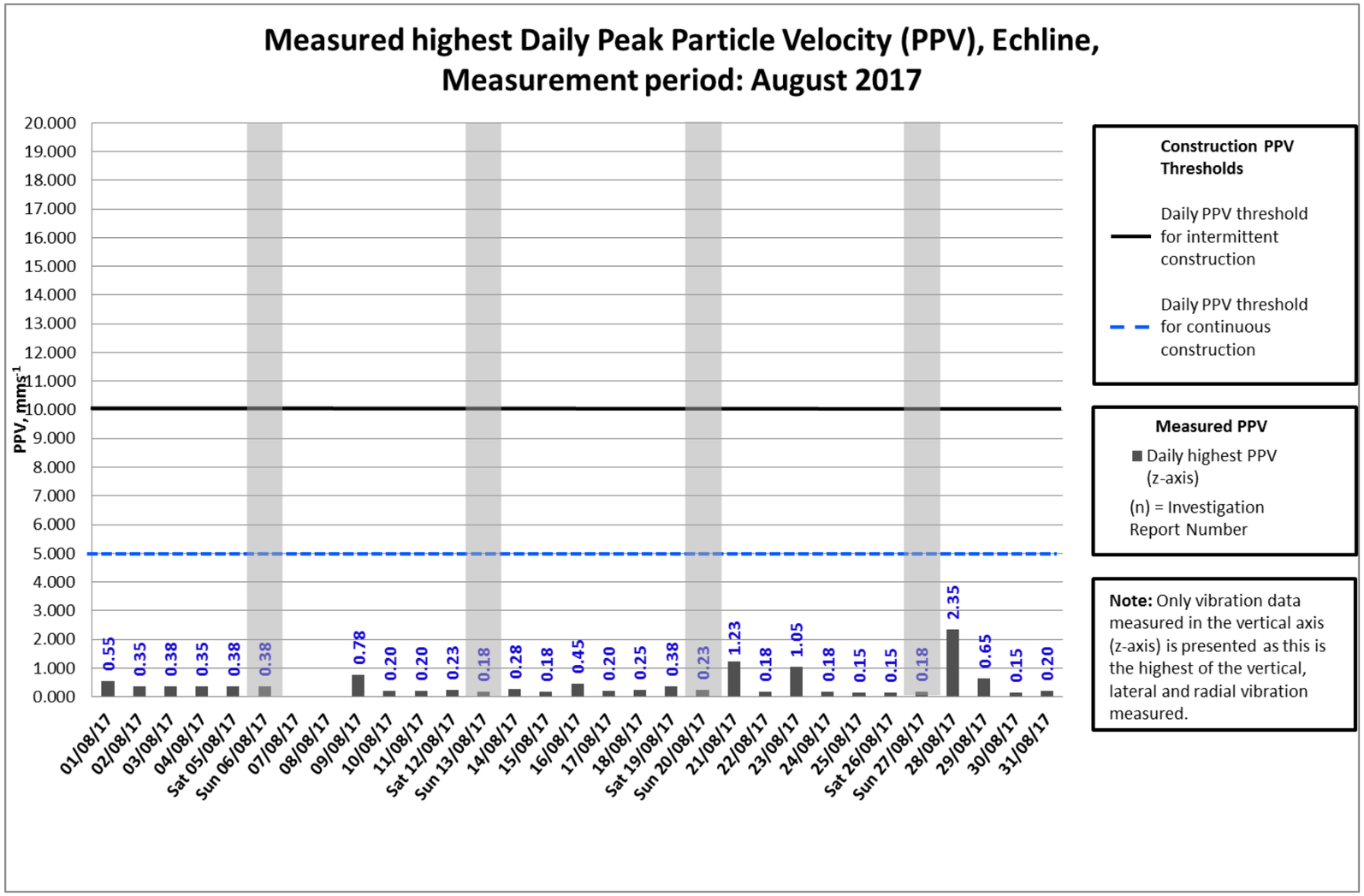

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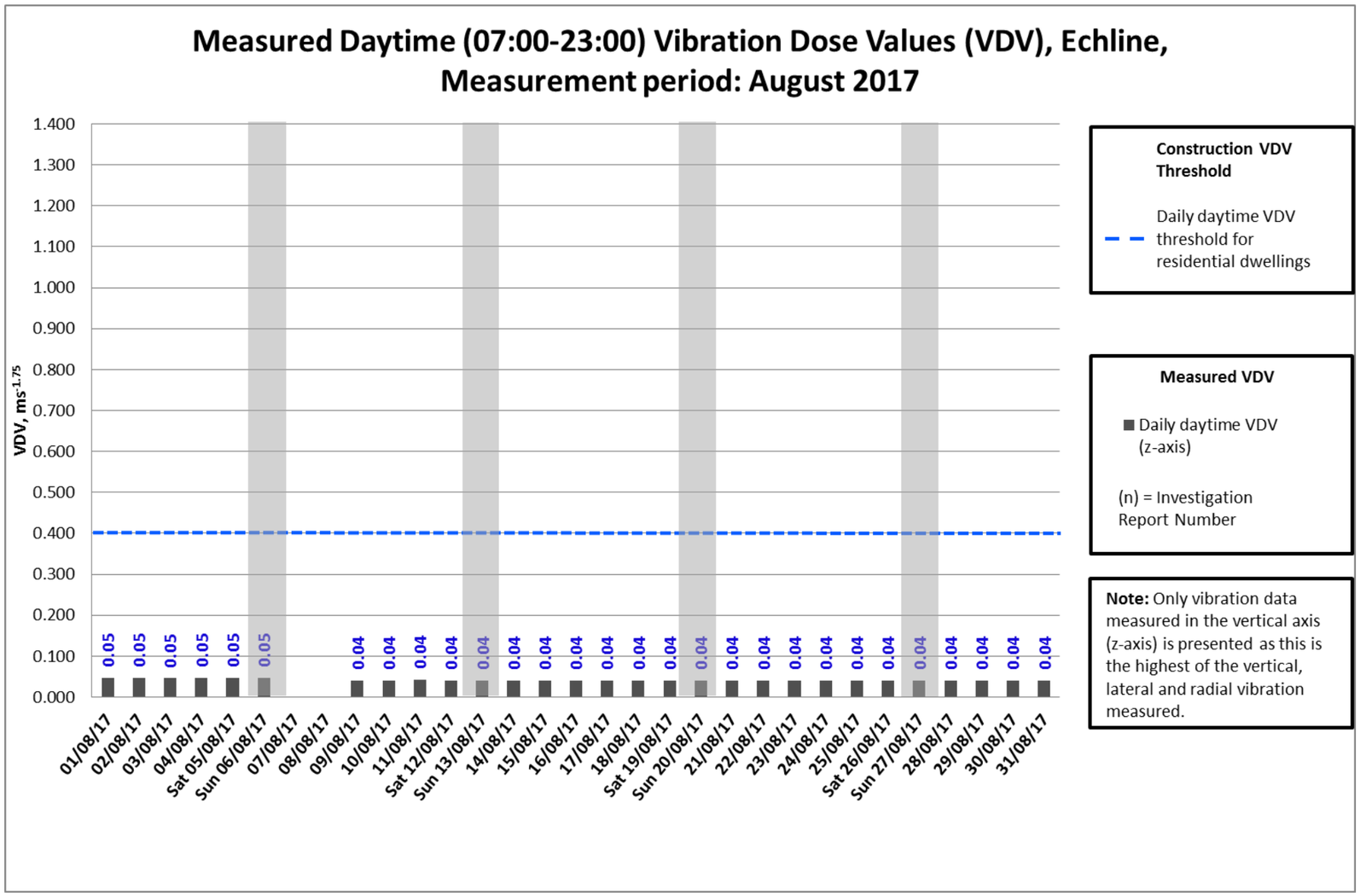

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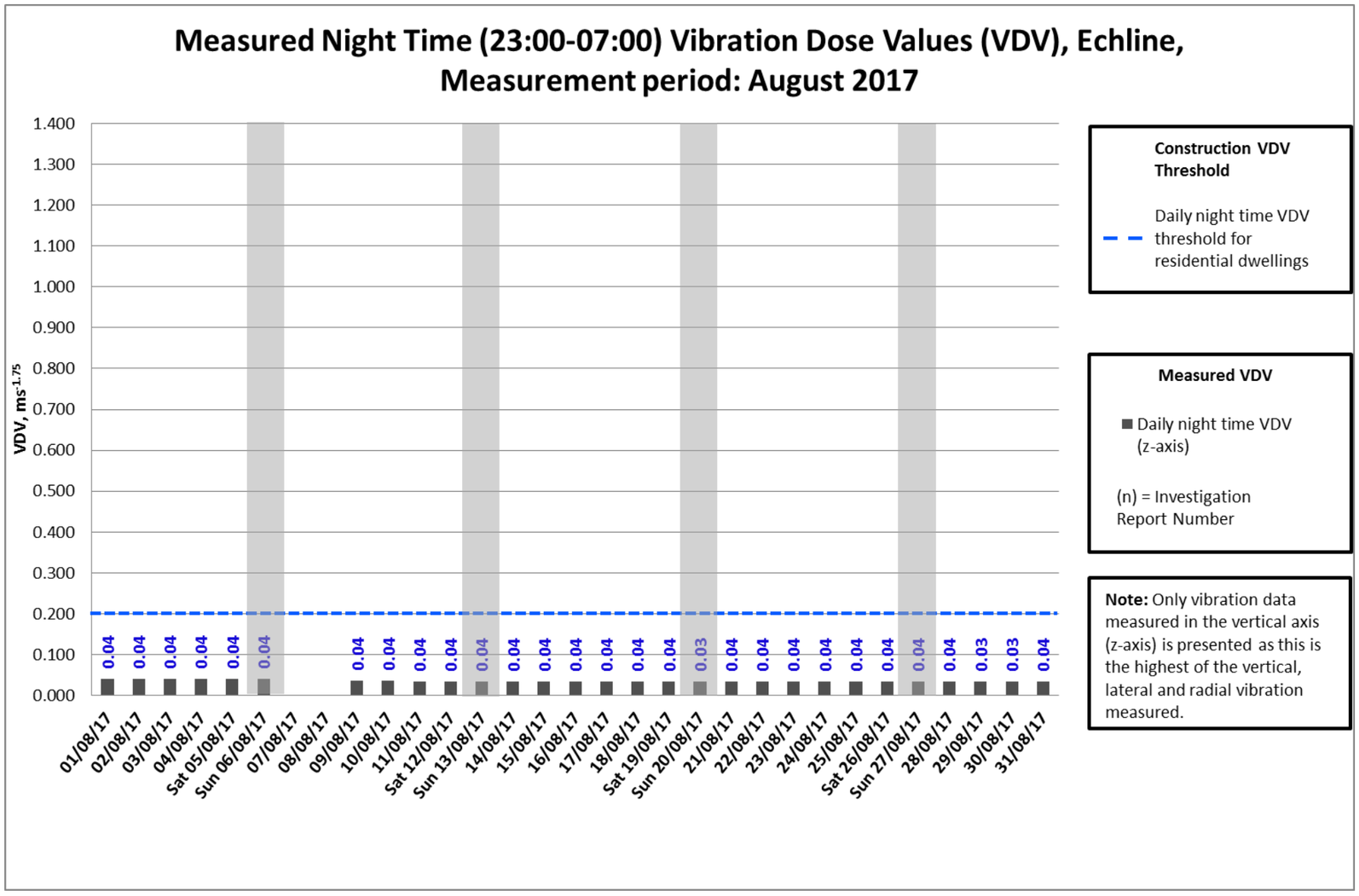

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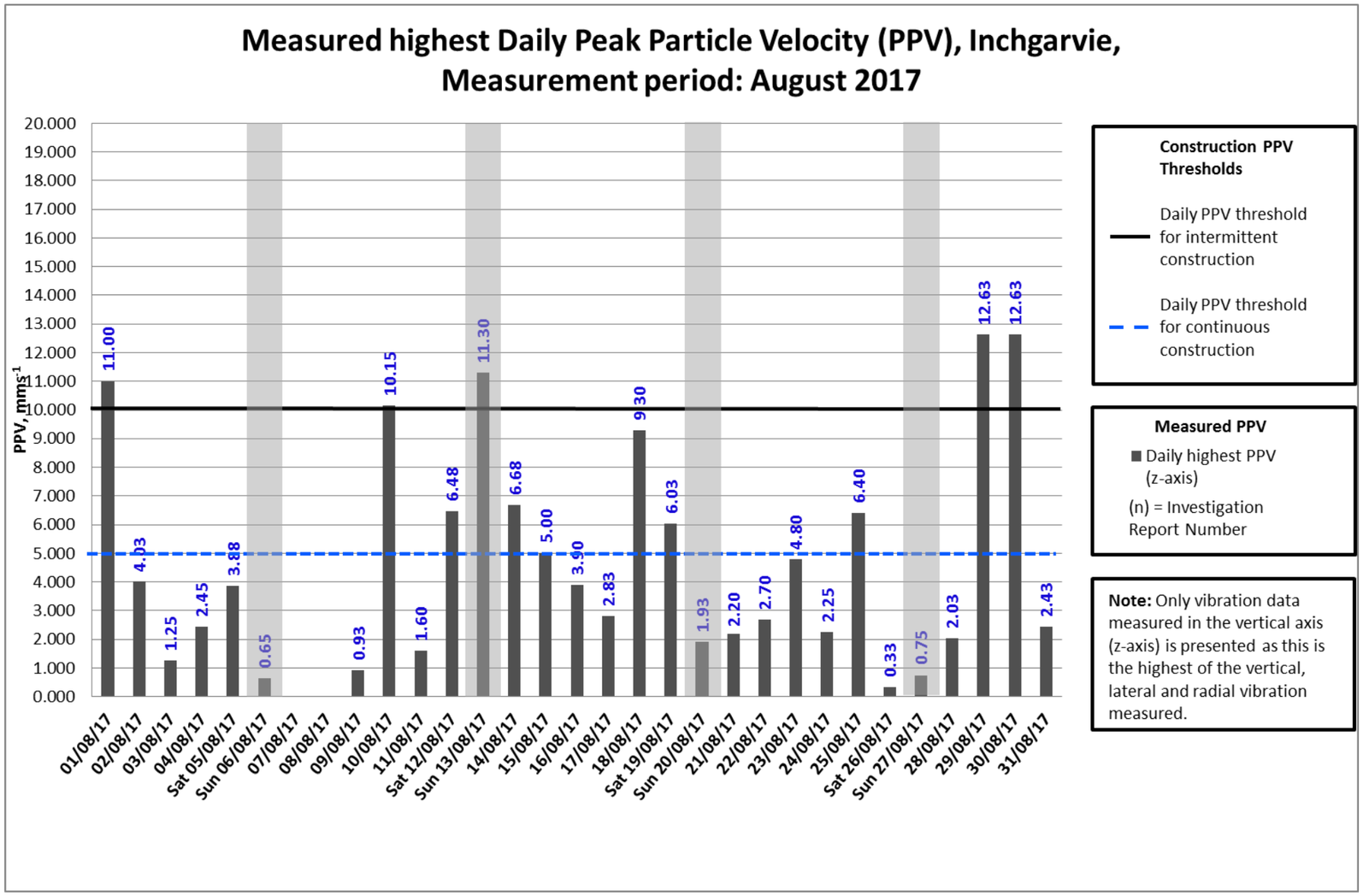

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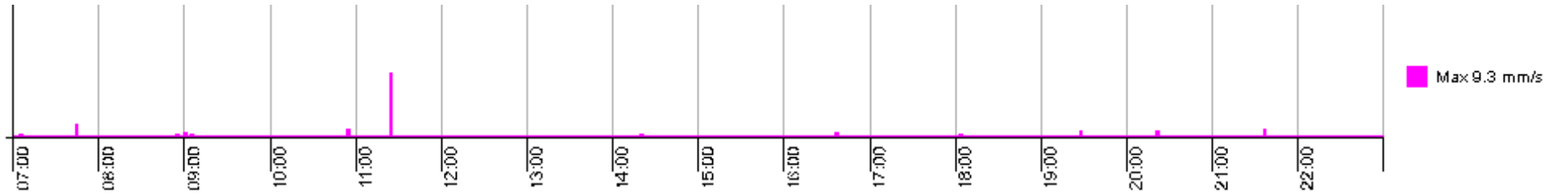
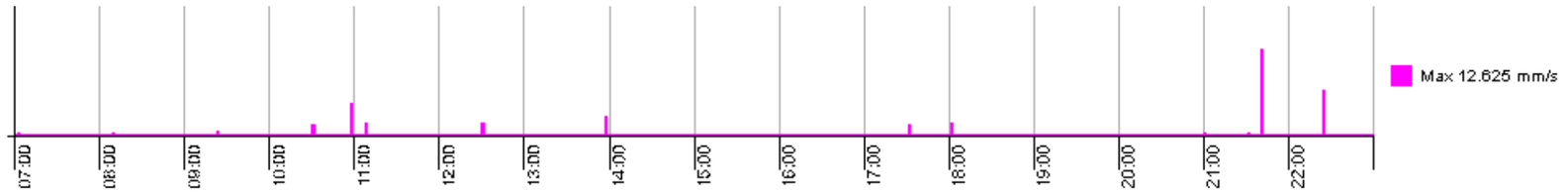
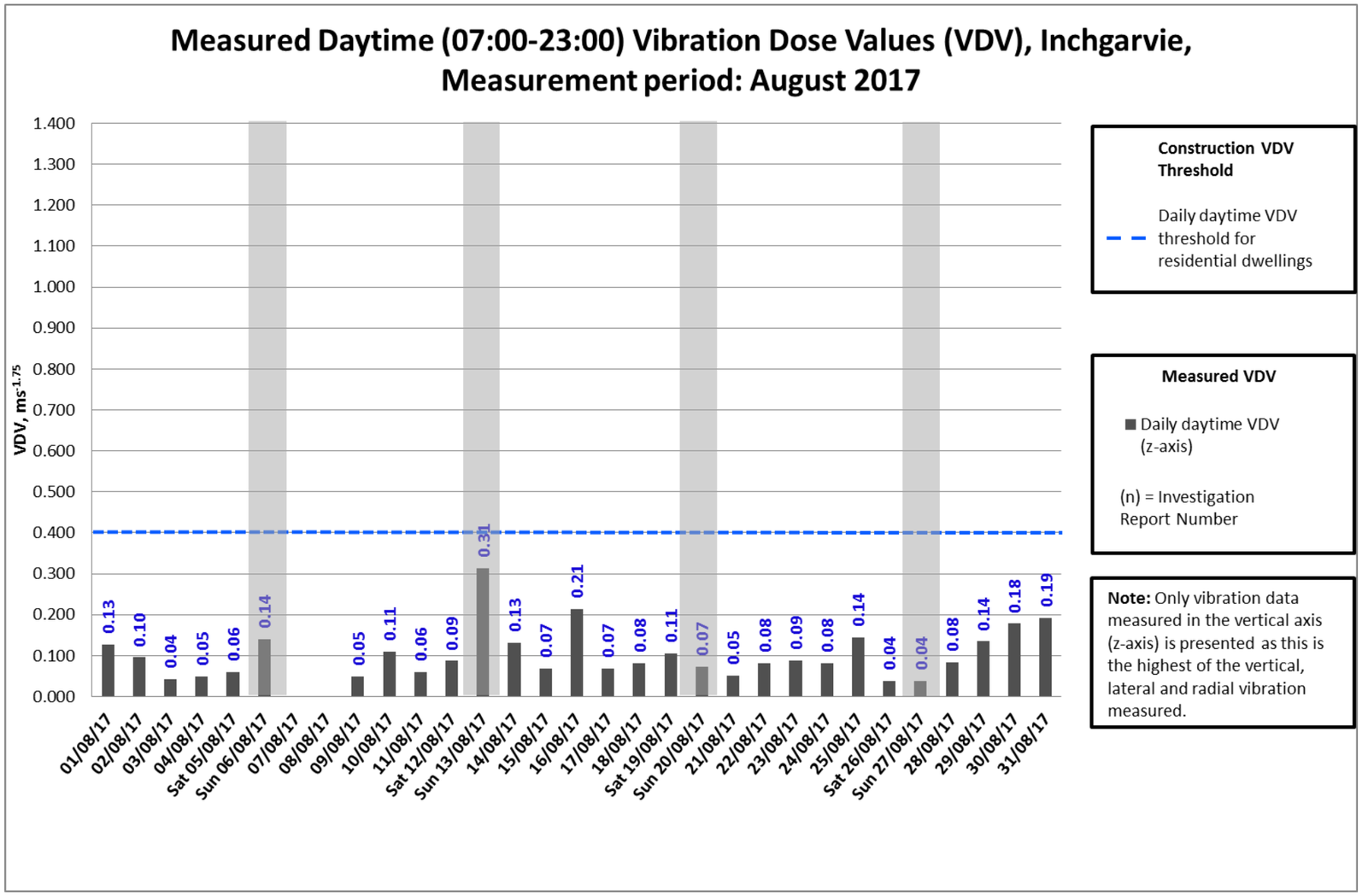


Exceedances on the 1st, 10th, 12th, 13th, 14th, 15th, 18th, 19th and 25th of August have been investigated and found to be caused by individual isolated events that are unlikely to have been construction related activities (graph above from the 18/08/2017). The vibration monitor is located in the residents back garden, therefore resident's activity may have caused these exceedances.



Exceedances on the 29th and 30th of August have been investigated and found to be caused out with construction working hours therefore it is unlikely that a construction related activity was the cause of these events (graph above from the 29/08/2017).



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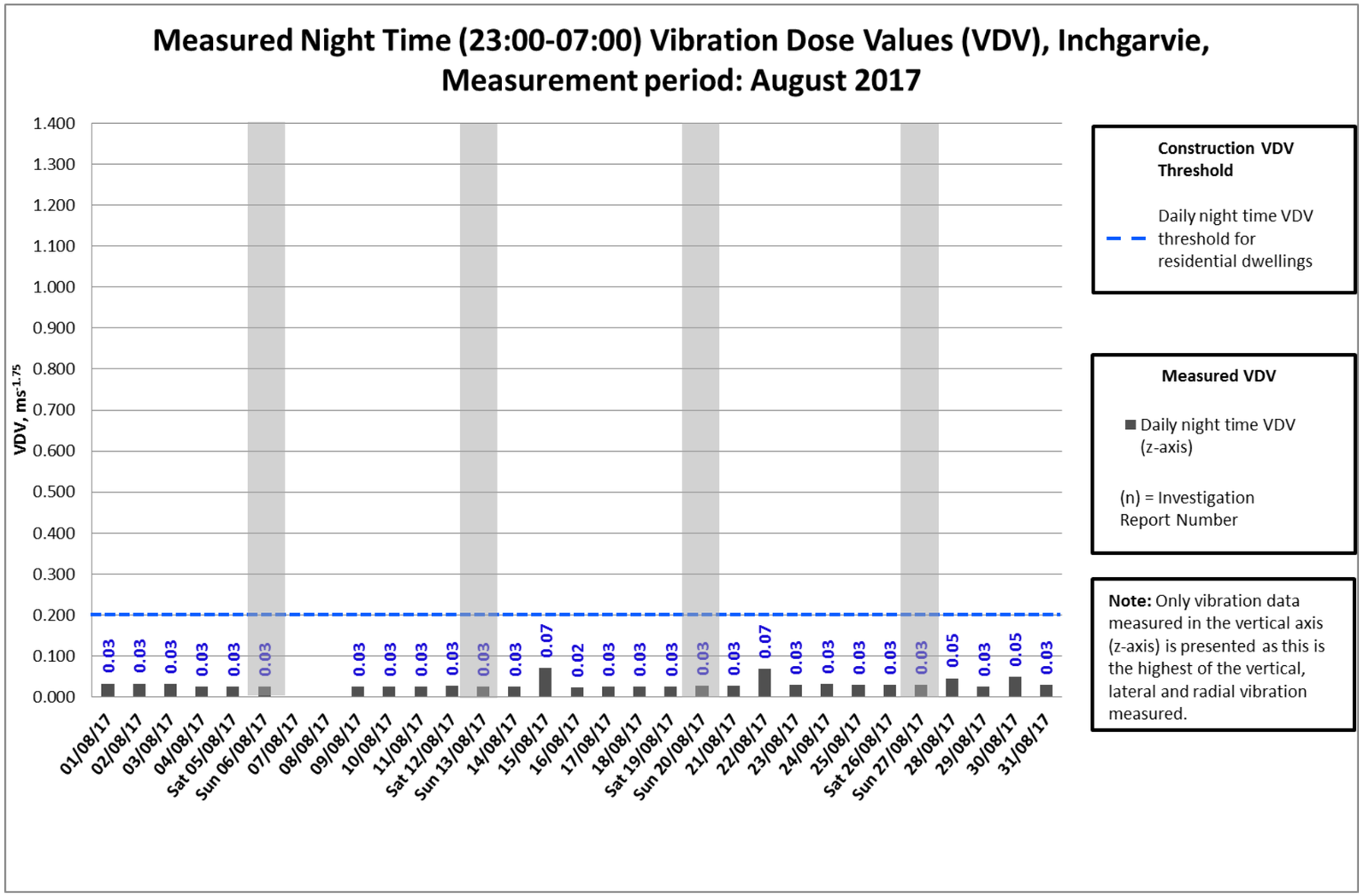

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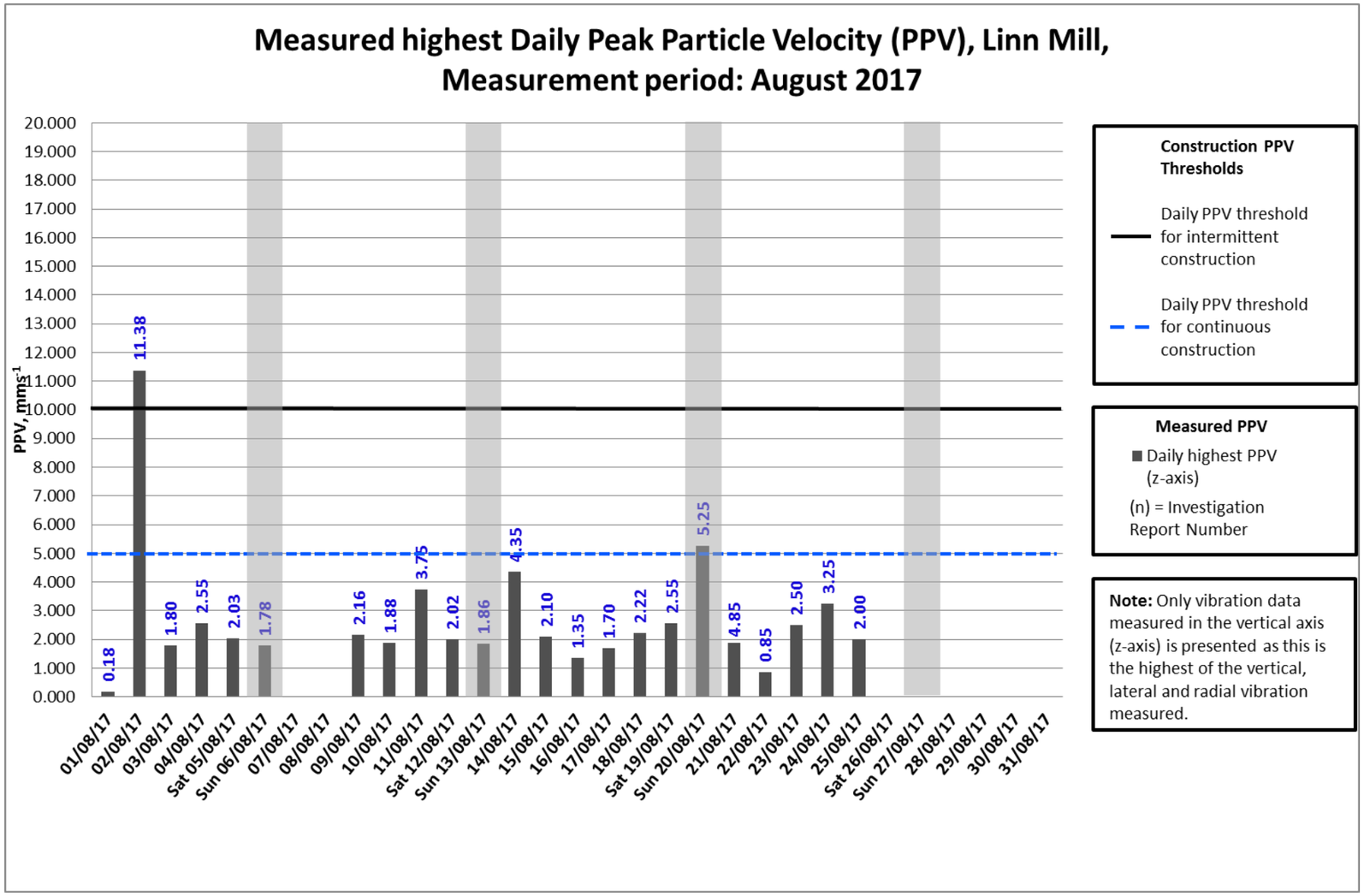

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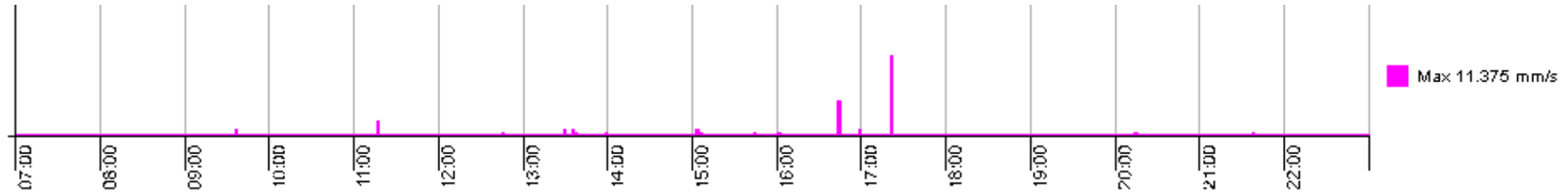
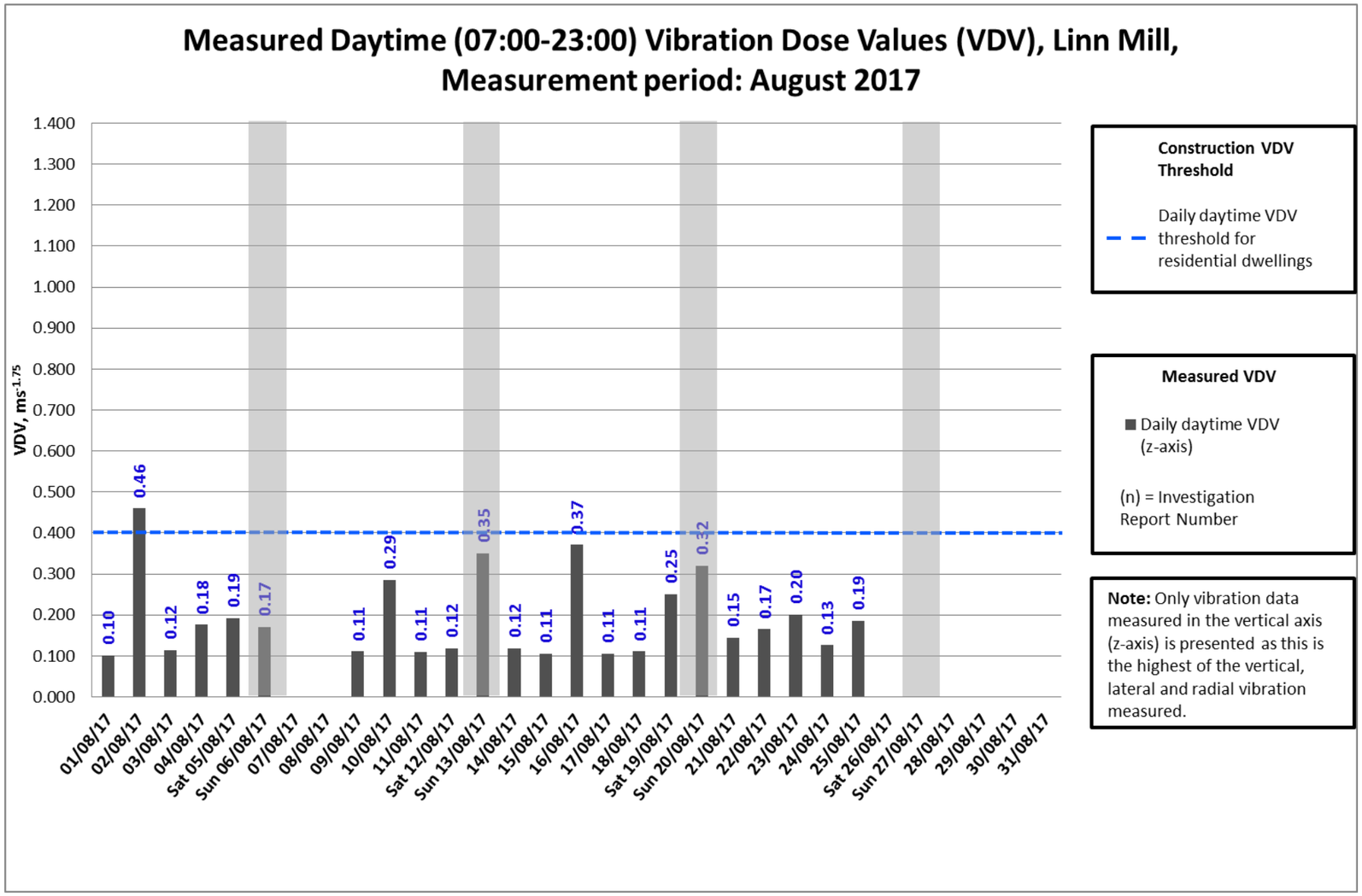


Exceedances on the 2nd and 20th of August have been investigated and found to be caused by individual isolated events that are unlikely to have been construction related activities (graph above from the 02/08/2017).



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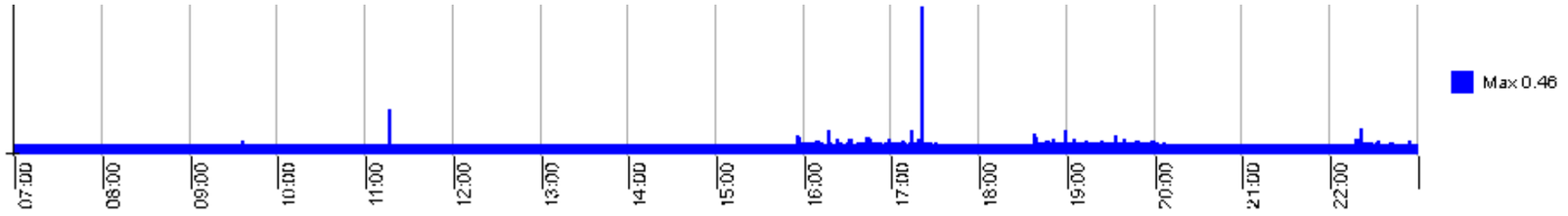
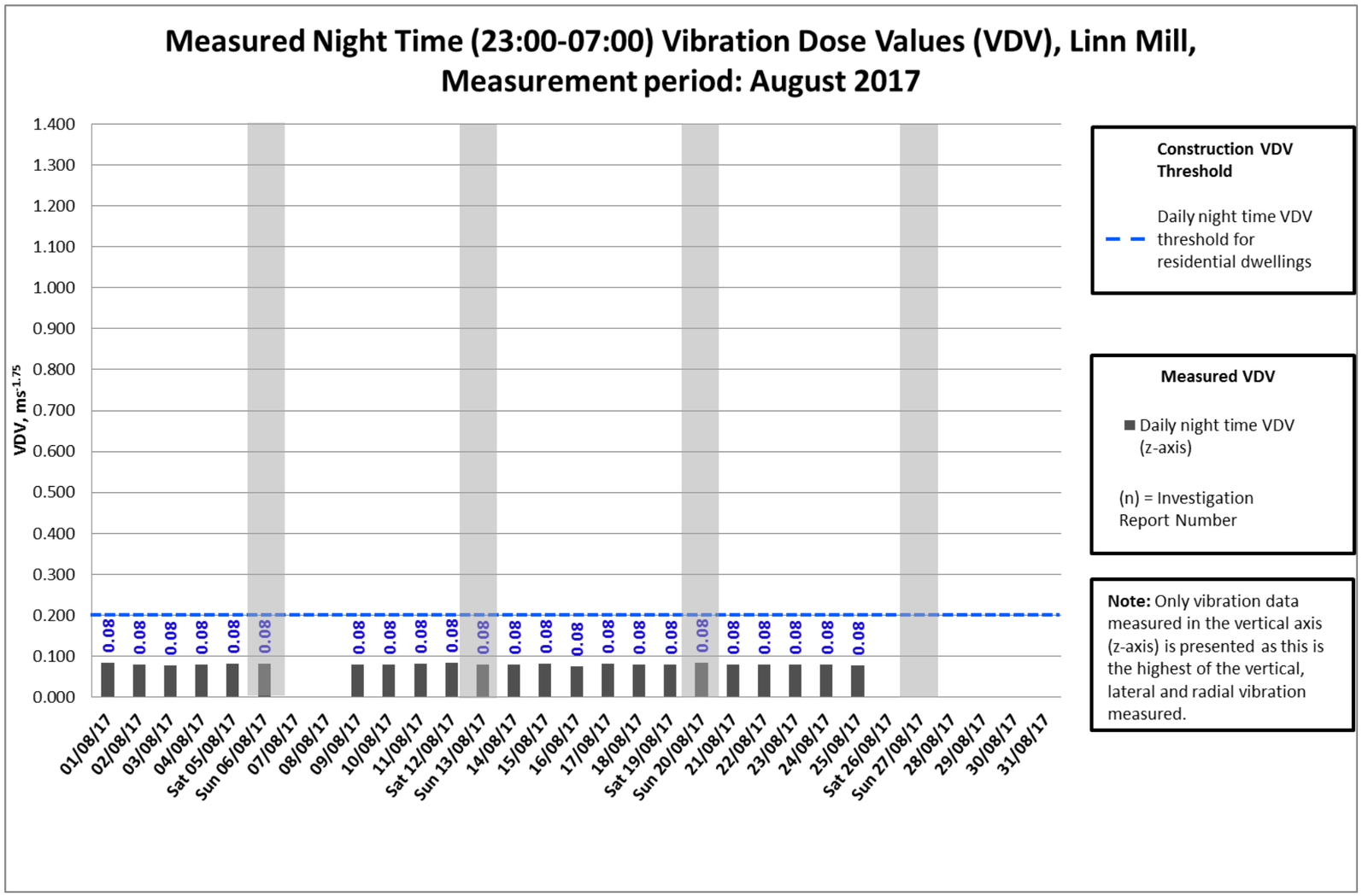


Exceedance on the 2nd of August has been investigated and found to be caused by an individual isolated event that is unlikely to have been a construction related activity (graph above from 02/08/2017).



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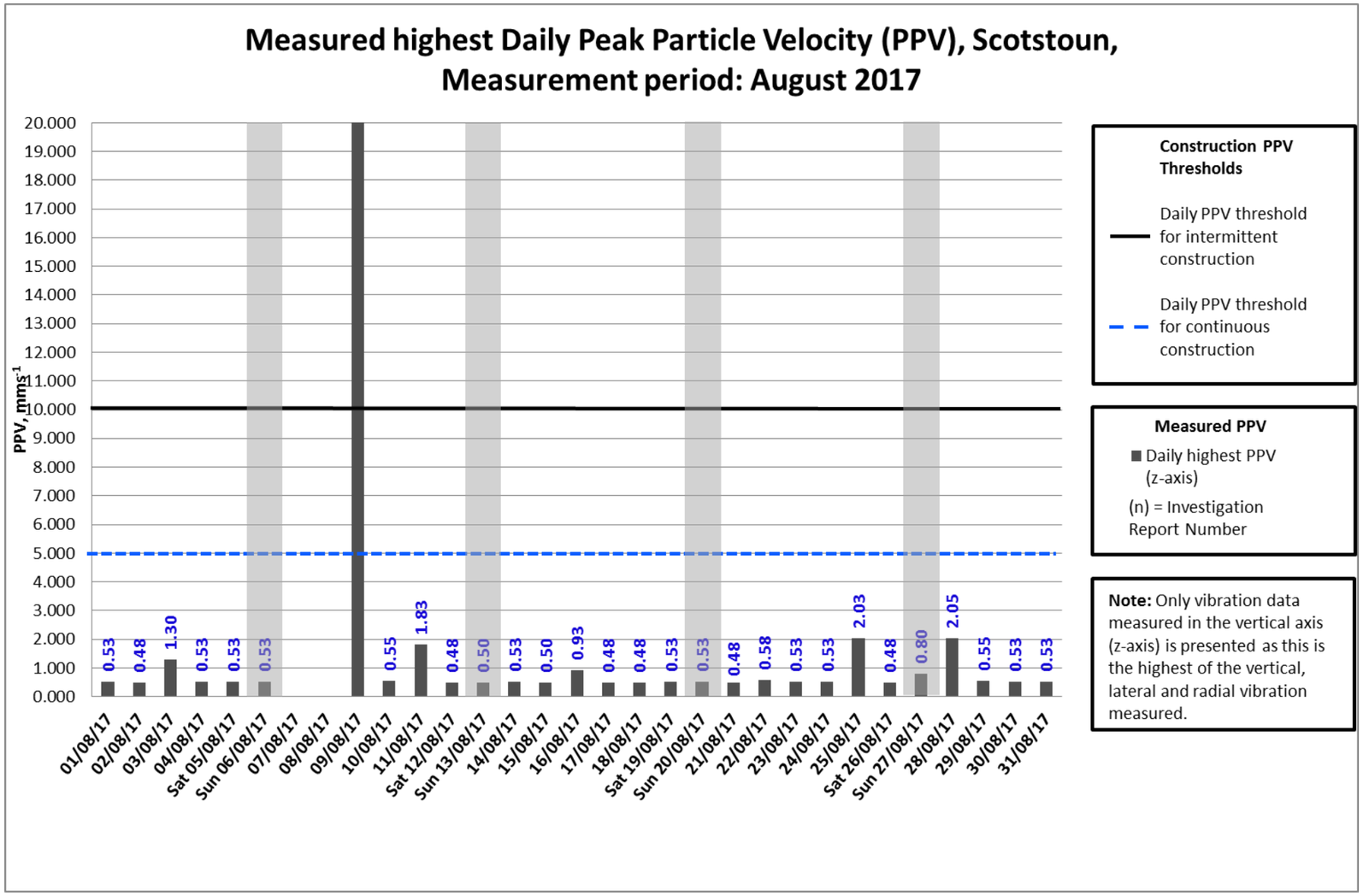

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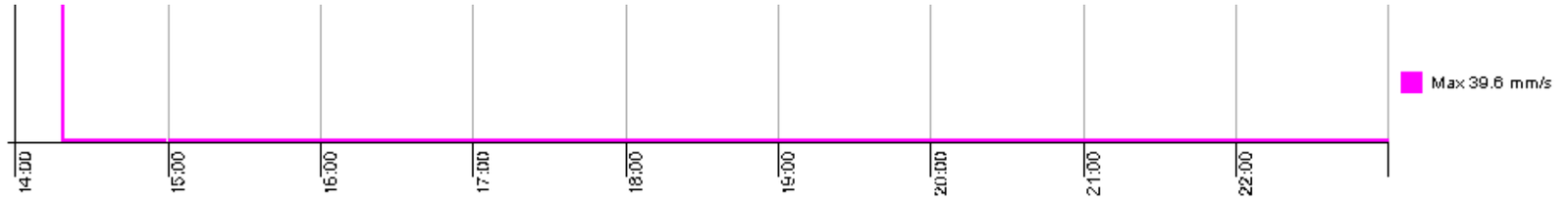
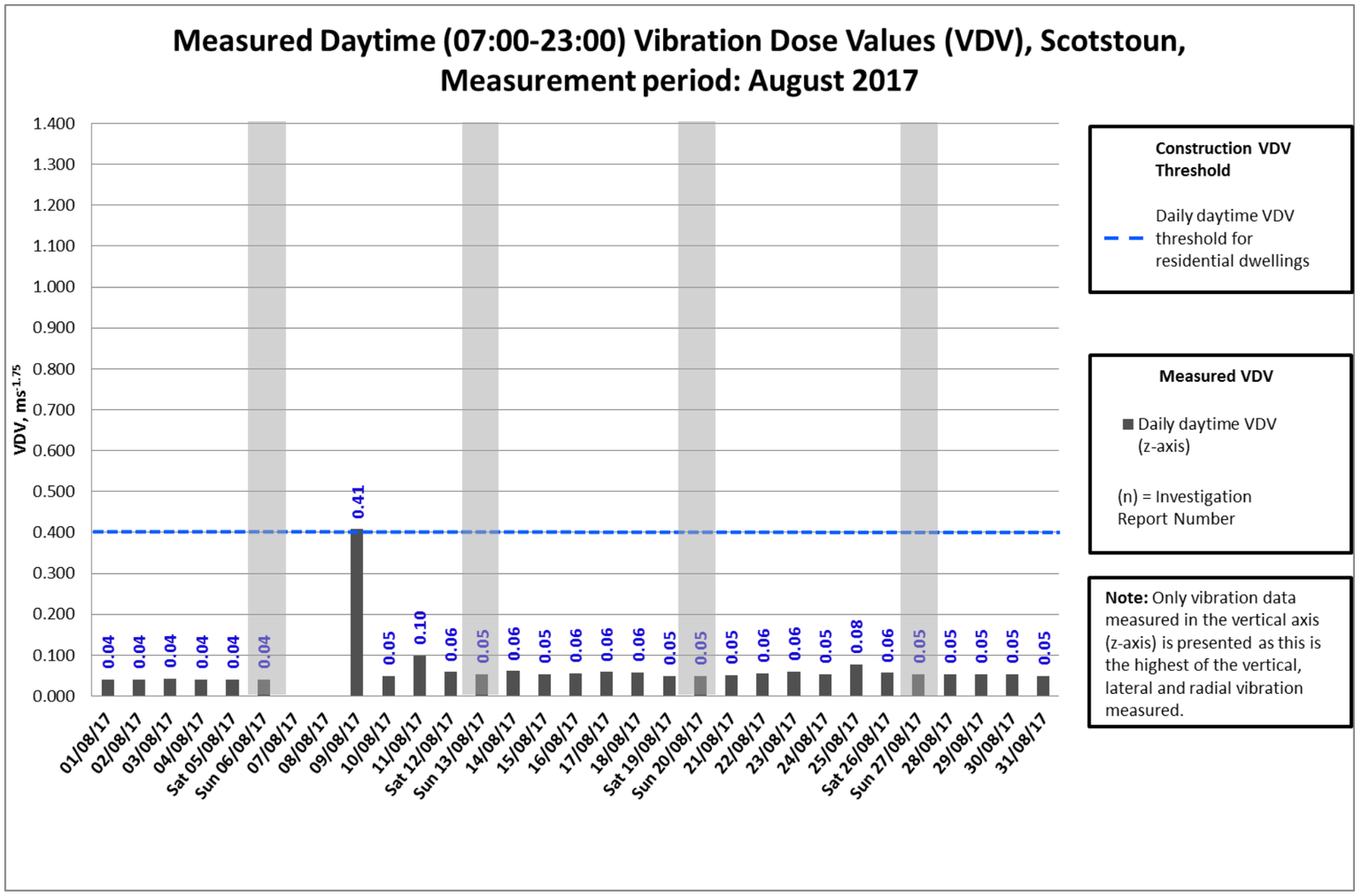


Exceedance on the 9th of August has been investigated and found to be caused by the environmental team reinstalling the vibration monitor.



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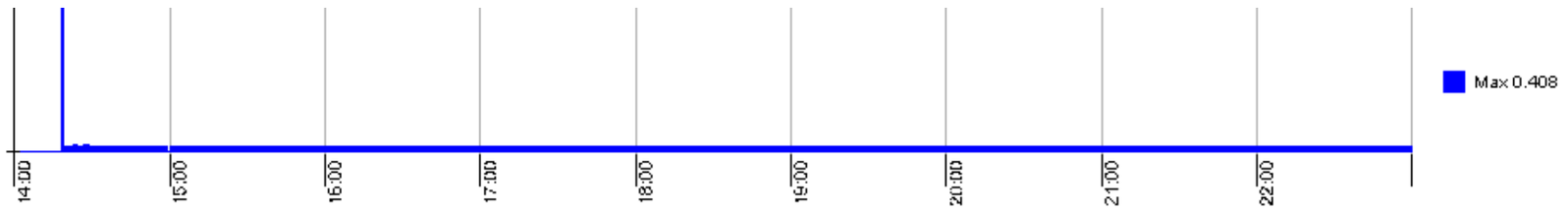

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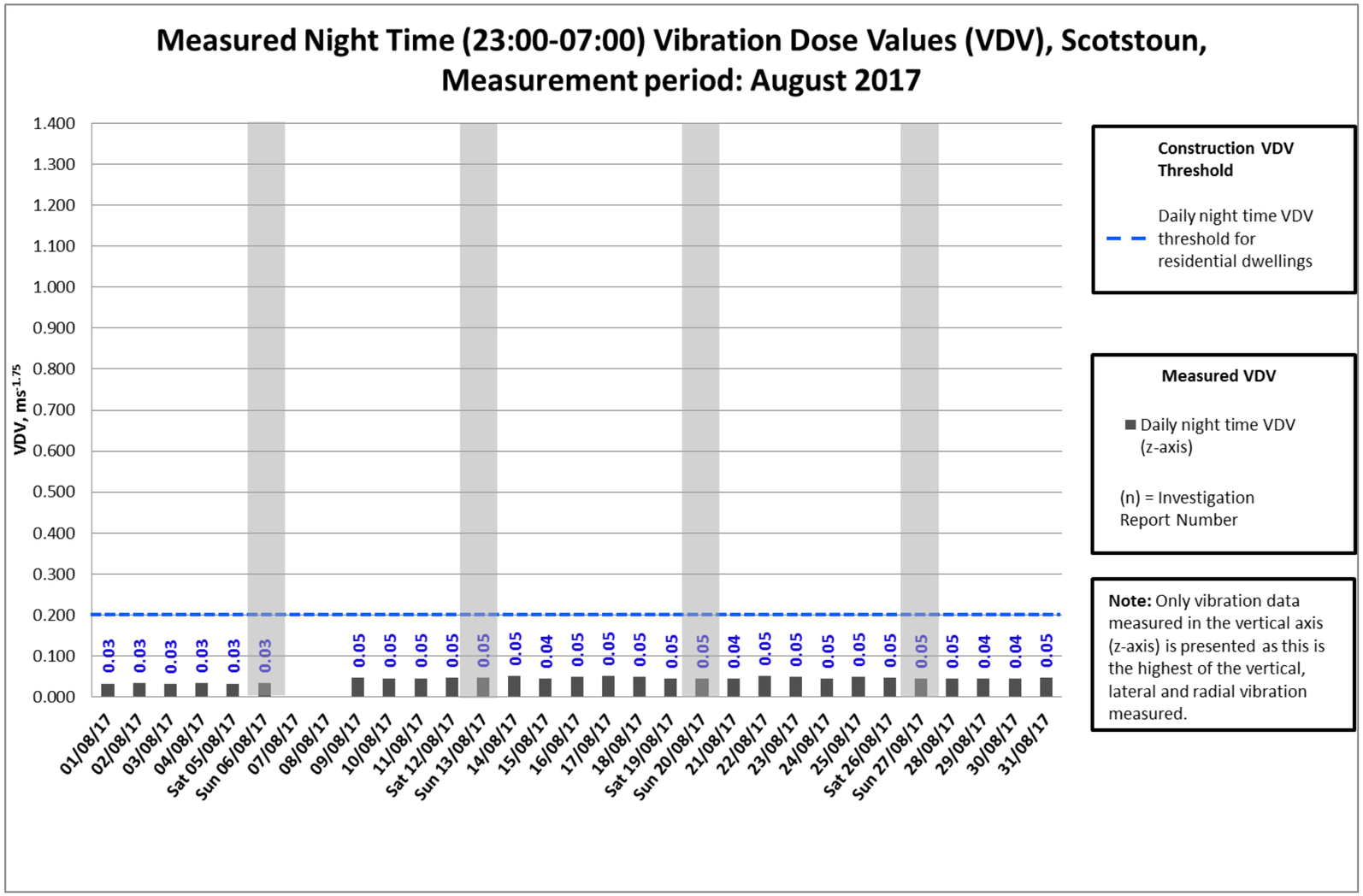

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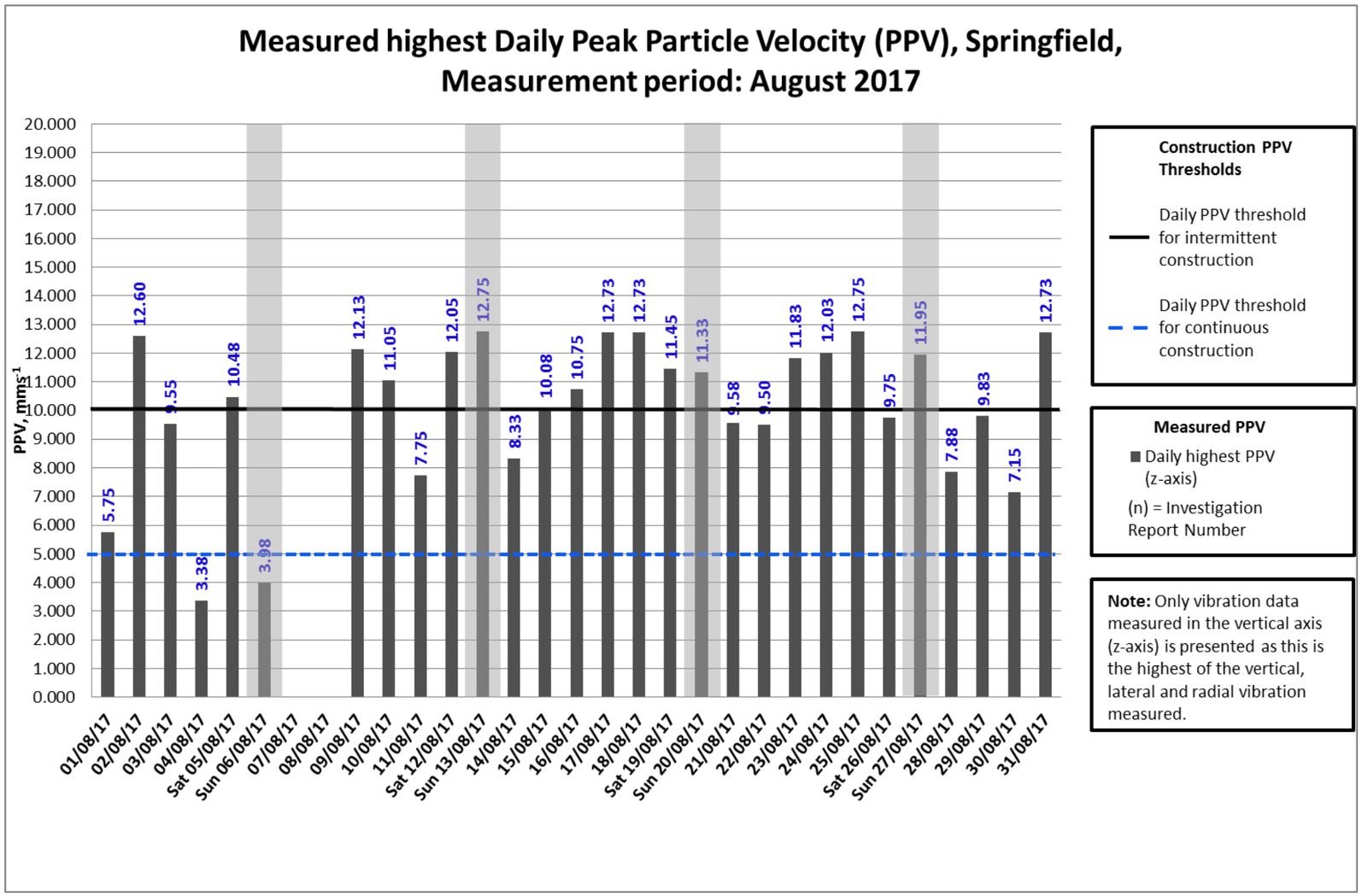
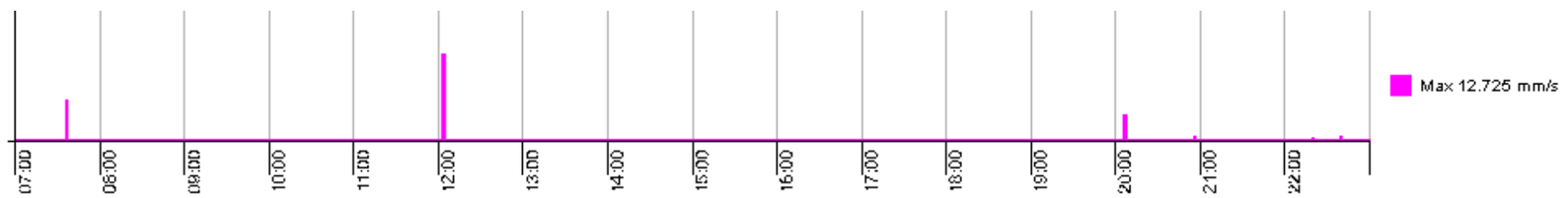
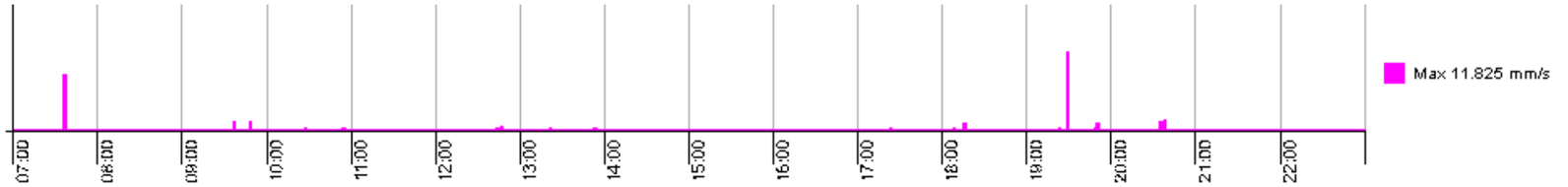


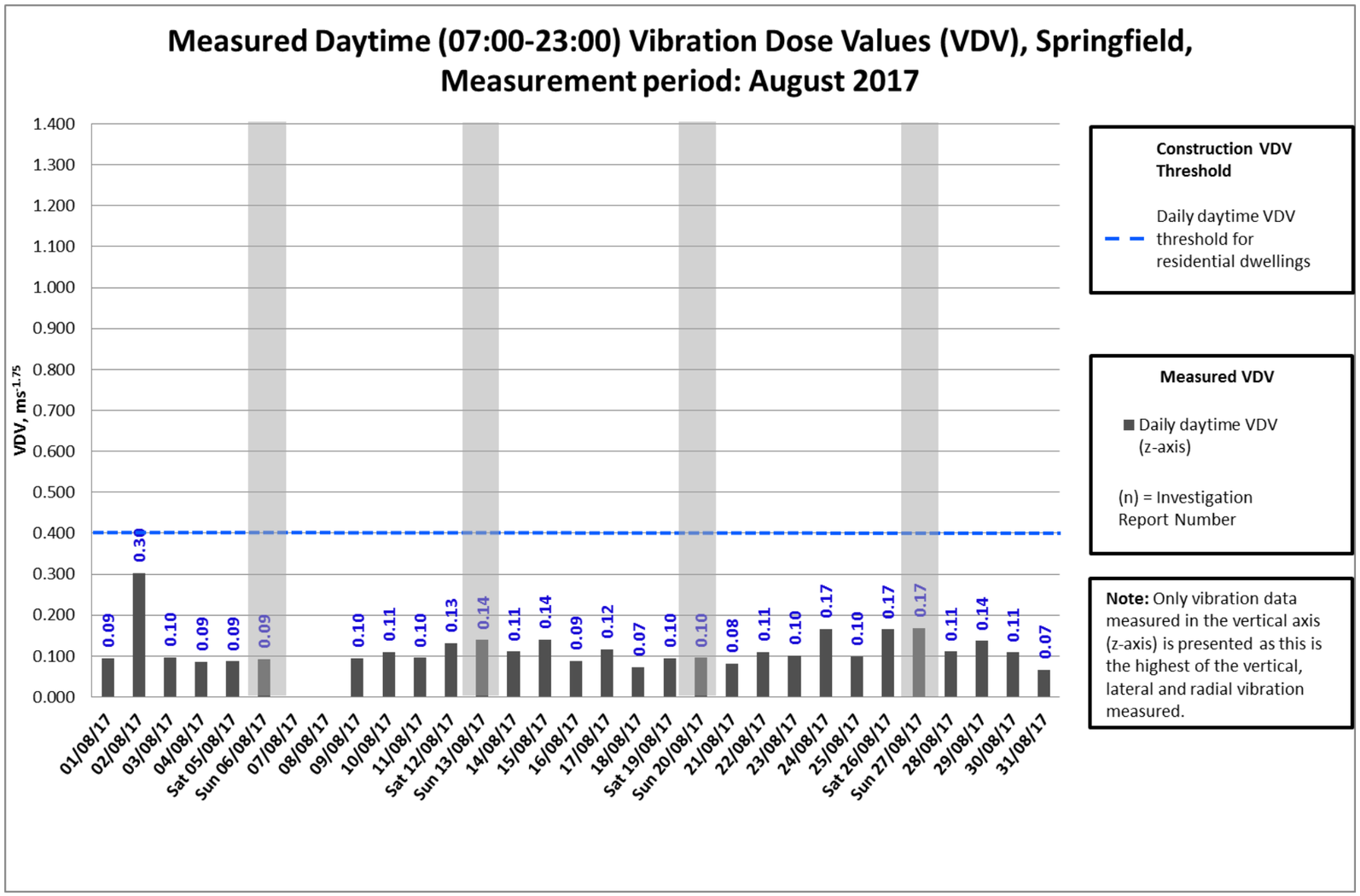
Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.



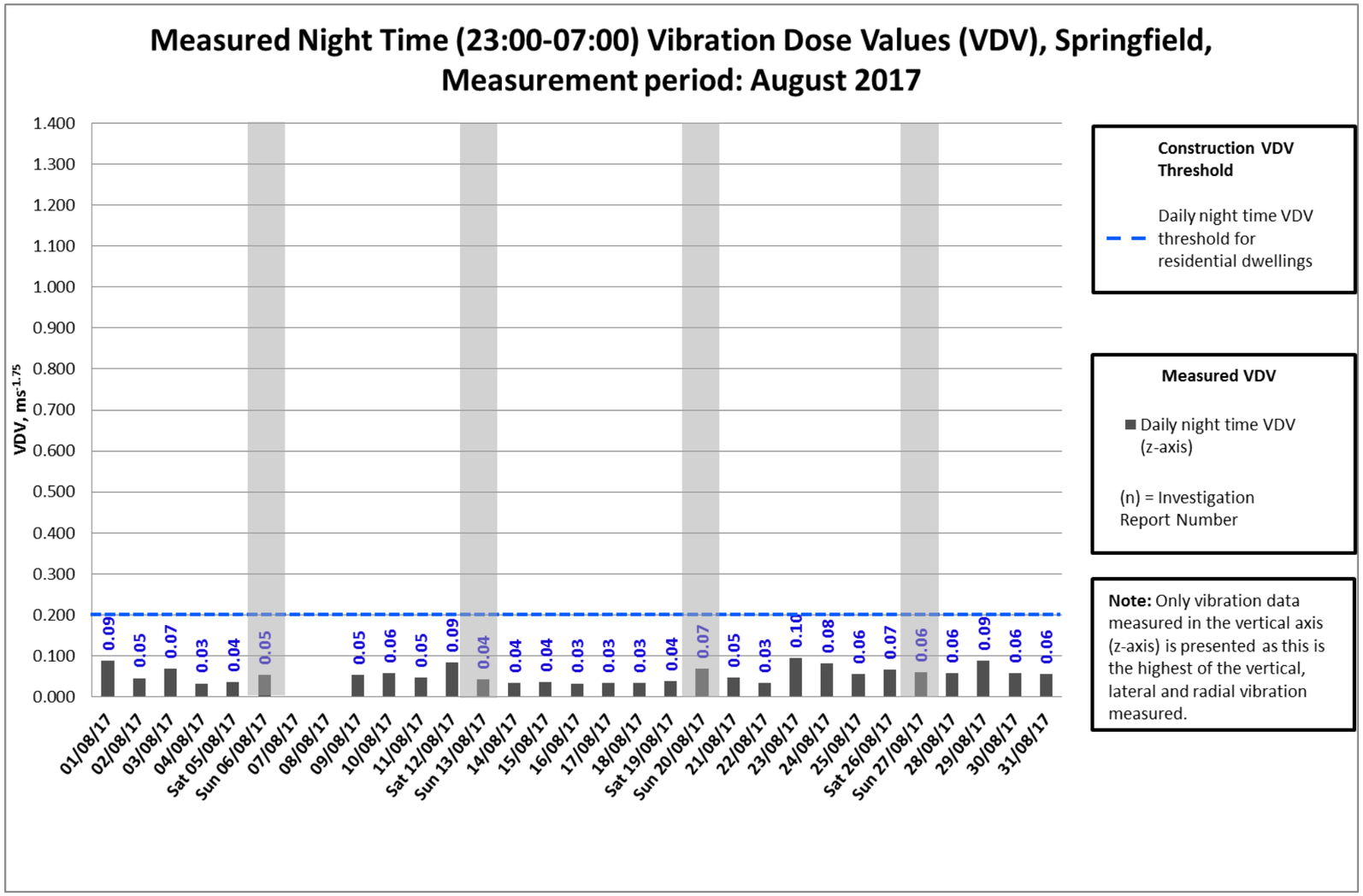
Exceedances throughout August have been investigated and found to be caused by individual isolated events that are unlikely to have been construction related activities (graph above from the 18/08/2017). The vibration monitor is located in the residents back garden, therefore resident's activity may have caused these exceedances.



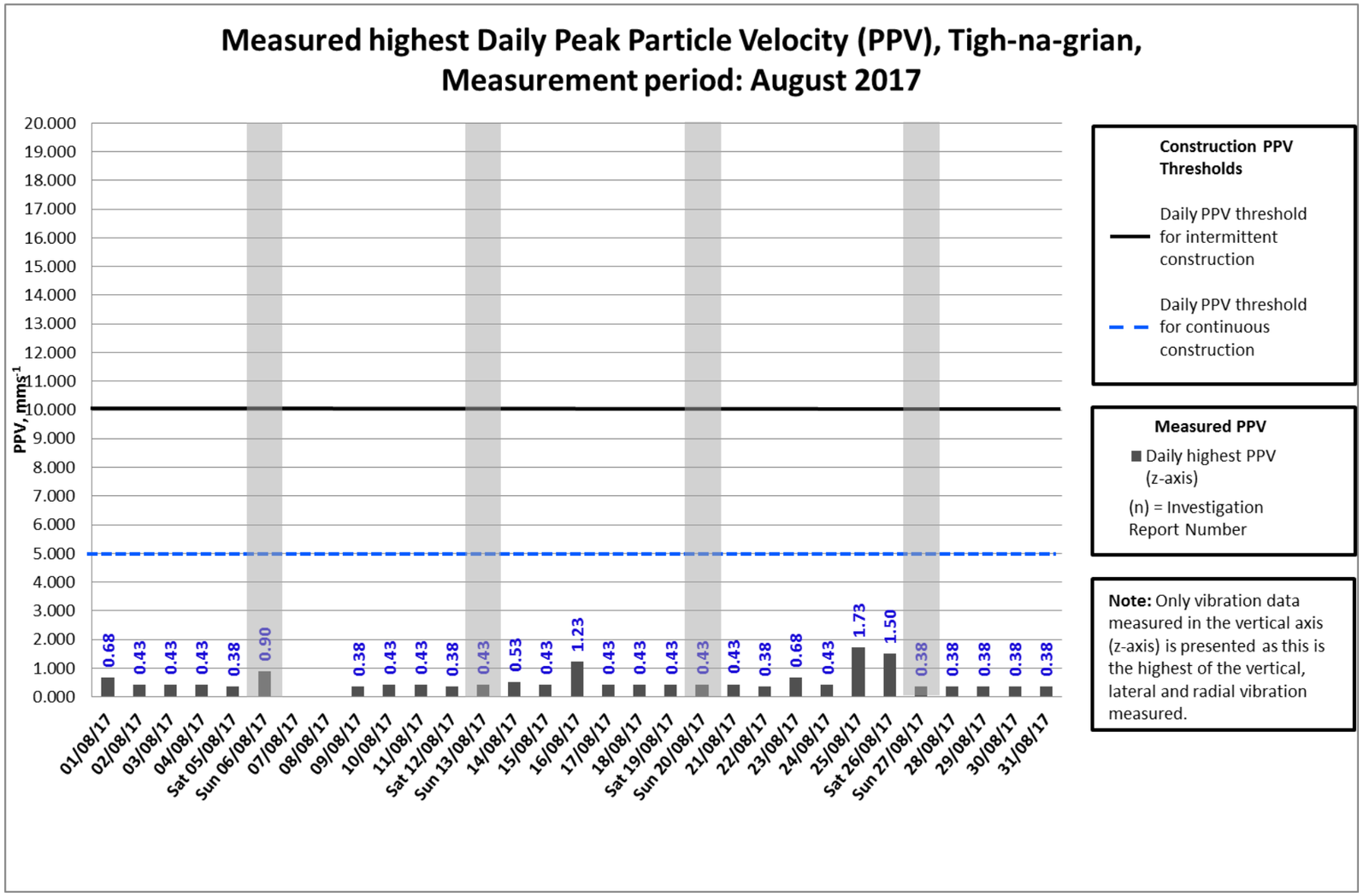
Exceedances on the 23rd, 26th, 27th and 28th of August have been investigated and found to be caused out with construction working hours therefore it is unlikely that a construction related activity was the cause of these events (graph above from the 24/08/2017).



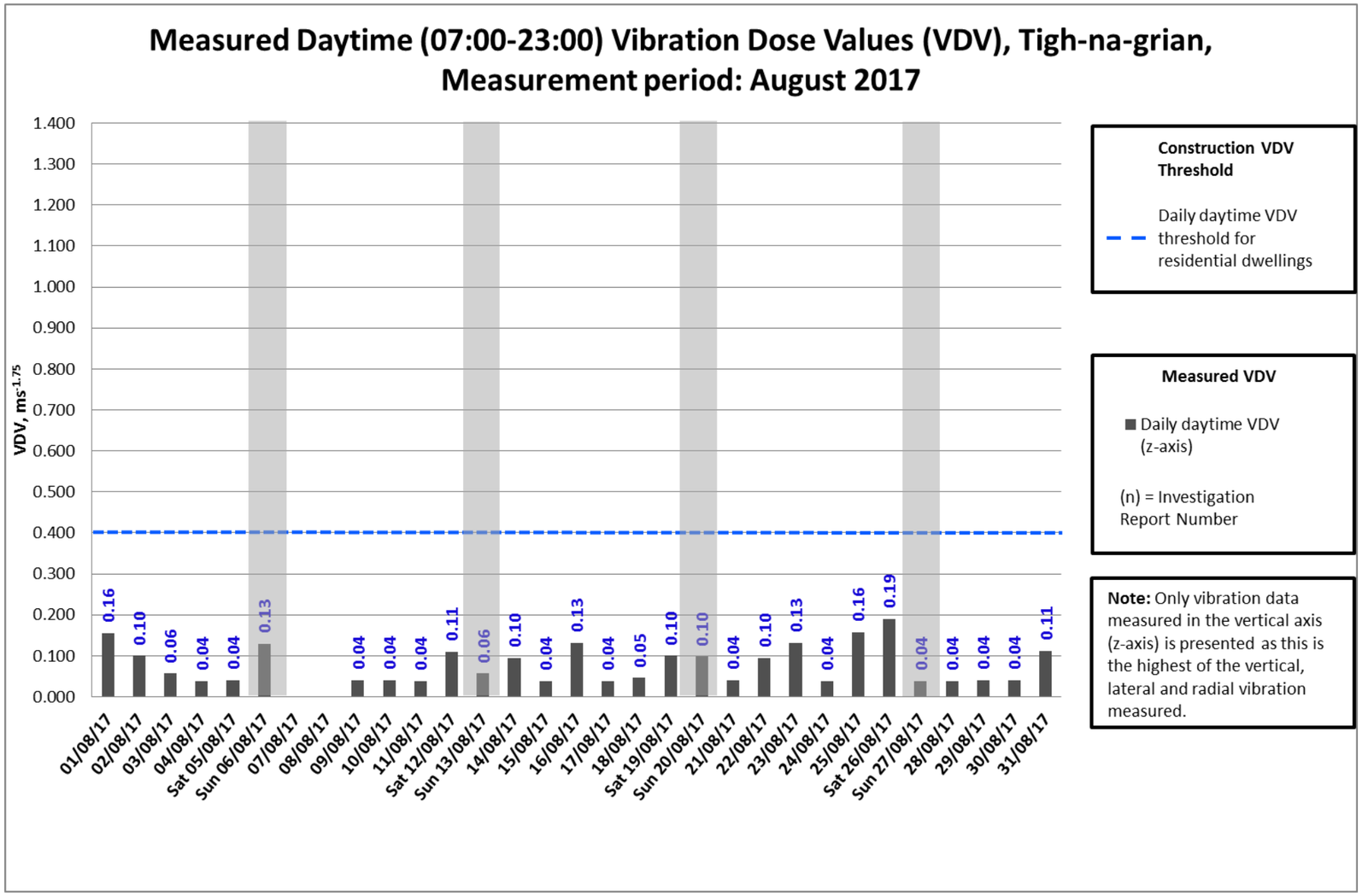
Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.



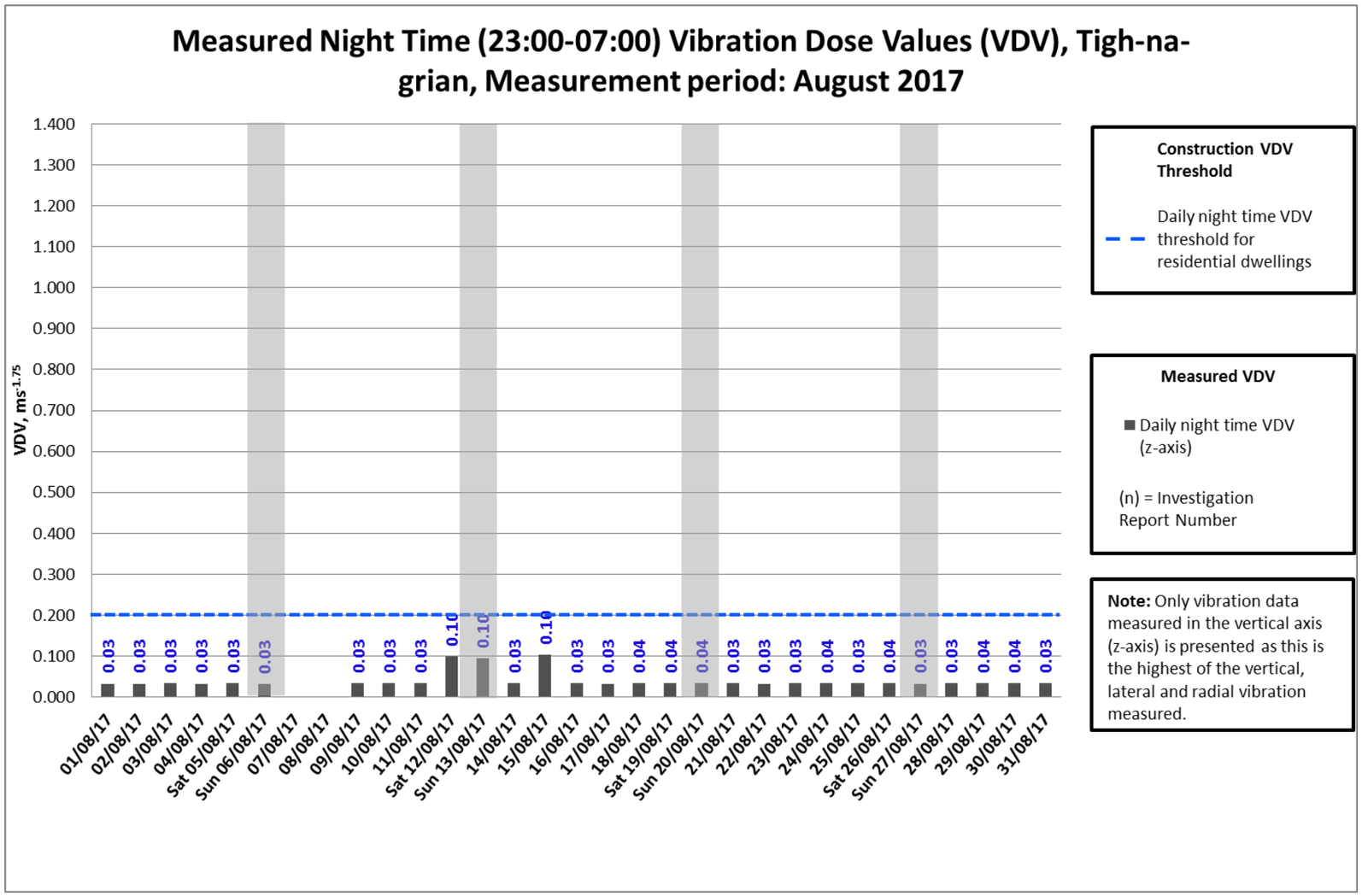
Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.



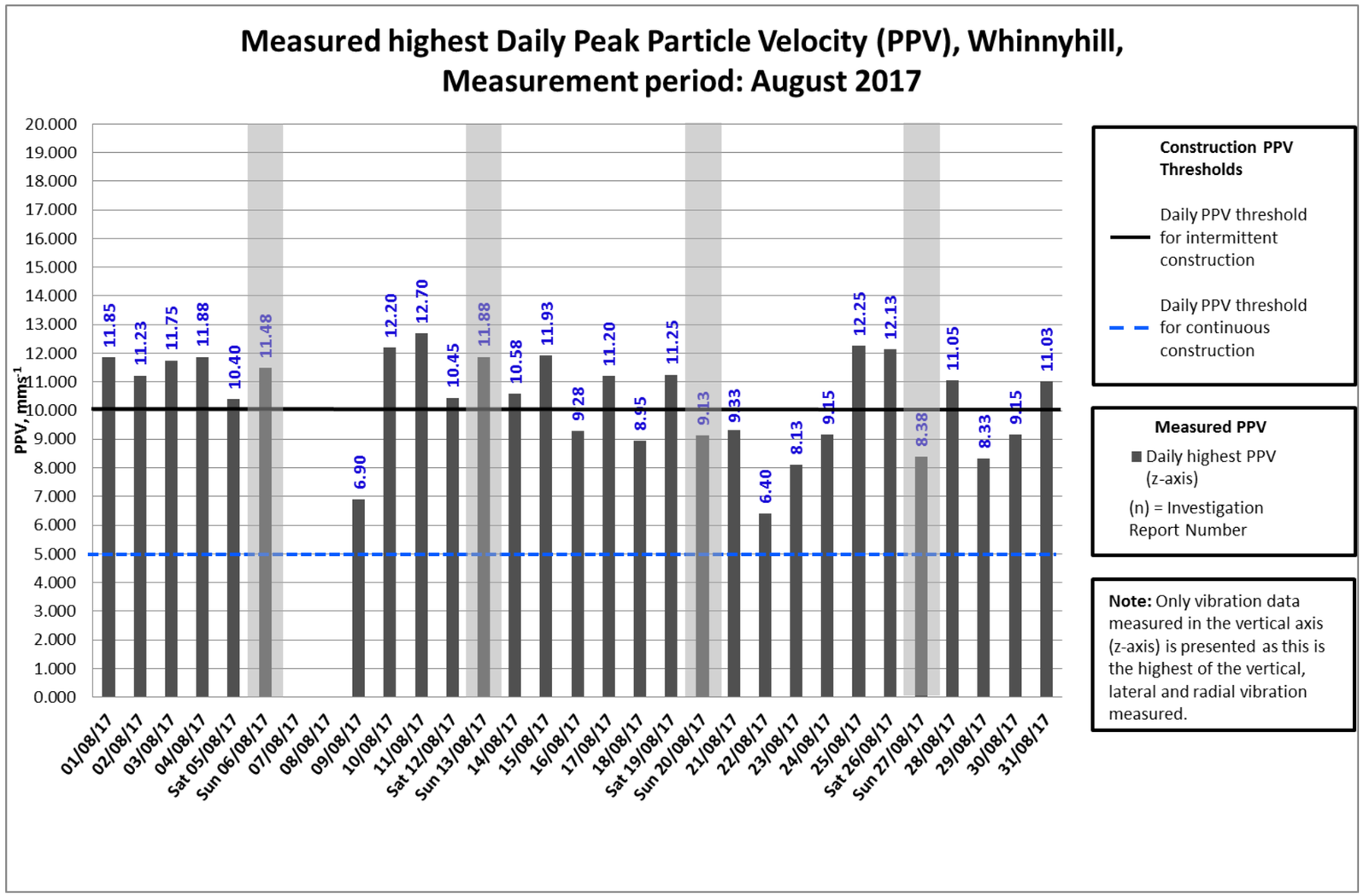
Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.



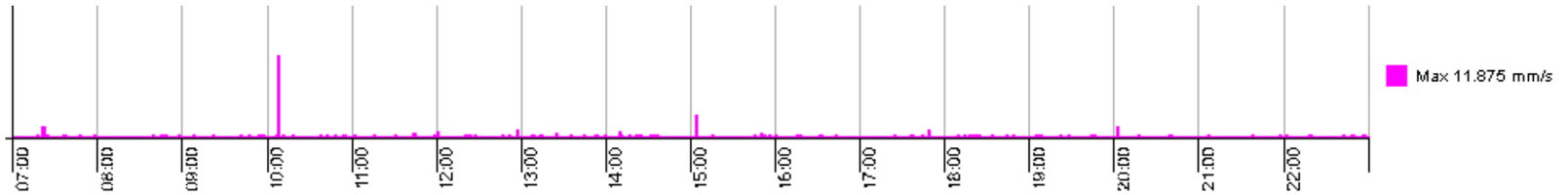
Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.



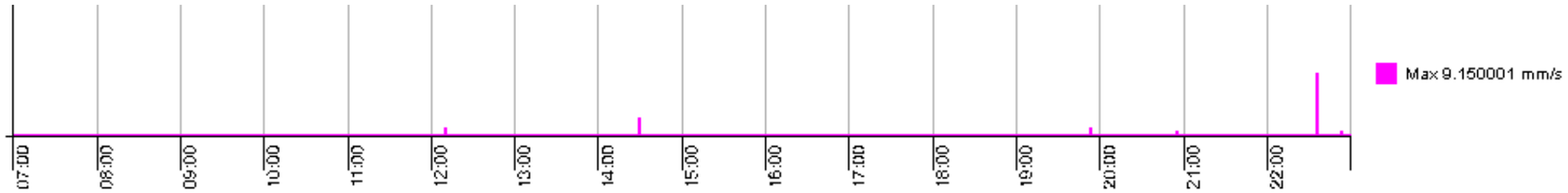
Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.



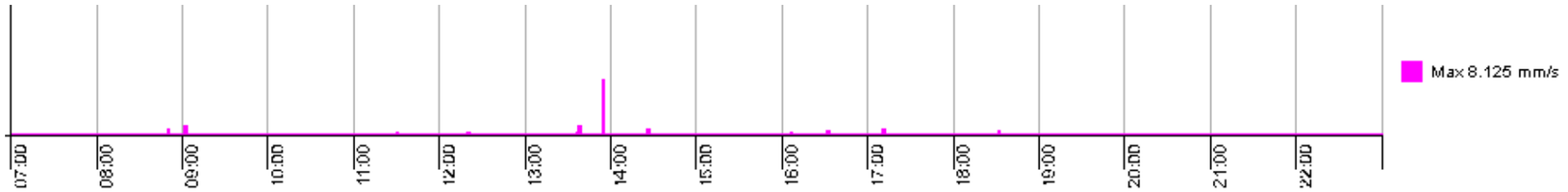
Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.



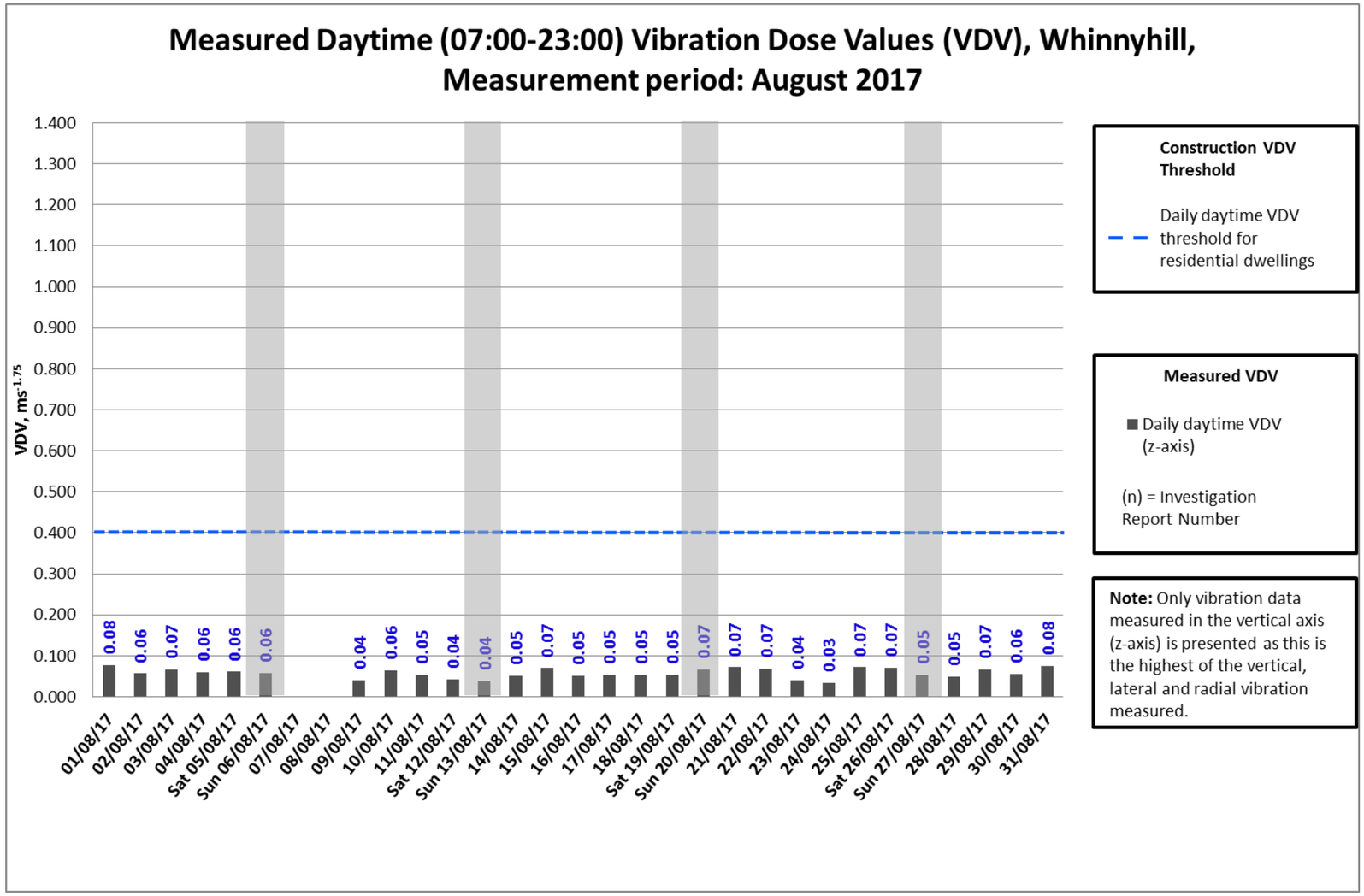
Exceedances throughout August have been investigated and found to be caused by individual isolated events that are unlikely to have been construction related activities (graph above from the 04/08/2017). During this period, the closest works to this location was undertaken approx. 450m away at the Ferrytoll gyratory.



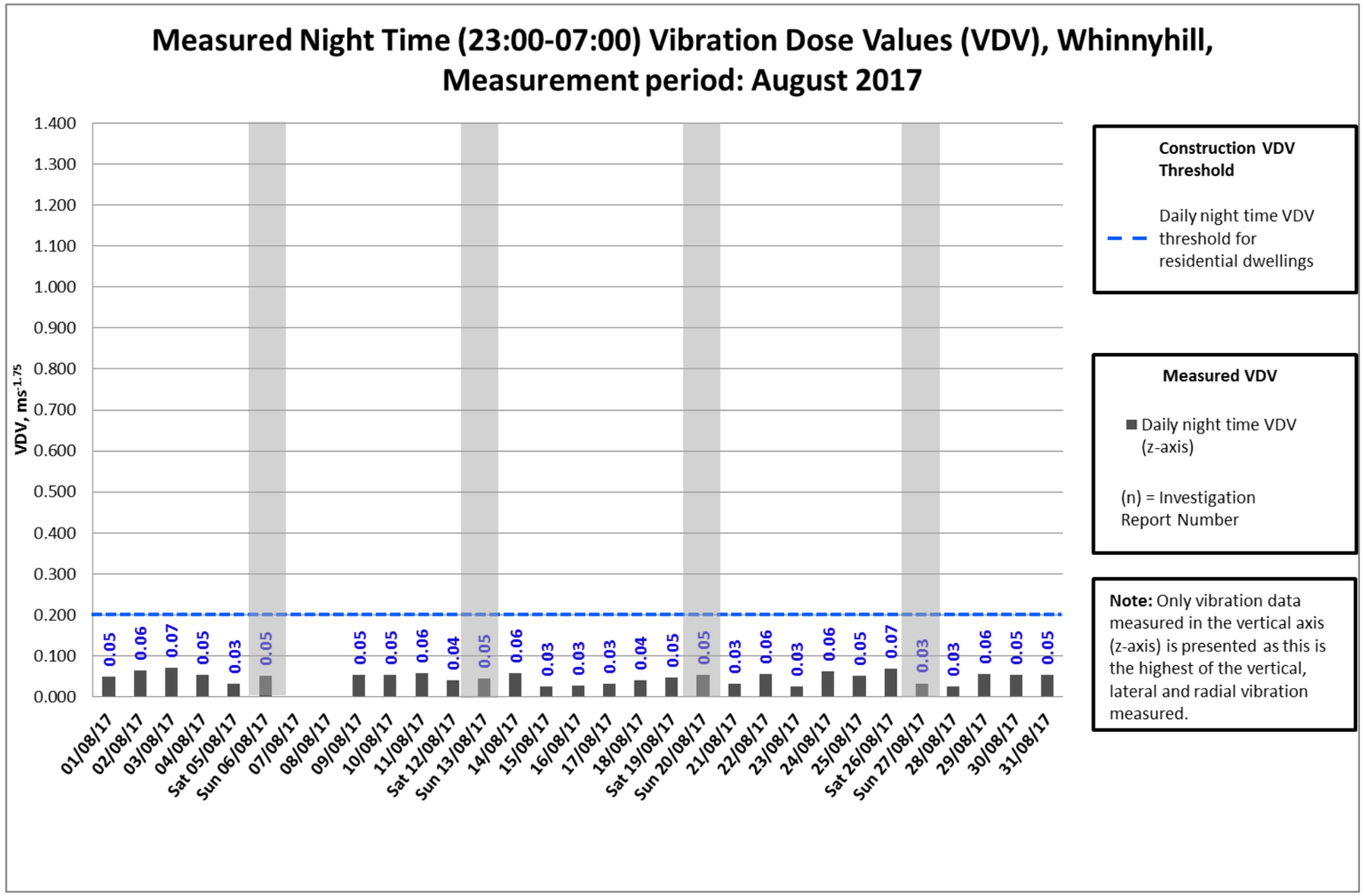
Exceedances on the 2nd, 18th, 24th and 25th of August have been investigated and found to be caused out with construction working hours therefore it is unlikely that a construction related activity was the cause of these events (graph above from the 24/08/2017).



Exceedance on the 23rd of August has been investigated and found to be caused by the environmental team collecting air quality samples (graph above from the 23/08/2017).



Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.



Data missing on the 7th - 8th August was caused by the annual calibration of the vibration monitor.