The Sizewell C Project

6.14 Environmental Statement Addendum
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Chapter 9 Rail
Appendices 9.3.A-E Noise and Vibration Part 1 of 2

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1 INTRODUCTION

1.1.1 A comprehensive noise and vibration survey was carried out in August 2020 to update and corroborate the airborne assessment set out in the Environmental Statement (ES) that accompanied the Development Consent Order (DCO) application, and to provide site-specific information to update the assessment of groundborne noise and vibration. .

1.1.2 This document sets out the findings of the August 2020 survey, and where appropriate, provides an update in the assessment outcomes. Although the detail is contained in this document, and its appendices, in summary the airborne and groundborne noise and vibration levels measured in August 2020 suggest that the ES over-estimated the potential effects, and that it is now possible to be both more precise in the locations of expected adverse effects, and to state that the effects will be reduced from those set out in the ES.

1.1.3 The assessment of railway noise and vibration presented in the ES submitted with the application for development consent considered the potential effects of both airborne noise and groundborne noise and vibration, taking account of the expected frequency of train movements, and the level of information on train configuration available at the point of submission.

1.1.4 The assessment of railway noise and vibration was included in **Volume 9, Chapter 4** of the **Environmental Statement (ES)** and its associated appendices and figures (Doc Ref 6.10) [APP-545 to APP-547]. The derivation of the criteria used in the assessment and an explanation of the groundborne noise and vibration levels were set out in **Volume 1, Appendix 6G, Annex 6G.2** of the **ES** (Doc Ref 6.1) [APP-171].

1.1.5 The assessment, as submitted, is not replicated in this document, but is summarised **Chapter 2** of this document.

1.1.6 The assessment presented in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545] was informed by a series of noise and vibration measurements, as described in **Volume 9, Appendix 4B** of the **ES** (Doc Ref 6.10) [APP- 546] for airborne noise and **Volume 1, Appendix 6G, Annex 6G.2** of the **ES** (Doc Ref 6.1) [APP-171] for groundborne vibration. Following the submission of the DCO application, a further noise and vibration survey was undertaken to corroborate or update the source information upon which the assessment presented in the ES was based. This further work was anticipated in the ES as noted in **paragraphs 4.7.10 and 4.7.22** in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545], and it builds upon the information reported in the ES to further refine the assessment.

1.1.7 The findings of the survey are contained in **Appendix A** of this document for airborne noise, and **Appendix B** of this document for groundborne noise and vibration.

1.1.8 This document provides an overview of the findings of the survey, without replicating the entirety of the detailed findings, which are contained in **Appendix A** and **Appendix B** of this document. As was anticipated in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545], this document sets out the implications for the DCO assessment of the survey results and, where appropriate, provides an update on the DCO findings. It is expected that this document will inform both the detailed track design of the Saxmundham to Leiston branch line and rail extension route, and the draft 'Rail Noise Mitigation Strategy', as contained in **Volume 3, Appendix 9.3.A** of the **ES Addendum** (Doc Ref 6.14).

1.1.9 It is important to note at the start of this document, that the track conditions encountered during the August 2020 survey were not considered representative of future operating conditions, but were an opportunity to obtain data that could be used in a refinement of the DCO assessment. The poor quality of the track, the presence of damaged sleepers and vegetation, and old, worn jointed track, caused certain outcomes that are not expected once the track is relaid.

1.1.10 Examples included flange squeal, caused by the poor track condition pushing the train wheels out of alignment, the ground radar cleaning system engaging frequently, caused by the general poor quality track and vegetation, and high levels of groundborne noise and associated rattling of internal fixtures and fittings, caused by the train passing over poor condition rail joints. All of these sources are considered atypical for a train running on standard quality track, under normal conditions.

1.1.11 The experience of people close to the line in the future, should the DCO be consented, will not be the same as experienced during the August 2020 survey.

1.1.12 The various atypical sources are discussed in **Section 3** of this document.

1.1.13 This document only relates to noise and vibration associated with the operation of trains on the railway, not its construction, nor does it consider any of its infrastructure, such as level crossings. These other sources were considered in the **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545], and the conclusions drawn in respect of those sources are not affected by the August 2020 survey.

1.1.14 All references to ***'the ES'*** in this document are to **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545], unless stated otherwise.

2 SUMMARY OF THE DCO RAILWAY NOISE AND VIBRATION ASSESSMENT

2.1.1 The assessment of railway noise and vibration was set out in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545], accompanied by **Volume 9, Figures 4.1 to 4.4** (Doc Ref 6.10) [APP-547], **Volume 9, Appendix 4A** (Doc Ref 6.10) [APP-546] relating to construction noise and **Volume 9, Appendix 4B** (Doc Ref 6.10) [APP-546] relating to operational railway noise. The derivation of criteria used in the assessment was contained in **Volume 1, Appendix 6G** of the **ES** (Doc Ref 6.1) [APP-171].

2.1.2 This chapter of the document sets out a summary of the criteria relating to operation of the railway line; full assessment details of the assessment are contained in the ES, as described above.

2.2 Assessment Criteria

2.2.1 The assessment considered both the potential effect in terms of the requirements of the EIA Regulations [Ref 1], and the compliance with planning policy, as set out in NPS EN-1 [Ref 2].

a) Airborne Noise

2.2.2 The following criteria were adopted to define the potential effect in terms of the EIA Regulations.

2.2.3 Receptor sensitivity categories are as set out in **Table 4.2, Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545]. To provide some context for the receptor sensitivity categories, residential properties are considered ‘medium’ sensitivity receptors.

2.2.4 The impacts of changes in railway noise along existing railway lines were assessed against the criteria set out in **Table 2.1**.

Table 2.1 (Table 4.6 from Volume 9, Chapter 4 of the ES (Doc Ref 6.10) [APP-545]): Impact scale for comparison of future railway noise against existing railway noise.

Change in Noise Level dB(A)	Subjective Response	Magnitude of Impact
0	Not present	No change*
0.1 to 0.9	Unlikely to be noticeable	Very low*
1.0 to 2.9	Present but unlikely to be intrusive	Low*

Change in Noise Level dB(A)	Subjective Response	Magnitude of Impact
3.0 to 9.9	Present and potentially intrusive, particularly at higher end of scale	Medium*
10.0+	Present and disruptive	High*

Note: *Where the resultant noise level is below a low threshold of effect (see Table 4.7 [of the Volume 9, Chapter 4 of the ES (Doc Ref 6.10) [APP-545]]), then the effect would be negligible, irrespective of the magnitude of change.

2.2.5 The impact of noise from trains on new or altered railway lines was assessed against the criteria set out in **Table 2.2**. The L_{Amax} criteria in **Table 2.2** were also applied to trains on existing lines.

Table 2.2 (Table 4.7 from Volume 9, Chapter 4 of the ES (Doc Ref 6.10) [APP-545]): Thresholds for magnitude of noise impact for new or altered railway lines at different sensitivities (all values are free field).

Sensitivity of receptor	Period	Magnitude of impact [1]				Parameter
		Very low	Low	Medium	High	
High	Any	Bespoke assessment method to be used				
Medium	Day	<50	50[2]	60	66	$L_{Aeq, 16h}$, dB
	Night	<40	40[2]	55	59	$L_{Aeq, 8h}$, dB
		<60	60[2]	70	77	L_{Amax}, dB
Low	Day or night	<50	55[2]	65	66	$L_{Aeq, 8h}$, dB
Very low	Any	No assessment normally required				

Notes: [1] consideration of the scale of any changes in railway noise should also be considered, where there is existing railway noise.

[2] These are the values to use for the lowest threshold of effect referred to in Table 4.6 [of Volume 9, Chapter 4 of the ES (Doc Ref 6.10)[APP-545]] above

2.2.6 In addition to assessing the magnitudes of impact, railway noise was assessed against thresholds that were equated to planning policy thresholds of the lowest observed adverse effect level (LOAEL) and the significant observed adverse effect level (SOAEL), as shown in **Table 2.3**.

Table 2.3 (Table 4.16 from Volume 9, Chapter 4 of the ES (Doc Ref 6.10) [APP-545]): LOAEL and SOAEL values for railway noise (all free-field values).

Time Period	LOAEL	SOAEL
Day (07:00-23:00)	50dB $L_{Aeq,16hr}$	66dB $L_{Aeq,16hr}$
Night (23:00-07:00)	40dB $L_{Aeq,8hr}$	59dB $L_{Aeq,8hr}$
	60dB L_{Amax}	77dB L_{Amax}

2.2.7 For the purposes of this document, **Table 2.4** summarises the most important airborne noise criteria.

Table 2.4: Summary of criteria for airborne railway noise (all free-field values) (medium sensitivity receptors)

Time Period	LOAEL	EIA Significance(1)	SOAEL
Day (07:00-23:00)	50dB $L_{Aeq,16hr}$	60dB $L_{Aeq,16hr}$	66dB $L_{Aeq,16hr}$
Night (23:00-07:00)	40dB $L_{Aeq,8hr}$	55dB $L_{Aeq,8hr}$	59dB $L_{Aeq,8hr}$
	60dB L_{Amax}	70dB L_{Amax}	77dB L_{Amax}
Note: (1) - EIA Significance value is the moderate adverse effect threshold, which is the lowest threshold at which a significant effect is considered to occur.			

b) Groundborne Noise and Vibration

2.2.8 The magnitudes of impact from groundborne vibration were assessed against the criteria in **Table 2.5**.

Table 2.5 (Table 4.8 from Volume 9, Chapter 4 of the ES (Doc Ref 6.10) [APP-545]): Magnitude of impact from railway vibration.

Sensitivity of receptor	Period(1)	Magnitude of impact				Parameter
		Very low	**Low**	**Medium**	**High**	
High	Bespoke assessment method to be used					
Medium	Day	≤0.2	0.2-0.4	0.4-0.8	>0.8	VDV(2) $m/s^{1.75}$
	Night	≤0.1	0.1-0.2	0.2-0.4	>0.4	
Low	Day	≤0.4	0.4-0.8	0.8-1.6	>1.6	

Sensitivity of receptor	Period[(1)]	Magnitude of impact				Parameter
		Very low	**Low**	**Medium**	**High**	
	Night	Night time assessment not normally required				
Very low	Day	≤0.8	0.8-1.6	1.6-3.2	>3.2	
	Night	Night time assessment not normally required				

Notes:

(1) day is 0700 to 2300 hours and night is 2300 to 0700 hours.

(2) VDV is the vibration dose value

2.2.9 The magnitudes of impact from groundborne noise were assessed against the criteria in **Table 2.6**.

Table 2.6 (Table 4.9 from Volume 9, Chapter 4 of the ES (Doc Ref 6.10) [APP-545]): Magnitude of impact from groundborne noise due to railway movements (internal values).

Sensitivity of receptor	Period	Magnitude of impact				Parameter
		Very low	Low	Medium	High	
High	Bespoke assessment method to be used					
Medium	Any	<35	35	45	50	L_{ASmax}, dB
Low	Any	<35	35	45	50	
Very low	Any	Assessment not normally required				

2.2.10 As with airborne noise, groundborne vibration and noise were assessed against thresholds that were equated to the LOAEL and SOAEL, as shown in **Tables 2.7 and 2.8**.

Table 2.7 (Table 4.17 from Volume 9, Chapter 4 of the ES (Doc Ref 6.10) [APP-545]): LOAEL and SOAEL values (internal) for groundborne vibration from rail movements on the green rail route and refurbished branch line and East Suffolk line at night.

Receptor sensitivity	Period	LOAEL	SOAEL	Parameter
High	Would require site specific criteria.			VDV, $m/s^{1.75}$
Medium	Day (07:00 to 23:00 hours)	0.2	0.8	
	Night (23:00 to 07:00 hours)	0.1	0.4	
Low	Day (07:00 to 23:00 hours)	0.4	1.6	
Very low	Day (07:00 to 23:00 hours)	0.8	3.2	

Table 2.8 (Table 4.18 from Volume 9, Chapter 4 of the ES (Doc Ref 6.10) [APP-545]): LOAEL and SOAEL values (internal) for groundborne noise from rail movements on the green rail route and refurbished branch line and East Suffolk line at night.

Receptor type	Period	LOAEL	SOAEL	Parameter
Medium	At any time during occupation / use	35	50	L_{ASmax}, dB
Low		35	50	

2.2.11 The criteria relating to groundborne noise are summarised in **Table 2.9**.

Table 2.9: Summary of criteria for groundborne railway noise (medium sensitivity receptors) L_{ASmax}

Period	LOAEL	EIA Significance(1)	SOAEL
At any time during occupation / use	35dB	45dB	50dB
Note: (1) - EIA Significance value is the moderate adverse effect threshold, which is the lowest threshold at which a significant effect is considered to occur.			

2.3 Input Assumptions

2.3.1 The assessment was based on a Class 66 locomotive hauling 20 wagons, which were assumed to be either full or empty, depending on direction of travel.

2.3.2 The daytime and night-time airborne L_{Aeq} calculations were undertaken in accordance with the 'Calculation of Railway Noise' [Ref 3]. The trains were assumed to travel at the speeds shown in **Table 2.10**.

Table 2.10: Modelled train speeds

Section of line (see figures in Annex A [Appendix 4B of the ES] for details)	Modelled train speed, mph	
	Daytime	Night-time
Westerfield to south of Woodbridge	20	20
Through Woodbridge	15	10
North of Woodbridge to south of Campsea Ashe	20	20
Through Campsea Ashe	20	10
Between Campsea Ashe and Saxmundham	20	20
Through Saxmundham	15	10
On Saxmundham to Leiston branch line	20	20

2.3.3 The daytime speeds are based on existing trains speeds along each part of the line, and the night-time train speeds will be limited to the values shown in **Table 2.10** as a primary mitigation measure.

2.3.4 **Volume 9, Figures 4.2, 4.3** and **4.4** of the **ES** (Doc Ref 6.10) [APP-547] presented the speed limit zones graphically. The figures are included in **Appendix C** of this document. Once the locomotive is beyond the speed limit zones, the engine could speed up to the higher speeds indicated in **Table 2.10**.

2.3.5 The speeds and speed limits set out in **Table 2.10** and **Volume 9, Figures 4.2, 4.3** and **4.4** of the ES (Doc Ref 6.10) [APP-547] apply to the Sizewell C freight trains only; no speed limits should be inferred for any other trains.

2.3.6 The airborne L_{Amax} calculations were based on survey data, which suggested the values set out in **Table 2.11** would be appropriate.

Table 2.11 (partial repeat of Table 1.6 of Volume 9, Appendix 4B of the ES (Doc Ref 6.10) [APP-546]): L_{Amax} values under different train conditions

Speed (mph)	Condition	Airborne L_{Amax}, dB at 10 metres
10	Constant speed	77
0-20	Under load	89
20	Constant speed	85

2.3.7 Although not explicitly stated in the ES, the airborne L_{Amax} values were quantified in terms of a 'fast' time-weighting.

2.3.8 It was assumed that the locomotives would be under load for 800 metres as they travel away from any speed restrictions, and for the entire length of the Saxmundham to Leiston branch line when travelling east due to the uphill gradient.

2.3.9 Groundborne noise and vibration calculations were extrapolated from measurements of freight trains moving at between 9 and 30 mph. The method for determining groundborne noise and vibration levels within properties close to the railway line from the measured levels was set out in **Volume 1, Appendix 6G, Annex 6G.2** of the **ES** (Doc Ref 6.1) [APP-171].

2.3.10 In the ES, the assessment was based on the train movements shown in **Table 2.12**. The distinction between the 'Early Years' and 'Later Years' is marked by the construction of the rail extension route, or green rail route (GRR) as it is described in **Table 2.12**.

Table 2.12 [extract from Table 1.1 of Volume 9, Appendix 4B of the ES (Doc Ref 6.10) [APP-545]]: Predicted train numbers

Period	Proposed trains in "Early Years" – before GRR is operational (Total freight movements)	Proposed trains in "Later Years" – when GRR is operational (Total freight movements)
00:00 to 06:00	3 (2 full, 1 empty)	4 (2 full, 2 empty)
06:00 to 07:00	0	0
07:00 to 23:00	0	1 (full)

Period	Proposed trains in “Early Years” – before GRR is operational (Total freight movements)	Proposed trains in “Later Years” – when GRR is operational (Total freight movements)
23:00 to 00:00	1 (empty)	1 (empty)

2.4 Assessment Conclusions

2.4.1 The ES assessment outcomes are summarised below.

a) Airborne Noise

2.4.2 All of the outcomes relate to night-time effects, as the daytime effects were found to be negligible or minor adverse at worst.

2.4.3 For the Saxmundham to Leiston branch line and rail extension route, primary and tertiary mitigation was proposed in the form of continuously welded rail and speed restrictions, with a prohibition of movements through Leiston at night during the early years prior to the construction of the rail extension.

2.4.4 Secondary mitigation in the form of the ‘Noise Mitigation Scheme’ would be applied where the eligibility criteria are met. The draft ‘Noise Mitigation Scheme’ is contained in **Volume 2, Appendix 11H** of the **ES** (Doc Ref 6.3) [APP-210].

2.4.5 Notwithstanding the effect of the secondary mitigation, i.e. the ‘Noise Mitigation Scheme’, major adverse effects were predicted at two properties in the early years prior to the completion of the rail extension route (Kelsale Covert and Westhouse Crossing Cottage), with a similar effect predicted at three properties during the later years after the rail extension route is open (Kelsale Covert, Westhouse Crossing Cottage, and Crossing East) plus a moderate adverse effect at Crossing Cottage.

2.4.6 The highest L_{AFmax} noise levels during the early years were predicted to be 97dB and 95dB at Kelsale Covert and Westhouse Crossing Cottage respectively. The highest L_{AFmax} noise levels during the later years were predicted to be 93dB, 91dB and 81dB at Kelsale Covert, Westhouse Crossing Cottage and Crossing East respectively.

2.4.7 In all instances, it is expected that enhanced sound insulation would be available under the ‘Noise Mitigation Scheme’ so that the internal levels are reduced and exceeding the SOAEL is avoided.

2.4.8 Avoiding the SOAEL in this way is an appropriate response and directly accords with the approach taken in the noise Planning Practice Guidance [Ref 4], which recognises the use of noise insulation to avoid the SOAEL. The use of insulation as a mitigation is also identified in paragraph 5.11.13 of the NPS EN-1 as a valid response in comparable situations.

2.4.9 Whilst the SOAEL is an external level, the effect that is to be avoided is an internal consideration, i.e. sleep disturbance. The conclusions set out in the ES related solely to the external levels, so while the improved sound insulation available under the 'Noise Mitigation Scheme' was set out as relevant and appropriate secondary mitigation, the effect magnitudes were not amended as a result. The mitigation would address the effect internally, at the location where the effect is relevant, but as the mitigation would not change the external noise levels, the magnitude of the effect is not reduced in the terms set out by the ES.

2.4.10 It is important to recognise the true benefit of the enhanced sound insulation available under the 'Noise Mitigation Scheme' as a direct method of reducing the adverse effect. The internal noise levels for the properties listed above are expected to be reduced to below 65dB L_{AFmax} in all cases once the enhanced glazing available under the 'Noise Mitigation Scheme' is taken into account.

2.4.11 The 65dB L_{AFmax} value was the internal root of the SOAEL, derived from research by Basner et al, as applied in the case of HS2. Detail of the derivation of the SOAEL and its internal equivalent value is set out in **Volume 1, Appendix 6G** of the **ES** (Doc Ref 6.1) [APP-171].

2.4.12 The 'Noise Mitigation Scheme' was designed to be flexible in its application to accommodate a range of potential glazing solutions, which could be specified according to the requirements at a particular property. In the cases of the above properties, upgrading the glazing such that a sound reduction performance similar to that typically achieved by a 6/6-16/6 laminated double-glazing system would result in internal levels of below 60dB L_{AFmax}.

2.4.13 The convention for describing double-glazing is glass thickness in mm / airgap in mm / glass thickness in mm. In this example, the double-glazing unit has two panes of 6mm thick glass, one of which is laminated, separated by an airgap of between 6 and 16mm. The sound reduction assumed is as set out in British Standard BS EN 12758: 2011 [Ref 5]; the glazing specification would be regarded as marginally better than standard double glazing, but not an unusually high specification. Glazing with significantly better sound reduction performances are commonly available, such as the secondary glazing systems specified under the 'Noise Insulation Regulations' [Ref 6].

2.4.14 Glazing systems are available with sound reduction performances in excess of that typically achieved by the double-glazing system described above, and it is likely that even for the highest external L_{AFmax} anticipated along the Saxmundham to Leiston branch line, as set out above, internal levels almost as low as the internal LOAEL of 45dB could be achieved.

2.4.15 All of the properties identified as being adversely affected were former crossing cottages, as their names suggest, and are properties that were previously tied to the railway. As a result of their previous railway function, they are all very close to the railway line, generally within 5 metre of the nearest rail. While significant adverse effects are considered and dealt with in accordance with the planning policy and guidance in the assessment, their proximity to the railway line as a result of their former function is a material consideration.

2.4.16 On this basis, the ES considered that the requirements of planning policy are met for the Saxmundham to Leiston branch line.

2.4.17 Along the East Suffolk line, the primary mitigation proposed was speed restrictions, which would apply through Woodbridge, Campsea Ashe and Saxmundham. Additional secondary mitigation in the form of ‘change arrangements’ at Saxmundham junction, and the Noise Mitigation Scheme were also set out.

2.4.18 The ‘change arrangements’ were described in **paragraph 1.3.2** of **Volume 9, Appendix 4B** of the **ES** (Doc Ref 6.10) [APP-545], and can be summarised as changing the signalling and track infrastructure at the Saxmundham junction to avoid the need for trains to stop when entering or leaving the Saxmundham to Leiston branch line.

2.4.19 A further secondary mitigation measure was proposed in the form of a ‘Rail Noise Mitigation Strategy’, which is contained in draft in **Volume 3, Appendix 9.3.E** of this **ES Addendum** (Doc Ref 6.14); this document will inform the emerging ‘Rail Noise Mitigation Strategy’.

2.4.20 Prior to the consideration of secondary mitigation, 40 to 50 properties were expected to be subject to major adverse effects with sound levels above the SOAEL of 77dB L_{AFmax}. This was predicted to reduce to between 5 and 10 properties once the change arrangements at Saxmundham junction were taken into account.

2.4.21 Properties subject to railway noise of more than 77dB L_{AFmax} (free-field) would be eligible for sound insulation under the ‘Noise Mitigation Scheme’ and the internal sound levels will be reduced in the same manner as described for the Saxmundham to Leiston branch line. The policy requirement to avoid exceeding the SOAEL will therefore be met.

2.4.22 Again, prior to the consideration of the change arrangements at Saxmundham junction, 150 to 160 properties were expected to be subject to moderate adverse effects with sound levels between 70 and 77dB L_{AFmax}. This reduced to between 100 and 110 properties once the change arrangements at Saxmundham junction were taken into account. The application of speed restrictions and change arrangements at Saxmundham junction meet the policy requirements to mitigate and minimise adverse impacts, i.e. those that fall above the LOAEL, but below the SOAEL.

2.4.23 A further 390 to 410 properties, or 320 to 350 properties once the change arrangements at Saxmundham junction were taken into account, were predicted to be subject to sound levels of 60 to 70dB L_{AFmax}, which would be classed as minor adverse effects and are not significant in EIA terms.

b) Groundborne Noise and Vibration

2.4.24 No adverse effects were predicted as a result of groundborne vibration.

2.4.25 For groundborne noise, speed restrictions were set out as the key primary or tertiary mitigation, with the draft 'Rail Noise Mitigation Strategy' (**Volume 3, Appendix 9.3.E** of the **ES Addendum** (Doc Ref 6.14)) and further detailed assessment to consider vibration-isolating track support systems put forward as secondary mitigation, as noted in **paragraphs 4.7.19 to 4.7.22** in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545]. This document is the first stage of that further detailed assessment, which will, in due course, inform the emerging 'Rail Noise Mitigation Strategy'.

2.4.26 For the Saxmundham to Leiston branch line and rail extension, major or moderate adverse effects were predicted for all receptors within 20 metres of the operational lines, and moderate or minor adverse effects for receptors within 20 to 50 metres of the operational lines.

2.4.27 All effects were expected to reduce to minor adverse once the secondary mitigation was taken into account; the secondary mitigation was not set out in detail in the ES, but this document presents the first stage of defining what it might look like.

2.4.28 For the East Suffolk line, speed restrictions were set out as the primary or tertiary mitigation. Further detailed assessment to refine the groundborne noise calculations, and the 'Rail Noise Mitigation Strategy' were put forward as secondary mitigation measures.

2.4.29 The extent of the adverse effects along the East Suffolk line was dependent on train speed; a night-time speed limit of 10mph would apply through Woodbridge, Campsea Ashe and Saxmundham, with 20mph elsewhere.

2.4.30 Major adverse effects were predicted within 5 metres of the operational lines at 10mph, and within 10 metres of the line at 20mph. These major adverse effects would also exceed the SOAEL. These distances are measured from the property to the closest rail.

2.4.31 Subsequent to the submission of the DCO application, it has now been determined that four residential properties fall within a distance of 5 metres from the nearest rail and 15 fall within a distance of 10 metres of the closest line, including the four within 5 metres. Taking into account the 10mph night-time speed limits in the built-up areas of Woodbridge, Campsea Ashe and Saxmundham, a total of seven properties would have exceeded the SOAEL, if the ES had identified property numbers.

2.4.32 Of these seven properties, two are within 5 metres of the railway line in an area expected to have a 10mph speed limit, and five are within 10 metres on a section of track where the train would be expected to travel at 20mph.

2.4.33 Moderate adverse effects were predicted at receptors between 5 and 14 metres from the line at 10mph and between 10 and 20 metres of the line at 20mph. Taking into account the 10mph speed limits in the built-up areas of Woodbridge, Campsea Ashe and Saxmundham, a total of 32 properties would have been subject to moderate effects, if the ES had identified property numbers.

2.4.34 Of these 32 properties, two properties are between 10 and 20 metres of the nearest rail along a section of the East Suffolk line that was proposed to have a speed limit of 20mph, and the remaining 30 properties are within 14 metres of the nearest rail along sections of the East Suffolk line that was proposed to have a speed limit of 10mph.

2.4.35 Minor adverse effects were predicted at receptors between 14 and 42 metres of the line at 10mph and between 20 and 50 metres of the line at 20 mph. The number of properties subject to minor adverse effects has not been quantified.

2.4.36 The properties closest to the East Suffolk line are listed in **Appendix D**.

3 AIRBORNE NOISE: UPDATE

3.1 Introduction

3.1.1 The need for further work was anticipated in the ES; **paragraph 4.7.10** of **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545] set this out. The August 2020 survey was the first element of this additional work, and the findings update the assessment presented in the ES.

3.1.2 The daytime and night-time L_{Aeq} calculations set out in the ES were undertaken using the methods set out in the 'Calculation of Railway Noise' (CRN) [Ref 3], as described in **Volume 9, Appendix 4B** of the **ES** (Doc Ref 6.10) [APP-546]. The assessment of L_{AFmax} levels was based on survey data of slow-moving freight trains, as it is not possible to predict L_{AFmax} levels using CRN.

3.1.3 The August 2020 noise survey updates the L_{AFmax} survey data gathered during the preparation of the ES. The measurements of the train are not relevant to the L_{Aeq} calculations as the train was not configured in the same way as normal freight trains, there being an engine at each end both generating noise. The assessment of daytime and night-time L_{Aeq} levels will remain as set out in the ES, calculated in accordance with CRN.

3.1.4 Through the measurements in August 2020, it was possible to obtain additional data for Class 66 locomotives, and to supplement the Class 66 measurements with a similar range of measurements of Class 68 locomotives. Class 66 and Class 68 locomotives are understood to be the most common freight engines on the rail network, and are the locomotives most likely to be used in the delivery of the project.

3.1.5 As was noted in **Chapter 1** of this document, the conditions encountered during the August 2020 survey were not fully representative of the future operating conditions of the Saxmundham to Leiston branch line. The poor quality of the track, i.e. the presence of damaged sleepers and vegetation, and old, worn jointed track, caused airborne noises from the train that will not occur once the Saxmundham to Leiston branch line track is relaid.

3.1.6 The conditions experienced by anyone close to the Saxmundham to Leiston branch line during the survey, including those within properties, would have been considerably worse than is likely to be experienced in the future.

3.1.7 It was possible to operate the trains in both eastbound and westbound directions multiple times along the Saxmundham to Leiston branch line in August 2020, without interfering with the operation of the passenger service on the East Suffolk line. It was also possible to undertake further measurements in Woodbridge at the start and end of the survey days as the train passed by on its way from or back to its overnight stabling location.

3.1.8 The airborne noise findings from the August 2020 survey are set out in Sharps Redmore's report *Sizewell C – Rail noise Report on noise survey carried out to determine noise from slow moving freight trains*, as contained in **Appendix A**. It is referred to in this document as *'the airborne noise survey report'*.

3.2 Updated Source Terms

3.2.1 As a result of the August 2020 survey, the L_{AFmax} values that informed the ES have been reviewed, and are shown in **Table 3.1**, together with the values used in the ES.

Table 3.1: Updated L_{AFmax} values under different train conditions, all at a reference distance of 10 metres – L_{AFmax} dB

Speed (mph) / Condition	Values used in the ES	Class 66 Locomotive	Class 68 Locomotive
10mph	77	74	76
20mph	85	81	79
Under load	89	-	-

3.2.2 The values shown in **Table 3.1** are all 95% upper confidence limit values, and therefore represent a consistently-derived set of values; the 95% upper confidence limit values were used in the ES. The values shown for Class 66 locomotives take account of both the original survey information presented in the ES and the August 2020 survey data. The Class 68 locomotive data is based on the August 2020 survey only.

3.2.3 It can be seen from **Table 3.1** that the values adopted in the ES were higher than the values now suggested as appropriate by the larger dataset for Class 66 locomotives. It can also be seen that L_{AFmax} levels adopted in the ES were also higher than the appropriate values for Class 68 locomotives. On the basis of these findings, it can reasonably be concluded that the ES presented a worst-case assessment by over-estimating the likely L_{AFmax} levels from Class 66 and 68 locomotives travelling at a constant speed.

3.2.4 No measurements were made of locomotives 'under load' during the August 2020 survey, as those conditions were not encountered during the survey; the train did not run under full load at any point, other than when initially pulling away from a stationary position, which was not close to the monitoring equipment.

3.2.5 Since the updated values for locomotives travelling at 10 and 20mph are lower than the levels adopted in the ES, and since all of the source data used in the ES was sourced from the same surveys, it is considered reasonable to conclude that the 'under load' value used in the ES is likely to be a robust value.

3.2.6 The L_{AFmax} calculations for the Saxmundham to Leiston branch line in the ES were based on the assumption that eastbound trains would operate 'under load' due to the gradient. However, it was observed during the August 2020 that neither the Class 66 nor the Class 68 locomotive required full power to negotiate the gradient.

3.2.7 It is considered that the assumption that the locomotives will operate under load when travelling east may no longer be required, other than when the trains initially move from a stationary position. Adopting the L_{AFmax} level for constant speed would reduce the highest levels expected at the properties along the Saxmundham to Leiston branch line by 12dB where the locomotives travel at 10mph.

3.2.8 The basis for this reduction is that the previously-assumed 'under load' condition generated an L_{AFmax} level of 89dB, whereas the constant speed noise levels would reduce to 77dB at 10mph, where all figures are quoted at a distance of 10 metres, and taken from the information in **Volume 9, Appendix 4B** of the **ES** (Doc Ref 6.10) [APP-545]. The results of the August 2020 survey suggest that the 10mph and 20mph values may reduce further still.

3.2.9 On this basis, the highest L_{AFmax} levels would reduce to 85dB for trains travelling at 10mph, i.e. 12dB lower than the previously-identified highest L_{AFmax} values along the Saxmundham to Leiston branch line at Kelsale Covert, where the trains are not pulling away from a stationary position.

3.2.10 With an appropriate specification of glazing under the 'Noise Mitigation Scheme', the internal L_{AFmax} levels will be below the 65dB threshold that is the basis of the external SOAEL and depending on the exact glazing specification, the internal L_{AFmax} level may be close to the LOAEL.

3.3 Additional Sound Sources

3.3.1 During the August 2020 survey, three sources of noise were identified that had not been present during any of the rail noise surveys that informed the ES. These additional sources were:

- noise from wheels on track, primarily associated with the passage of wheels over joints;

- squeal from wheels rubbing against the track, known as 'flange squeal', caused by a combination of a flexible bogie on the Class 66 locomotive that facilitates working on tight radii, and the poor condition of the track; and
- hiss from air cleaners on the ground radar that measures the locomotive's speed.

3.3.2 All of these sources were found to have been caused by track conditions that will not be present should the DCO be consented and the Saxmundham to Leiston branch line upgraded. None of these sources were observed during measurements along the East Suffolk line in Woodbridge as part of the August 2020 survey, nor during the surveys that informed the ES.

3.3.3 The use of continuously welded rail, or long welded rail, will remove the distinctive impulsive sound as train wheels pass over joints. Welded joints may still give rise to an impulsive sound, but at a much lower level than for jointed track.

3.3.4 New rails with a uniform profile will remove the flange squeal.

3.3.5 The ground radar hiss was associated with a compressed air cleaning system that operates whenever an imperfect signal is returned; the system first assumes that the radar lens is obscured and triggers the cleaning system. However, it is known that track in poor conditions, with broken sleepers, vegetation, and joints in poor condition, can all increase the incidence of the ground radar cleaning system. The Saxmundham to Leiston branch line suffered from all three of these problems, and as a result the ground radar cleaning system operated frequently, often several times during a single train movement.

3.3.6 Despite being fitted on all Class 66 locomotives, the ground radar cleaning system had not been measured or witnessed in operation during any of the surveys undertaken during the preparation of the ES. It is understood that for track in 'normal' condition, the ground radar cleaning system will operate infrequently, perhaps no more than once per journey.

3.3.7 Even with the ground radar cleaning system operating at an atypically high frequency, it only affected the L_{AFmax} levels on 7% of the measurements.

3.3.8 The ground radar hiss is a predominantly high frequency sound, as shown in **Table 3.2**.

Table 3.2: Estimated ground radar hiss noise, free-field values at 10 metres - L_{AFmax}

Source	Level in each octave band (dB, LIN)								Overall A-weighted, dB
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Average hiss spectrum	0	0	0	0	65	70	76	75	80

3.3.9 The frequencies at which the ground radar cleaning system generates sound coincide with the frequencies at which glazing is typically effective at reducing the transmission of sound. It is shown in **Appendix A** of this document that the internal L_{AFmax} level caused by the ground radar hiss is lower than the equivalent L_{AFmax} levels for the two locomotives. It is therefore expected that the ground radar cleaning system will not materially affect the outcomes of the assessment.

3.3.10 On the basis that the ground radar cleaning system is highly unlikely to operate in a way that affects the L_{AFmax} for any given train, and even in the unlikely event that this does happen, it will not materially affect the outcome within a property, it is not considered necessary to include its effect in the assessment.

3.3.11 Overall, the August 2020 survey shows that the source data used in the ES resulted in an over-estimate of the potential impacts, in terms of both the absolute levels for trains, and the core assumptions as to where the trains would operate 'under load', i.e. at full power. The effects are likely to be reduced from those set out in the ES.

4 GROUNDBORNE NOISE AND VIBRATION: UPDATE

4.1 Introduction

4.1.1 The groundborne noise and vibration assessment presented in the ES was based on surveys of freight train movements, as set out in **Volume 1, Appendix 6G, Annex 6G.2** of the **ES** (Doc Ref 6.1) [APP-171], and calculated the groundborne noise and vibration levels based on assumptions as to how vibration would propagate away from the railway and transfer into adjacent buildings.

4.1.2 It was anticipated at the time of producing the ES that further work would be carried to provide site-specific, more detailed conclusions; **paragraphs 4.7.19 to 4.7.22** of **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545] set this out. This document, and its appendices, are the first element of that further work.

4.1.3 The purpose of the additional groundborne noise and vibration measurements in August 2020 was to obtain more precise, site-specific information on the propagation of groundborne vibration away from the railway line and into buildings, which could then manifest as either tactile vibration or sound within properties.

4.1.4 As was noted in **Chapter 1** of this document, the conditions encountered during the August 2020 survey are not considered representative of the future operating conditions of the Saxmundham to Leiston branch line. The presence of damaged sleepers and old, worn jointed track along the Saxmundham to Leiston branch line caused higher levels of groundborne noise than will occur once the track is relaid.

4.1.5 The groundborne noise and vibration findings are set out in Rupert Taylor Limited's report *Sizewell C – Assessment of Ground-borne Noise and Vibration from Freight Trains* as contained in **Appendix B**. It is referred to in this document as *'the groundborne noise and vibration survey report'*.

4.1.6 The conclusions reached in the groundborne noise and survey report are based on and extrapolated from the survey findings. The propagation of groundborne noise and vibration is highly site-specific, however, it is not possible to undertake measurements within every property close to the East Suffolk line, so general conclusions have been extrapolated from the survey findings.

4.1.7 It is also noted that the separation distances between the railway line and properties, or other assessment locations, set out in the groundborne noise and vibration survey report relate to the centreline of the track. The rail to rail width of standard gauge UK railway lines is 1.435 metres; the distance between the closest rail and the same assessment location will therefore be approximately 0.72 metres less than the stated distance to the centreline, i.e. the distance reduces by half the width of the railway track. For ease, distances to both the centreline and the nearest rail are stated in this document for groundborne noise and vibration.

4.1.8 It is also noted that where references are made to minimum separation distances between receptors and ‘welded joints’ or ‘rail joints’, it is aluminothermic joints that are generally intended, since flash-butt or arc welded joints are considered to be the same as continuous rail, in terms of groundborne noise or vibration.

4.1.9 Fish-plate joints or switches/crossings are a special case insofar as they contain track elements that introduce a discontinuity into the track running surface. Where reference is made minimum separation distances between receptors and ‘welded joints’ or ‘rail joints’, these apply to fish-plate joints, switches and crossings as well.

4.2 Revised Groundborne Noise Assessment Method

4.2.1 Groundborne noise from trains associated with the Sizewell C project will not be heard in isolation, but in combination with airborne noise entering the dwellings primarily through the windows. This combined effect is complicated by different approaches to setting maximum sound level criteria for airborne and groundborne noise within residential properties. Setting aside consideration of slow or fast time-weighting, which will make a difference in the sound level depending on the nature of the source measured, the level at which groundborne noise is considered significant, in EIA terms, is numerically equal to the lowest level of adverse effect for airborne noise, i.e. the LOAEL.

4.2.2 Even allowing for the difference in time-weighting, the LOAEL and SOAEL for airborne noise are approximately 10 dB(A) or more higher than those for groundborne noise.

4.2.3 No project since the publication of the ‘Noise Policy Statement for England’ [Ref 7] has been required to address the in-combination effects of groundborne and airborne noise, as a result of which there are no precedents for values of LOAEL and SOAEL for the overall indoor sound level due to combined airborne and groundborne noise. There have been studies on the effect of noise and tactile vibration experienced in combination, but no studies on the effect of airborne and groundborne noise experienced in combination.

4.2.4 Furthermore, the precedents for setting thresholds for groundborne noise from railways all relate to train services where the duration of the train passage is only a few seconds and there are many more trains than will be the case for Sizewell. In this case, the combination of low speeds and long freight trains results in the duration of train passages being in excess of one minute.

4.2.5 The frequency spectrum of internal train noise from airborne sound entering via a partially open window contains most of its A-weighted energy above 125 Hz, which is different from the frequency spectrum of groundborne noise, which is predominantly contained in frequency bands below 125Hz. Human reaction to low frequency noise is not the same as the reaction to a broader noise spectrum, so a simple comparison between criteria for the two types of noise is not necessarily valid.

4.2.6 Aside from the differences in the dominant frequencies of airborne and groundborne noise, occupants of a building typically have more options for controlling airborne noise than they do for groundborne noise; airborne noise can generally be reduced by closing the windows, or if required, by utilising windows with a better acoustic performance. However, there are no equivalent options for groundborne noise; typically, this cannot be reduced and is often present in rooms not facing the railway.

4.2.7 The mechanisms that cause the peaks of noise differ between airborne and groundborne noise. For low speed freight trains, airborne L_{Amax} values are likely to be caused by locomotive engines and exhausts, whereas groundborne noise is generated by wheel/rail-excited rolling noise particularly where wheels pass over track joints.

4.2.8 In the light of these considerations, it is suggested that the following approach to assessing groundborne and low frequency airborne noise in combination be adopted instead of the approach set out in the ES, where groundborne noise was considered in isolation:

- airborne noise should be assessed in the normal way;
- groundborne noise, where it is present in combination with airborne noise from the same source, should be assessed by considering the decibel sum of both the internal groundborne noise and the internal airborne noise in the octave bands up to and including 125Hz using ‘Slow’ time-weighting rather than ‘Fast’, assuming windows are fully closed;
- the combined groundborne and airborne noise levels, determined as above, should then be assessed against the LOAEL and SOAEL values previously set out for groundborne noise alone.

4.2.9 The assessment of combined groundborne and low frequency airborne noise is a more stringent approach than was adopted in the ES, where the same LOAEL and SOAEL were assessed for groundborne noise in isolation. It is considered appropriate to alter the approach due to the unique circumstances at Sizewell C, where airborne and groundborne noise are likely to combine in a manner not addressed in previous groundborne noise assessments.

4.2.10 Further changes are required to reflect the difference between railway lines with existing train movements, and those without, and between daytime and night-time periods.

4.2.11 The assessment of development projects nearly always involves assessing new railway lines, which give rise to groundborne noise in locations where there is no significant baseline.

4.2.12 There may be exceptions where proposed new and existing lines cross or converge, but in those cases established practice in London, where there are significant underground railways where groundborne noise is commonly assessed, is to assess groundborne noise from the new line only. It is expected that future improvements to the existing infrastructure will bring about reductions in the pre-existing groundborne noise levels. The need to assess the introduction of new and different trains operating at different speeds on the same track in an existing tunnel along with pre-existing trains has never arisen.

4.2.13 Where there is intensification of an existing railway line, as opposed to a new line, L_{Amax} is not a full indicator of the effect of adding a proposed new service to the baseline service. The L_{Aeq} index is considered the logical alternative.

4.2.14 Historically there has been no requirement to set different groundborne noise thresholds for times other than night, as it is generally accepted that noise sensitivity at night is greater than at other times, and it follows that if an acceptable level of groundborne noise is achieved for trains operating at night, then the situation in the day and evening will also be acceptable.

4.2.15 This link between daytime and night-time outcomes is underpinned by the use of the L_{Amax} metric, which is not affected by the number of trains, and by the similarity in operational characteristics between the daytime and night-time, i.e. the railway operates in a similar manner during the daytime and night-time, other than the number of trains, which is typically the case.

4.2.16 There is also no definitive information on which to set a threshold based on L_{Amax} for periods other than night.

4.2.17 As described in **Appendix B**, an L_{Aeq}-based approach is recommended for the daytime to better reflect the effect of adding new and different types of train to the existing services along the East Suffolk line.

4.2.18 The following LOAEL and SOAEL thresholds have been defined for groundborne noise for the daytime period in terms of the L_{Aeq} index:

- LOAEL: 25dB $L_{Aeq,16hrs}$
- SOAEL: 40dB $L_{Aeq,16hrs}$

4.2.19 These L_{Aeq} thresholds are internal levels and should be assessed on the basis of closed windows, as is the case for the night-time L_{ASmax} thresholds.

4.2.20 This L_{Aeq}-based approach is not recommended for the Saxmundham to Leiston branch line, where there are no regular existing services; the Sizewell C construction trains will be a new service, not an additional service. For the Saxmundham to Leiston branch line, it is recommended that the night-time L_{ASmax} thresholds are applied. The same reasoning also applies to the rail extension route although there are no receptors close enough to the rail extension route for groundborne noise to be a material issue.

4.2.21 In summary, **Table 4.1** summarises the groundborne noise thresholds now proposed for the project.

Table 4.1: Summary of internal criteria for combined groundborne and low frequency airborne railway noise (medium sensitivity receptors)

Period	LOAEL	SOAEL
Night-time (all locations)	35dB L_{ASmax}	50dB L_{ASmax}
Daytime (East Suffolk line only)	25dB $L_{Aeq,16hrs}$	40dB $L_{Aeq,16hrs}$
Daytime (Saxmundham to Leiston branch line and rail extension route only)	35dB L_{ASmax}	50dB L_{ASmax}

4.2.22 The overall revised process for the assessment of groundborne noise is as follows:

- airborne noise should be assessed in the normal way;
- groundborne noise, where it is present in combination with airborne noise from the same source, should be assessed by considering the decibel sum of both the internal groundborne noise and the internal airborne noise in the octave bands up to and including 125Hz using ‘Slow’ time-weighting rather than ‘Fast’, assuming windows are fully closed;

- the combined groundborne and airborne noise levels, determined as above, should then be assessed against the following LOAEL and SOAEL values:
  - East Suffolk line during the daytime: $L_{Aeq16hrs}$ thresholds in **Table 4.1**;
  - East Suffolk line during the night: L_{ASmax} thresholds in **Table 4.1**;
  - Saxmundham to Leiston branch line and rail extension route at any time: L_{ASmax} thresholds in **Table 4.1**.

4.3 Updated Assessment Outcomes

4.3.1 The assessment in the ES considered the two elements of the rail infrastructure separately; the Saxmundham to Leiston branch line, where the track will be modified and upgraded as part of the project, and the East Suffolk line, where major upgrades to the line are understood to be unlikely, but where more minor works may be possible. Discussions with Network Rail are ongoing to determine which modifications are likely to be beneficial and feasible, and will provide a long-term legacy for the line.

4.3.2 The groundborne noise and vibration survey report sets out the levels measured at and within properties close to the track in more detail than was possible in the ES, taking account of site-specific information gathered in August 2020. The measurements during the August 2020 survey covered multiple train movements along the Saxmundham to Leiston branch line, where it was possible to repeatedly run the train backwards and forwards without interfering with existing rail services, to capture detailed, site-specific data.

4.3.3 Additional measurements were made along the East Suffolk line in Woodbridge, when the train passed at the start and end of the survey. The conclusions reached for the East Suffolk line are based on the track condition and construction as encountered at the Woodbridge measurement location, together with the elements of the Saxmundham to Leiston branch line measurements that were more general in nature. For example, it is possible to draw conclusions for the East Suffolk line by analysing specific elements of the Saxmundham to Leiston branch line measurements, including the way in which noise and vibration propagate between unloaded ground and a building, and within a building itself.

4.3.4 A three-dimensional numerical model was used in conjunction with the survey results, to determine what combination of physical and operational measures would be required to achieve acceptable levels of groundborne noise and vibration. The conclusions are set out below for the two elements of the railway.

4.3.5 It is noted that the groundborne noise from the passage of each fully loaded train is likely to be perceived as a series of similar peaks; unlike airborne noise where the locomotive will be the greatest source of noise, the groundborne noise levels from passing loaded wagons will be similar in magnitude to the groundborne noise levels from the engine. There is likely to be more of a difference between the groundborne noise levels of the locomotive and empty wagons during the passage of empty trains.

4.3.6 The assessment in the groundborne noise and vibration survey report has followed the recommended revised methods, which take account of the unique circumstances encountered by the project. As previously described, the factors that are considered unique are the potential for combined groundborne noise and low frequency airborne noise, which are typically only present in isolation, and the introduction of new and different trains onto an existing line, with existing services.

a) Saxmundham to Leiston Branch Line

4.3.7 The August 2020 survey suggested that the outcomes and effects along the Saxmundham to Leiston branch line were over-estimated in the ES. Groundborne noise levels in particular were found to be lower than was anticipated in the ES. There is a high level of confidence in the August 2020 data as it is based on site-specific measurements, which account for the particular ground and building conditions encountered during the measurements.

4.3.8 Using the updated approach to assessing groundborne noise, the potential effects along the Saxmundham to Leiston branch line are considered against the L_{ASmax} criteria for both the daytime and night-time. No distinction is made between day and night, since the same criteria apply day and night to each train.

4.3.9 The groundborne noise and vibration survey report set out the following conclusions for the combined groundborne and low frequency airborne noise levels, providing there are no welded joints within 25 metres of a receptor:

- With a train speed limit of 10mph, the SOAEL of 50dB L_{ASmax} will not be exceeded at any property along the Saxmundham to Leiston branch line, where the track is upgraded with long welded rail and concrete sleepers.
- Irrespective of the train speed, it will be necessary to use under ballast mats where there is a receptor within 15 metres of the line to maintain

a similar relationship between the track and surrounding ground as was encountered during the survey. In broad terms, laying new track and ballast may stiffen the connection between the track and the ground and under ballast mats will neutralise this effect.

- Alternatives to under ballast mats may be acceptable, where the same effect is achieved.

4.3.10 In terms of groundborne noise alone, the groundborne noise and vibration survey report sets out the following, again, on the basis that there are no welded joints within 25 metres of a receptor:

- With a train speed limit of 10mph, the L_{ASmax} levels inside all of the properties along the Saxmundham to Leiston branch line will be no higher than 40dB L_{ASmax} where the track is upgraded with long welded rail and concrete sleepers. This is below the EIA significance threshold of 45dB L_{ASmax} and would meet the objective in **paragraph 4.7.19** in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545].

4.3.11 The detail of the under ballast mats assumed in the calculations are set out in **Appendix B** of this document.

4.3.12 It is noted that the conclusion relating to the outcome for properties along the Saxmundham to Leiston branch line at train speeds of 20mph is based on current information.

4.3.13 Once the Saxmundham to Leiston branch line has been upgraded and all required mitigation installed, further measurements and assessment will be undertaken to determine the effect of the in-situ track to determine whether speeds higher than 10mph are possible without reducing the protection to the receptors.

4.3.14 While the groundborne noise measurements undertaken in August 2020 provide excellent site-specific information on the generation and propagation of groundborne noise, the effect of the proposed mitigation is based on its likely minimum benefit. Once installed, the proposed mitigation may be more effective than has been assumed in this assessment and therefore speeds higher than 10mph on the Saxmundham to Leiston branch line may be possible in the later years, once the proposed rail extension route is complete.

4.3.15 It is recommended that the 10mph speed limit on the Saxmundham to Leiston branch line be imposed in the early years, during which further measurements and assessment will be undertaken to determine if a speed limit of 20mph is possible without reducing the protection to the receptors.

4.3.16 With the removal of rail joints in close proximity to receptors, the significant effect threshold for tactile vibration, as quantified using the VDV scale, will not be exceeded along the Saxmundham to Leiston branch line.

4.3.17 On the basis of the findings of the groundborne noise and vibration survey report, recommendations for the Saxmundham to Leiston branch line have been developed so that the groundborne noise levels alone are below 45dB L_{ASmax}, the combined groundborne and low frequency airborne noise are below the 50dB L_{ASmax} SOAEL, and the significant VDV effect thresholds are not exceeded. The recommendations are:

- Re-lay track using long-welded rail and concrete sleepers, and as far as possible, avoid welded joints within 25 metres of any property;
- Steel sleepers may be used instead of concrete sleepers, with no detrimental effect on the outcomes.
- Use under ballast mats (or equal and approved) where there are properties within 15 metres of the railway line, extending at least 10 metres either side of the adjacent property;
- Specification of under ballast mat is as set out in **Appendix B** of this document;
- Limit speed on Saxmundham to Leiston branch line to 10mph during the early years;
- Pending the results of further assessment of the upgraded and mitigated Saxmundham to Leiston branch line during the early years operation, the speed limit on Saxmundham to Leiston branch line may be increased to 20mph.

4.3.18 These recommendations have been provided to the engineering team working on the design of the upgraded Saxmundham to Leiston branch line track. The recommendations are captured in the draft 'Rail Noise Mitigation Strategy', which is contained in **Appendix 9.3.E** of the **ES Addendum** (Doc Ref 6.14).

4.3.19 In addition to the recommendations set out above, the management of drivers has been discussed with Freight Operating Companies to explore further improvements. The groundborne noise and vibration survey report notes that higher Saxmundham to Leiston branch line speeds may be possible if locomotives can coast past sensitive locations.

4.3.20 It is understood that, at the present time, a commitment to using driving techniques such as coasting cannot be made, so no reliance can be placed on this measure.

4.3.21 These conclusions confirm a lower level of adverse effect than was set out in the ES where it was suggested that the SOAEL could be exceeded for properties within 5 metres of the track for trains travelling at 10mph, and within 10 metres of the track for trains travelling at 20mph.

4.3.22 The new, site-specific data suggests that this will not be the case, and the SOAEL will not be exceeded at any properties along the Saxmundham to Leiston branch line.

b) East Suffolk line

4.3.23 As was the case for the Saxmundham to Leiston branch line, the August 2020 survey suggested that the outcomes and effects along the East Suffolk line were over-estimated in the ES. Groundborne noise levels in particular were found to be lower than was anticipated in the ES. There is a high level of confidence in the August 2020 data as it is based on site-specific measurements, which account for the particular ground and building conditions encountered during the measurements.

4.3.24 Using the updated approach to assessing groundborne noise, the potential effects along the East Suffolk line are considered against the L_{Aeq} criteria for the daytime, and the L_{ASmax} criteria for the night-time.

4.3.25 Upgrades to the track along the East Suffolk line are understood to be unlikely, but more minor works may be possible. Discussions with Network Rail are ongoing in respect of these matters.

4.3.26 Notwithstanding the outcome of these discussions, the groundborne noise and vibration survey report set out the following outcomes for the combined groundborne and low frequency airborne noise levels:

- The night-time SOAEL of 50dB L_{ASmax} will not be exceeded at any properties 7 metres or more from the centreline of the track (6.28 metres from the nearest rail) at a train speed of 20mph, providing there are no rail joints. Flash-butt or arc welded joints are considered to be the same as no joints being present.
- Where there are joints, the night-time SOAEL of 50dB L_{ASmax} will not be exceeded at any properties 10 metres or more from the centreline of the track (9.28 metres from the nearest rail) for a train speed of 20mph.
- The night-time LOAEL of 35dB L_{ASmax} will not be exceeded at any property 25 metres or more from the centreline of the track (24.28 metres from nearest rail) for a train speed of 20mph.

- The night-time SOAEL of 50dB L_{ASmax} will not be exceeded at any properties 3 metres or more from the centreline of track (2.28 metres from the nearest rail) for a train speed of 10mph, providing there are no rail joints within 25 metres of the property. Flash-butt or arc welded joints are considered to be the same as no joints being present.

- Where aluminothermic joints only are present, the night-time SOAEL of 50dB L_{ASmax} will not be exceeded at any properties that are 10 metres or more from a weld for a train speed of 10mph, subject to a minimum receptor-track separation distance of 3 metres to the track centreline (2.28 metres to te nearest rail).

- Where fish-plate joints or switches/crossings are present, the night-time SOAEL of 50dB L_{ASmax} will not be exceeded at any properties that are 25 metres or more from them.

- The daytime internal SOAEL of 40dB $L_{Aeq,16hrs}$ will not be exceeded at any property along the East Suffolk line by the combination of existing passenger services and the additional construction trains, where the construction trains travel at 20mph, although this is subject to the proximity of rail joints.

4.3.27 The presence of welded rail joints will not cause tactile vibration, as quantified using the VDV scale, to exceed significant effect thresholds.

4.3.28 The most important outcome from the groundborne noise and vibration survey report is that the better, site-specific information gathered in August 2020 confirms that the SOAEL should not be exceeded within properties located 7 metres or more from the centreline of the track (6.28 metres from the nearest rail) for a train speed of 20mph, or within properties located 3 metres or more from the centreline of the track (2.28 metres from the nearest rail) for a train speed of 10mph. The equivalent distances set out in the ES were 10 metres from nearest rail for a train speed of 20mph and 5 metres from the nearest rail for trains for a train speed of 10mph.

4.3.29 There are no properties along the East Suffolk line within 3 metres of the track centreline in locations where the train will be travelling at 10mph at night. The closest property is 1 Albion Street in Saxmundham, which is just over 3.3 metres from the centreline of the track; even at this location, the combined groundborne and low frequency airborne noise level is expected to be below the 50dB L_{ASmax} SOAEL at night.

4.3.30 During the daytime, the groundborne noise and vibration survey report confirms that the 40dB $L_{Aeq,16hrs}$ SOAEL will be achieved, even if there were three construction train movements.

4.3.31 It is also likely that the property will be eligible for enhanced glazing under the 'Noise Mitigation Scheme', and the ultimate level expected within the property will be considered under that scheme in due course.

4.3.32 There are two properties within 6.28 metres of the nearest rail along sections of the East Suffolk line where the trains are likely to be travelling at 20mph during the night-time; based on the 'average' sound reduction performance of the glazing present during the August 2020 survey, the SOAEL may be exceeded at the following properties:

- Crossing Cottage, Kiln Lane South, Benhall, Saxmundham IP17 1HA, at a distance of 4.72 metres from the track centreline (4 metres from the nearest rail); and
- Unnamed property, Blackstock Crossing Road, Campsea Ashe, Woodbridge IP13 0QL, at a distance of 5.42 metres from the track centreline (4.7 metres from the nearest rail).

4.3.33 These two properties are likely to be eligible for enhanced glazing under the 'Noise Mitigation Scheme', and therefore the airborne component of the internal sound level will reduce such that the SOAEL is not exceeded. While further analysis of these two properties will be undertaken as part of the implementation of the 'Noise Mitigation Scheme' to determine the detail of the mitigation, it is expected that a sufficient reduction in the low frequency airborne noise component can be achieved so that SOAEL is not exceeded.

4.3.34 In conclusion, the findings of the groundborne noise and vibration survey report suggest that, providing the recommendations for the Saxmundham to Leiston branch line are adopted, and subject to the detailed design of sound insulation at two properties, SOAEL will not be exceeded at any locations along the length of the East Suffolk line from Westerfield Junction to the Sizewell C site.

4.3.35 This conclusion, which is an update on the position set out in the ES as a result of the more accurate, site-specific detail available after the August 2020 survey, suggests fewer adverse effects than were anticipated at the time of the DCO submission.

5 ADDITIONAL TRAIN MOVEMENTS

5.1.1 To optimise the sustainable movement of materials, additional train movements are being considered. The DCO submission was based on the train movements shown in **Table 5.1**.

Table 5.1 [extracted from Table 1.1 of Volume 9, Appendix 4B of the ES (Doc Ref 6.10) [APP-546]]: Predicted train numbers

Period	Proposed train movements in "Early Years" – before GRR is operational (Total freight movements)	Proposed train movements in "Later Years" – when GRR is operational (Total freight movements)
Night-time (23:00 to 07:00)	4 movements (2 full trains arriving at the site and 2 empty trains leaving the site)	5 movements (2 full trains arriving at the site and 3 empty trains leaving the site)
Daytime (07:00 to 23:00)	0 movements	1 movement (1 full train arriving at the site)

5.1.2 At that time, two trains were expected during the early years, giving rise to four movements, all of which would occur at night, and three trains were expected during later years, giving rise to six movements, five of which would occur during the night, and one of which would occur during the daytime.

5.1.3 The updated 'Freight Management Strategy' (Doc Ref 8.18) proposes an extra construction train per day during the 'later years', after the rail extension route is open. The additional two movements associated with the extra construction train would both occur at night.

5.1.4 It is understood that it is possible that the daytime movement that was considered in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545] may also occur during the night. Therefore it is possible that all eight movements would occur at night.

5.1.5 No change to the number of construction trains is proposed during the 'early years', before the rail extension route is open.

5.1.6 The potential for a fifth construction train is considered in the 'Freight Management Strategy' (Doc Ref 8.18), and it is understood that these extra two movements would occur during the daytime.

5.1.7 The ES did not take account of the day of the week, nor of the number of days per week where trains were anticipated. The assessment criteria do not vary according to day of the week, and the effect is assessed within the timeframe of a single night; the effect does not worsen, in terms of the assessment criteria, if the trains run on consecutive nights.

5.1.8 The key indicators of potential impact in this instance are linked to maximum sound levels, whether airborne noise or groundborne noise. These are instantaneous events and are judged on an individual night; increasing the number of trains will increase the number of these events per night, but the findings set out in the ES and in this document, will not materially change. Where impacts are identified, these will remain. Where no impacts are identified, these would not change.

5.1.9 The time-averaged indicators of effect, which are daytime and night-time L_{Aeq} values for airborne noise and VDVs for groundborne vibration, will need to be reviewed. However, the increase from five train movements per night to seven train movements will result in an increase in L_{Aeq} noise level of 1.5dB, and a doubling of the number of trains is required to obtain a 20% increase in the VDV.

5.1.10 On this basis, the time-averaged outcomes are not expected to materially change although some shifting of impact categories is possible where particular receptors previously lay just below a threshold value.

5.1.11 The other time-averaged consideration to take into account is the noise generated by the processing of the trains at their destination, both in terms of additional unloading activities and the need for additional shunting movements. Subject to clarifying the timing of the processing of the trains at the site, it is expected that there will be no material change in the outcomes set out in **Volume 2, Chapter 11** of the **ES** (Doc Ref 6.3) [APP-202].

5.1.12 Notwithstanding any potential changes to the level of activity at the site associated with processing the trains, the **'Code of Construction Practice'** (CoCP) (Doc Ref 8.11(A)) [APP-615] will remain the primary monitoring and control mechanism once the works are underway. The thresholds set out in that document remain the same, irrespective of the number of trains and consequential processing activities. The provisions of the 'Noise Mitigation Scheme' will also apply where eligible properties are identified.

6 CONCLUSION

6.1.1 This document summarises the findings of the August 2020 survey and where appropriate, provides an update of the noise assessment set out in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545] using the survey results.

6.1.2 The key findings are:

- The additional survey data for Class 66 locomotives, and new data for Class 68 locomotives, suggest that the L_{AFmax} airborne noise source terms used in the ES were an over-estimate and therefore the ES findings can be considered robust and representative of a worst-case outcome.

- The time-averaged daytime and night-time L_{Aeq} values do not change as a result of the August 2020 survey, as they were determined by calculation using the 'Calculation of Railway Noise'.

- Additional sources of airborne noise were observed during the August 2020 survey, these being flange squeal, wheel/joint noise, and ground radar cleaning hiss. All three sources are considered to be anomalous and likely to have been caused by the condition of the Saxmundham to Leiston branch line track during the survey. All three sources are expected to be removed by the relaying of the Saxmundham to Leiston branch line with new, welded track. These sources were not observed during measurements along the East Suffolk line in Woodbridge, nor during the surveys that informed the ES.

- In light of the above, in particular given that the August 2020 data indicates that the ES may have over-estimated noise levels, it remains the position that all SOAEL impacts from airborne noise can be avoided, if necessary through insulation under the Noise Mitigation Scheme.

- The groundborne noise and vibration report has identified a different way of assessing groundborne noise, which results in a more stringent assessment, but recognises the unique circumstances associated with the project, where groundborne and airborne noise may be present simultaneously and where new and different trains are introduced on a line with existing services.

- The approach set out in the ES required only groundborne noise to be tested against the SOAEL and the new approach assesses combined groundborne and low frequency airborne noise against the same SOAEL as used in the ES. Daytime effects are also considered, and criteria are specified according the presence of existing services on the railway line.

- The groundborne noise measurements in August 2020 suggest that the ES presented an over-estimate of the potential effect, and the findings can be updated on the site-specific information now available.

- The groundborne noise assessment suggests that the use of long welded rail, under ballast mats, and a speed limit of 10mph will result in the combined groundborne/low frequency airborne noise SOAEL being met at every property along the Saxmundham to Leiston branch line. This is an improvement on the conclusion reached in the ES, where exceedances at the closest properties were considered possible.

- The combined groundborne and low frequency airborne noise levels should meet the SOAEL at all of the properties along the East Suffolk line, providing the track parameters are similar to those encountered during the survey. If the ES had identified the number of similarly-affected properties, seven would have been identified.

- There are two properties where the combined groundborne and low frequency airborne noise levels may exceed the SOAEL. However, these properties are likely to be eligible for enhanced glazing under the ‘Noise Mitigation Scheme’, and therefore the airborne component of the internal sound level will reduce such that the SOAEL is not exceeded.

- There is no ‘in principle’ reason why the number of night-time trains cannot be increased. The adverse assessment outcomes will occur more frequently per night, but the proposals would remain policy compliant as set out above. The criteria do not vary according to day of the week or according to number of days per week; the prospect of trains on six days per week also does not alter the conclusions

REFERENCES

1. The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (SI 2017 No 572)

2. DECC (2011) Overarching National Policy Statement (NPS) for Energy (NPS EN-1)

3. Calculation of Railway Noise, Department of Transport (1995)

4. Planning Practice Guidance – Noise, MHCLG (2019)

5. BS EN 12758: 2011 Glass in building — Glazing and airborne sound insulation — Product descriptions and determination of properties

6. The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996

7. DEFRA (2010) Noise Policy Statement for England

APPENDIX 9.3.A.
APPENDIX A: AIRBORNE NOISE SURVEY REPORT

SHARPS REDMORE

ACOUSTIC CONSULTANTS ▪ Established 1990

Report

Sizewell C – Rail noise

Report on noise survey carried out to determine noise from slow moving freight trains

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Contents

Appendices

1.0 Introduction

1.1 A noise assessment has been carried out (ES Ref. Book 6.10 Vol.9 Ch 4) to determine the potential effects of proposals to run freight trains at night between Westerfield junction and the proposed Sizewell C Power Station construction site. This assessment concluded that trains running on the line at night would need to travel at 20mph and when passing through Woodbridge, Campsea Ashe and Saxmundham would need to reduce their speeds to 10mph in order to control noise.

1.2 Based on the number of trains proposed in the DCO submission, the key noise parameter to control was found to be the L_{Amax} parameter; this is the highest level measured (using a fast time weighting) during any train pass. All references to L_{Amax} within this report are to this parameter measured using the Fast time weighting. Since there is no published method for the assessment of the L_{Amax} from trains moving at such slow speeds, survey work was carried out to determine the range of noise levels which occurs when freight trains run at these slow speeds. It was concluded that the mean level from a Class 66 locomotive running at between 9 and 11mph was 74dB, L_{Amax} at 10 metres and that the 95% upper Confidence Interval (C.I.) for the mean from those survey results was 77dB, L_{Amax} at 10 metres. At 20mph, the mean and upper C.I. were 80 and 85dB, L_{Amax}.

1.3 Accordingly, the assessment was based on source levels for locomotives of 77dB, L_{Amax} at 10 metres from the line for parts of the line where the speed would be 10mph and on 85dB, L_{Amax} at 10m for parts of the line where the speed would be 20mph. A copy of the earlier survey details and results (extracted from ES Ref. Book 6.10 Vol.9 Ch 4 Appendix 4B) is shown in Appendix A.

1.4 However, since the Class 68 locomotive is being considered for the project in addition to, or as an alternative to, the Class 66 locomotive and since the majority of the survey data had been taken in a limited number of locations, it was decided that the Class 66 and Class 68 should be tested for comparison and that the additional data collected for the Class 66 would form useful additional information to supplement the data used in the original assessment.

1.5 Therefore, EDF Energy commissioned a 325m long freight train with both a Class 66 and a Class 68 locomotive (one at each end) to run along the Saxmundham to Leiston branch line over three days in August 2020 so that noise and vibration levels could be tested. Details and analysis of the vibration measurements are contained in a separate report.

1.6 Section 2.0 of this report provides details of the survey methodology and results are presented in Section 3.0.

1.7 Section 4.0 considers provides a synthesis of the results from this survey and earlier survey work and Section 5.0 provides conclusions and considers the findings from earlier assessment work in the light of those conclusions.

2.0 Assessment Methodology and Criteria

2.1 Survey work was undertaken on 5th, 6th and 10th August 2020 at the six locations shown in Figure B1 in Appendix B.

2.2 Measurements were undertaken using Type 1 sound level meters within laboratory calibration certification. Copies of calibration certificates are in Appendix C. Before and after all sound level measurements, field-calibration was undertaken and no adverse calibration drifts were found to have occurred.

2.3 The microphone at each survey location was fitted with an appropriate windshield at all times to minimise the influence of air movement across the microphone.

2.4 All measurements were made in free-field conditions and at distances ranging between 7.5 and 10 metres from the line. Other than the ground, there were no reflective surfaces within 3.5 metres of the sound level meters in accordance with the 'Description and measurement of environmental noise' BS 7445-1:2003.

2.5 All sound survey locations were attended by competent field operatives who recorded the sound level meter position, the weather conditions and who kept a record of key information pertinent to the survey. The time taken for each train to pass was also recorded and this was used to estimate the train speed. Distances between the survey location and the passing train were also recorded and all measurements of train noise have been normalised to 10 metres.

2.6 Weather conditions were suitable for the measurement of environmental noise at the distances concerned. Ambient and background noise levels during survey work were considerably below measured L_{Amax} levels and so did not interfere with readings at any time.

2.7 On the first day of surveying (5th August), trains were run up and down the line with the Class 66 pulling when travelling east and the Class 68 pulling when travelling towards the west. On the second and third days (6th and 10th August) the Class 66 pulled the train towards the west and the Class 68 pulled towards the east. Speeds were tested in the range 6 to 24 miles per hour (mph) during the survey. Train crews were instructed to keep the locomotives running at a constant speed throughout their passage past the monitoring locations, so far as was possible.

2.8 The condition of the line was poor as it had not been used for a number of years other than by engineering trains carrying out periodic test runs. Some of the noise (and vibration) which arose as a result of trains passing was caused by the poor quality of the line and the joints between the tracks. A careful note was kept of the sources of noise and the degree to which different sources affected the readings for every pass-by measured. From this, is was generally possible to post process the results to obtain a level for the locomotive in isolation. Where this was not possible, for example, if a loud flange squeal occurred at the same time as a locomotive maximum noise level, the reading was discarded.

2.9 The line was relatively flat throughout, although there was a small gradient between locations 2 and 3 (uphill going east), which meant that trains heading in an east bound direction may have been under greater load than those heading west. The effect of this has been effectively negated by swapping the direction of the train on different days.

2.10 It was not possible to set up a survey using the exact same train dimensions and weight as those proposed for the Sizewell C project and the wagons used were empty. Nevertheless, a train with total mass of 772 tonnes and the length was 325 metres so it is considered that the test conditions were sufficiently similar to the proposed trains for the results to be meaningful.

3.0 Results

3.1 Although a range of parameters were measured and recorded during the survey, only the L_{Amax} levels have been reported, as this is the key parameter of interest for the noise assessment for the number of trains proposed in the DCO submission. In all cases the ambient noise level was greater than 20dB below the L_{Amax} recorded, so other sources did not interfere with measurements at all. All results are shown in Table D1 in Appendix D and graphically in Appendix E.

3.2 There were four main contributors to the measured L_{Amax} levels from trains passing. These were:

a) The noise from the locomotive engine and associated mechanical services;

b) Noise from the occasional hiss from radar air cleaners as locomotives passed;

c) Noise from locomotive and wagons wheels, particularly noticeable as these passed over the joints in the tracks; and

d) Noise from the squeal of wheel flanges striking the rails which occurred occasionally as the Class 66 locomotive passed over certain sections of track.

3.3 The noise from sources c) and d) only occurred due to the poor condition of the track and would either not be present or would be considerably reduced in level once the track is upgraded to continuously welded rail (as is proposed). Sources a) and b) would remain when the track has been upgraded so need to be considered further. These four sources are discussed in more detail below.

Locomotive noise

3.4 This is the main noise source which needs to be considered and the results shown in Table D1 show noise levels from this source only. Statistical processing of this data has been carried out and this is the source of noise which is the main focus of the noise assessment for the project.

Hiss from air cleaners

3.5 Locomotives are fitted with air cleaners on the radar used for ground speed measurements and these blow air at regular intervals to keep the radar clean. This sound, which is a high frequency “hiss” occurred relatively often during the survey, but it was only when it occurred in the same second as the highest level from the locomotive itself that the hiss influenced with readings. The hiss was present and affected readings during the survey for 7% of the train passbys.

3.5 It is understood that the state of track has a significant impact on how the speed sensors function as the system continuously scans for a point of reference from the track bed to enable a speed calculation. The presence of jointed track, vegetation and broken sleepers impacts greatly on the frequency of use of the air cleaners. If the system has an imperfect signal returned to it, it is programmed to first assume that the radar lens is obscured and it will use the air system to clean the radar face. On long welded track and jointed track where the passage of trains clears most of the vegetation and where the sleepers are new or in good condition, this self-cleaning will occur infrequently.

3.6 The branch line from Saxmundham to Leiston, which is in poor condition, had all three of these challenges to overcome and the frequency at which the cleaning systems operated during the survey was significantly increased beyond what would normally be expected. The proposed improvements to the track along the branch line will have a positive reduction in the number of times the air cleaning system would operate and the hiss is not anticipated to be present (other than rarely). This is also the case for the the East Suffolk line, which is in better condition and has no vegetation, no broken sleepers and fewer joints.

3.7 Where it does occur on the East Suffolk line, the likelihood of it occurring at the same time as the maximum level from a locomotive passing is considered to be extremely small. It is notable that the hiss was not present at any of the other locations at which train noise has been surveyed; although it was a noise source present on the branch line at the time of our survey, it is not generally a noise source which needs to be considered for trains during normal operating conditions.

Noise from wheels on track

3.8 It is understood that the track had not been used for a large freight train for many years. Although the track has been assessed as safe for use for this testing, it is understood that it would need to be upgraded in future to enable regular use by freight trains. The track was rusty and had surface imperfections and sleepers that were described by the train operator as ‘in poor condition’. The track was bullhead rail and this does not provide such as good a relationship between the railhead profile and the wheel profile as would exist with a modern continuously welded track. The gauge accuracy was also not as good as would be the case once the rail has been upgraded.

3.9 The interface between the rail and the wheels meant that the characteristic sound of wheels “clicking” when moving over a joint in the line was higher than would occur on continuously welded rail, as would be the case for the proposed line upgrade. Notwithstanding the potential increases in noise caused by the rail/wheel interface, it was found that the noise from wheels on the track remained lower than the noise of passing locomotives for all measurements recorded.

Noise from squeal of occasional wheels from Class 66 locomotive

3.10 The Class 66 locomotive is fitted with a flexible or self-steering bogie. This is designed to reduce track wear and to help the locomotive turn through track bends. Unfortunately, when the track condition is poor, imperfections in the track surface and the less than ideal gauge accuracy result in the bogie being knocked slightly out of alignment; as the wheel flanges re-align, they will often strike the edge of the rails leading to a brief but loud scraping, squealing sound. This was found to be pronounced in some sections of line and this sound occurred virtually every time the train passed these sections. The sound was at such a level at times that it interfered with the measurements. One of the intended monitoring locations was abandoned as a consequence, as it proved impossible to obtain readings there without this sound being present.

3.11 Since the latter two noise sources would not be present once the track is upgraded only the noise from locomotives and the hiss sound need to be taken into consideration for the purposes of this assessment.

Results

3.12 The results were processed to isolate the locomotive sounds from the noise from wheels striking rail joints; the hiss from the radar cleaner and sounds from wheel flanges striking rail joints. Where it was not possible to robustly separate the sounds, the measurement was discarded. Locomotive sound is considered in detail in Section 4.0 below. Hiss is considered in Section 5.0.

3.13 A total of 204 useable measurements of L_{AFmax} levels for locomotives were obtained and these shown, alongside estimated train speeds and normalised to 10m in Table D1 in Appendix D.

3.14 Appendix E contains graphical representations of the results showing all data (Figure E1) and data divided to show Class 66 and Class 68 locomotives (Figures E2 and E3 respectively).

4.0 Synthesis of Results for Locomotive Noise

4.1 Previous measurements of freight trains passing were made between October 2019 and January 2020 at Ely Station, Ipswich Station, at various locations along the line between Westerfield junction and Felixstowe Port and near to the Loughborough to Leicester line in the vicinity of Mountsorrel Quarry. A description of this earlier work and a summary of those results is shown in Appendix A. These were for Class 66 locomotives only. These have been combined with the results for Class 66 locomotives from this survey to provide an overall prediction of the likely mean levels at each speed category. The same analysis has been carried out using Class 68 data from this survey only, as no data for Class 68 locomotives had previously been gathered.

4.2 As previously, results were grouped into bands of different speeds and all results were fed into each speed band. Tables 4.1 and 4.2 below show a summary of the means, and the upper and lower 95% confidence levels for Class 66 and Class 68 locomotives, respectively.

Table 4.1: Summary of data for Class 66 locomotives

Train speed, mph	6-8	9-11	12-14	15-17	18-20	21-23	24-26
Mean L_{Amax}, dB	72	73	75	77	79	81	83
Std dev	2.0	2.8	3.2	3.5	3.7	4.6	3.0
N	14	32	16	20	10	22	3
Lower 95% C.I. L_{Amax}, dB	71	72	73	76	77	79	78
Upper 95% C.I. L_{Amax}, dB	73	74	76	79	81	83	88

Table 4.2: Summary of data for Class 68 locomotives

Train speed, mph	6-8	9-11	12-14	15-17	18-20	21-23	24-26
Mean L_{Amax}, dB	73	75	76	78	78	78	76
Std dev	2.6	3.1	2.3	3.6	2.7	1.7	-
N	8	47	12	27	16	18	1
Lower 95% C.I. L_{Amax}, dB	72	75	75	77	77	78	-
Upper 95% C.I. L_{Amax}, dB	75	76	77	79	79	79	-

4.3 These results are shown graphically in Figures 4.1 and 4.2 below. Levels in the 24-26 speed range are ignored as there is not sufficient data from this testing to create a meaningful graph of results in this range.

Figure 4.1: Graph showing mean relationship for speed against L_{Amax} level at reference distance of 10m for Class 66 locomotives

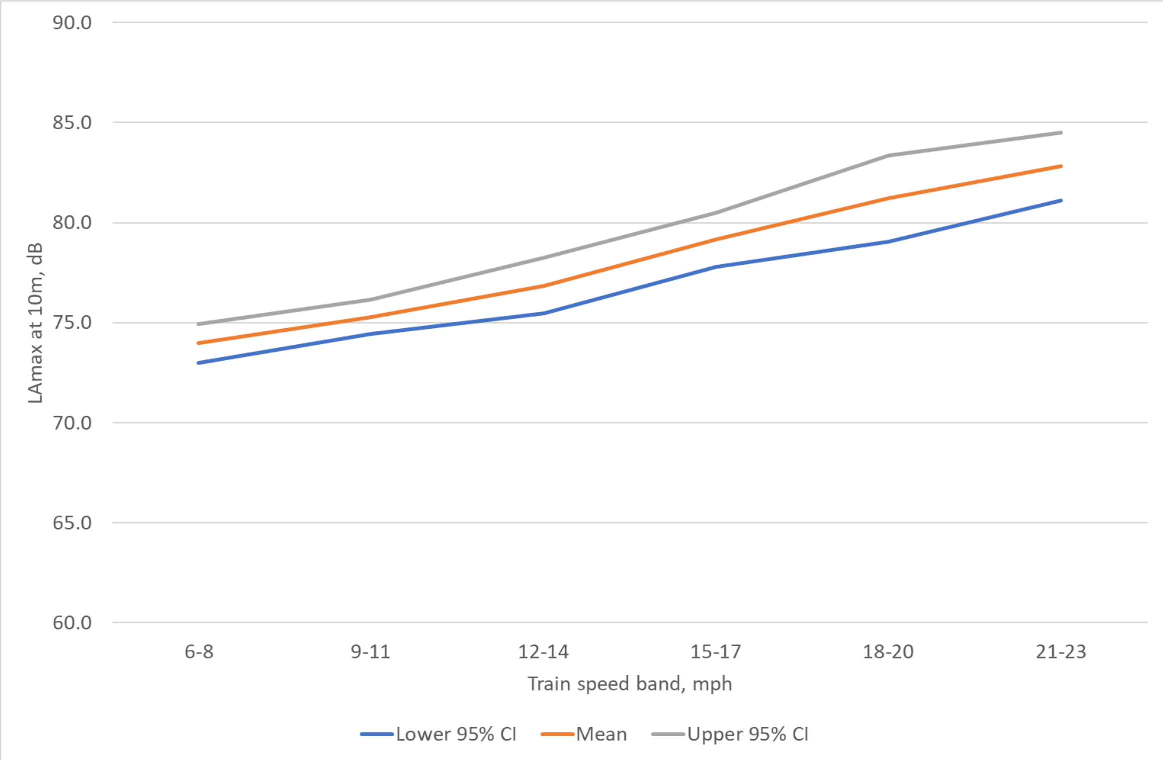
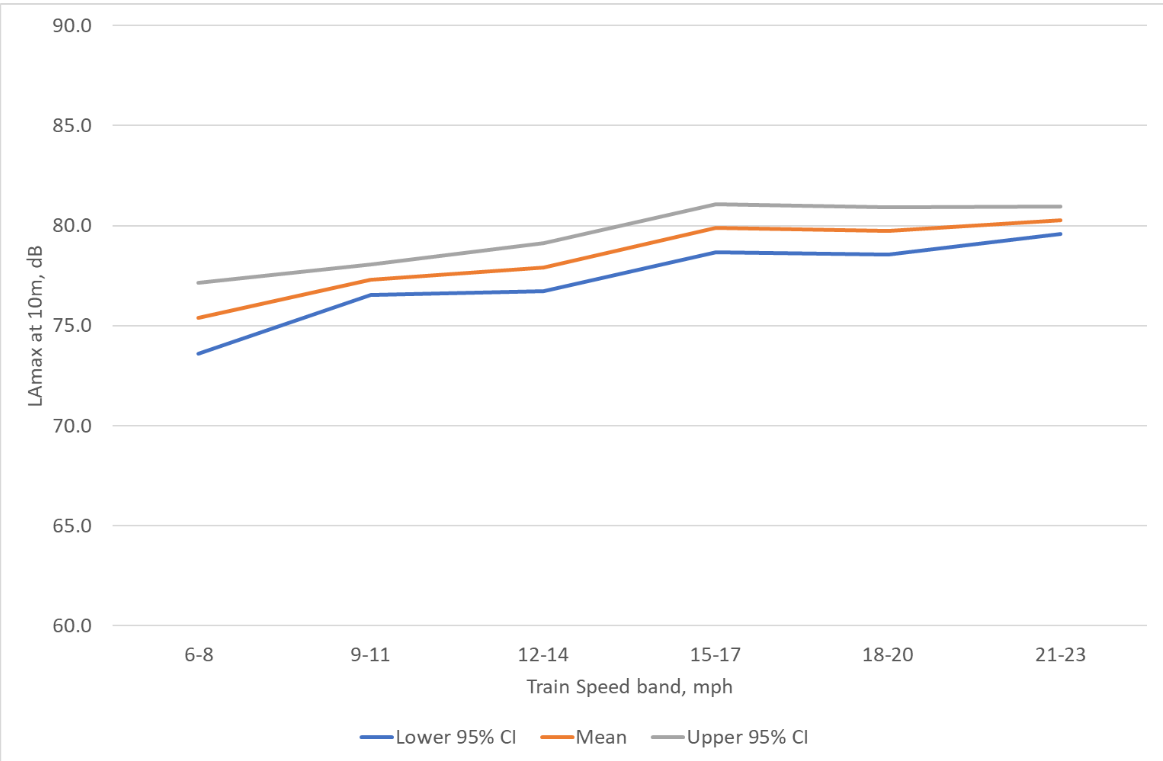


Figure 4.2: Graph showing mean relationship for speed against L_{Amax} level at reference distance of 10m for Class 68 locomotives



Summary of measured external levels of locomotive noise

4.4 The earlier survey work had resulted in an estimate of mean L_{Amax} level at 10m for Class 66 locomotives at 9-11mph of 74dB with an upper Confidence Interval (C.I.) of 77dB and mean L_{Amax} level at 10m at 18-20mph 80dB with an upper C.I. of 85dB. Predictions of noise level from passing trains were made in the ES (ES Ref. Book 6.10 Vol.9 Ch 4) using the upper C.I. values of 77dB and 85dB for trains moving at constant speeds of 10 and 20mph, respectively.

4.5 With the additional data for the Class 66 locomotives, the standard deviation and hence the Confidence Interval is reduced and the overall mean is very slightly (1dB) lower. The mean and upper 95% confidence levels for the L_{Amax} at 10m at 10 and 20mph for a Class 66 locomotive passing by are:

At 10mph: Mean = 73dB Upper 95% C.I. = 74dB and

At 20mph: Mean = 79dB Upper 95% C.I. = 81dB.

4.6 Hence, the levels used to predict noise from passing locomotives in the ES are between 3 and 4dB higher than the levels suggested by the new survey data, taking into account the additional measured levels for Class 66 locomotives moving at constant speeds in the range 9-20mph.

4.7 Analysis of Class 68 data shows the following mean and upper 95% confidence levels for the L_{Amax} at 10m at 10 and 20mph:

At 10mph: Mean = 75dB Upper 95% C.I. = 76dB and

At 20mph: Mean = 78dB Upper 95% C.I. = 79dB.

4.8 The additional survey results lead to the following conclusions:

- The maximum levels from Class 66 locomotives are lower than the values used in the DCO at all speeds
- The maximum noise levels from Class 68 locomotives are 2dB higher than the levels from Class 66 locomotives at 10mph, and 2dB lower at 20mph (based on the upper 95% C.I.). This means that the Class 66 locomotives are likely to be more suitable from a noise control perspective through the main built up areas on the East Suffolk line where low speeds will be maintained.

5.0 Noise from radar cleaning "hiss"

5.1 Since the hiss was only present at a high level in a relatively small percentage of readings, and was often only present at the same time as the maximum noise from the locomotive and / or the sound of wheel flange striking the rails, it was only possible to retrieve three measurements which were sufficiently uncontaminated with other sounds to analyse the loudest hisses which occurred during testing. This was carried out by obtaining the levels from the second in which the hiss occurred and the levels from the second immediately after the hiss occurred. As with all other reported values, the L_{max} parameter was assessed using the fast time weighting. The results of these three events are shown (as L_{max}, free field values at 10 metres) in Table 5.1 below.

Table 5.1: Measurements of hiss plus train noise at 10 metres, free field

Source	Level in each octave band (dB, LIN)								Overall A-weighted, dB
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Loco 1 no hiss	83	74	65	70	64	60	53	42	70
Loco 1 plus hiss	81	74	66	70	68	71	76	76	81
Loco 2 no hiss	91	78	71	71	68	63	63	58	74
Loco2 plus hiss	90	78	69	71	70	73	79	77	83
Loco 3 no hiss	89	77	66	70	65	60	60	47	72
Loco 3 plus hiss	83	76	61	66	65	68	74	73	78

5.2 The small variations between levels with and without hiss in the 63Hz to 500Hz range are due to small differences in engine noise occurring between one second and the next and not due to the hiss. The differences in level in the range 1 to 8kHz are due to the hiss. Subtracting the levels with the hiss present from the levels in the absence of the hiss provides an estimate of the levels caused by the hiss alone. This results in a logarithmic average spectrum (in this range) for hiss noise as shown in Table 5.2 below.

Table 5.2: Estimated noise from hiss alone (free field values at 10 metres)

Source	Level in each octave band (dB, LIN)								Overall A-weighted, dB
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Average hiss spectrum	0	0	0	0	65	70	76	75	80

5.3 As can be seen from Table 5.2, the air cleaners produce only sound high frequency sound energy.

6.0 Internal noise levels

6.1 Taking the upper 95% confidence interval for locomotive noise at 10 and 20mph, internal noise levels can be predicted using an average sound spectrum at each of these speeds.

6.2 Since the level of the radar cleaning "hiss" is independent of speed, the hiss spectrum shown in Table 5.2 can be used all speeds and added to the predicted internal noise level for each train / speed type.

6.3 In order to predict internal levels, the degree to which the sound would break into a room must be considered. The external façade, and/or roof, of a building typically provide significantly higher sound reduction performance than doors, windows and, if applicable, ventilators, and the overall sound reduction to bedrooms is usually dictated by the glazing and ventilator elements.

6.4 To provide a robust representation of a typical dwelling reference has been made to guidance documents in terms of establishing a representative glazing performance. A value of 25dB $R_w + C_{tr}$ has been assumed as the performance of a basic thermal double glazing, i.e. 4/(6-16)/4mm glass configuration.

6.5 The following assumptions have been made in the calculations:

- No distance or screening correction of the source data has been applied.
- The windows and any ventilators are closed.
- Ventilators and external walls/roof are not a contributing factor.
- Internal noise levels are standardised to 0.5 second reverberation time internally in all octave bands to be representative of a typical residential bedroom. This is the same approach adopted for standardising internal sound insulation values in Approved Document E of the Building Regulations (ADE), BS EN ISO 140-4:1998 which ADE currently refers to and the subsequent British Standard: BS EN ISO 16283-1:2014+A1:2017.
- Glazing data based on BS EN 12759:2011 with predicted 63 Hz and 8 kHz values as these are outside the range quoted in the standard.
- No other external or internal contributions to noise levels within rooms.
- Bedroom window of $1.5m^2$.
- External facade of $10m^2$ including window.
- $32m^3$ room volume (average master bedroom floor area $13.4m^2$ and average residential ceiling height of modern dwellings at 2.4m).

6.6 The calculated internal L_{max} unweighted octave band and overall, A-weighted levels for the different trains and speeds are shown below rounded to the nearest decibel in Table 6.1 below, assuming a receptor at a distance of 10m from the line.

Table 6.1: Predicted internal noise levels resulting from different sources

Source	Level in each octave band (dB, LIN)								Overall A-weighted, dB
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz	
Class 66, 10mph	67	52	51	45	30	24	25	13	47
Class 66, 20mph	70	64	55	48	38	33	37	37	53
Class 68, 10mph	72	63	53	43	32	25	25	19	51
Class 68, 20mph	78	64	55	46	37	29	29	18	54
Hiss spectrum	0	0	0	0	28	31	43	42	46

7.0 Conclusions

7.1 On the basis of the levels measured to date, there is little level difference (considered using the L_{Amax} parameter) between noise levels from the Class 66 and Class 68 locomotives at 20mph. However, as the train speed is reduced, the Class 66 produces a lower L_{Amax} level than the Class 68.

7.2 The Class 68 locomotive generated a more consistent sound level across the tested speeds than the Class 66 locomotive, varying by only 3dB, while the Class 66 locomotive was quieter at low speed, louder at higher speeds, with an overall range of 6dB in the mean levels.

7.3 The levels used in the DCO submission for Class 66 locomotives are above the levels which would be used with the benefit of this additional data, which means that the assessment within Book 6.10, Volume 9, Chapter 4 of the ES presented an overestimate of the effect of night time airborne noise from trains passing along the East Suffolk line and the Saxmundham to Leiston branch line, irrespective of whether a Class 66 or Class 68 locomotive were to be used; the overestimate in maximum noise level was approximately 3 to 4dB for Class 66 locomotives and 1 to 6dB for Class 68 locomotives.

7.4 Using the 95% confidence levels to predict locomotive noise, the predicted external and internal noise levels from the Class 66 and Class 68 locomotives with are summarised in Tables 7.1 and 7.2 below. The values used for the DCO submission for Class 66 locomotives (Class 68 locomotives were not considered in the DCO) are shown for ease of comparison.

Table 7.1 Class 66 locomotives, L_{Amax} at 10m, dB as free field values

Speed	DCO submission		Locomotive only with additional survey data	
	External levels	Internal levels*	External levels	Internal levels
10mph	77	50	74	47
20mph	85	57	81	53

*Internal levels were not reported in the DCO, as the assessment criteria were for external levels only. The levels presented in this Table use the same glazing specification as described in 6.4 above.

Table 7.2: Class 68 locomotives, L_{Amax} at 10m, dB as free field values

Speed	DCO submission		Locomotive only with additional survey data	
	External levels	Internal levels	External levels	Internal levels
10mph	-	-	76	51
20mph	-	-	79	54

Appendix A

Survey Details From October 2019 and January 2020

Survey details

1 Measurements were undertaken using type 1 or class 1 sound level meters within laboratory calibration certification. Before and after all baseline sound measurements, field-calibration was undertaken and no adverse calibration drifts were found to have occurred.

2 The microphone at each survey location was fitted with an appropriate windshield at all times to minimise the influence of air movement across the microphone.

3 All measurements were made in free-field conditions. Other than the ground, there were no reflective surfaces within 3.5 metres of the sound level meter in accordance with the 'Description and measurement of environmental noise' BS 7445-1:2003.

4 All baseline sound survey locations were attended by competent field operatives who recorded the sound level meter position, the weather conditions and record of key information pertinent to the survey. A video and audio recording was made of each freight train as it passed to record details of the locomotive, number and type of wagons. These enabled post processing of this information to identify duration of event, maximum level, and length of train. Distances between the survey location and the passing train were also recorded.

5 In general, weather conditions were suitable for the measurement of environmental noise. However, on some occasions, since the key parameter of interest for both sets of survey work was the L_{Amax} parameter and, when close to a passing locomotive, with levels in excess of 70dB, L_{Amax}, weather conditions have little effect on measurements, survey work continued in some conditions when environmental survey work would normally not be carried out due to the potential influence of the sound of rainfall or the effects of wind, where it was appropriate to do so.

6 Measurements of freight trains passing were made between October 2019 and January 2020 at Ely Station, Ipswich Station, at various locations along the line between Westerfield junction and Felixstowe Port and near to the Loughborough to Leicester line in the vicinity of Mountsorrel Quarry. Results are shown in Tables A1 and A2 for Class 66 locomotives at a slow steady speed and under load, respectively.

Table A1: Survey results for freight trains pulled at a steady pace at a range of low speeds at a reference distance 10 metres

Speed, mph	Measured level, L_{Amax}, dB at reference distance of 10m										
9-11	72	78	77	74	76	69					
12-14	80	67	73	73	73	80	73	75	78	76	75
15-17	75	75	79	83	87	73	82	75	77	79	
18-20	78	80	85	73	85						

Figure A1: Graph showing mean relationship for speed against L_{Amax} level a steady pace at reference distance of 10m

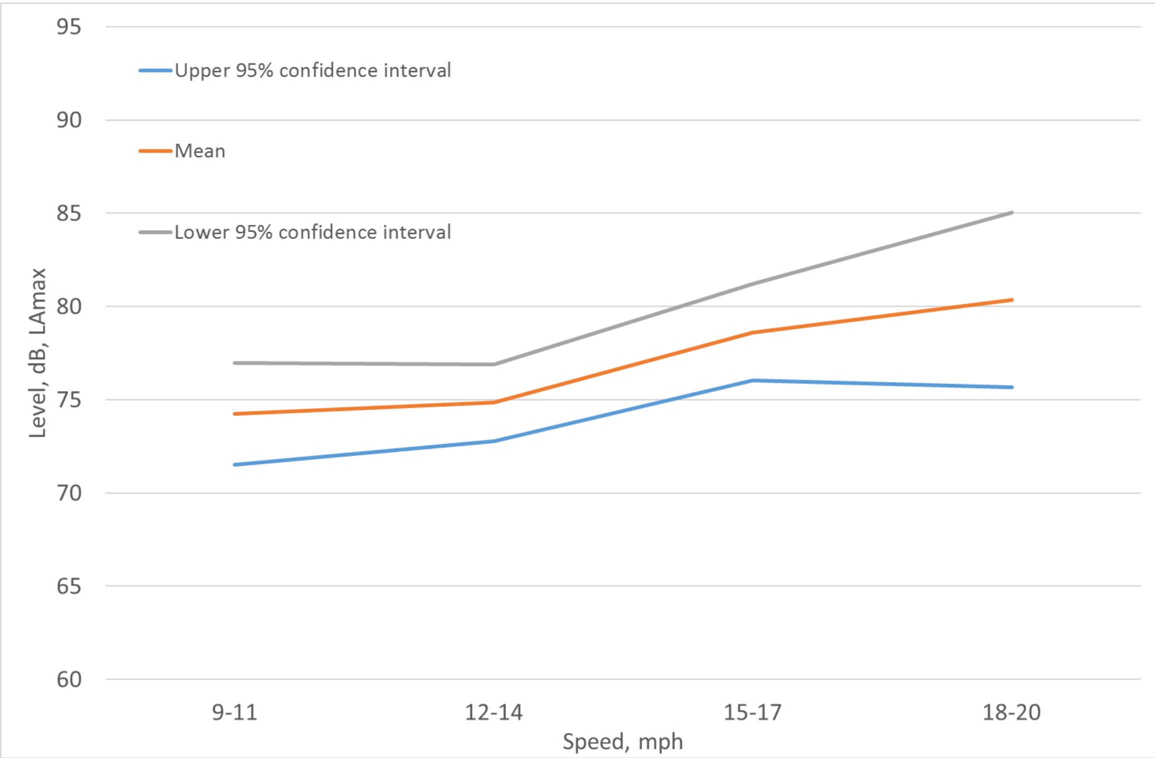
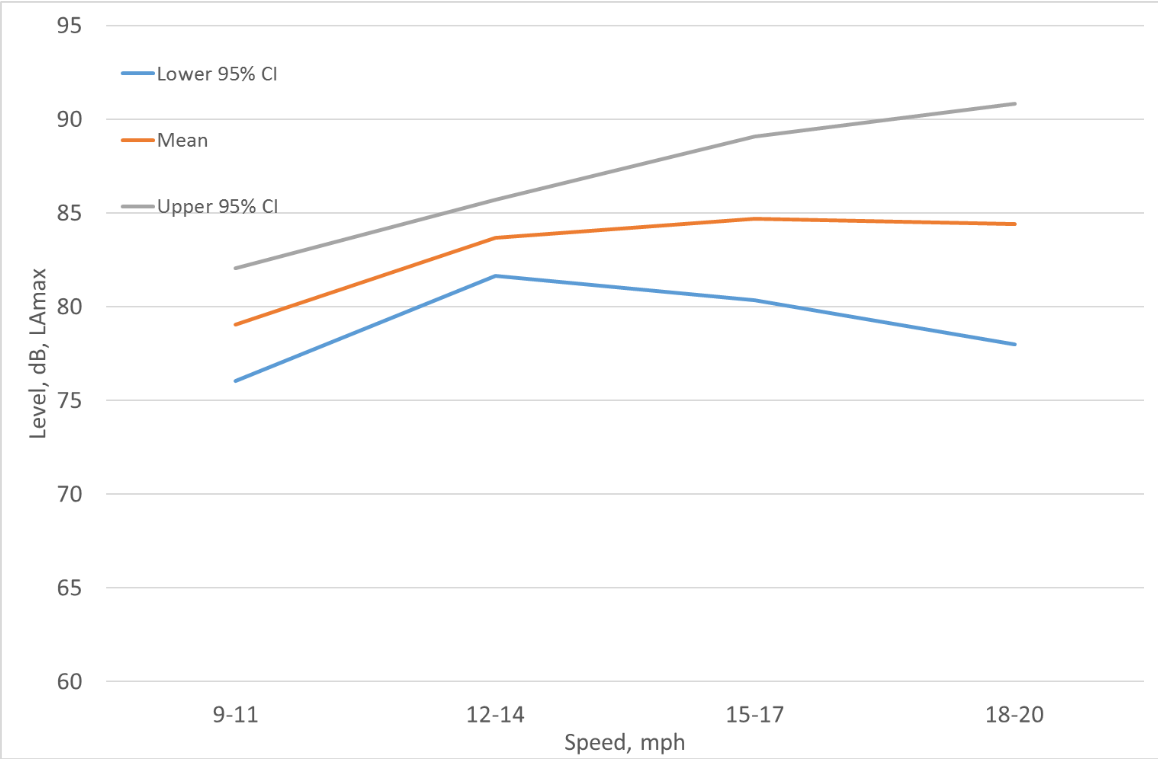


Table A2: Survey results for freight trains under load at a range of low speeds at a reference distance of 10 metres

Speed, mph	Measured level, L_{Amax}, dB at reference distance of 10m							
9-11	80	78	81	77				
12-14	83	88	83	85	82	82	82	
15-17	77	87	87	90	79	80	87	90
18-20	84	87	82					

Figure A2: Graph showing mean relationship for speed against L_{Amax} level under load at reference distance of 10m



Appendix B

Noise Survey Locations

Figure B1: Aerial photo showing monitoring locations

Appendix C

Sound Level Meter Calibration Certificates

Certificate Cover Sheet

CAMPBELL ASSOCIATES
SOUND, VIBRATION & AIR SOLUTIONS

Sharps Redmore Partnership **SHA650**

Equipment	*SOP*	*Tech Log*	*Bin No*	*Group No*	*Cal Number / Period*		*Cover Flag*
NOR-1251.30795	**24407**	**20558**	**138**	**1**	**2**	**12 Months**	☑

CustomerID:	SHA650
EquipmentID:	NOR-1251.30795
EquipmentType:	Cal
CertificateNo:	34057
IssueDate:	14-Feb-20
ExpiryDate:	13-Feb-21
CalComments:	

Campbell Associates Ltd
5b Chelmsford Road Industrial Estate
GREAT DUNMOW, CM6 1HD, England
www.campbell-associates.co.uk
info@campbell-associates.co.uk
Phone 01371 871030 Facsimile 01371879106

CALIBRATION

Certificate number: 34057

Certificate of Calibration and Conformance

Test object:	**Sound Calibrator**
Manufacturer:	**Norsonic**
Type:	**1251**
Serial no:	**30795**

Customer:	Sharps Redmore Partnership
Address:	The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.
Contact Person:	Emily Sharpe.

Measurement Results:	Level	Level Stability	Frequency	Frequency Stability	Distortion
1:	114.03 dB	0.06 dB	1000.66 Hz	0.00 %	0.36 %
2:	114.02 dB	0.05 dB	1000.66 Hz	0.00 %	0.36 %
3:	114.02 dB	0.06 dB	1000.66 Hz	0.00 %	0.37 %
Result (Average):	**114.02 dB**	**0.06 dB**	**1000.66 Hz**	**0.00 %**	**0.36 %**
Expanded Uncertainty:	0.10 dB	0.02 dB	1.00 Hz	0.01 %	0.10 %
Degree of Freedom:	>100	>100	>100	>100	>100
Coverage Factor:	2.00	2.00	2.00	2.00	2.00

The stated level is relative to 20μPa. The level is traceable to National Standards.
The stated level is valid at reference conditions. The following correction factors have been applied during the measurement: Pressure: 0.0005 dB/kPa Temperature: 0.003 dB/°C Relative humidity: 0.000 dB/%RH Load volume : 0.0003 dB/mm3
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.
Records: K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2020\NOR1251_30795_M1.nmf

Environmental conditions:	Pressure:	Temperature:	Relative humidity:
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	101.115 ± 0.043 kPa	22.2 ± 0.1 °C	36.5 ± 1.2 %RH

Date received for calibration:	05/02/2020
Date of calibration:	14/02/2020
Date of issue:	14/02/2020

Engineer [redacted]

Supervisor [redacted]

Certificate number: 34057

Preconditioning
The equipment was preconditioned for more than 4 hours in the specified calibration environment.

Measurements
The calibrator has been tested as described in the following annexes to BS EN IEC60942:2003 Sound Calibrators; B3.4 for sound pressure level, B3.5 for frequency, B3.6 for total distortion and A4.4 for short term stability of the pressure level.

Method
Calibration has been performed as set out in the current version of CA Technical procedure TP01

Instruments and program
A complete list of equipment, hardware and software that has been used in this calibration is available from the calibration laboratory on request.

Traceability
The measured values are traceable to an accredited national physical laboratory within the EU or EFTA.

Comment
Calibrated as received, no adjustments made.

Statement of conformance
As public evidence was available[1], from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in annex A of BS EN IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of that BS EN IEC 60942:2003.

[1] This evidence is held on file at the calibration laboratory.

Notes:
The sound pressure level generated by the calibrator in its ½ inch configuration was measured five times and averaged by a WS2P working standard microphone for class 1 or 2 devices or a LS2P reference microphone for class 0 or LS devices as specified in the International Standard BS EN 61094-4. The results of three replications and the mean of the measurements obtained are given in the measurement results table of this certificate. The frequency and distortion were measured in a similar manner. The figures in **BOLD** are the final results; a small correction factor may need to be added to the sound pressure level quoted here if the device is used to calibrate a sound level meter that is fitted with a free field response microphone. See manufacturer's handbooks for full details of this and other corrections that may be applicable.

Sonitus House, 5b Chelmsford Road Industrial Estate, Great Dunmow, GB-CM6 1HD
Tel (+44) 01371 871030 Fax (+44) 01371 879106
email calibration@campbell-associates.co.uk

Calibration Report

Certificate No.:31090

Manufacturer:	**Norsonic**
Type:	**1225**
Serial no:	**96168**

Customer:	**Sharps Redmore Partnership**
Address:	**The White House, London Road,**
	Copdock, Ipswich, Suffolk. IP8 3JH.
Contact Person:	**Dean Barke**

Measurement Results:

	Sensitivity: (dB re 1V/Pa)	Capacitance: (pF)
1:	-26.16	24.5
2:	-26.16	24.6
3:	-26.16	24.6
Result (Average):	**-26.16**	**24.6**
Expanded Uncertainty:	0.10	2.00
Degree of Freedom:	>100	>100
Coverage Factor:	2.00	2.00

The following correction factors have been applied during the measurement:
Pressure:-0.001 dB/kPa Temperature:-0.005 dB/°C Relative humidity:0.000 dB/%RH

Reference Calibrator: WSC1 - Nor1253-24269 Volume correction: 0.000 dB
Records:K:\C A\Calibration\Nor-1504\Nor-1017 MicCal\2019\NOR1225_96168_M1.nmf
Measurement procedure: TP05
All results quoted are directly traceable to National Physical Laboratory, London

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication EA-4/02.

Comment:

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
102.547 ± 0.040 kPa	23.1 ± 0.1 °C	33.9 ± 0.7 %RH

Date of calibration: 26/02/2019
Date of issue: 26/02/2019

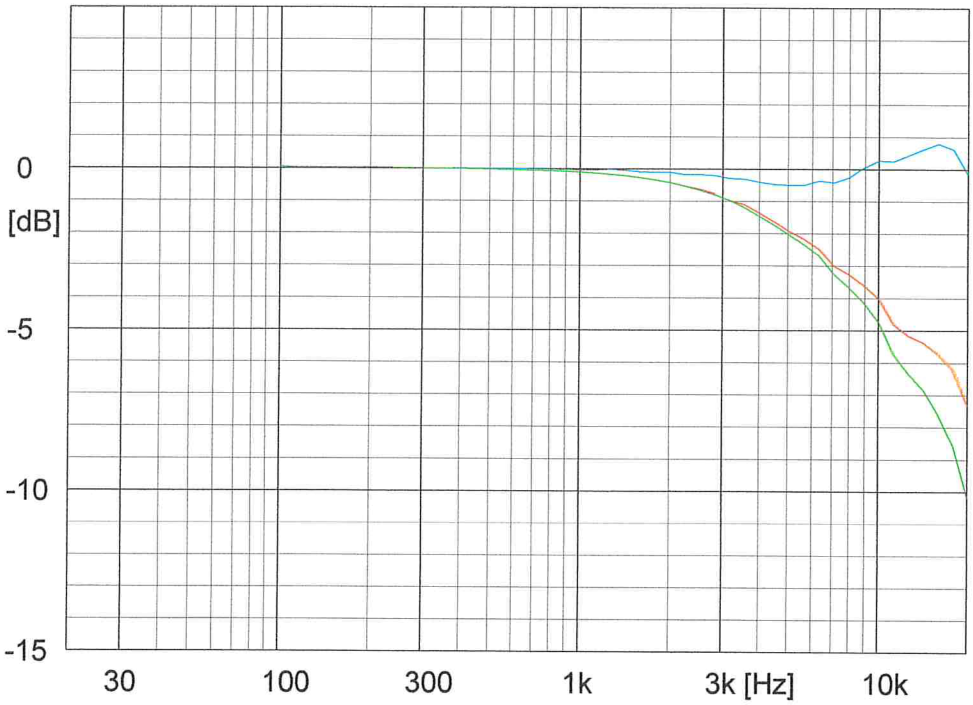
Supervisor : Darren Batten TechIOA
Engineer :

Palan[redacted]

Software version: 6.0h

Campbell Associates
www.campbell-associates.co.uk

Microphone Calibration Certificate



Norsonic
Type: 1225

Serial no: 96168

Sensitivity: 49.20 mV/Pa
-26.16 ±0.10 dB re. 1 V/Pa
Capacitance: 24.6 ±2.0 pF
Date: 26/02/2019

Signature: [redacted]

Measurement conditions:

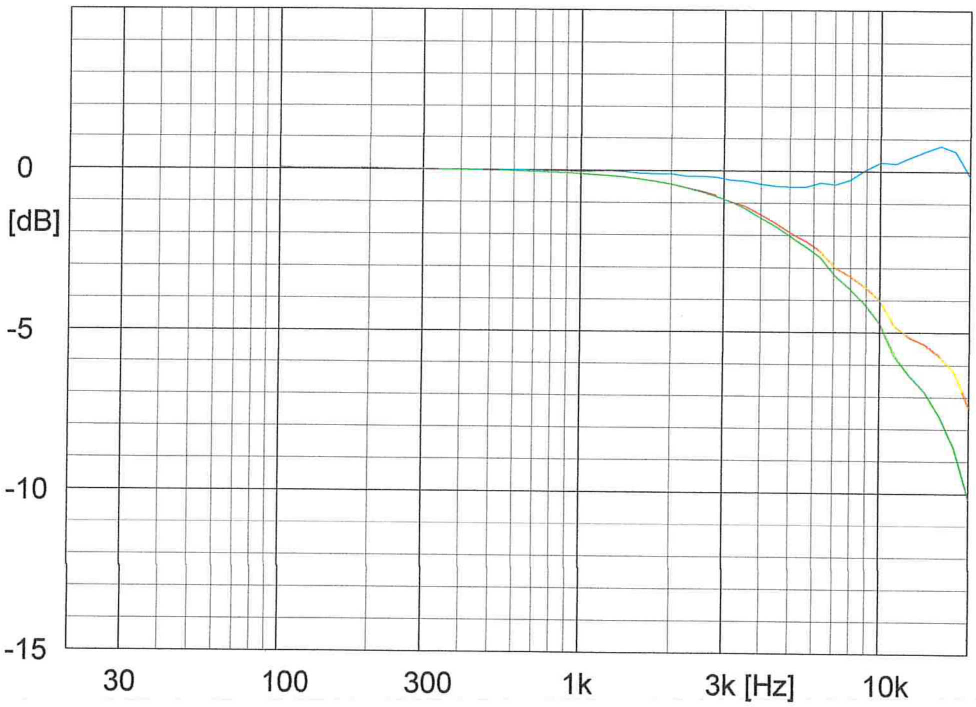
Polarisation voltage:	200.0 V
Pressure:	102.55 ±0.04 kPa
Temperature:	23.1 ±0.1 °C
Relative humidity:	33.9 ±0.7 %RH

Results are normalized to the reference conditions.

Free field response
Diffuse field response
Pressure (Actuator) response

Campbell Associates
www.campbell-associates.co.uk

Microphone Calibration Certificate



Norsonic
Type: 1225

Serial no: 96168

Sensitivity: 49.20 mV/Pa
-26.16 ±0.10 dB re. 1 V/Pa
Capacitance: 24.6 ±2.0 pF
Date: 26/02/2019

Signature: [redacted]

Measurement conditions:

Polarisation voltage:	200.0 V
Pressure:	102.55 ±0.04 kPa
Temperature:	23.1 ±0.1 °C
Relative humidity:	33.9 ±0.7 %RH

Results are normalized to the reference conditions.

Free field response
Diffuse field response
Pressure (Actuator) response

Campbell Associates
www.campbell-associates.co.uk

Comment:

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5b Chelmsford Road Industrial Estate
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www.campbell-associates.co.uk
Phone 01371 871030 Facsimile 01371879106

CALIBRATION

Certificate of Calibration and Conformance

Certificate number: **31091**

Test object:	**Sound Level Meter, BS EN IEC 61672-1:2003 Class 1 (Precision) and associated Frequency Analyser BS EN IEC 61260, Class 1**
Producer :	**Norsonic**
Type :	**118**
Serial No.:	**30600**
Customer:	**Sharps Redmore Partnership**
Address:	**The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.**
Contact Person:	**Dean Barke**

Method :
Calibration has been performed as set out in CA Technical Procedures TP01 & 02 as appropriate. These are based on the procedures for periodic verification of sound level meters as set out in BS EN IEC 61672-3:2006 and for electrical testing of frequency filters as set out in BS EN IEC 61260. Results and conformance statement are overleaf and detailed results are in the attached Test Report.

Tested

	Producer:	Type:	Serial No:	Certificate number
Microphone	Norsonic	1225	96168	31090
Calibrator*	Norsonic	1251	30795	29972
Preamplifier	Norsonic	1206	30288	Included

Additional items that also have been submitted for verification

Wind shield	Norsonic	Nor1451 (ø 60mm)
Attenuator	-	
Extension cable	-	

These items have been taken into account wherever appropriate.

Instruction manual: Nor118 User Guide- November 2002 Edition Firmware version: v2.0.752 The test object is a single channel instrument.

Conditions	Pressure	Temperature	Humidity
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	102.24 ±0.27 kPa	22.1 ±0.8 °C	33.4 ±0.7 %RH

Date received for calibration:	20/02/2019
Date of calibration:	27/02/2019
Date of issue:	27/02/2019

Engineer [redacted]

Supervisor

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.
* The calibrator was complete with any required coupler for the microphone specified.

Certificate of Calibration and Conformance

UKAS Laboratory Number 0789

Certificate number: 31091

Conformance

From markings on the sound level meter or by reference to the manufacturer's published literature it has been determined that the instrument submitted for verification was originally manufactured to BS EN IEC 61672-1:2002 and similarly that the associated sound calibrator conforms to BS EN IEC 60942.

Statement of conformance

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of BS EN IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available[1], from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with BS EN IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in BS EN IEC 61672-1:2002, and that the sound level meter submitted for testing conforms to the class 1 requirements of BS EN IEC 61672-1:2003.
The filter functions have been found to conform, by electrical testing, to the relative attenuation requirement of BS EN IEC 61260 for a class 1 filter over the range of frequencies shown in the attached test report.

[1] This evidence is held on file at the calibration laboratory

Summary of Measurement Results

Indication at the calibration check frequency - IEC61672-3 Ed.1 Clause 9	Passed
Self-generated noise - IEC 61672-3 Ed.1 Clause 10.2	Passed
Acoustical signal tests of a frequency weighting - IEC 61672-3 Ed.1 Clause 11	Passed
Electrical signal tests of frequency weightings - IEC 61672-3 Ed.1 Clause 12	Passed
Frequency weightings: A Network - IEC 61672-3 Ed.1 Clause 12.3	Passed
Frequency weightings: C Network - IEC 61672-3 Ed.1 Clause 12.3	Passed
Frequency weightings: Z Network - IEC 61672-3 Ed.1 Clause 12.3	Passed
Frequency and time weightings at 1 kHz IEC 61672-3 Ed.1 Clause 13	Passed
Level linearity on the reference level range - IEC 61672-3 Ed.1 Clause 14	Passed
Toneburst response - IEC 61672-3 Ed.1 Clause 16	Passed
Peak C sound level - IEC 61672-3 Ed.1 Clause 17	Passed
Overload indication - IEC 61672-3 Ed.1 Clause 18	Passed
1/1octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3	Passed
1/3octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3	Passed

Comment

Correct level with associated calibrator is 113.9dB(A). This was determined with the meter CAL sensitivity set to -26.2dB and G preamplifier correction only enabled and set to 0.1dB.

Observations

The details of the uncertainty for each measurement is available from the Calibration Laboratory on request and is based on the standard uncertainty multiplied by a coverage factor K=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA publication EA-4/02. Details of the sources of corrections and their associated uncertainties that relate to this verification are contained within the test report accompanying this certificate.

Certificate Cover Sheet

CAMPBELL ASSOCIATES
SOUND, VIBRATION & AIR SOLUTIONS

Sharps Redmore Partnership SHA650

Equipment	*SOP*	*Tech Log*	*Bin No*	*Group No*	*Cal Number / Period*		*Cover Flag*
NOR-1251.30868	**24407**	**20558**	**138**	**1**	**2**	**12 Months**	☑

CustomerID:	SHA650
EquipmentID:	NOR-1251.30868
EquipmentType:	Cal
CertificateNo:	34058
IssueDate:	14-Feb-20
ExpiryDate:	13-Feb-21
CalComments:	

NEW! Calibration Certificate Platform – Coming Soon

You may have noticed this new cover sheet with your certificates; it is in preparation for our exciting calibration project which is now in beta testing. Coming soon for our calibration customers is a free, cloud-based Calibration Certificate Platform. Watch this space for more information on its launch.

Campbell Associates Ltd
5b Chelmsford Road Industrial Estate
GREAT DUNMOW, CM6 1HD, England
www.campbell-associates.co.uk
info@campbell-associates.co.uk
Phone 01371 871030 Facsimile 01371879106

CALIBRATION

Certificate number: 34058

Certificate of Calibration and Conformance

Test object:	**Sound Calibrator**
Manufacturer:	**Norsonic**
Type:	**1251**
Serial no:	**30868**

Customer:	Sharps Redmore Partnership
Address:	The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.
Contact Person:	Emily Sharpe.

Measurement Results:	Level	Level Stability	Frequency	Frequency Stability	Distortion
1:	114.01 dB	0.05 dB	1000.77 Hz	0.00 %	0.42 %
2:	114.01 dB	0.05 dB	1000.76 Hz	0.00 %	0.41 %
3:	114.01 dB	0.05 dB	1000.77 Hz	0.00 %	0.41 %
Result (Average):	**114.01 dB**	**0.05 dB**	**1000.77 Hz**	**0.00 %**	**0.41 %**
Expanded Uncertainty:	0.10 dB	0.02 dB	1.00 Hz	0.01 %	0.10 %
Degree of Freedom:	>100	>100	>100	>100	>100
Coverage Factor:	2.00	2.00	2.00	2.00	2.00

The stated level is relative to 20µPa. The level is traceable to National Standards.
The stated level is valid at reference conditions. The following correction factors have been applied during the measurement: Pressure: 0.0005 dB/kPa Temperature: 0.003 dB/°C Relative humidity: 0.000 dB/%RH Load volume : 0.0003 dB/mm3
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.
Records: K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2020\NOR1251_30868_M1.nmf

Environmental conditions:	Pressure:	Temperature:	Relative humidity:
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	101.085 ± 0.044 kPa	21.9 ± 0.5 °C	35.8 ± 1.3 %RH

Date received for calibration:	05/02/2020
Date of calibration:	14/02/2020
Date of issue:	14/02/2020

Engineer [redacted]

Supervisor

Certificate number: 34058

Preconditioning
The equipment was preconditioned for more than 4 hours in the specified calibration environment.

Measurements
The calibrator has been tested as described in the following annexes to BS EN IEC60942:2003 Sound Calibrators; B3.4 for sound pressure level, B3.5 for frequency, B3.6 for total distortion and A4.4 for short term stability of the pressure level.

Method
Calibration has been performed as set out in the current version of CA Technical procedure TP01

Instruments and program
A complete list of equipment, hardware and software that has been used in this calibration is available from the calibration laboratory on request.

Traceability
The measured values are traceable to an accredited national physical laboratory within the EU or EFTA.

Comment
Calibrated as received, no adjustments made.

Statement of conformance
As public evidence was available[1], from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in annex A of BS EN IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of that BS EN IEC 60942:2003.

[1] This evidence is held on file at the calibration laboratory.

Notes:
The sound pressure level generated by the calibrator in its ½ inch configuration was measured five times and averaged by a WS2P working standard microphone for class 1 or 2 devices or a LS2P reference microphone for class 0 or LS devices as specified in the International Standard BS EN 61094-4. The results of three replications and the mean of the measurements obtained are given in the measurement results table of this certificate. The frequency and distortion were measured in a similar manner. The figures in **BOLD** are the final results; a small correction factor may need to be added to the sound pressure level quoted here if the device is used to calibrate a sound level meter that is fitted with a free field response microphone. See manufacturer's handbooks for full details of this and other corrections that may be applicable.

Measurements performed by

Campbell Associates

Sonitus House, 5b Chelmsford Road Industrial Estate, Great Dunmow, GB-CM6 1HD
Tel (+44) 01371 871030 Fax (+44) 01371 879106
email calibration@campbell-associates.co.uk

Calibration Report

Certificate No.:29422

Manufacturer: GRAS
Type: 40AF
Serial no: 73283

Customer:	**Sharps Redmore Partnership**
Address:	**The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.**
Contact Person:	**Jeremy Fosker.**

Measurement Results:

	Sensitivity: (dB re 1V/Pa)	Capacitance: (pF)
1:	-25.74	22.4
2:	-25.77	22.4
3:	-25.76	22.4
Result (Average):	**-25.76**	**22.4**
Expanded Uncertainty:	0.10	2.00
Degree of Freedom:	>100	>100
Coverage Factor:	2.00	2.00

The following correction factors have been applied during the measurement:
Pressure:-0.010 dB/kPa Temperature:-0.007 dB/°C Relative humidity:0.000 dB/%RH

Reference Calibrator: WSC2 - GRAS42AA-18277 Volume correction: 0.000 dB
Records:K:\C A\Calibration\Nor-1504\Nor-1017 MicCal\2018\GRAS40AF_73283_M1.nmf
Measurement procedure: TP05
All results quoted are directly traceable to National Physical Laboratory, London

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication EA-4/02.

Comment:

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
101.497 ± 0.041 kPa	21.4 ± 0.1 °C	46.4 ± 1.3 %RH

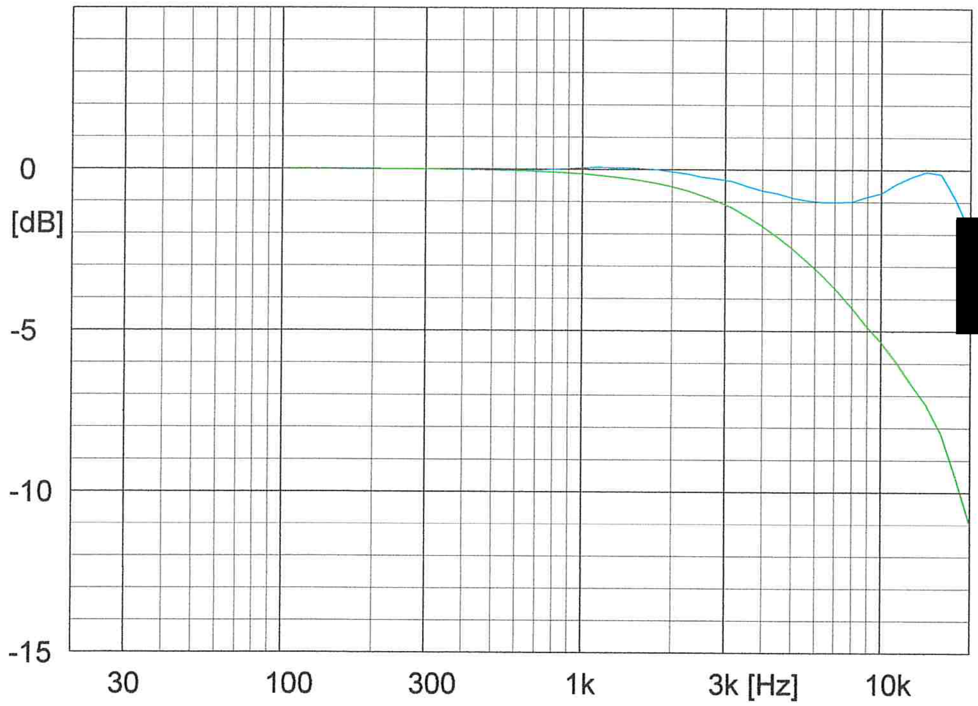
Date of calibration: 03/09/2018
Date of issue: 03/09/2018

Supervisor : Darren Batten TechIOA
Engineer :

[redacted]

Campbell Associates
www.campbell-associates.co.uk

Microphone Calibration Certificate



GRAS
Type: 40AF

Serial no: 73283

Sensitivity: 51.53 mV/Pa
-25.76 ±0.10 dB re. 1 V/Pa
Capacitance: 22.4 ±2.0 pF
[redacted]
Polarisation voltage: 200.0 V
Pressure: 101.50 ±0.04 kPa
Temperature: 21.4 ±0.1 °C
Relative humidity: 46.4 ±1.3 %RH
Results are normalized to the reference conditions.

Free field response
Pressure (Actuator) response

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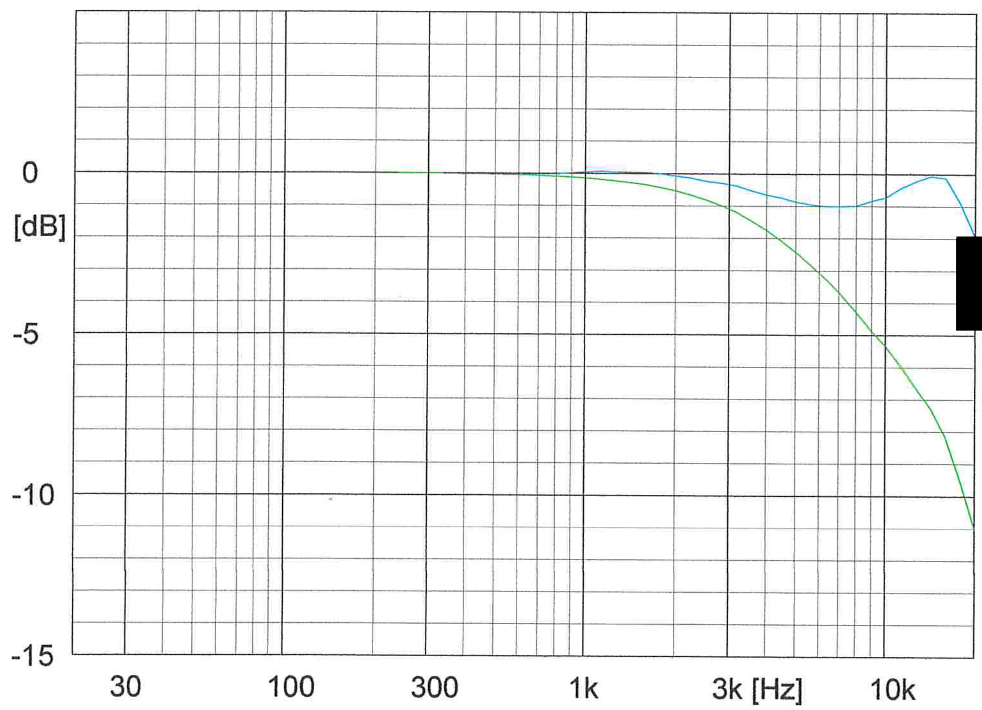
Microphone Calibration Certificate



GRAS
Type: 40AF

Serial no: 73283

Sensitivity: 51.53 mV/Pa
-25.76 ±0.10 dB re. 1 V/Pa
Capacitance: 22.4 ±2.0 pF
Date: 03/09/2018
[redacted]
Polarisation voltage: 200.0 V
Pressure: 101.50 ±0.04 kPa
Temperature: 21.4 ±0.1 °C
Relative humidity: 46.4 ±1.3 %RH
Results are normalized to the reference conditions.

Free field response
Pressure (Actuator) response

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Comment:

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www.campbell-associates.co.uk
Phone 01371 871030 Facsimile 01371879106

Certificate of Calibration and Conformance

CALIBRATION

Certificate No.: 29423

Test object:	**Sound Level Meter, BS EN IEC 61672-1:2003 Class 1 (Precision) and associated Frequency Analyser BS EN IEC 61260, Class 1**
Manufacturer:	**Norsonic**
Type:	**118**
Serial no:	**31342**
Customer:	**Sharps Redmore Partnership**
Address:	**The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.**
Contact Person:	**Jeremy Fosker.**

Method :
Calibration has been performed as set out in CA Technical Procedures TP01 & 02 as appropriate. These are based on the procedures for periodic verification of sound level meters as set out in BS EN IEC 61672-3:2006 and for electrical testing of frequency filters as set out in BS EN IEC 61260. Results and conformance statement are overleaf and detailed results are in the attached Test Report.

	Producer:	Type:	Serial No:	Certificate number
Microphone	GRAS	40AF	73283	29422
Calibrator*	Norsonic	1251	30868	26949
Preamplifier	Norsonic	1206	30370	Included

Additional items that also have been submitted for verification

Wind shield	None
Attenuator	None
Extension cable	None

These items have been taken into account wherever appropriate.

Environmental conditions:	Pressure:	Temperature:	Relative humidity:
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	101.49 ±0.01kPa	21.5 ±0.2°C	47.6 ±2%RH

Date received :	29/08/2018
Date of calibration:	03/09/2018
Date of issue:	03/09/2018

Engineer [redacted]

Supervisor

Certificate of Calibration and Conformance

Certificate No.: 29423

Conformance

From markings on the sound level meter or by reference to the manufacturer's published literature it has been determined that the instrument submitted for verification was originally manufactured to BS EN IEC 61672-1:2002 and similarly that the associated sound calibrator conforms to BS EN IEC 60942.

Statement of conformance

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of BS EN IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available[1], from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with BS EN IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in BS EN IEC 61672-1:2002, and that the sound level meter submitted for testing conforms to the class 1 requirements of BS EN IEC 61672-1:2003.
The filter functions have been found to conform, by electrical testing, to the relative attenuation requirement of BS EN IEC 61260 for a class 1 filter over the range of frequencies shown in the attached test report.

[1] This evidence is held on file at the calibration laboratory

Measurement Results:

Indication at the calibration check frequency - IEC61672-3 Ed.1 #9	Passed
Self-generated noise - IEC 61672-3 Ed.1 #10	Passed
Acoustical signal tests of a frequency weighting - IEC 61672-3 Ed.1 #11	Passed
Frequency weightings: A Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency weightings: C Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency weightings: Z Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency and time weightings at 1 kHz IEC 61672-3 Ed.1 #13	Passed
Level linearity on the reference level range - IEC 61672-3 Ed.1 #14	Passed
Toneburst response - IEC 61672-3 Ed.1 #16	Passed
Peak C sound level - IEC 61672-3 Ed.1 #17	Passed
Overload indication - IEC 61672-3 Ed.1 #18	Passed
Filter Test - IEC 61260 1/1octave: Relative attenuation - IEC 61260, #4.4 & #5.3	Passed
Filter Test - IEC 61260 1/3octave: Relative attenuation - IEC 61260, #4.4 & #5.3	Passed
Electrical signal tests of frequency weightings - IEC 61672-3 Ed.1 #12	Passed

Comment

Correct level with associated calibrator is 113.9dB(A). This was determined with the meter CAL sensitivity set to -25.8dB and G preamplifier correction only enabled and set to 0.1dB.

Observations

The details of the uncertainty for each measurement is available from the Calibration Laboratory on request and is based on the standard uncertainty multiplied by a coverage factor K=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA publication EA-4/02. Details on the sources of corrections and their associated uncertainties that relate to this verification are contained the detailed test report accompanying this certificate.

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CALIBRATION

Certificate number: 34972

Certificate of Calibration and Conformance

Test object:	**Sound Calibrator**
Manufacturer:	**Norsonic**
Type:	**1251**
Serial no:	**31679**

Customer:	Sharps Redmore Partnership
Address:	The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.
Contact Person:	Dean Barke.

Measurement Results:	Level	Level Stability	Frequency	Frequency Stability	Distortion
1:	113.98 dB	0.05 dB	1000.17 Hz	0.00 %	0.36 %
2:	113.96 dB	0.05 dB	1000.17 Hz	0.00 %	0.35 %
3:	113.97 dB	0.05 dB	1000.17 Hz	0.00 %	0.35 %
Result (Average):	**113.97 dB**	**0.05 dB**	**1000.17 Hz**	**0.00 %**	**0.35 %**
Expanded Uncertainty:	0.10 dB	0.02 dB	1.00 Hz	0.01 %	0.10 %
Degree of Freedom:	>100	>100	>100	>100	>100
Coverage Factor:	2.00	2.00	2.00	2.00	2.00

The stated level is relative to 20µPa. The level is traceable to National Standards.
The stated level is valid at reference conditions. The following correction factors have been applied during the measurement: Pressure: 0.0005 dB/kPa Temperature: 0.003 dB/°C Relative humidity: 0.000 dB/%RH Load volume : 0.0003 dB/mm3
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.
Records: K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2020\NOR1251_31679_M1.nmf

Environmental conditions:	Pressure:	Temperature:	Relative humidity:
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	101.004 ± 0.042 kPa	22.8 ± 0.2 °C	42.2 ± 0.8 %RH

Date received for calibration:	12/06/2020
Date of calibration:	15/06/2020
Date of issue:	15/06/2020

Engineer

[redacted]

Supervisor

This certificate is issued in accordance with the CA quality management system. It provides traceability of measurement to recognized national standards, and to the units of measurement realized at the National Physical Laboratory or other recognized national standards laboratories. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Template Cert_Traceable_PE_v1.1

Certificate number: 34972

Preconditioning
The equipment was preconditioned for more than 4 hours in the specified calibration environment.

Measurements
The calibrator has been tested as described in the following annexes to BS EN IEC60942:2003 Sound Calibrators; B3.4 for sound pressure level, B3.5 for frequency, B3.6 for total distortion and A4.4 for short term stability of the pressure level.

Method
Calibration has been performed as set out in the current version of CA Technical procedure TP01

Instruments and program
A complete list of equipment, hardware and software that has been used in this calibration is available from the calibration laboratory on request.

Traceability
The measured values are traceable to an accredited national physical laboratory within the EU or EFTA.

Comment
Calibrated as received, no adjustments made.

Statement of conformance
As public evidence was available[1], from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in annex A of BS EN IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of that BS EN IEC 60942:2003.

[1] This evidence is held on file at the calibration laboratory.

Notes:
The sound pressure level generated by the calibrator in its ½ inch configuration was measured five times and averaged by a WS2P working standard microphone for class 1 or 2 devices or a LS2P reference microphone for class 0 or LS devices as specified in the International Standard BS EN 61094-4. The results of three replications and the mean of the measurements obtained are given in the measurement results table of this certificate. The frequency and distortion were measured in a similar manner. The figures in **BOLD** are the final results; a small correction factor may need to be added to the sound pressure level quoted here if the device is used to calibrate a sound level meter that is fitted with a free field response microphone. See manufacturer's handbooks for full details of this and other corrections that may be applicable.

Measurements performed by

Campbell Associates

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email calibration@campbell-associates.co.uk

Calibration Report

Certificate No.:34973

Manufacturer:	**Norsonic**
Type:	**1225**
Serial no:	**332080**

Customer:	**Sharps Redmore Partnership**
Address:	**The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.**
Contact Person:	**Dean Barke.**

Measurement Results:

	Sensitivity: (dB re 1V/Pa)	Capacitance: (pF)
1:	-25.91	22.5
2:	-25.89	22.5
3:	-25.89	22.4
Result (Average):	**-25.90**	**22.5**
Expanded Uncertainty:	0.10	1.00
Degree of Freedom:	>100	>100
Coverage Factor:	2.00	2.00

The following correction factors have been applied during the measurement:
Pressure:-0.001 dB/kPa Temperature:-0.005 dB/°C Relative humidity:0.000 dB/%RH

Reference Calibrator: WSC2 - GRAS42AA-18277 Volume correction: 0.000 dB
Records:K:\C A\Calibration\Nor-1504\Nor-1017 MicCal\2020\NOR1225_332080_M1.nmf
Measurement procedure: TP05
All results quoted are directly traceable to National Physical Laboratory, London

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication EA-4/02.

Comment:

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
100.990 ± 0.042 kPa	22.5 ± 0.2 °C	40.4 ± 0.8 %RH

Date of calibration: 15/06/2020
Date of issue: 15/06/2020

Supervisor : Darren Batten TechIOA
Engineer :

[redacted]

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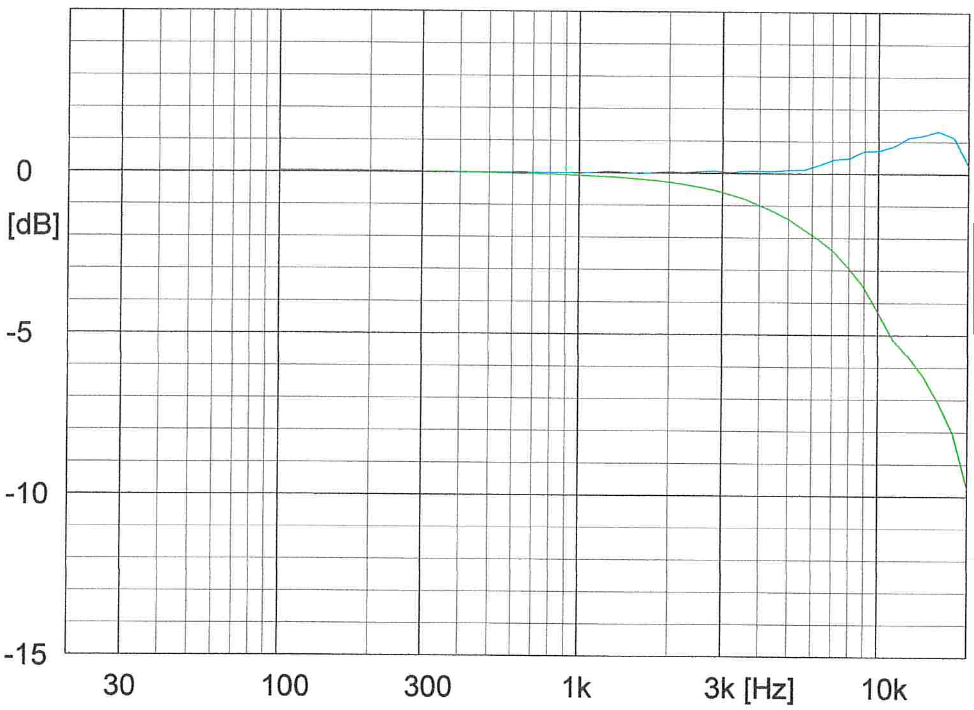
Microphone Calibration Certificate



Norsonic
Type: 1225

Serial no: 332080

Sensitivity: 50.70 mV/Pa
-25.90 ±0.10 dB re. 1 V/Pa
Capacitance: 22.5 ±1.0 pF
[redacted]

Polarisation voltage:	200.0 V
Pressure:	100.99 ±0.04 kPa
Temperature:	22.5 ±0.2 °C
Relative humidity:	40.4 ±0.8 %RH

Results are normalized to the reference conditions.

Free field response
Pressure (Actuator) response

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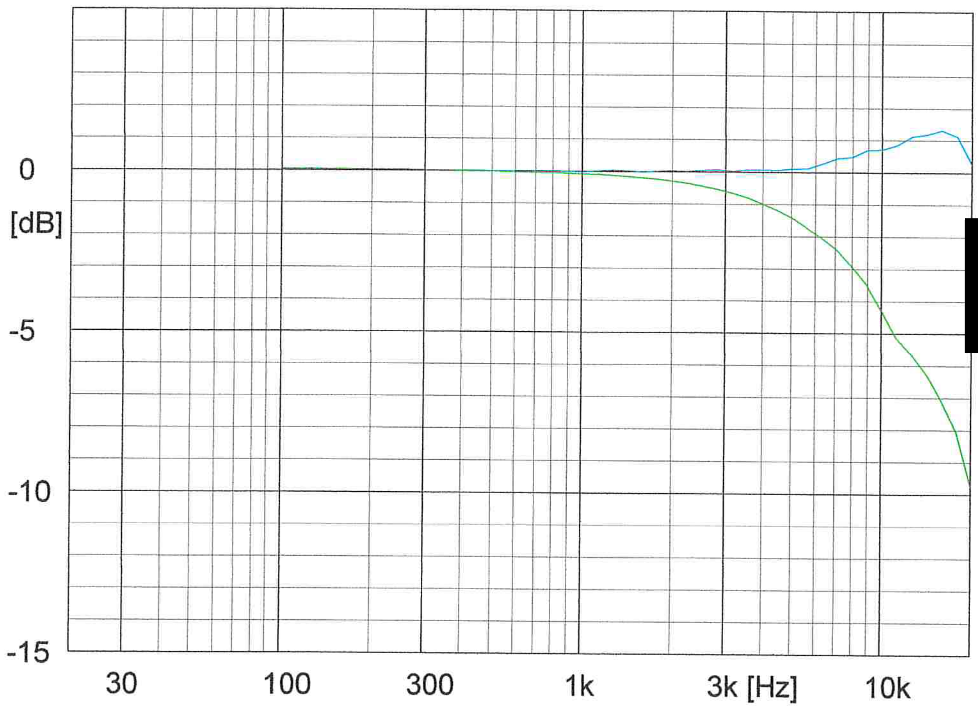
Microphone Calibration Certificate



Norsonic
Type: 1225

Serial no: 332080

Sensitivity: 50.70 mV/Pa
-25.90 ±0.10 dB re. 1 V/Pa
Capacitance: 22.5 ±1.0 pF

[redacted]

Pressure:	100.99 ±0.04 kPa
Temperature:	22.5 ±0.2 °C
Relative humidity:	40.4 ±0.8 %RH

Results are normalized to the reference conditions.

Free field response
Pressure (Actuator) response

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Comment:

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Phone 01371 871030 Facsimile 01371879106

CALIBRATION

Certificate of Calibration and Conformance

Certificate number: **34974**

Test object:	**Sound Level Meter, BS EN IEC 61672-1:2003 Class 1 (Precision)**
Producer :	**Norsonic**
Type :	**140**
Serial No.:	**1403669**
Customer:	**Sharps Redmore Partnership**
Address:	**The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.**
Contact Person:	**Dean Barke.**

Method :
Calibration has been performed as set out in CA Technical Procedures TP01 & 02 as appropriate. These are based on the procedures for periodic verification of sound level meters as set out in BS EN IEC 61672-3:2006. Results and conformance statement are overleaf and detailed results are in the attached Test Report.

Tested

	Producer:	Type:	Serial No:	Certificate number
Microphone	Norsonic	1225	332080	34973
Calibrator*	Norsonic	1251	31679	34972
Preamplifier	Norsonic	1206	30968	Included

Additional items that also have been submitted for verification

Wind shield	Norsonic	Nor1451 (ø 60mm)
Attenuator	-	
Extension cable	Norsonic	Nor1408A/5M

These items have been taken into account wherever appropriate.

Instruction manual: Im140_1Ed6R3En Firmware version: 2.1.670 The test object is a single channel instrument.

Conditions	Pressure	Temperature	Humidity
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	100.99 ±0.05 kPa	22.5 ±0.2 °C	39.3 ±0.7 %RH

Date received for calibration: 12/06/2020
Date of calibration: 15/06/2020
Date of issue: 15/06/2020
Engineer [redacted]

Supervisor

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.
* The calibrator was complete with any required coupler for the microphone specified.

Certificate of Calibration and Conformance

UKAS Laboratory Number 0789

Certificate number: 34974

Conformance

From markings on the sound level meter or by reference to the manufacturer's published literature it has been determined that the instrument submitted for verification was originally manufactured to BS EN IEC 61672-1:2002 and similarly that the associated sound calibrator conforms to BS EN IEC 60942.

Statement of conformance

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of BS EN IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available[1], from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with BS EN IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in BS EN IEC 61672-1:2002, and that the sound level meter submitted for testing conforms to the class 1 requirements of BS EN IEC 61672-1:2003.

[1] This evidence is held on file at the calibration laboratory

Summary of Measurement Results

Indication at the calibration check frequency - IEC61672-3 Ed.1 Clause 9	Passed
Self-generated noise - IEC 61672-3 Ed.1 Clause 10.2	Passed
Acoustical signal tests of a frequency weighting - IEC 61672-3 Ed.1 Clause 11	Passed
Electrical signal tests of frequency weightings - IEC 61672-3 Ed.1 Clause 12	Passed
Frequency weightings: A Network - IEC 61672-3 Ed.1 Clause 12.3	Passed
Frequency weightings: C Network - IEC 61672-3 Ed.1 Clause 12.3	Passed
Frequency weightings: Z Network - IEC 61672-3 Ed.1 Clause 12.3	Passed
Frequency and time weightings at 1 kHz IEC 61672-3 Ed.1 Clause 13	Passed
Level linearity on the reference level range - IEC 61672-3 Ed.1 Clause 14	Passed
Toneburst response - IEC 61672-3 Ed.1 Clause 16	Passed
Peak C sound level - IEC 61672-3 Ed.1 Clause 17	Passed
Overload indication - IEC 61672-3 Ed.1 Clause 18	Passed

Comment

Correct level with associated calibrator is 113.8dB(A). This was determined with the meter CAL sensitivity set to -25.7dB and G preamplifier correction only enabled and set to 0.1dB. Case reflections have been excluded as tests were made with a microphone extension cable.

Observations

The details of the uncertainty for each measurement is available from the Calibration Laboratory on request and is based on the standard uncertainty multiplied by a coverage factor K=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA publication EA-4/02. Details of the sources of corrections and their associated uncertainties that relate to this verification are contained within the test report accompanying this certificate.

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CALIBRATION

0789

Certificate number: U34280

Certificate of Calibration and Conformance

Test object:	**Sound Calibrator**
Manufacturer:	**Norsonic**
Type:	**1251**
Serial no:	**33001**

Customer:	Sharps Redmore Partnership
Address:	The White House, London Road, Copdock, Ipswich. Suffolk. IP8 3JH.
Contact Person:	Emily Sharpe
Order No:	ESS 2000015

Measurement Results:	Level	Level Stability	Frequency	Frequency Stability	Distortion
1:	114.03 dB	0.04 dB	1000.53 Hz	0.00 %	0.35 %
2:	114.02 dB	0.04 dB	1000.53 Hz	0.00 %	0.35 %
3:	114.03 dB	0.04 dB	1000.53 Hz	0.00 %	0.35 %
Result (Average):	**114.03 dB**	**0.04 dB**	**1000.53 Hz**	**0.00 %**	**0.35 %**
Expanded Uncertainty:	0.10 dB	0.02 dB	1.00 Hz	0.01 %	0.10 %
Degree of Freedom:	>100	>100	>100	>100	>100
Coverage Factor:	2.00	2.00	2.00	2.00	2.00

The stated level is relative to 20µPa. The level is traceable to National Standards.
The stated level is valid at reference conditions.The following correction factors have been applied during the measurement: Pressure: 0.0005 dB/kPa Temperature: 0.003 dB/°C Relative humidity: 0.000 dB/%RH Load volume : 0.0003 dB/mm3
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.
Records: K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2020\NOR1251_33001_M1.nmf

Environmental conditions:	Pressure:	Temperature:	Relative humidity:
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	99.832 ± 0.041 kPa	22.3 ± 0.1 °C	33.9 ± 0.8 %RH

Date received for calibration:	26/02/2020
Date of calibration:	06/03/2020
Date of issue:	06/03/2020

Engineer

[redacted]

Supervisor

Certificate number: U34280

Preconditioning
The equipment was preconditioned for more than 4 hours in the specified calibration environment.

Measurements
The calibrator has been tested as described in the following annexes to BS EN IEC60942:2003 Sound Calibrators; B3.4 for sound pressure level, B3.5 for frequency, B3.6 for total distortion and A4.4 for short term stability of the pressure level.

Method
Calibration has been performed as set out in the current version of CA Technical procedure TP01

Instruments and program
A complete list of equipment, hardware and software that has been used in this calibration is available from the calibration laboratory on request.

Traceability
The measured values are traceable to an accredited national physical laboratory within the EU or EFTA.

Comment
Calibrated as received, no adjustments made.

Statement of conformance
As public evidence was available[1], from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in annex A of BS EN IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of that BS EN IEC 60942:2003.

[1] This evidence is held on file at the calibration laboratory.

Notes:
The sound pressure level generated by the calibrator in its ½ inch configuration was measured five times and averaged by a WS2P working standard microphone for class 1 or 2 devices or a LS2P reference microphone for class 0 or LS devices as specified in the International Standard BS EN 61094-4. The results of three replications and the mean of the measurements obtained are given in the measurement results table of this certificate. The frequency and distortion were measured in a similar manner. The figures in **BOLD** are the final results; a small correction factor may need to be added to the sound pressure level quoted here if the device is used to calibrate a sound level meter that is fitted with a free field response microphone. See manufacturer's handbooks for full details of this and other corrections that may be applicable.

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email calibration@campbell-associates.co.uk

Calibration Report

Certificate No.:34281

Manufacturer: Norsonic
Type: 1225
Serial no: 168158

Customer:	**Sharps Redmore Partnership**
Address:	**The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.**
Order No:	**ESS 2000015**
Contact Person:	**Emily Sharpe**

Measurement Results:

	Sensitivity: (dB re 1V/Pa)	Capacitance: (pF)
1:	-25.38	21.2
2:	-25.38	21.3
3:	-25.38	21.3
Result (Average):	**-25.38**	**21.3**
Expanded Uncertainty:	0.10	2.00
Degree of Freedom:	>100	>100
Coverage Factor:	2.00	2.00

The following correction factors have been applied during the measurement:
Pressure:-0.001 dB/kPa Temperature:-0.005 dB/°C Relative humidity:0.000 dB/%RH

Reference Calibrator: WSC2 - GRAS42AA-18277 Volume correction: 0.000 dB
Records:K:\C A\Calibration\Nor-1504\Nor-1017 MicCal\2020\NOR1225_168158_M1.nmf
Measurement procedure: TP05
All results quoted are directly traceable to National Physical Laboratory, London

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication EA-4/02.

Comment:

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
99.850 ± 0.042 kPa	22.2 ± 0.1 °C	33.4 ± 0.8 %RH

Date of calibration: 06/03/2020
Date of issue: 06/03/2020

Supervisor : Darren Batten TechIOA
Engineer :

[redacted]

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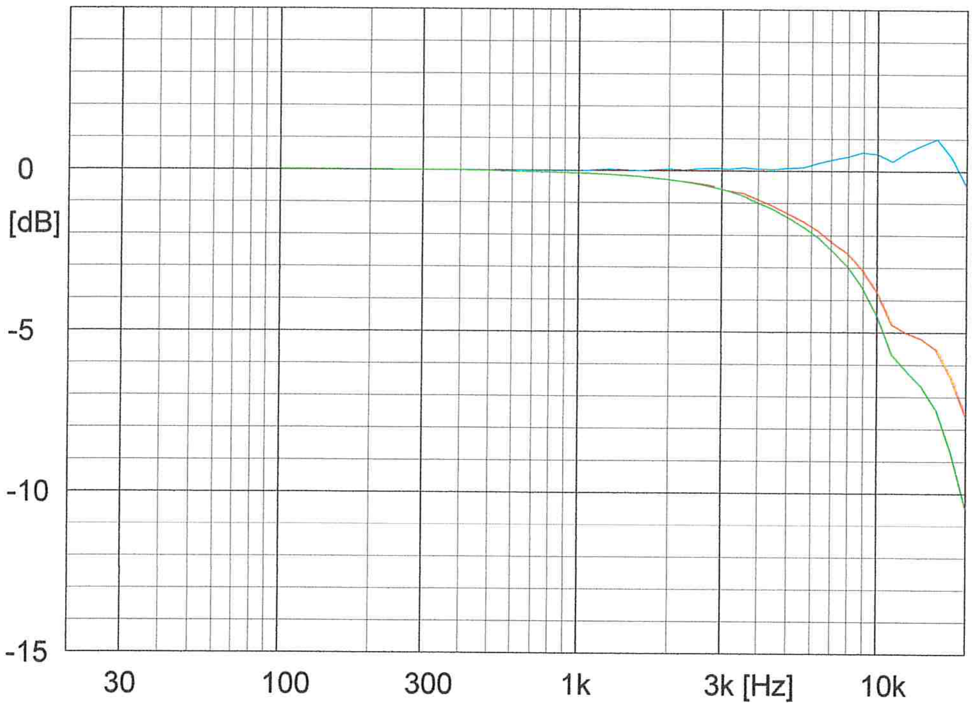
Microphone Calibration Certificate



Norsonic
Type: 1225

Serial no: 168158

Sensitivity: 53.85 mV/Pa
-25.38 ±0.10 dB re. 1 V/Pa
Capacitance: 21.3 ±2.0 pF
Date: 06/03/2020

Si[redacted]

Me[redacted]

Polarisation voltage:	200.0 V
Pressure:	99.85 ±0.04 kPa
Temperature:	22.2 ±0.1 °C
Relative humidity:	33.4 ±0.8 %RH

Results are normalized to the reference conditions.

Free field response
Diffuse field response
Pressure (Actuator) response

Campbell Associates
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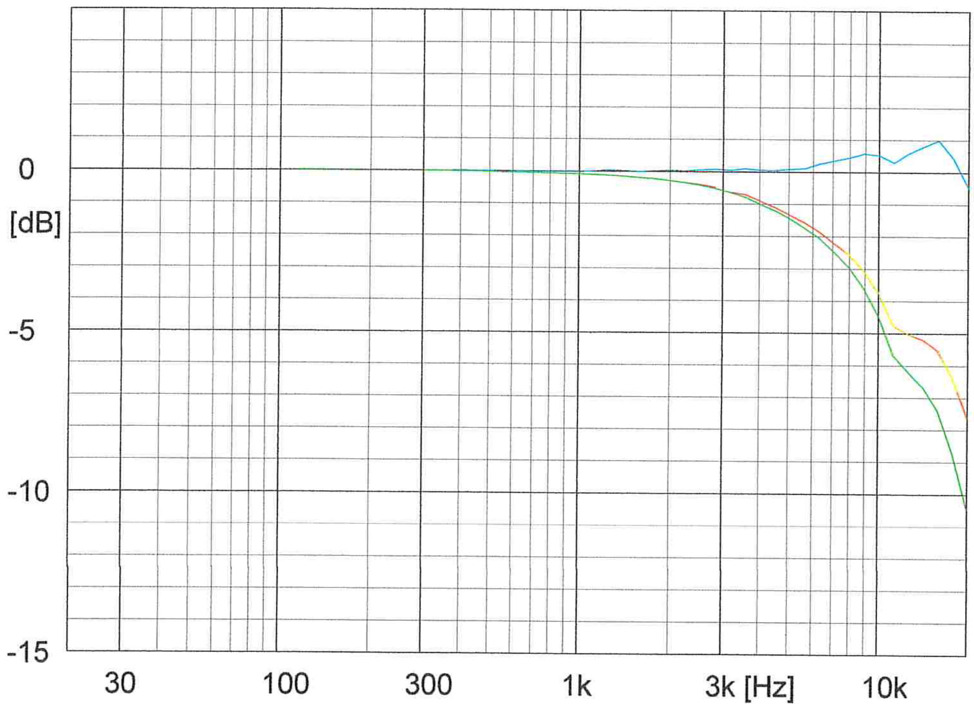
Microphone Calibration Certificate



Norsonic
Type: 1225

Serial no: 168158

Sensitivity: 53.85 mV/Pa
-25.38 ±0.10 dB re. 1 V/Pa
Capacitance: 21.3 ±2.0 pF

[redacted]

Polarisation voltage:	200.0 V
Pressure:	99.85 ±0.04 kPa
Temperature:	22.2 ±0.1 °C
Relative humidity:	33.4 ±0.8 %RH

Results are normalized to the reference conditions.

Free field response
Diffuse field response
Pressure (Actuator) response

Campbell Associates
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Comment:

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Phone 01371 871030 Facsimile 01371879106

Certificate of Calibration

CALIBRATION

0789

Certificate number: **U34282**

Test object:	**Sound Level Meter, Type 1 (Precision) and Frequency Analyser, class 1**
Producer :	**Norsonic**
Type :	**140**
Serial No.:	**1404434**

Customer:	**Sharps Redmore Partnership**
Address:	**The White House, London Road, Copdock, Ipswich, Suffolk. IP8 3JH.**
Contact Person:	**Emily Sharpe**

Method :
Calibration has been performed as set out in CA Technical Procedures TP01 & 02 as appropriate. The following items have been calibrated as set out in BS 7580 Part 1:1997 whilst the associated frequency filters have been electrically tested to BS EN IEC 61260.

Tested

	Producer:	Type:	Serial No:	Certificate number
Microphone	Norsonic	1225	168158	34281
Calibrator*	Norsonic	1251	33001	U34280
Preamplifier	Norsonic	1206	30747	Included

Additional items that also have been submitted for verification

Wind shield	Norsonic	Nor1451 (ø 60mm)
Attenuator	-	
Extension cable	-	

These items have been taken into account wherever appropriate.

Conditions	Pressure	Temperature	Humidity
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	99.94 ±0.13 kPa	22.3 ±0.3 °C	33.9 ±0.7 %RH

Date received for calibration:	26/02/2020
Date of calibration:	06/03/2020
Date of issue:	06/03/2020
Engineer	[redacted]
Supervisor	

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to the SI system of units and/or to units of measurement realised at the National Physical Laboratory or other recognised national metrology institutes. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

* The calibrator was complete with any required coupler for the microphone specified

Calibration Certificate

UKAS Laboratory Number 0789

Certificate number: U34282

Method

From markings on the sound level meter or by reference to the manufacturer's published literature it has been determined that the instrument submitted for verification was originally manufactured to BS EN 60651 and or BS EN 60804 with the associated filter function conforming to BS EN IEC 61260. The reference range, reference sound pressure level, primary indicator range, secondary indicator range, pulse range, linearity range and display range as specified by the manufacturer were used for the verification. The sound level meter was set to A weighting and adjusted to read correctly in response to the associated sound calibrator the reading was derived from the calibrator calibration certificate and manufacturer's instruction manuals. A measurement of the self noise of the sound level meter was then made using a dummy microphone having a capacitance of ±20% of the associated microphones self capacitance. The sound level meter was then tested, and its overall sensitivity adjusted, in accordance with Section 5 of BS 7580:Part 1:1997. The acoustic calibration at 1 kHz specified in sub-clause 5.6.1 of the standard was performed by application of a reference sound calibrator, whilst the tests at 125 Hz and 8k Hz (sub-clause 5.6.2) were performed by the electrostatic actuator method. At the end of the test, the associated sound calibrator was reapplied to the sound level meter and the meter reading was recorded and is noted below in the statements section.
The frequency filter functions were tested with electrical inputs introduced via the line input adaptor having a capacitive load within 20% of the polarised self capacitance of the microphone detailed above.

Traceability :
The following measured values are traceable to the National Physical Laboratory, United Kingdom.
Sound Pressure Level, Voltage, Frequency, Barometric Pressure, Temperature & Relative Humidity

Summary of Measurement Results

Indication at the calibration check frequency - BS7580 Clause 5.4	Passed
Noise test - BS 7580 Clause 5.5.2	Passed
Level Linearity Test - BS 7580, Clause 5.5.3	Passed
Frequency weightings: A Network - BS 7580 Clause 5.5.4	Passed
Frequency weightings: C Network - BS 7580 Clause 5.5.4	Passed
Frequency weightings: Z Network - BS 7580 Clause 5.5.4	Passed
Time weightings F and S - BS 7580 Clause 5.5.5	Passed
Peak response - BS 7580 Clause 5.5.6	Passed
RMS accuracy - BS 7580 Clause 5.5.7	Passed
Time weighting I - BS 7580 Clause 5.5.8	Passed
Integrating Test : Time averaging - BS 7580 Clause 5.5.9	Passed
Integrating Test : Pulse range - BS 7580 Clause 5.5.10	Passed
Integrating Test : Sound exposure level - BS 7580 Clause 5.5.11	Passed
Overload SPL Test - BS 7580 Clause 5.5.12	Passed
Overload Leq Test - BS 7580 Clause 5.5.12	Passed
Acoustic tests - BS 7580 Clause 5.4 and 5.6	Passed
Summation of acoustic tests - BS 7580 Clause 5.5.4	Passed
1/1octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3	Passed
1/3octave: Relative attenuation - IEC 61260, Clause 4.4 & #5.3	Passed

Statements
The sound level meter in the configuration tested conforms to the requirements of BS 7580 Part 1.
The self-generated noise recorded in the test specified in § 5.5.2 was: 5.2 (Below MSD)dB(A), 7.5 (Below MSD)dB(C) and 15.4 (Below MSD)dB(Z).
The following response was finally obtained using the associated calibrator.(§5.6.3): 114.0dB(A)
This reading should be used henceforth to set up the sound level meter for field use.
A stricter test than that specified in paragraphs 5.5.6 of BS7580:1997 has been used by verifying that the 10 ms reference pulse is also correct. The level uncertainty of the Laboratory's 1 kHz sound calibrator used during this verification is ± 0.1 dB.
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.

The sound level meter in the configuration tested was found to comply with BS 7580:1997 part 1 for a type 1 device. The associated calibrator has been corrected for barometric pressure at the time of calibration in accordance with the relevant manufacturer's instructions.
The filter functions indicated have been found to conform to the relative attenuation requirement of BS EN IEC 61260 (as required by UKAS Lab23) for a class 1 filter as indicated by the paragraph numbers (#) of the standard mentioned in the Measurement Results section above.

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GREAT DUNMOW, Essex, GB-CM6 1HD
www.campbell-associates.co.uk
Phone 01371 871030 Facsimile 01371879106

CALIBRATION

Certificate of Calibration and Conformance

Certificate number: **35140**

Test object:	**Sound Level Meter, BS EN IEC 61672-1:2013 Class 1 (Precision)**
Producer :	**01dB**
Type :	**Fusion**
Serial No.:	**11433**
Customer:	**Sharps Redmore**
Address:	**The White House, London Road, Copdock, Ipswich. IP8 3JH.**
Contact Person:	**Emily Sharpe**
Order No:	**ESS 20 00043**

Method :
Calibration has been performed as set out in CA Technical Procedures TP01 & 02 as appropriate. These are based on the procedures for periodic verification of sound level meters as set out in BS EN IEC 61672-3:2013. Results and conformance statement are overleaf and detailed results are in the attached Test Report.

Tested

	Producer:	Type:	Serial No:	Certificate number
Microphone	GRAS	40CE	291904	35139
Calibrator*	01dB	Cal21	34675333	35138
Preamplifier	01dB	Integral	NotMarked	Included

Additional items that also have been submitted for verification

Wind shield	01dB	Short windscreen
Attenuator	-	
Extension cable	-	

These items have been taken into account wherever appropriate.

Instruction manual: DOC1131 - February 2019 P-FWa 2.47 – FWm 2.12 FUSION User Manual Firmware version: Application FW: v2.40 / Metrology FW: v2.12 The test object is a single channel instrument.

Conditions	Pressure	Temperature	Humidity
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	101.33 ±0.07 kPa	22.1 ±0.4 °C	42.2 ±0.7 %RH

Date received for calibration:	02/07/2020
Date of calibration:	07/07/2020
Date of issue:	07/07/2020
Engineer	[redacted]
Supervisor	

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* The sound calibrator was complete with the coupler specified in the instruction manual for the sound calibrator and the sound level meter as appropriate for the coupling of the microphone provided to the specified sound calibrator.

Certificate of Calibration and Conformance

UKAS Laboratory Number 0789

Certificate number: 35140

Conformance

From markings on the sound level meter or by reference to the manufacturer's published literature it has been determined that the instrument submitted for verification was originally manufactured to BS EN IEC 61672-1:2013 and similarly that the associated sound calibrator conforms to BS EN IEC 60942.

Statement of conformance

The sound level meter submitted for testing has successfully completed the periodic tests of BS EN IEC 61672-3:2013, for the environmental conditions under which the tests were performed. As evidence was publicly available[1], from an independent testing organisation responsible for approving the results of pattern-evaluation tests performed in accordance with BS EN IEC 61672-2:2013, to demonstrate that the model of sound level meter fully conformed to the requirements in BS EN IEC 61672-1:2013, and that the sound level meter submitted for testing conforms to the class 1 specifications of BS EN IEC 61672-1:2013.

[1] This evidence is held on file at the calibration laboratory

Summary of Measurement Results

Indication at the calibration check frequency - IEC61672-3 Ed.2 Clause 10	Passed
Self-generated noise - IEC 61672-3 Ed.2.0 Clause 11.2	Passed
Acoustical signal tests of a frequency weighting - IEC 61672-3 Ed.2.0 Clause 12	Passed
Electrical signal tests of frequency weightings - IEC 61672-3 Ed.2.0 Clause 13	Passed
Frequency weightings: A Network - IEC 61672-3 Ed.2.0 Clause 13.3	Passed
Frequency weightings: C Network - IEC 61672-3 Ed.2.0 Clause 13.3	Passed
Frequency weightings: Z Network - IEC 61672-3 Ed.2.0 Clause 13.3	Passed
Frequency and time weightings at 1 kHz IEC 61672-3 Ed.2.0 Clause 14	Passed
Level linearity on the reference level range - IEC 61672-3 Ed.2.0 Clause 16	Passed
Toneburst response - IEC 61672-3 Ed.2.0 Clause 18	Passed
Peak C sound level - IEC 61672-3 Ed.2.0 Clause 19	Passed
Overload indication - IEC 61672-3 Ed.2.0 Clause 20	Passed
High level stability test - IEC 61672-3 Ed.2.0 Clause 21	Passed
Long term stability test - IEC 61672-3 Ed.2.0 Clause 15	Passed

Comment

Correct level with associated calibrator is 93.8dB(A).

The 01dB Fusion meter was calibrated in the following set up:
Configuration: 1 - Integrated GRAS-40CE microphone - Reference direction set to 0 Degree, small windscreen with No Nose cone.

Observations

The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a coverage probability of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA publication EA-4/02.
Details of the uncertainty for each measurement are available from the Calibration Laboratory upon request. Details of the sources of corrections and their associated uncertainties that relate to this verification are contained within the test report accompanying this certificate.

Certificate No.:35139

Calibration Report

Manufacturer: GRAS
Type: 40CE
Serial no: 291904

Customer: Sharps Redmore
Address: The White House, London Road, Copdock, Ipswich. IP8 3JH.
Order No: ESS 20 00043
Contact Person: Emily Sharpe

Measurement Results:

	Sensitivity: (dB re 1V/Pa)	Capacitance: (pF)
1:	-27.40	12.6
2:	-27.40	12.6
3:	-27.40	12.6
Result (Average):	**-27.40**	**12.6**
Expanded Uncertainty:	0.10	2.00
Degree of Freedom:	>100	>100
Coverage Factor:	2.00	2.00

The following correction factors have been applied during the measurement:
Pressure:-0.014 dB/kPa Temperature:-0.010 dB/°C Relative humidity:0.000 dB/%RH

Reference Calibrator: WSC1 - Nor1253-24269 Volume correction: 0.000 dB
Records:K:\C A\Calibration\Nor-1504\Nor-1017 MicCal\2020\GRAS40CE_291904_M1.nmf
Measurement procedure: TP05
All results quoted are directly traceable to National Physical Laboratory, London

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication EA-4/02.

Comment:

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
101.373 ± 0.046 kPa	22.1 ± 0.5 °C	43.4 ± 1.5 %RH

Date of calibration: 07/07/2020
Date of issue: 07/07/2020

Supervisor : Darren Batten TechIOA
Engineer :

[redacted]

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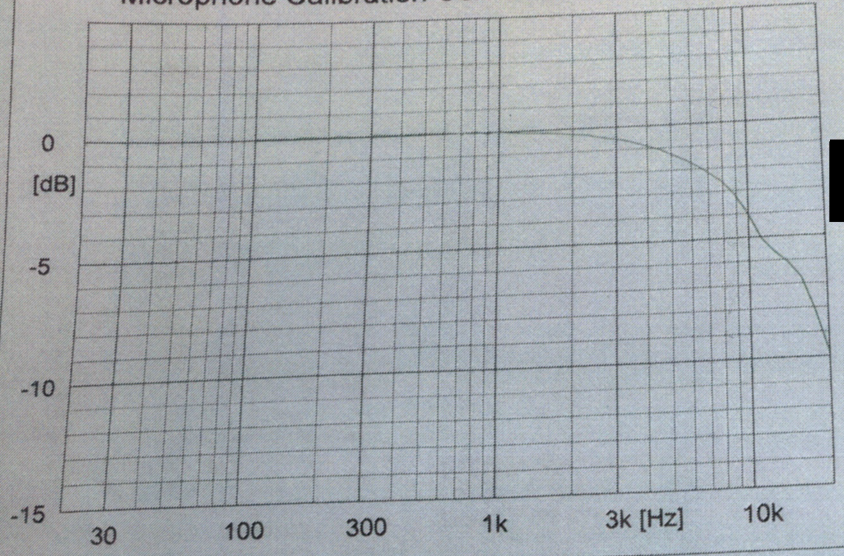
Microphone Calibration Certificate



GRAS
Type: 40CE

Serial no: 291904

Sensitivity: 42.66 mV/Pa
-27.40 ±0.10 dB re. 1 V/Pa
Capacitance: 12.6 ±2.0 pF
[redacted]
Polarisation voltage: 0.0 V
Pressure: 101.37 ±0.05 kPa
Temperature: 22.1 ±0.5 °C
Relative humidity: 43.4 ±1.5 %RH
Results are normalized to the reference conditions.

Pressure (Actuator) response

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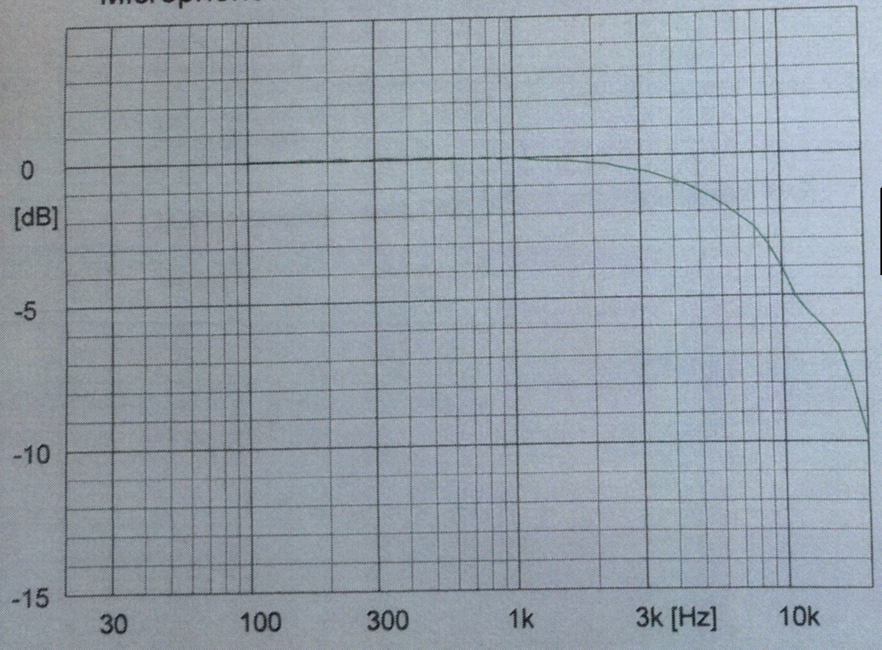
Microphone Calibration Certificate



GRAS
Type: 40CE

Serial no: 291904

Sensitivity: 42.66 mV/Pa
-27.40 ±0.10 dB re. 1 V/Pa
Capacitance: 12.6 ±2.0 pF

[redacted]
Measurement conditions:

Polarisation voltage: 0.0 V
Pressure: 101.37 ±0.05 kPa
Temperature: 22.1 ±0.5 °C
Relative humidity: 43.4 ±1.5 %RH
Results are normalized to the reference conditions.

Pressure (Actuator) response

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Comment:

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CALIBRATION

Certificate number: 35138

Certificate of Calibration

Test object:	**Sound Calibrator**
Manufacturer:	**01dB**
Type:	**Cal21**
Serial no:	**34675333**
Customer:	Sharps Redmore
Address:	The White House, London Road, Copdock, Ipswich. IP8 3JH.
Contact Person:	Emily Sharpe
Order No:	ESS 20 00043

Measurement Results:	Level	Level Stability	Frequency	Frequency Stability	Distortion
1:	94.11 dB	0.02 dB	1000.96 Hz	0.00 %	1.46 %
2:	94.11 dB	0.02 dB	1000.97 Hz	0.00 %	1.45 %
3:	94.12 dB	0.01 dB	1000.95 Hz	0.00 %	1.43 %
Result (Average):	**94.11 dB**	**0.02 dB**	**1000.96 Hz**	**0.00 %**	**1.45 %**
Expanded Uncertainty:	0.10 dB	0.02 dB	1.00 Hz	0.01 %	0.10 %
Degree of Freedom:	>100	>100	>100	>100	>100
Coverage Factor:	2.00	2.00	2.00	2.00	2.00

The stated level is relative to 20µPa. The level is traceable to National Standards.
The stated level is valid at reference conditions.The following correction factors have been applied during the measurement: Pressure: 0.000 dB/kPa Temperature: 0.000 dB/°C Relative humidity: 0.000 dB/%RH Load volume : 0.00072 dB/mm3
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.
Records: K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2020\01dBCAL21_34675333_M1.nmf

Environmental conditions:	Pressure:	Temperature:	Relative humidity:
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	101.379 ± 0.041 kPa	21.6 ± 0.1 °C	43.7 ± 0.8 %RH

Date received for calibration:	02/07/2020
Date of calibration:	07/07/2020
Date of issue:	07/07/2020
Engineer	[redacted]
Supervisor	

Certificate number: 35138

Preconditioning
The equipment was preconditioned for more than 4 hours in the specified calibration environment.

Measurements
The calibrator has been tested as described in the following annexes to BS EN IEC60942:2003 Sound Calibrators; B3.4 for sound pressure level, B3.5 for frequency, B3.6 for total distortion and A4.4 for short term stability of the pressure level.

Method
Calibration has been performed as set out in the current version of CA Technical procedure TP01

Instruments and program
A complete list of equipment, hardware and software that has been used in this calibration is available from the calibration laboratory on request.

Traceability
The measured values are traceable to an accredited national physical laboratory within the EU or EFTA.

Comment
Calibrated as received, no adjustments made.

Notes:
The sound pressure level generated by the calibrator in its ½ inch configuration was measured five times and averaged by a WS2P working standard microphone for class 1 or 2 devices or a LS2P reference microphone for class 0 or LS devices as specified in the International Standard BS EN 61094-4. The results of three replications and the mean of the measurements obtained are given in the measurement results table of this certificate. The frequency and distortion were measured in a similar manner. The figures in **BOLD** are the final results; a small correction factor may need to be added to the sound pressure level quoted here if the device is used to calibrate a sound level meter that is fitted with a free field response microphone. See manufacturer's handbooks for full details of this and other corrections that may be applicable.

Measurements performed by
Campbell Associates

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email calibration@campbell-associates.co.uk

Appendix D

Table of Results

Table D1: Results – all locations, all dates

Date	Time	Loco	Direction	Estimated Speed, mph	L_{Amax} at 10m
05-Aug	10:04	66	EB	9.6	72
05-Aug	10:06	66	EB	9.7	67
05-Aug	10:06	66	EB	11.0	70
05-Aug	10:07	66	EB	10.1	76
05-Aug	10:18	68	WB	9.7	81
05-Aug	10:18	68	WB	9.6	80
05-Aug	10:18	68	WB	9.0	74
05-Aug	10:19	68	WB	9.3	79
05-Aug	10:22	68	WB	9.3	73
05-Aug	10:39	66	EB	9.7	72
05-Aug	10:51	68	WB	9.7	78
05-Aug	10:53	68	WB	10.1	79
05-Aug	11:11	68	WB	11.4	80
05-Aug	11:11	68	WB	10.5	76
05-Aug	11:11	68	WB	10.4	79
05-Aug	11:43	68	WB	16.9	81
05-Aug	11:43	68	WB	17.3	83
05-Aug	11:44	68	WB	16.2	79
05-Aug	11:51	66	EB	19.6	77
05-Aug	11:58	68	WB	20.2	81
05-Aug	11:58	68	WB	19.1	81
05-Aug	11:58	68	WB	18.2	83
05-Aug	11:58	68	WB	19.0	75
05-Aug	12:05	66	EB	15.8	76
05-Aug	12:05	66	EB	14.0	76
05-Aug	12:14	68	WB	14.8	83
05-Aug	12:15	68	WB	15.8	81
05-Aug	12:16	68	WB	15.8	80
05-Aug	12:16	68	WB	15.0	72
05-Aug	12:23	66	EB	15.1	76
05-Aug	12:30	68	WB	13.0	81
05-Aug	12:32	68	WB	15.5	81
05-Aug	12:32	68	WB	15.5	85
05-Aug	14:02	68	WB	11.5	79
05-Aug	14:02	68	WB	10.4	79
05-Aug	14:03	68	WB	10.9	78
05-Aug	14:04	68	WB	10.4	75
05-Aug	14:12	66	EB	8.0	71
05-Aug	14:13	66	EB	9.6	73
05-Aug	14:14	66	EB	10.4	74
05-Aug	14:21	68	WB	10.9	72
05-Aug	14:21	68	WB	10.7	81

Date	Time	Loco	Direction	Estimated Speed, mph	L_{Amax} at 10m
05-Aug	14:22	68	WB	11.7	79
05-Aug	14:23	68	WB	11.0	74
05-Aug	14:24	68	WB	10.2	76
05-Aug	14:30	66	EB	9.0	70
05-Aug	14:31	66	EB	10.5	74
05-Aug	14:32	66	EB	11.9	74
05-Aug	14:39	68	WB	10.7	76
05-Aug	14:40	68	WB	11.2	79
05-Aug	14:41	68	WB	10.7	76
05-Aug	14:41	68	WB	10.0	75
05-Aug	14:48	66	EB	9.0	74
05-Aug	14:49	66	EB	11.0	76
05-Aug	14:56	68	WB	10.2	81
05-Aug	14:57	68	WB	10.7	79
05-Aug	14:59	68	WB	10.2	74
05-Aug	15:07	66	EB	11.4	76
05-Aug	15:13	68	WB	15.1	83
05-Aug	15:14	68	WB	15.8	81
05-Aug	15:14	68	WB	16.2	78
05-Aug	15:15	68	WB	12.0	76
05-Aug	15:16	68	WB	15.5	77
05-Aug	15:26	68	WB	17.7	80
05-Aug	15:28	68	WB	20.2	82
05-Aug	15:28	68	WB	18.6	77
05-Aug	15:35	68	WB	17.0	82
06-Aug	09:57	68	EB	10.5	74
06-Aug	09:57	68	EB	11.4	76
06-Aug	09:57	68	EB	9.0	69
06-Aug	09:58	68	EB	13.0	76
06-Aug	10:08	66	WB	7.5	75
06-Aug	10:09	66	WB	8.5	72
06-Aug	10:12	66	WB	11.0	72
06-Aug	10:12	66	WB	10.0	69
06-Aug	10:27	68	EB	9.7	72
06-Aug	10:29	68	EB	9.8	73
06-Aug	10:29	68	EB	10.1	72
06-Aug	10:29	68	EB	9.0	70
06-Aug	10:30	68	EB	10.7	75
06-Aug	10:38	66	WB	8.6	74
06-Aug	10:39	66	WB	9.8	77
06-Aug	10:40	66	WB	10.0	73
06-Aug	10:41	66	WB	8.0	70
06-Aug	10:49	68	EB	18.6	79
06-Aug	10:51	68	EB	19.6	75

Date	Time	Loco	Direction	Estimated Speed, mph	L_{Amax} at 10m
06-Aug	10:52	68	EB	17.3	75
06-Aug	10:53	68	EB	17.0	74
06-Aug	10:58	66	WB	17.3	77
06-Aug	10:58	66	WB	17.3	76
06-Aug	10:59	66	WB	18.0	81
06-Aug	11:12	68	EB	10.4	74
06-Aug	11:13	68	EB	10.5	74
06-Aug	11:13	68	EB	9.0	75
06-Aug	11:14	68	EB	11.2	76
06-Aug	11:22	66	WB	11.2	75
06-Aug	11:22	66	WB	10.7	73
06-Aug	11:23	66	WB	10.0	69
06-Aug	11:24	66	WB	9.0	75
06-Aug	11:35	68	EB	10.9	76
06-Aug	11:37	68	EB	10.5	77
06-Aug	11:37	68	EB	10.4	75
06-Aug	11:37	68	EB	9.0	72
06-Aug	11:46	66	WB	10.1	76
06-Aug	11:46	66	WB	10.1	73
06-Aug	11:58	68	EB	15.8	79
06-Aug	11:59	68	EB	14.8	74
06-Aug	12:00	68	EB	15.0	74
06-Aug	12:07	66	WB	15.5	77
06-Aug	12:16	68	EB	13.7	75
06-Aug	12:17	68	EB	14.3	75
06-Aug	12:17	68	EB	13.0	75
06-Aug	12:18	68	EB	15.8	79
06-Aug	12:25	66	WB	14.0	77
06-Aug	12:26	66	WB	15.0	75
06-Aug	13:57	68	EB	18.2	77
06-Aug	13:57	68	EB	17.0	79
06-Aug	13:58	68	EB	15.8	78
06-Aug	14:04	66	WB	20.2	76
06-Aug	14:12	68	EB	20.2	74
06-Aug	14:12	68	EB	21.0	75
06-Aug	14:13	68	EB	20.2	76
06-Aug	14:29	68	EB	10.5	70
06-Aug	14:37	66	WB	11.0	77
06-Aug	14:37	66	WB	11.9	75
06-Aug	14:42	66	WB	12.0	74
06-Aug	14:48	68	EB	14.0	74
06-Aug	14:49	68	EB	12.8	74
06-Aug	14:49	68	EB	13.7	74
06-Aug	14:57	66	WB	15.8	77

Date	Time	Loco	Direction	Estimated Speed, mph	L_{Amax} at 10m
06-Aug	14:57	66	WB	16.0	77
06-Aug	15:04	68	EB	19.1	77
06-Aug	15:05	68	EB	20.0	78
06-Aug	15:10	66	WB	21.4	78
06-Aug	15:11	66	WB	21.0	78
06-Aug	15:19	68	EB	15.1	74
06-Aug	15:19	68	EB	16.0	74
06-Aug	15:20	68	EB	14.8	75
06-Aug	15:25	66	WB	16.5	75
06-Aug	15:25	66	WB	16.0	75
06-Aug	15:32	68	EB	15.0	77
06-Aug	15:33	68	EB	14.0	76
06-Aug	15:33	68	EB	14.8	74
10-Aug	09:43	68	EB	8.5	75
10-Aug	09:44	68	EB	9.3	76
10-Aug	09:44	68	EB	9.7	76
10-Aug	09:44	68	EB	8.0	72
10-Aug	09:54	66	WB	6.9	71
10-Aug	09:54	66	WB	7.3	73
10-Aug	10:08	68	EB	8.3	75
10-Aug	10:08	68	EB	7.0	72
10-Aug	10:09	68	EB	8.3	76
10-Aug	10:19	66	WB	7.8	70
10-Aug	10:19	66	WB	7.7	73
10-Aug	10:19	66	WB	7.3	75
10-Aug	10:22	66	WB	9.0	73
10-Aug	10:30	68	EB	8.8	73
10-Aug	10:31	68	EB	7.0	69
10-Aug	10:32	68	EB	8.5	75
10-Aug	10:33	68	EB	8.3	76
10-Aug	10:33	68	EB	8.7	76
10-Aug	10:43	66	WB	7.3	73
10-Aug	10:43	66	WB	7.4	74
10-Aug	10:44	66	WB	8.0	68
10-Aug	10:53	68	EB	24.2	76
10-Aug	10:53	68	EB	22.0	80
10-Aug	10:54	68	EB	19.6	78
10-Aug	10:54	68	EB	22.0	79
10-Aug	10:54	68	EB	20.0	76
10-Aug	11:00	66	WB	19.6	79
10-Aug	11:01	66	WB	20.8	76
10-Aug	11:01	66	WB	19.0	79
10-Aug	11:08	68	EB	21.4	77
10-Aug	11:08	68	EB	21.9	80

Date	Time	Loco	Direction	Estimated Speed, mph	L_{Amax} at 10m
10-Aug	11:08	68	EB	21.0	79
10-Aug	11:15	66	WB	22.0	78
10-Aug	11:16	66	WB	20.8	79
10-Aug	11:22	68	EB	22.0	79
10-Aug	11:22	68	EB	22.0	77
10-Aug	11:23	68	EB	21.4	78
10-Aug	11:23	68	EB	21.4	79
10-Aug	11:30	66	WB	21.4	79
10-Aug	11:30	66	WB	23.0	79
10-Aug	11:38	68	EB	8.8	76
10-Aug	11:38	68	EB	9.2	71
10-Aug	11:48	66	WB	8.6	76
10-Aug	11:48	66	WB	8.3	75
10-Aug	11:49	66	WB	8.0	72
10-Aug	11:58	68	EB	21.0	82
10-Aug	11:59	68	EB	20.8	79
10-Aug	11:59	68	EB	21.4	79
10-Aug	12:00	68	EB	22.0	79
10-Aug	12:04	66	WB	21.4	80
10-Aug	12:04	66	WB	22.0	82
10-Aug	12:05	66	WB	22.7	78
10-Aug	12:09	68	EB	22.7	79
10-Aug	12:10	68	EB	20.8	78
10-Aug	12:10	68	EB	21.0	81
10-Aug	12:11	68	EB	20.8	76
10-Aug	12:15	66	WB	22.0	81
10-Aug	12:17	66	WB	20.8	75
10-Aug	12:17	66	WB	23.5	78
10-Aug	12:22	66	WB	23.0	80
10-Aug	12:28	66	WB	21.4	79

Appendix E

Graphs of Results

Figure E1: Graph showing train speed against L_{Amax} level at 10m – all results

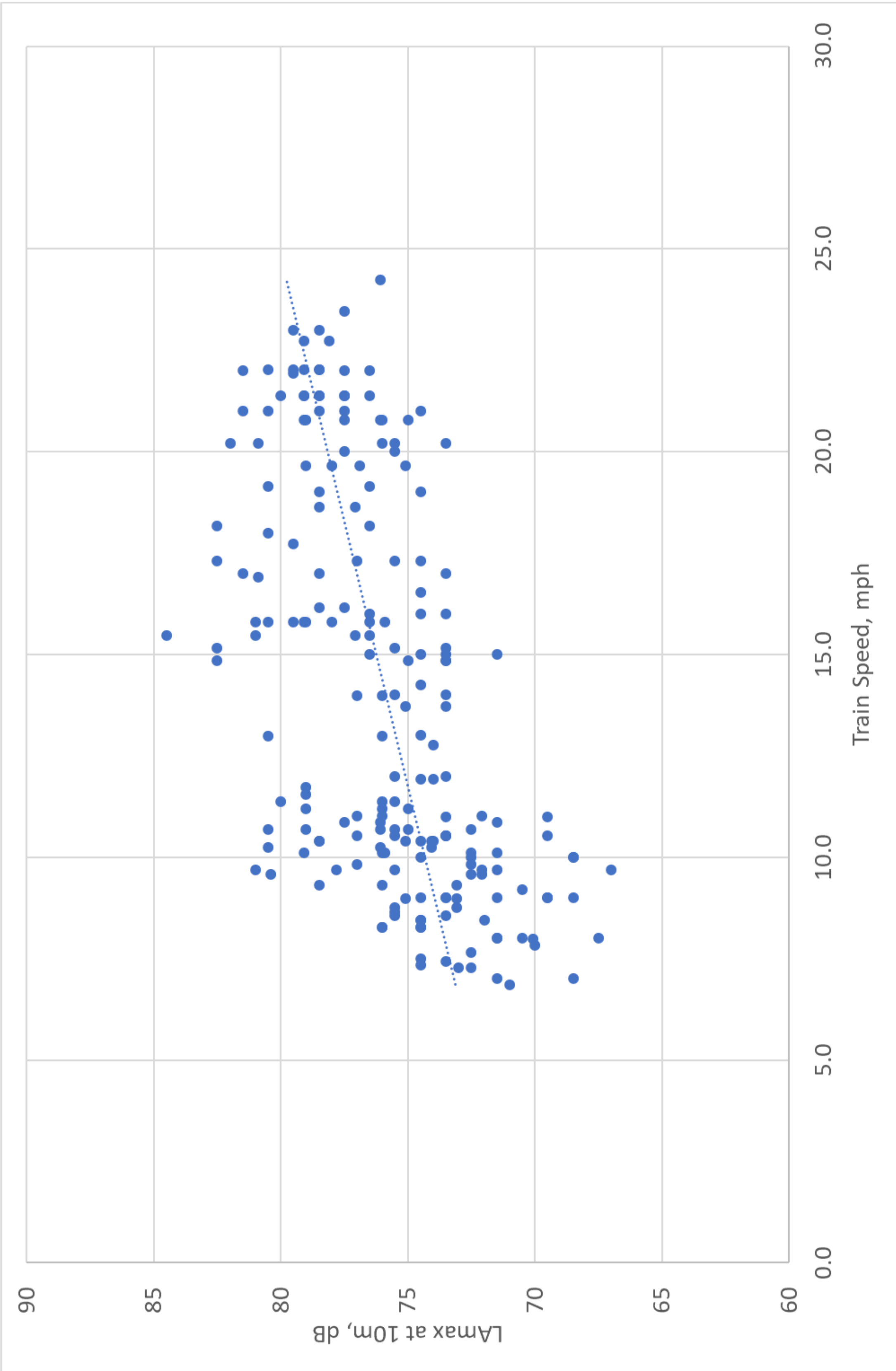


Figure E2: Graph showing train speed against L_{Amax} level at 10m – Class 66 locomotives

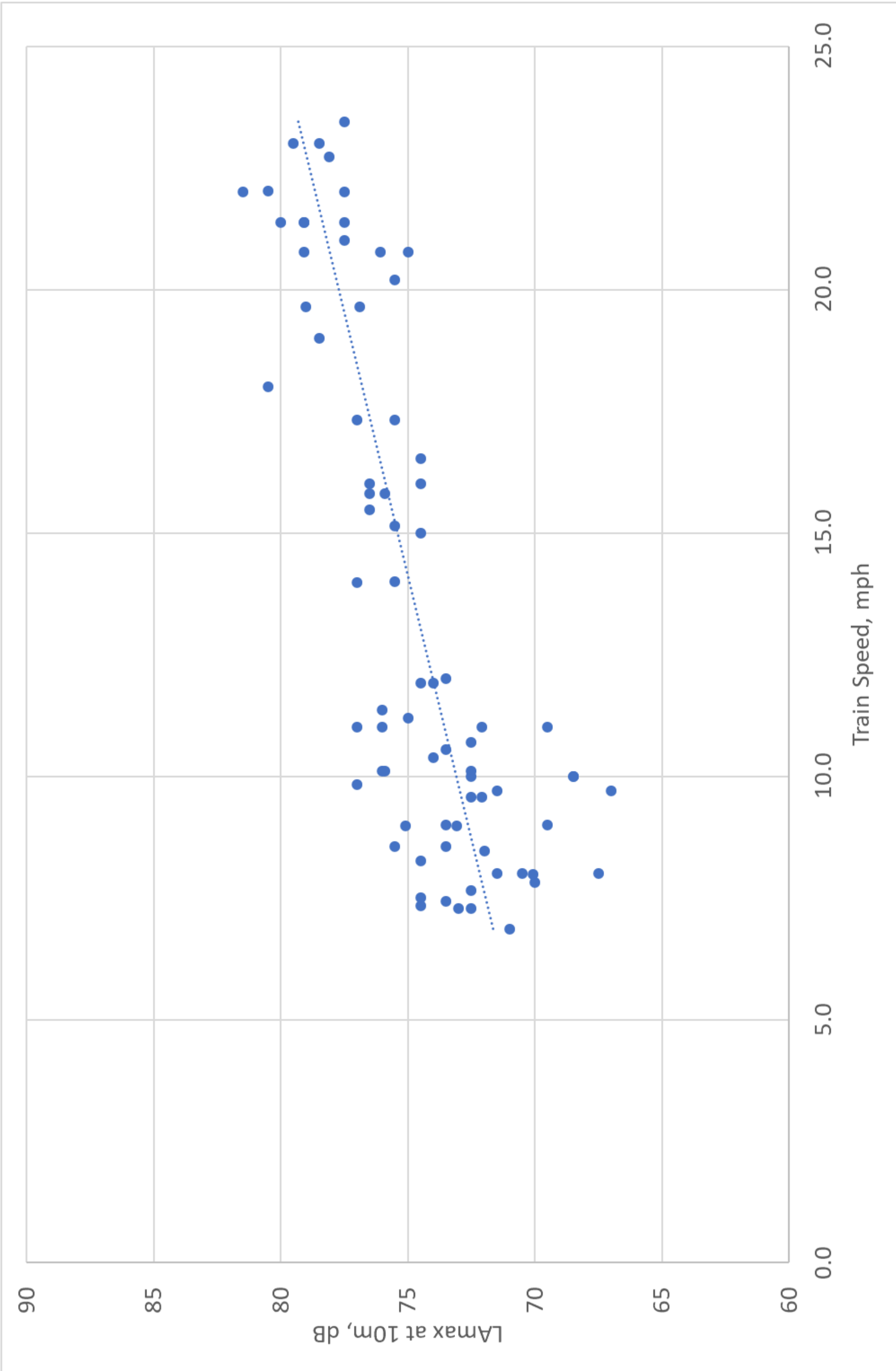
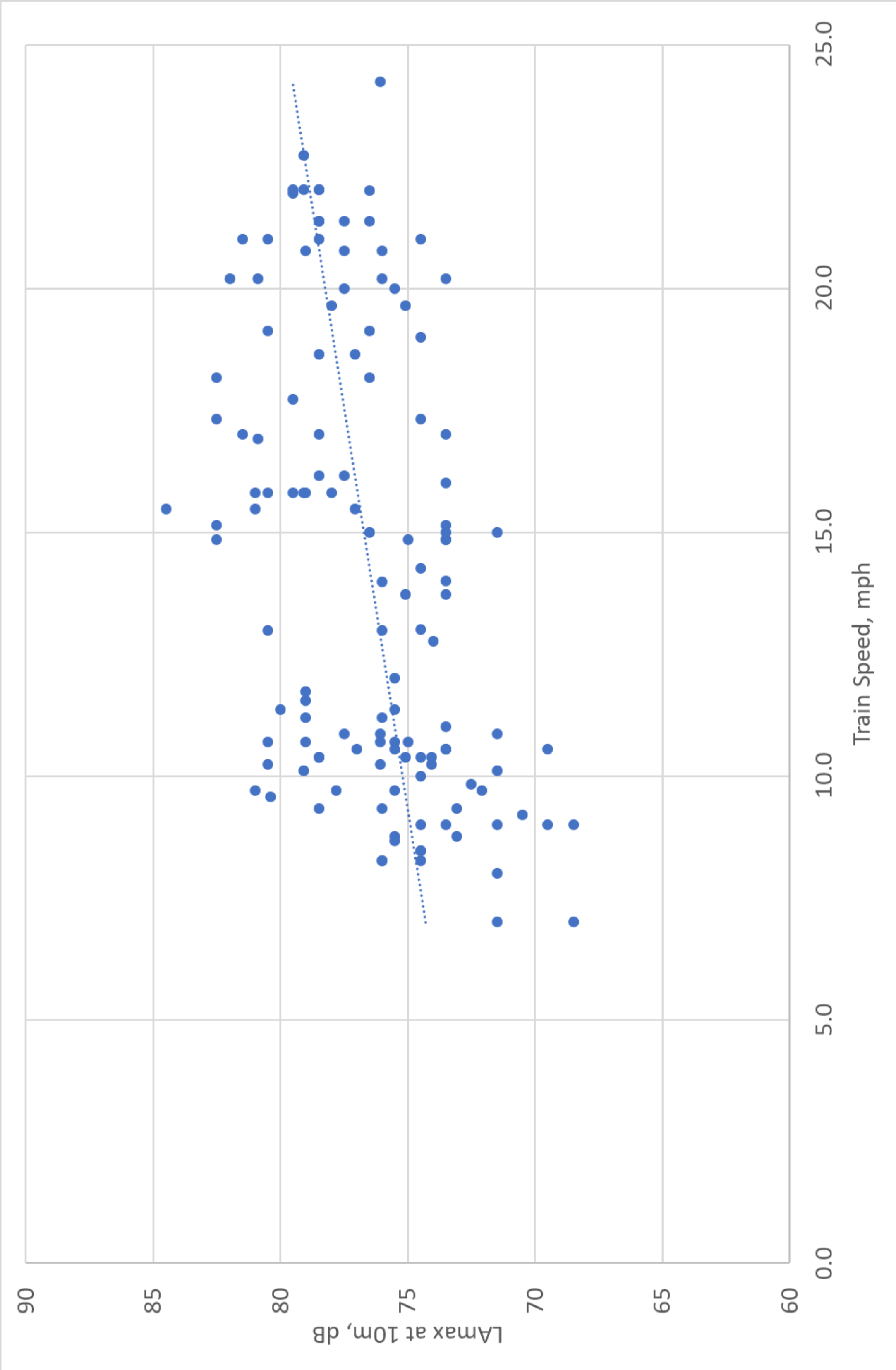


Figure E3: Graph showing train speed against L_{Amax} level at 10m – Class 68 locomotives



APPENDIX 9.3.A.
APPENDIX B: GROUNDBORNE NOISE AND VIBRATION SURVEY REPORT

EDF

Sizewell C
Assessment of Ground-borne Noise and Vibration from Freight Trains

Report

8 December 2020

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CONTENTS Page

1. INTRODUCTION

Rupert Taylor Ltd was instructed by Quod on behalf of EDF to carry out a study of groundborne noise and vibration from the operation of the railway associated with the Sizewell C project. In particular, the study has considered the use of the East Suffolk Line and the Leiston branch from Saxmundham towards Sizewell Halt by freight trains during the construction phase of the project.

The East Suffolk Line is an operational railway carrying passenger and freight services on modern track. The Leiston Branch, a remnant of the closed branch line to Aldeburgh, still has 60ft fishplate-jointed bull-head rail. Until 2014 it was used by nuclear flask trains serving the former Sizewell A power station. It is no longer in regular use.

2. APPROACH AND METHODOLOGY

The study has involved gaining an understanding of the alignment, its surroundings with regard to sensitive receptors, the underlying geology, the track design and the likely types of locomotives and wagons and the times and frequency of movements. Prediction and assessment of groundborne noise and vibration from the proposed rail movements has involved measurements of vibration and sound from a set of test train movements in August 2020, the creation of a 3-dimensional numerical model of typical dwellings close to the track, analysis of the results to study the characteristics of the sources of groundborne noise and vibration, together with associated airborne noise, transmission from source to receiver, and the dynamic response of the receiving structures. The measurements were made inside dwellings and were attended so as to gain full information about the passage of the train. The numerical model was then used to model the performance on mitigation measures to remove significant effects, both in terms of environmental assessment and policy terminology. These results led to the making of recommendations for the mitigation and avoidance of significant effects.

The measurements were made jointly by Sharps Redmore, Resound Acoustics and Rupert Taylor Ltd; the airborne noise measurements are described and summarised in the Sharps Redmore report *Sizewell C – Rail noise: Report on noise survey carried out to determine noise from slow moving freight trains.*

3. REVIEW OF GROUNDBORNE NOISE/VIBRATION CRITERIA IN THE ENVIRONMENTAL STATEMENT

The three vibro-acoustic effects of the operation of railway trains will potentially all occur together in the proposed rail operations which are the subject of this study. This is unusual, as groundborne noise is normally assessed in connection with the effects of operating railways in tunnels so that airborne noise is absent. In the Sizewell case, noise will potentially be perceived in several ways in combination. The first is airborne sound emitted by railway sources of which the locomotive engines are predominant, but also include rolling noise caused by the wheels running on rails. The second is groundborne noise transmitted from the track into the ground so that it enters the receiving buildings causing secondary radiation into the air in the rooms within. The third is sound resulting from rattling of structural components set into motion by ground-transmitted vibration.

The establishment of assessment criteria

In the years since the publication of the Noise Policy Statement for England (NPSE), a significant number of infrastructure projects have been assessed and subject to scrutiny, leading to either grant of powers by the Secretary of State, or enactment in Parliament. The environmental assessments for those projects included the setting of assessment criteria and thresholds of significance as required by environmental assessment law, and also numerical interpretation of the LOAELs and SOAELs [1] contained in the Explanatory Note to the NPSE (as developed by the Planning Practice Guidance.

As far as railway noise and vibration is concerned, by far the largest project is HS2, Phase 1 of which is empowered by the High Speed Rail (London-West Midlands) Act 2017. During the passage of the Bill the HS2 approach to the assessment of groundborne noise and vibration, including its interpretation of the LOAEL and SOAEL system, were put before the Select Committees of both houses of Parliament and, no change having been required during that process, they form part of the Environmental Minimum Requirements which are an undertaking by the Secretary of State for Transport.

Following the publication of the World Health Organization Environmental Noise Guidelines for the European Region in 2018, HS2 reviewed its criteria and concluded that no amendment to the HS2 LOAEL and SOAEL values was necessary to take account of the new WHO recommendation.

Other recent rail projects include the Northern Line Extension in London, which underwent scrutiny at a Transport and Works etc Act public inquiry, leading to approval by the Secretary of State. The significance criteria employed on the Northern Line Extension informed the subsequent scope and methodology of the Crossrail 2 project. Which, although it has not undergone external scrutiny, is the up to date approach taken by London Underground.

Unlike HS2, London Underground operates underground railways of varying ages and standards of design, including some with jointed track. For that reason LUL chose, in their Asset Design Guidance, to set their criteria in terms of the more sensitive L_{AFmax} scale compared with L_{ASmax} used by HS2. Where there is jointed track, L_{AFmax} may exceed L_{ASmax} by a considerable margin and that margin is of great

[1] Lowest Observable Adverse Effect Level and Significant Observed Adverse Effect Level

relevance when it comes to mitigation. In the case of continuous welded rail (CWR), the difference between L_{Asmax} and L_{AFmax} is small (1-2 dB) and as L_{ASmax} is predictable in the design process with less uncertainty, it was chosen for use in the HS2 criteria.

No project since the publication of the Noise Policy Statement for England has been required to address the in-combination effects of groundborne and airborne noise as a result of which there are no precedents for values of LOAEL and SOAEL for the overall indoor sound level due to combined airborne and groundborne noise. There have been studies on the effect of noise and tactile vibration experienced in combination, but no studies on the effect of airborne and groundborne noise experienced in combination. Furthermore, the precedents for setting thresholds for groundborne noise from railways all relate to train services where the duration of the train passage is only a few seconds. The combination of very low speeds and long freight trains results in the duration of train passages in this case being, at over a minute, some twenty times longer than the equivalent duration of an HS2 train passage. On the other hand, HS2 services are assumed to be at least twenty trains per hour, compared with a maximum of five trains per night on the East Suffolk Line.

In the SZC ES, using EIA terminology in terms of 'impact' and 'effects', the significance depends on the sensitivity of the receptors, and the impact thresholds are as follows. The ES Table numbers are taken from Vol 9 Ch 4 of the ES (Book Ref 6.10)).

Table 1 (ES Table 4.2): Assessment of the value or sensitivity of receptors for noise and vibration

Sensitivity	Description
High	Receptors that are highly sensitive to noise or vibration such as theatres, auditoria, recording studios, concert halls and highly vibration sensitive structures or uses such as certain laboratories medical facilities or industrial processes.
Medium	Noise and vibration sensitive receptors such as permanent residential buildings, hospitals and other buildings in health/community use, buildings in educational use, hotels and hostels.
Low	Receptors with limited sensitivity to noise and vibration such as offices, libraries buildings in religious use, and other workplaces with a degree of sensitivity due to the need to concentrate.
Very Low	Receptors of very low sensitivity to noise and vibration such as industrial or commercial buildings and transient or mobile receptors.

Table 2 **(ES Table 4.8): Magnitude of impact from railway vibration.**

Sensitivity of receptor	Period(1)	Magnitude of impact				Parameter
		Very low	Low	Medium	High	
High	Bespoke assessment method to be used					
Medium	Day	≤0.2	0.2-0.4	0.4-0.8	>0.8	VDV $m/s^{1.75}$
	Night	≤0.1	0.1-0.2	0.2-0.4	>0.4	
Low	Day	≤0.4	0.4-0.8	0.8-1.6	>1.6	
	Night	Night time assessment not normally required				
Very low	Day	≤0.8	0.8-1.6	1.6-3.2	>3.2	
	Night	Night time assessment not normally required				

Note: (1) day is 0700 to 2300 hours and night is 2300 to 0700 hours.

Table 3 **(ES Table 4.9): Magnitude of impact from groundborne noise due to railway movements (internal values).**

Sensitivity of receptor	Period	Magnitude of impact				Parameter
		Very low	Low	Medium	High	
High	Bespoke assessment method to be used					
Medium	Any	<35	35	45	50	L_{ASmax}, dB
Low	Any	<35	35	45	50	
Very low	Any	Assessment not normally required				

The output of this table is used in a classification of effect table

Table 4 **(ES Table 4.11): Classification of effects.**

		Value/Sensitivity of Receptor			
		Very Low	Low	Medium	High
Magnitude	Very low	Negligible	Negligible	Negligible	Negligible
	Low	Negligible	Minor	Minor	Moderate
	Medium	Minor	Minor	Moderate	Major
	High	Minor	Moderate	Major	Major

The output of this table is used in a definitions table

Table 5 **(Table 4.12): Effect definitions**

Effect	Description
Major	The noise causes a material change in behaviour attitude or other physiological response. Adverse change may result in the potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished or improved due to change in acoustic character of the area.
Moderate	Effects that may result in moderate changes in behaviour, attitude or other physiological response. Adverse effects may result in some reported sleep disturbance. Changes to the acoustic character of the area such that there is a perceived change in the quality of life.
Minor	Effects that may result in small changes in behaviour attitude or other physiological response. Adverse effects may result in some minor reported sleep disturbance. Small changes to the acoustic character of the area such that there is a low perceived change in the quality of life.
Negligible	Noise can be heard, but does not cause any change in behaviour, attitude or other physiological response. Can slightly affect the acoustic character of the area but not such that there is a change in the quality of life.

Then, "As a general rule, major and moderate effects are considered to be significant and minor and negligible effects are considered to be not significant. However, professional judgement is also applied where appropriate. In addition to considering these tables, other project-specific factors, such as the number of receptors affected and the duration and character of the impact need to be considered where these have a potential bearing on significance."

This multistage process leads to the conclusion that a residential receptor (medium sensitivity) with 45 dB L_{ASmax} receives a medium impact and therefore moderate classification and therefore a significant effect. For vibration the equivalent figures are 0.2 VDV_{night} and 0.4 VDV_{day}

With regard to the setting of values for LOAEL and SOAEL Tables 4.17 and 4.18 from the ES (Volume 9 Chapter 4 Book Ref 6.10) set out the thresholds used in the DCO submission.

Table 6 **(Table 4.17): LOAEL and SOAEL values (internal) for groundborne vibration from rail movements on the green rail route and refurbished branch line and East Suffolk line at night.**

Receptor sensitivity	Period	LOAEL	SOAEL	Parameter
High	Would require site specific criteria.			VDV, $m/s^{1.75}$
Medium	Day (07:00 to 23:00 hours).	0.2	0.8	
	Night (23:00 to 07:00 hours).	0.1	0.4	
Low	Day (07:00 to 23:00 hours).	0.4	1.6	
Very low	Day (07:00 to 23:00 hours).	0.8	3.2	

Table 7 **(ES Table 4.18): LOAEL and SOAEL values (internal) for groundborne noise from rail movements on the green rail route and refurbished branch line and East Suffolk line at night.**

Receptor type	Period	LOAEL	SOAEL	Parameter
Medium	At any time during occupation / use	35	50	L_{ASmax}, dB
Low		35	50	

Thus for residential receptors the SOAEL is 50 dB L_{ASmax} and 0.4 VDV_{night} and 0.8 VDV_{day}.

For comparison the HS2 criteria are as follows, from Phase 2a Information Paper E10.

Table 8 **(HS2 Table 1) - Ground-borne noise and vibration effect levels for permanent residential buildings**

Ground-borne noise	Lowest Observed Adverse Effect Level	L_{pASMax} [dB]	35
	Significant Observed Adverse Effect Level	L_{pASMax} [dB]	45
Vibration	Lowest Observed Adverse Effect Level	VDVday[$m/s^{1.75}$]	0.2
		VDVnight[$m/s^{1.75}$]	0.1
	Significant Observed Adverse Effect Level	VDVday[$m/s^{1.75}$]	0.8
		VDVnight[$m/s^{1.75}$]	0.4

The HS2 SOAEL for groundborne noise is the same as the threshold of significant effects in the SZC ES but 5 dB lower than the SZC SOAEL. The VDV SOAELs are the same for both projects.

EIA significance thresholds may differ from SOAELs, and HS2, for airborne noise, assesses EIA significance based on noise change and the size of the community effects in a process which also brings in LOAEL and SOAEL.

When the threshold for EIA significance differs from the SOAEL threshold using the same assessment process and the same index it is necessary to take into account the legal and policy consequences of exceeding either of these two thresholds. In Environmental Assessment law, where there is a significant effect, mitigation to avoid, reduce or remedy the effect must be considered but residual significant effects may still remain. This is not as strong as the NPSE requirement to avoid significant effects that is associated with SOAEL. Thus the consequence of the significant effect threshold being lower than SOAEL (but higher than LOAEL) is to introduce an additional threshold with an intermediate mitigation requirement.

In the SZC case, the number of events attributable to train movements to and from Sizewell C is much less than the case for HS2, which involves no freight trains. Some of the source documents in the technical literature which originally proposed L_{max}-based criteria for groundborne noise did suggest lower thresholds for circumstances where there are most movements, and as a general principle a disturbing event may be more disturbing the more frequently it occurs, and vice-versa, but 50 dB L_{ASmax} is a very high level of groundborne noise, often accompanied by secondary effects such as rattle. Furthermore the duration of underground train events may be only of the order of 10 seconds whereas freight train passby events in the present context may be as long as a minute or more.

Because, in the Sizewell case, groundborne noise is not heard in isolation, but in combination with airborne noise entering the interior of the dwellings primarily through the windows, it is necessary to consider the groundborne noise criteria in the context of the airborne noise criteria for LOAEL and SOAEL, which are set out in table Table 9.

Table 9 **(ES Table 1.25): LOAEL and SOAEL values for rail noise**

Time Period	LOAEL	SOAEL
Day (07:00-23:00)	50dB $L_{Aeq, 16h}$, (free field)	66dB $L_{Aeq, 16h}$, (free field)
Night (23:00-07:00)	40dB $L_{night, outside}$ (free-field)	59dB $L_{Aeq, 8h}$, (free field)
	60dB, L_{Amax}, (free field)	77dB, L_{Amax}, (free field)

Although the time weighting for the L_{Amax} levels is not explicit in the ES, they are derived from the HS2 L_{AFmax} thresholds. These are set in terms of the external free-field sound level, on the assumption that the internal sound level with windows partially open will be 12 dBA less (i.e. 15 dB less than the facade level, 3dB greater than the free-field level[2]). Thus the LOAEL and SOAEL are approximately equivalent to internal levels of 47 dBL_{AFmax} and 65 dB L_{AFmax} respectively. In the Sizewell case the relationship between L_{AFmax} and L_{ASmax} is dependent on the presence of joints in the track. On the Leiston branch line, it is shown below that L_{AFmax} exceeds L_{ASmax} by as much as 7 dBA. On welded rail, in locations where there are no rail welds, the difference is only of the order of 2 dBA. Despite the difference in time weighting the LOAEL and SOAEL for airborne noise are still of the order of 10 dBA or more higher than those for groundborne noise. This difference becomes much less if the windows are closed.

However, the spectrum of internal train noise from airborne sound entering via a partially open window is quite different from the spectrum of groundborne noise, particularly the type of groundborne noise which has given rise to the choice of LOAEL and SOAEL, which is predominantly contained in frequency bands below 125 Hz. By contrast, airborne train noise in a room with partially open windows contains most of its A-weighted energy above 125 Hz. Human reaction to low frequency noise is not the same as to noise of a broader spectrum. Thus a simple comparison between criteria for the two types of noise is not necessarily valid.

This highlights an essential difference between airborne noise and groundborne noise. Airborne noise entering via partially open windows can be reduced, if the occupant chooses, by closing the windows. It can be reduced further by the installation of acoustic secondary glazing. There is no equivalent option for groundborne noise, which cannot be reduced and is present even in rooms not facing the railway.

[2] Note that the façade/free-field correction varies. In the statutory calculation procedures for road traffic and Railway noise it is 2.5 dB.

An important consideration is the fact that while wheel/rail noise is the principal component of groundborne noise, and while it is also present in airborne noise, enhanced by wheel/rail-excited rolling noise radiated from wheel discs and bogie members, the maximum free-field airborne noise level during the passage of high speed trains is some 30 dBA higher than the same spectrum limited to the range 10Hz-125Hz. This is because aerodynamic noise predominates over wheel/rail rolling noise at high speeds.

The maximum noise events in the case of low speed freight trains are likely to be due to locomotive engines and exhausts in addition to enhanced wheel/rail-excited rolling noise radiated from wheel discs and bogie members. The margin between wheel/rail noise and locomotive noise is dependent on the notch setting selected by the driver, in turn dependent on whether the locomotive is accelerating and on the presence of a gradient. In contrast to the case of groundborne noise, airborne wheel/rail noise contains little energy at low frequencies. By inspection of the time series of wayside airborne sound levels it is possible to distinguish the noise level during the passage of the locomotive and during the subsequent passage of the wagons and the trailing unpowered locomotive. In the survey carried out in August 2020 the difference between these two parts of the pass-by signal was of the order of 7 dBA.

These considerations provide an answer to the question of how to reconcile mitigation requirements arising from the two types of noise and their separate criteria. If there were no significant groundborne noise, an occupier of a dwelling with airborne train noise exactly at SOAEL, thus experiencing an internal L_{AFmax} of about 65 dBA, would, if they chose to close the windows have the option of lowering the internal noise level to around 45 dBA or less if the windows included acoustic secondary glazing.

Daytime criteria

There has historically been no need to set different thresholds for times other than night (23:00-07:00). It is generally accepted that noise sensitivity at night is greater than at other times, and it follows that if an acceptable level of groundborne noise is achieved for trains operating at night, then the situation in the day and evening will also be acceptable without separate consideration since L_{Amax} measures are not dependent on service frequency. They are dependent on speed, but underground railways, including mainline railways operating in tunnels, do not usually run at slower speeds by night. In these cases, groundborne noise is normally the only railway noise heard, and airborne noise from the same source is normally absent. Projects such as HS2 do not involve locomotive-hauled trains so that the similar spectral content in low frequency diesel locomotive airborne noise and groundborne noise will not occur.

Daytime criteria where there is intensification

A feature of most underground railways is that it is seldom necessary to consider intensification of an existing system. Assessment of development projects nearly always involves assessing new lines which give rise to groundborne noise in locations where there is no significant baseline – the few exceptions being where proposed new and existing lines cross or converge, but in those cases established practice is to assess groundborne noise from the new line in terms of absolute levels. In London, for example, in locations where there may be groundborne noise from several different underground railways, the approach is to design new underground railways without taking into account exceedance of L_{Amax} criteria by pre-existing railways on the grounds that future improvements to their track support systems may result in reductions of the pre-existing noise levels. The need to assess the introduction of new and significantly different trains operating at different speeds on the same track in an existing tunnel along with pre-existing trains has never arisen.

Groundborne noise is normally assessed using an approach which differs from established assessment methods used for airborne noise, in that the L_{Aeq} index is not used. For night time this fits with the approach to airborne noise assessment to the extent that many night-time airborne noise assessment procedures take L_{Amax} into account as well as L_{night} or $L_{Aeq\ 2300\text{-}0700}$ [3].

It is difficult to use L_{Amax} as a daytime noise criterion, for lack of information in the literature about links between daytime noise quantified using L_{Amax} and community response. It is true that the origins of the L_{Amax} criteria that are in use lie in links between complaints and noise levels, and the complaints have not necessarily been confined to sleep disturbance problems. Nevertheless, there is no definitive information on which to set a threshold based on L_{Amax} for periods other than night.

Furthermore, where there is intensification of an existing railway L_{Amax} is not a full indicator of the effect of adding the effects of a proposed new service to the baseline service, so a logical option would be to use an L_{Aeq} based approach. Because of the need to follow planning guidance this will necessitate assigning values to daytime LOAEL and SOAEL for cases involving intensification.

An essential difference between an L_{Aeq} approach for airborne noise and groundborne noise is that LOAELs and SOAELs for airborne noise are normally set in terms of outdoor noise levels. That approach has no meaning for groundborne noise. The correction to convert outside noise levels to inside noise levels is dependent on the window specification and condition (open, partly open or closed). Because groundborne noise cannot be reduced by closing or improving windows, the closed condition should be the basis when airborne and groundborne noise are considered in combination.

[3] L_{night} is an annual index whereas $L_{Aeq\ 2300\text{-}0700}$ may use other periods

The outdoor airborne LOAEL and SOAEL L_{Aeq} values used in the SZC ES are, for daytime, 50 dB $L_{Aeq\ 16h}$ and 66 dB $L_{Aeq\ 16h}$, respectively, both free-field noise levels. Allowing for a closed sound-insulated window the internal equivalents would be of the order of 25 dB L_{Aeq} for the external LOAEL and of the order of 40 dB L_{Aeq} for the external SOAEL. BS 8233 states in 7.7.2 that in general, for steady external noise sources, it is desirable that the internal ambient noise level does not exceed the guideline values in its Table 4 in which the daytime guideline value is 35 dB $L_{Aeq\ 0700\text{-}2300}$. To this is added "NOTE 1 Table 4 provides recommended levels for overall noise in the design of a building. These are the sum total of structure-borne and airborne noise sources. Groundborne noise is assessed separately and is not included as part of these targets, as human response to groundborne noise varies with many factors such as level, character, timing, occupant expectation and sensitivity."

If the HS2 SOAEL for groundborne noise of 45 dB L_{ASmax} (considered in the absence of airborne noise) is converted into $L_{Aeq\ 0700\text{-}2300}$ based on the HS2 train service it is broadly equivalent to a figure around 40 dB $L_{Aeq\ 0700\text{-}2300}$ and the LOAEL is 10 dB less.

Relationship between $L_{Aeq\ 0700\text{-}2300}$ and L_{Amax} for SZC

In the method for calculating L_{Aeq} levels of train pass-bys an intermediate stage involves summing the noise intensity at the measurement point from the time just before the train arrives until the time just after it departs. The times are those when the noise level is 10dB below the level during the pass-by (the 10 dB-down points). The time between the 10dB down points of a SZC train passing at 25 mph is approximately 30 seconds. One train passage in the period 0700-2300 would yield a $L_{Aeq\ 16h}$ approximately 33 dB less than the L_{Amax} value. If a SOAEL threshold of 40 dB L_{Aeq} were selected, one train with an L_{Amax} value of about 73 dB would achieve the threshold. However, an internal L_{Aeq}-based criterion ought to take airborne noise into account which would reduce the 33 dB L_{Amax}-L_{Aeq} difference. That difference further reduces by 3dB for each doubling of train movement numbers.

As far as the baseline is concerned, the ES assumes no freight trains between 0700 and 2300. It assumes an average of 30 passenger trains per day. The passenger trains since October 2020 are all Class 755, although some are four-car (with a central power car) 80.7m long and some three-car 65m long. The nominal operating speed on the East Suffolk line is 55 mph so comparing durations and numbers only, the L_{Amax}-L_{Class} difference is in the region of 28 dB. Groundborne noise is primarily a function of unsprung mass and the locomotives of the freight trains may generate groundborne noise levels some 7dB greater than the Class 755 power cars at the same speed, and after allowing for the speed difference the contribution of one SZC freight trains may be a few dB less than that of 30 passenger trains. Thus, after combining the contributions of baseline and SZC trains, there is likely to be a small impact in terms of noise change. The absolute value of $L_{Aeq\ 16hour}$ is not likely to exceed an internal SOAEL threshold of 40 dB L_{Aeq} and indeed is likely to be near to a LOAEL of 15 dB less. On the same assumption, i.e. of closed windows, adding the associated airborne noise would not result in exceedance.

4. GOALS FOR GROUNDBORNE NOISE AND VIBRATION.

In the light of the considerations set out in section 3 above, the criteria for assessing groundborne noise and airborne noise in combination should be as follows:

1) For nighttime (2300-0700), groundborne noise should be assessed using the L_{Amax} index by considering the decibel sum of both the groundborne noise and the airborne noise in the octave bands up to and including 125Hz using 'S' rather than 'F' time weighting, with windows fully closed, including the benefit of acoustic secondary glazing to the windows if present. Combined groundborne noise and airborne noise, using the approach set out in the preceding paragraph, should then be assessed against the LOAEL and SOAEL values for groundborne noise alone, namely 35 dB L_{ASmax} and 50 dB L_{ASmax} respectively.

2) For daytime (0700-2300), two cases should be considered: (A) where there is no pre-existing source of groundborne railway noise and (B) where there is existing groundborne railway noise.

3) In case (A) the same criteria established for nighttime should be applied for all times of day. In case (B) groundborne noise should be assessed using the $L_{Aeq\ 0700\text{-}2300}$ index by considering the decibel sum of both the groundborne noise and the airborne noise in the octave bands up to and including 125Hz. The resulting value should then be assessed against an internal LOAEL of 25 dB $L_{Aeq\ 16h}$ and internal SOAEL of 40 dB $L_{Aeq\ 16h}$.

For the SZC project, the Leiston branch falls under case (A) and the East Suffolk line falls under case (B). Thus, groundborne noise and vibration for all receptors along the Leiston branch are assessed using the methodology set out in 4.1 above. All receptors along the East Suffolk Line are assessed using the methodology set out in 4.1 above for nighttime (2300-0700) and by the methodology set out in 4.3 above for daytime (0700-2300).

5. GROUNDBORNE NOISE/VIBRATION ASSESSMENT IN ES.

The ES makes the following predictions for groundborne noise. These were based on measurements of vibration from slowly moving freight trains at locations in the region. They assume the presence of continuous welded rail and the conclusion is that without further mitigation SOAEL is expected to be exceeded at receptors within 5m of the line for trains travelling at 10mph and within 10m of the line for trains travelling at 20mph. LOAEL is likely to be exceeded at receptors within 42m of the railway line for trains travelling at 10mph and 50m of the railway line for trains travelling at 20mph. No exceedances of the SOAEL or LOAEL are expected for vibration.

Table 10 **(ES Table 4.29): Predicted ground borne noise levels at different train speeds and distances from the line**

Speed	Distance from rail line	Level exceeded, dB, L_{ASmax}	Magnitude of impact
10mph	<5m	>50	High
	5-14m	45-50	Medium
	14-42m	35-45	Low
	>42m	<35	Very low
20mph	<10m	>50	High
	10-20m	45-50	Medium
	20-50m	35-45	Low
	>50m	<35	Very low

6. CALCULATION OF LIKELY LEVELS OF GROUNDBORNE NOISE AND VIBRATION FROM THE SZC TRAINS FOR BOTH LEISTON BRANCH LINE, AND ESL.

A three-dimensional numerical model was created using the Finite-Difference-Time Domain model *FINDWAVE®*.

FINDWAVE® is a fully three-dimensional finite-difference time-domain model specifically developed for modelling vibration and groundborne noise from railways. It has been used on many projects around the world, including HS2, Crossrail, Thameslink 2000, Jubilee Line Extension, Channel Tunnel Rail Link and Docklands Light Railway in London, Malmö Citytunnel and Västlänken in Sweden, Singapore Central Line, Parramatta rail link in Sydney, Mostoles-Navalcarnero in Madrid, Metro North in Dublin, and a large number of other projects.

This study involved the creation of a three-dimensional *FINDWAVE®* model of the track on the Leiston branch, together with two typical styles of building construction close to the track. At the time the model was created it was not known whether the ground floors of the crossing cottages or the houses near the former Leiston station had suspended or concrete slab floors, so an example of each was included and predicting and vibration, and thereby groundborne noise, in the buildings.

The model used

FINDWAVE® is a finite difference time-domain numerical model for computing the propagation of waves in elastic media. Full details of the model are given in Appendix I. The railway implementation of *FINDWAVE®* includes the train as a stack of damped masses and springs representing the rail vehicle. The excitation is provided from an input file containing an assumed vertical rail head profile, together with the gravitational effect of the rolling train. The train moves in the model and the location of the contact patch for each wheel is constantly advancing (re-entering the model at the front when it goes beyond the end). The interaction between the contact patch and the rail is transferred to the relevant fixed rail elements using polynomial interpolation.

The model predicts, in the time domain, the dynamic behaviour of the track and structure supporting the train, and the medium surrounding it, e.g. soil or air, together with structures below or above ground level. The structures concerned are represented as cells in a 3-dimensional orthogonal grid, each cell being assigned density, Lamé constants and loss factor.

The model has a basic cell size of 200mm, varied locally to suit the characteristics of elements in the model. A time step of 1/262144 milliseconds was used. The model was run for a time period of 1 second. Output from the model consists of time series of the velocity of relevant parts of the structure, which are subjected to discrete Fourier transform and expressed as 1/3 octave band spectra.

An isometric view of the model is shown in Figure 1. Longitudinal and cross sections are shown in Figures 2 and 3. The building on the left in Figure 2 (top in Figure 1) has a concrete slab floor at ground level. The other building has a suspended timber joist floor at ground level.

Rolling Stock

The model was run assuming JNA 60m^3 wagons hauled by a Class 66 locomotive. The relevant parameters of the Class 66 locomotive are listed in Appendix II. The parameters of the JNA box wagon are shown in Appendix III. The model assumed partly-loaded wagons

The train speed initially assumed was 20 mph.

Track

It was initially assumed that the track would be upgraded to modern standards and the rails were modelled as CEN 60 rail on baseplates having a vertical dynamic stiffness of 200MN/m, laid on concrete sleepers on ballast.

Where mitigation was considered necessary, the installation of resilient under-ballast mat with characteristics as shown in Appendix V was considered.

Material characteristics

The geological characteristics were taken from the database of the British Geological Survey, indicating superficial geology of Lowestoft formation – Diamicton, over bedrock of crag.

The properties assigned to the materials in the current model are given in Table 11. The modulus assumptions are relevant to the extremely small strains involved in groundborne noise and vibration, and are not necessarily the same as those used for civil engineering purposes. The property D is the compressive modulus, given by:

$$D=2G(1-\sigma)/(1-2\sigma)$$

where σ is Poisson's ratio and G is shear Modulus.

Table 11 Table of properties of materials in the model

Material	Shear Modulus, *Gmax*, GPa	Compression Modulus, *D*, GPa	Density, ρ kg/m^3	Loss factor η
Concrete	11.64	31.11	2400	0.05
Ballast	0.125	0.3	1800	0.1
Soil	0.452	5.8	1930	0.1
Blockwork	5.0	15.0	1400	0.03
Wood	5.0	17.5	600	0.05
Plasterboard	0.32	1.0	800	0.05
Roof tiles	2.9	7.8	2000	0.05

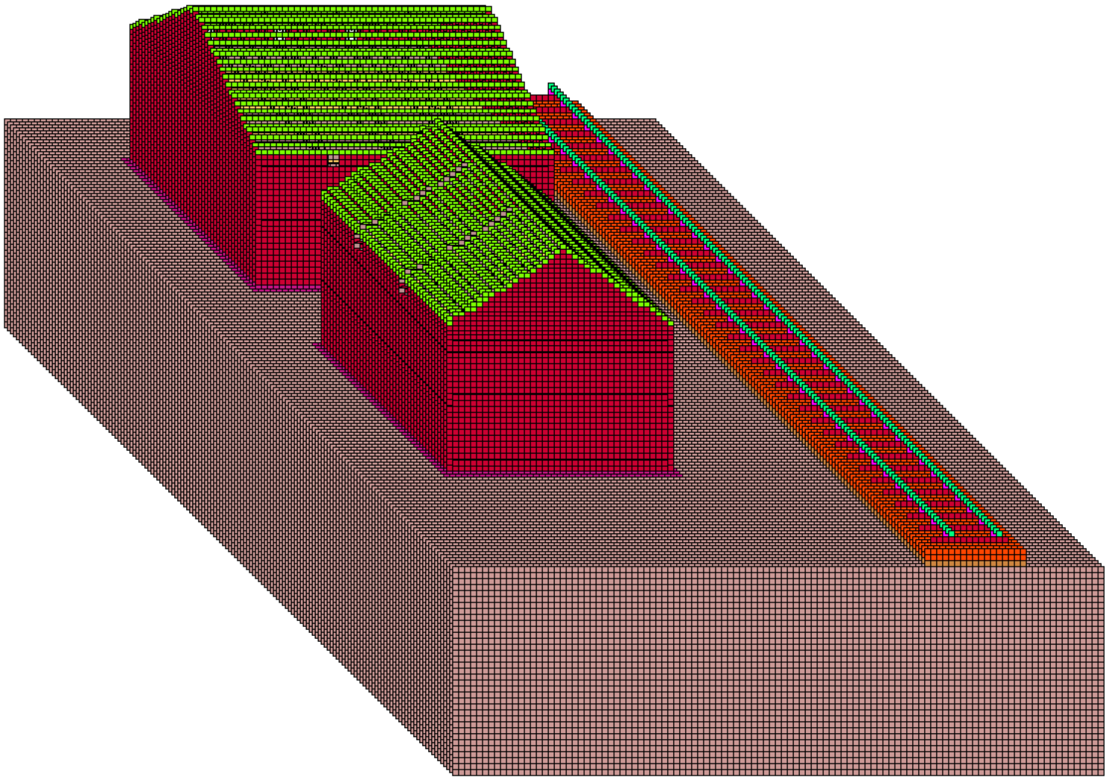

Figure 1 Isometric view of the model

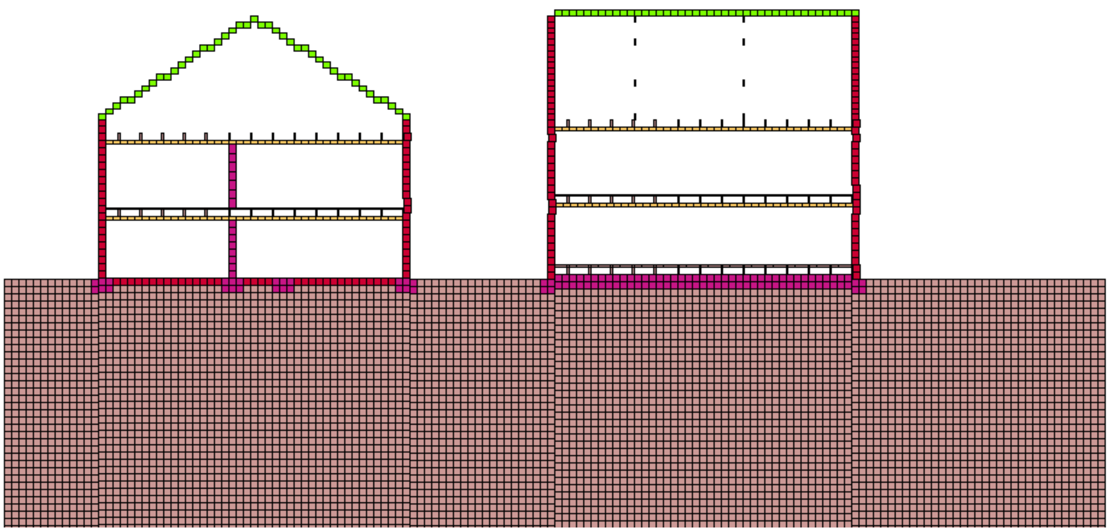

Figure 2 Longitudinal Section through the model

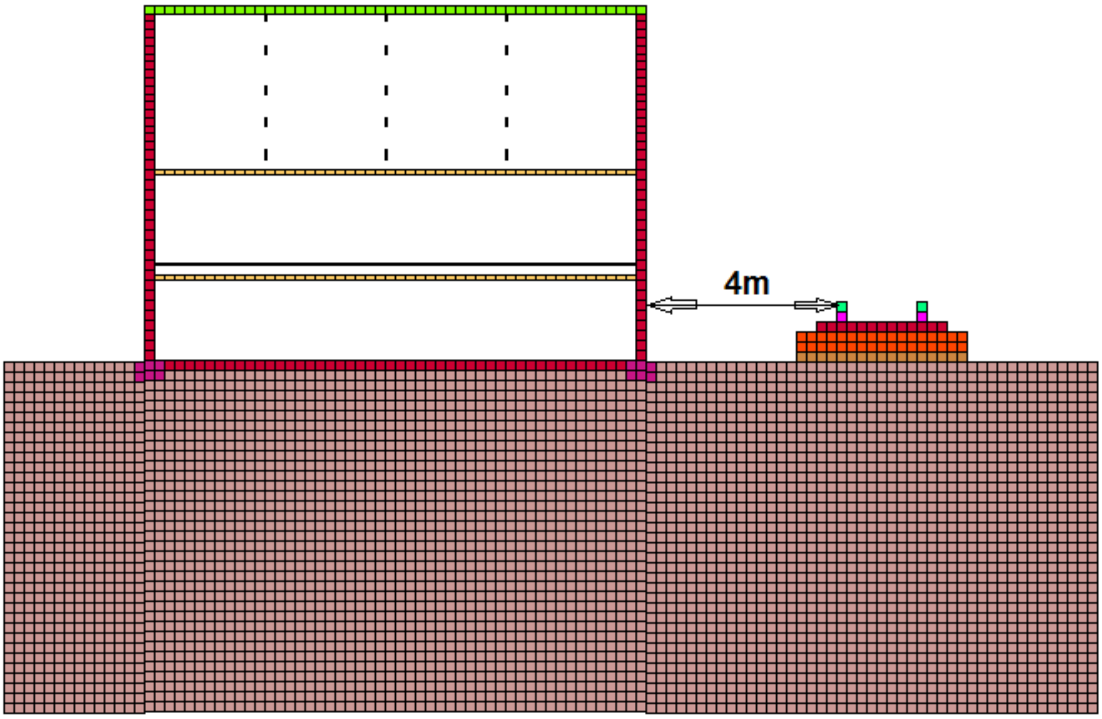

Figure 3 Cross Section through the model

Model results

The results of the initial model are given in terms of the airborne sound level (caused by vibration entering the building via the ground and foundations) inside rooms and spaces at a height of 1.25m above the level of the top of each floor slab in the assessed building assuming a reverberation time of 1.0 second.

It can be seen that the results range from 40 to 60 L_{Asmax}.

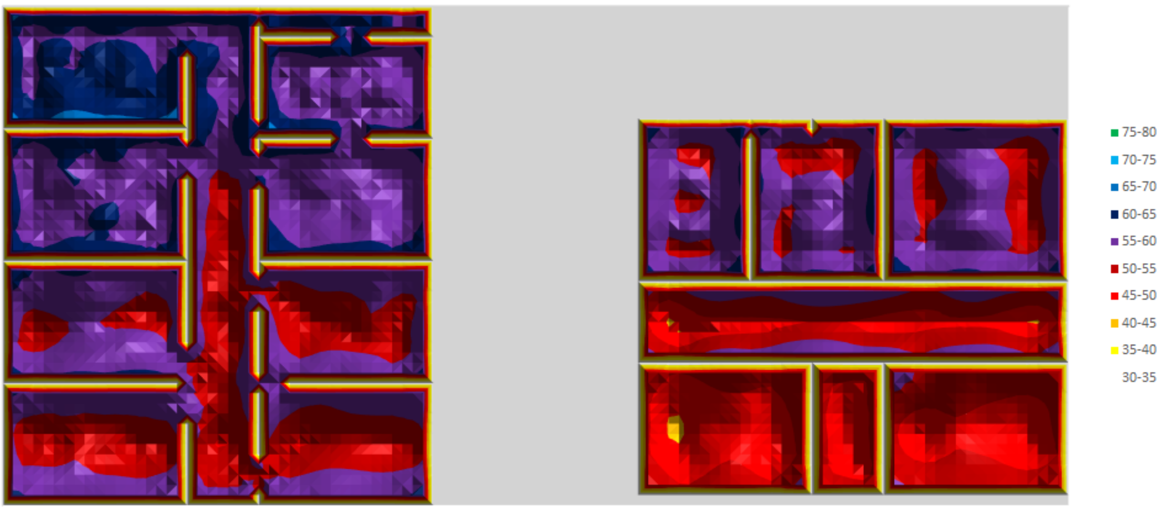

Figure 4 Model results L_{ASmax}, ground floor (plan view)

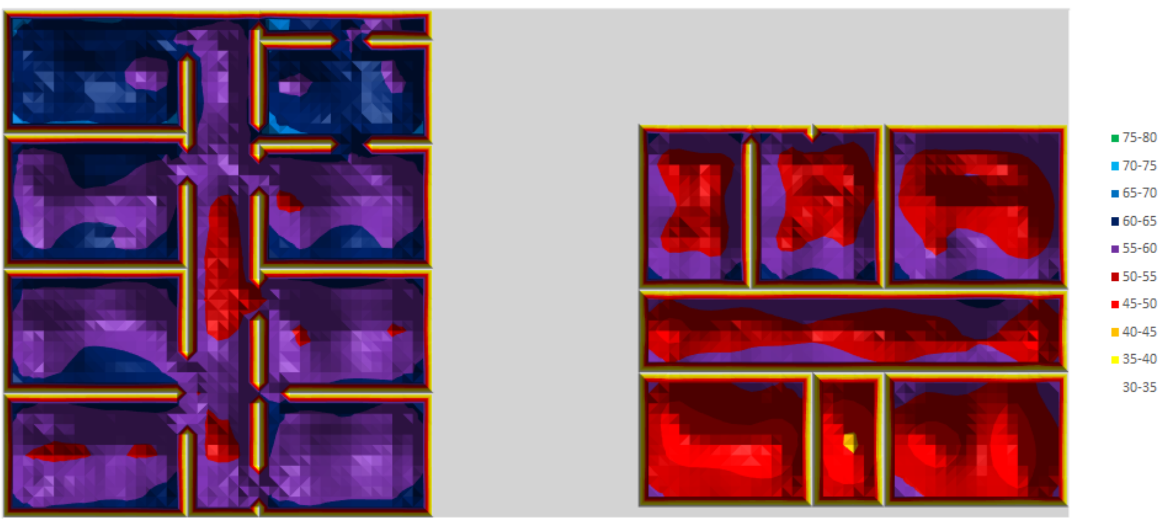

Figure 5 Model results L_{ASmax}, first floor (plan view)

7. SUMMARY OF MEASUREMENTS OF GROUNDBORNE NOISE AND VIBRATION FROM THE AUGUST 2020 SURVEY.

The survey carried out in August 2020 was of the sound and vibration caused by a test train running on the Leiston branch line, chartered for the occasion. Measurements during its passage to and from the branch line were also captured at a site in Woodbridge. The train was formed of 20 JNA-T wagons, unladen, hauled by a Class 66 locomotive at one end and a Class 68 locomotive at the other end. The trailing locomotive in each run was not applying tractive effort, but it was idling. Runs took place in each direction at speeds ranging from 10mph to 20 mph.

Measurements of both airborne sound and ground vibration were made in free-field at distances of 7.5m, 15m and 25m by Sharps Redmore. The airborne sound measurements are separately reported.

The measurements in Woodbridge were made at a location close to that of a long-term monitor set up by Sharps Redmore, with a sound level meter microphone approximately 5m from the track centreline and a vibration meter with an accelerometer on the blacktop car park of the former Suffolk Coastal District Council offices approximately 7.5m from the track centreline. This survey has continued through November 2020 which means that it has captured the sound and vibration resulting from the full replacement of the passenger train fleet that was not completed until October 2020 due to faults in the new Stadler FLIRT Class 755 trains.

Sound and vibration measurements were made inside dwellings by Resound Acoustics and Rupert Taylor Ltd. On 6 August the buildings were the two former level crossing cottages Gate House Knodishall and West House Crossing, Leiston. Both buildings are single storey. On 10 August measurements were made in two-storey buildings in Leiston, the first, 3 Westward Ho being a conversion of part of the former Leiston railway station, and the second, 53 Westward Ho, being a more recently constructed house a short distance to the west. Both houses appeared to have concrete slab floors at ground level, and timber and joist floors at first floor level.

Measurements were made of simultaneous three-axis floor vibration and airborne sound level, using four-channel Rion DA-20 data loggers details of which are given in Appendix VI. The signals were recorded as WAV files and post-processed in the laboratory.

It is known that both vibration amplitudes and sound levels are dependent on location within the room[4,5]. Because of the presence of floor coverings the choice of vibration measurement locations was restricted to places where it was possible to achieve a solid connection with the structural floor, and the associated microphone for the sound level was positioned nearby. In the case of the crossing cottages the rooms were irregular in plan, so that there would not have been a clear modal pattern in the room and sound variations with position would not have been as large as in a rectangular room. In the Leiston houses, the ground floor areas were not rectangular, and the first floor rooms were well furnished with sound absorbing materials which would have prevented the clear formation of room modes.

The first week of August 2020 was characterised by rising temperatures. On 6 August the ambient temperature at the times of the measurements was in the region of 25°C. On 10 August it was in the region of 29°C. The rails on the Leiston branch are jointed, and by 10 August the rails had expanded so that the joints were closed up as is evident in Figure 7 . For comparison, the rail joint in Figure 6 near Knodishall on 5 August was photographed in an ambient temperature of 18°C.

The results discussed below show that sound and vibration from the passage of the test train was dominated by the effect of rail joints, and the width of the gap at the joint has a very strong influence on the magnitude of the impulse caused by wheels passing over the joint.

The effect of rail joints is dependent on axle load, and the axle load of the tare wagon is 5.93 tonnes. The fully loaded wagon has an axle weight of 27.7 tonnes. The axle load of the Class 66 locomotive, which has three-axle bogies, is 21.6 tonnes, and of the Class 68, which has two-axle bogies, is 21.25 tonnes. By inspection of the results of the survey, it is possible to see that the effect of axle load is of the order of 5dB for axles passing over joints, but while axles are running between joints there is a very small effect of the order of 2dB.

[4] Thornely-Taylor, R. The relationship between floor vibration from an underground source and the airborne sound pressure level in the room. International Journal of Rail Transportation 4(4), 2016, pp. 247–255

[5] PD ISO/TS 14837-21:2017 Mechanical Vibration. Ground-borne noise and vibration arising from rail systems. Guideline on field measurements for the evaluation of human exposure in buildings, British Standards Institution. London 2018.

Figure 6 Rail joint near Knodishall in ambient temperature of 18°C

Figure 7 Rail joint near 3 Westward Ho in ambient temperature of 29°C

The findings were as follows. Windows in all cases were closed.

Gate House Cottage, Knodishall

The results are shown in Figures 9 to 11 in Appendix IV. Noise inside was dominated by structure-borne transmission coupled with rattling of structural components. With the Class 66 locomotive leading in a westbound direction, at 10 mph the L_{AFmax} reaches 60 dB. VDV_b for one train is just over 0.15 $ms^{-1.75}$. In Figure 10 , "pseudo noise levels" are shown, which are the A-weighted vertical velocity minus 27 dB to give an approximate indication of what the sound level would be within the room in the absence of a contribution of direct airborne sound.

Of particular note are the shapes of the spectra in Figure 11 which indicate a loaded track resonance below the frequency at which it would be expected with bull-head rail laid directly on to timber sleepers on ballast, with no resilient rail pad. The explanation is likely to be that some of the sleepers are not well-bedded on the ballast and were effectively hanging sleepers. This results in a lower bedding modulus for the track.

At 20 mph the L_{AFmax} goes up to the mid 60s and the VDV_b for one train passage is just under 0.25 $ms^{-1.75}$ as shown in Figures 14 to 18. These results may be compared with the ES Volume 1 Appendix 6G which indicates L_{ASmax} of 52 dB and VDV of 0.086 $ms^{-1.75}$ at 5m. However, the ES predictions assume that the track has been relaid, and L_{ASmax} is always lower than L_{AFmax}.

West House Crossing Cottage

The position at West House Crossing Cottage is fundamentally similar to that at Gate House Cottage, but the peaks in the spectra span a wider frequency range including 100-125Hz, which is where one would expect to see the track natural frequency with directly-fastened rails on sleepers and ballast. This suggests that the sleepers were well-bedded at this location. However, with newly laid track the 100-125Hz peak would be much more dominant dependent on the type of rail pad used.

Importantly, the airborne spectrum contains peaks that are not in the vibration spectrum, and these are due to rattling of structural component and the noise that causes. These would disappear with the removal of rail joints.

Leiston

As explained above, by 10th August there had been several successive days of rising temperature and the rail joints in Leiston had visibly closed up. Because of this, the conclusions to be reached about rail joints need to be taken from the Crossing Cottages. However, while the peaks due to joints are smaller at Leiston, it is still possible to look at the troughs particularly in the L_V-27 plots and see that without rail joints an L_{AFmax} of no more than 40dB at 20 mph is possible at 53 Westward Ho, approximately 15m from the track centreline. At 3 Westward Ho, approximately 3m from the track centreline, the same figure is achieved at 10 mph and the in-combination combined L_{ASmax} will not exceed the nighttime SOAEL of 50 dB.

The interest in Leiston is the effect of first floors versus ground floors, as the crossing cottages have no first floors.

Figures 28 to 41 show comparisons between the floors. There is an increase in VDV_b from just under 0.035 to 0.1 $ms^{-1.75}$ between ground and first floors. The difference between SPL and L_v-27 closes due to an increase of about 5dB in L_v-27 at 1st floor. This may be compared with the ES Volume 1 Appendix 6G which indicates VDV of 0.086 $ms^{-1.75}$ at 5m.

Woodbridge

With regard to the test train, the measurements obtained in Woodbridge are shown in Figures 42 to 44 and are assessed in section 9 below. The November 2020 results of the long term monitoring are reported separately by Sharps Redmore. It is important to take into account that the Woodbridge location is close to a welded rail joint that is believed to be aluminothermic and its effect is clearly evident in Figure 42 particularly in terms of its effect on pseudo groundborne noise.

On the East Suffolk line there are two scheduled passenger services between the hours of 2300-0700, and some freight services. The great majority of rail movements are in the period 0700-2300.

The principal finding from the long term Woodbridge survey is that groundborne pseudo noise levels have L_{Amax} values of approximately 45 dB at 7.5m from the track, and for the daytime period the $L_{Aeq\ 16h}$ level varies between 30 and 35 dB. The reason for the variation is not known—possible causes include operation of three-car trains and four-car trains, speed variations and the effect of groundwater levels. During night periods there were some L_{Amax} pseudo-noise events at approximately 49 dB. Because the survey did not include train identification it is not known whether these are attributable to freight trains. The daytime $L_{Aeq\ 16h}$ for the month was 55 dB at 5m distance, but on a daily basis varied between 53 dB and 58 dB. Because of the proximity of the rail joint, inter/extrapolation to other distances must be done with caution because the rail joint is a point source with a different geometric spreading characteristic from the normal line source.

8. MITIGATION TO AVOID SIGNIFICANT EFFECTS.

Leiston branch line

As explained in section 4 above the Leiston branch falls to be assessed using method A, using in-combination L_{Amax} criteria for both the nighttime and daytime periods.

At the crossing cottages, at 10 mph the effect of rail joints is to raise L_{AFmax} levels by over 10 dB for the locomotive and over 15 dB for the wagons. If the rail joints were removed, airborne transmission as the locomotive passes will then dominate. Taking into account airborne noise 10Hz-125Hz the combined airborne/groundborne L_{ASmax} would come down below 45 dB.

With loaded wagons, the effect of the joints will be greater, but the effect on the troughs between the joints will be small. Inspection of the troughs between the joints when the locomotive axles are passing shows the potential effect of loaded wagons.

At 20 mph the effect of the rail joints is less and if the rail joints were removed the L_{AFmax} would still be about 50 dB.

At 15 mph the results lie between the 10 mph and 20 mph result.

If the rail were relaid using rail without joints, the following effects would occur.

The vibration and noise signal would lose the peaks caused by the rail joints, and all other things being equal, the L_{AFmax} levels would come down as indicated above.

The effect of distance from the track will differ from that measured in the survey, because rail joints are point sources whereas other rail noise is close to being a line source. The effect of distance after removal of rail joints will be less than that measured,

Even with welded rail[6], there is some effect due to the presence of welded joints, and it will be necessary to lay rails so that welds are not located near to sensitive receptors. Reference to welded joints is to welds using the flash butt or electric arc welds, and not to aluminothermic welds which would have a much greater noise and vibration effect.

However, the peaks in the spectra are at lower frequencies than would be expected for rails directly fastened to sleepers on ballast. This suggests that the track support as it is at present is softer than would normally be the case, and the most likely reason for that is that not all sleepers are making good contact with the ballast and there are many hanging sleepers.

With newly laid long welded rail, new sleepers and ballast would be laid and all sleepers would be well bedded in the ballast. Consequently the track natural frequency would be increased with consequent increases in groundborne noise. As a result, the potential benefits of removing the rail joints indicated above would not be fully realised.

Thus it will be necessary to keep the track support stiffness no higher than it currently is, and with newly laid track that may necessitate the installation of under-sleeper pads or an under-ballast mat.

Assuming the track support stiffness can be maintained at its current value (and as indicated below it appears that the more modern Woodbridge track is similar - possibly achieved by resilient rail pads), the groundborne noise level can be reduced to no more than 45 dB L_{AFmax}. While at present the difference between

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[6] LWR is produced from rail of varying lengths (36, 72 and 108m) by flashbutt welding. CWR consists of LWR welded together to form one uninterrupted rail that may be several miles long.

L_{AFmax} and L_{ASmax} is large, after removal of the rail joints the L_{ASmax} would be only 1 or 2 dB below the L_{AFmax}.

The Findwave model described in Section 6 above was modified to include the insertion of resilient under-ballast ballast mat. The insertion gain achieved is shown in Figure 8 and is satisfactory. There is, as expected, a rise in vibration amplitude at the new, lower, track natural frequency, but this is more than offset by the attenuation at the original natural frequency and above. In velocity terms, the W_b weighting is fairly flat at both these frequencies, so there is no VDV penalty for moving the frequency of the peak.

Figure 8 Insertion gain of Getzner under-ballast mat

For this to remove significant effects and avoid SOAEL it is necessary to follow the procedure set out in section 4 above and combine groundborne noise levels with airborne noise levels in the range 10Hz-125Hz. It should be noted that the SPL plots in the survey results in Appendix IV are airborne noise from all sources, groundborne and airborne. The indications from the August 2020 survey are that the groundborne noise level and the internal airborne noise level 10Hz-125Hz would be below SOAEL of 50 dB L_{ASmax}, and at the significance threshold of 45 dB L_{ASmax} for a maximum speed of 15 mph.

Having avoided SOAEL, the requirement to mitigate and minimise between LOAEL and SOAEL could only be achieved by further lowering of the track support stiffness which would probably involve going over to resilient slab track and might be undesirable as it would increase vibration.

The VDV_b values are such that with the removal of rail joints the period VDV_b values would come down to below SOAEL. However, whereas lowering the track stiffness reduces dBA levels by shifting the peak further down the A-weighting curve, the W_b weighting curve does not tail off as does the A-weighting curve until much lower frequencies are reached, and lowering the track stiffness would not reduce VDV_b. VDV_d levels are very low, since BS6472:2008 changed from the basi-centric co-ordinate system to the geo-centric system, and at the frequencies concerned W_d weights much more heavily than W_b.

In summary, significant effects can be fully mitigated and SOAEL can be avoided at the crossing cottages by relaying the track with long-welded rail (ensuring that welds in the rail are not near to sensitive receptors) or continuous welded rail, together with under-ballast mat to a specification equivalent to that indicated in Appendix V.

Other properties in Leiston

As the crossing cottages are about as close to the track as any receptors, the mitigation solution identified under their heading will be true for more distant receptors. In order to avoid exceedance of the nighttime significant effect threshold under ballast mat will be required in the Leiston branch (where track is relaid) for locations where there are receptors within 20m of the track. The under-ballast mat should extend at least 10 metres beyond the end of the receptor building. While the sound insulation performance of the windows in the crossing cottages and the properties in Westward Ho is taken into account as internal sound level measurements were made, the condition of the windows of other properties in Leiston and along the East Suffolk Line is not known. Assuming they are not materially worse in their sound insulation performance than those measured on the Leiston branch line, the combination of groundborne noise with airborne noise 10Hz-125Hz would not be expected to alter the conclusion.

The East Suffolk Line

For train movements during the nighttime the assessment has been made using in-combination L_{Amax} criteria as explained in section 4 above. For train movements during the daytime the East Suffolk Line falls to be assessed using method B, using in-combination $L_{Aeq\ 16h}$ criteria.

The track support stiffness is not the same on the East Suffolk Line as it is on the Leiston branch. Measurements made in Woodbridge shown in Figures 42 and 44 indicate a loaded track natural frequency of 50-63Hz. which may be due to the presence of a resilient rail pad—absent from the Leiston branch line.

However, the effect of the welded joint is very evident, and in locations near to such welds the groundborne noise level on the L_{ASmax} scale is likely to be approximately 2 dB higher. It appears that this welded joint is of the aluminothermic type.

Beside the East Suffolk Line there are some residential buildings which are three storey. The effect of the additional storey will be vibration and groundborne noise no greater than at first floor. Airborne noise will be dependent on the locomotive and the position its engine exhaust outlet, and may be the same at second floor as at first floor.

9. ASSESSMENT OF GROUNDBORNE NOISE/VIBRATION FOR BRANCH LINE AND ESL

Leiston branch line

With a newly-laid track of long welded rail laid on concrete sleepers on ballast, the L_{Asmax} due to groundborne noise inside the crossing cottages and in Leiston will be less than 40 dB for all receptors if the train speed is limited to 10 mph.

This may be compared with Table 4.29 of the ES Volume 9 Chapter 4 which predicts 45-50 dB L_{ASmax} at 5-14m at 10 mph.

If the ballast is laid over an under-ballast mat as indicated in Appendix V, a higher train speed will be possible and the significant effect threshold of 45dB would be just achieved at 15 mph.

When groundborne noise and airborne noise 10Hz-125Hz are combined, the result does not exceed the proposed in-combination SOAEL threshold of 50 dB L_{ASmax} at 10 mph. It is exceeded at 20 mph due to locomotive engine noise. At 15 mph an in-combination figure of 50 dB L_{ASmax} could be achievable although this might necessitate the locomotive coasting at this location.

East Suffolk Line

The noise and vibration measurements that were carried out near the Leiston branch did not extend to the East Suffolk line except that a measurement was made 1m from the boundary fence with accelerometers in Woodbridge when the test train was returning to depot after completion of the Leiston survey. With regard to the baseline passenger service results are available from the Sharps long term survey in Woodbridge as referred to in section 7 above.

These results showed that the loaded track natural frequency is, at 50-63Hz, lower than would be the case for rail directly fastened to sleepers on ballast. It is assumed that the reason for this is the presence of a resilient rail foot pad, which would be the norm for modern track. If the first order approximation is made that the coupling loss factor between the car park surface and a residential building and the amplification of floors within a building were broadly equal and opposite (a reasonable assumption), then the pseudo noise level in such as building would, according to Figure 43 be approximately 47 dB L_{ASmax}. There was an aluminothermic welded joint near to this location, and if it were absent the L_{ASmax} would be no more than 40 dB.

In the absence of detailed information about the coupling loss factor and building dynamic response for properties along the East Suffolk Line, it is possible to apply an insertion gain to the Leiston branch measurements to show the effect of substituting modern track such as the track near the Woodbridge measurement for the existing track at Leiston. Because of the hanging sleeper effect at Leiston the loaded track natural frequency at 3 Westward Ho is in fact no higher than it was at Woodbridge.

The conclusion reached above for Westward Ho can also be applied to the East Suffolk Line, namely that at 15m from the track centreline groundborne noise L_{ASmax} of no more than 40dB is possible at 20 mph, in locations where there is no welded rail joint. Where there is a rail joint, the figure would still be below 45 dB. This may be compared with Table 4.29 of the ES Volume 9 Chapter 4 which predicts 45-50 dB L_{ASmax} at 10m-20m at 20 mph. In Saxmundham there is one receptor as close to the track as 3 Westward Ho, approximately 3m, and it will be possible to avoid exceeding the in-combination combined L_{ASmax} SOAEL of 50 dB with a speed limit of 10 mph if there is no joint in the vicinity.

The boundary of the extent of nighttime LOAEL for groundborne noise is likely to be approximately 25m from the track at 20mph. This is approximately half the distance indicated in the ES Volume 9 Chapter 4 and ES Volume 1 Appendix 6G Figure 4.

With regard to the daytime in-combination indoor SOAEL of 40 dB $L_{Aeq\ 16h}$, at 7.5m from the track this will neither be exceeded by the existing passenger service nor by the combinations of the existing service and one proposed freight train operating at the proposed speed of 20 mph within the daytime period depending on the proximity of the receptor to rail joints. The same would be true if three proposed daytime freight trains were added. The shortest distance to a receptor on the East Suffolk line is 2.6m. Provided that there is no rail joint or weld within 25m, the $L_{Aeq\ 16h}$ in-combination internal SOAEL is likely to be reached but not exceeded with 5 SZC trains at 20 mph.

Welded joints will not cause tactile vibration in VDV terms to exceed significant effect thresholds.

Effect of distance

The Woodbridge measurements made it possible to derive information about the soil loss factor, a property that is extremely difficult to discover, and which is key to enabling accurate prediction of the effect of distance.

In order to do this, a further Findwave model has been set up to include a sufficiently long section of rail so that the rise and decay rate of the vibration signal with the approach and departure of a train could be modelled, and the soil loss factor adjusted iteratively until the decay rate matched that measured. The measured decay rate at the train speed measured indicated an attenuation of 1 dB per metre with the source as the last axle of the train.

Taking the worst-case source as any individual axle passing over a welded rail joint, it is valid to apply the same decay rate as was measured for the last axle of the Woodbridge train measurement, as more than one impulse due to an axle passing over the joint will not occur simultaneously.

Where there is a rail joint, it is therefore valid to apply a distance attenuation of 1dB per metre to groundborne noise levels along the east Suffolk Line. This broadly agrees with the assumption made in the ES (Figure 4 Volume 1 Appendix 6G Annex 6G.2) at distances up to approximately 12m and is a higher attenuation at greater distances. In the absence of a rail joint, the distance effect will be less.

Results from the free-field groundborne vibration measurements made on the Leiston branch by Sharps Redmore, an example of which is given in Figure 45 indicate that without the presence of surface paving, with 60ft/18.3m jointed track, the L_{AFmax} falls by the order of 10 dB on increasing from 7.5m to 15m distance and a further 7 dB from 15m to 25m. This is a greater distance effect than indicated in Appendix 6G due to the effect of the rail joints, although the presence of paving in built-up locations will cause a reduced distance effect. With the removal of rail joints the spectrum shape will change, slightly reducing the attenuation with distance, and the dominant source will no longer be a point (the joint) changing the distance function from point source to line source.

10. CONCLUSIONS

The study which has been carried out and is reported above leads to the conclusion that for the Leiston Branch, the in-combination SOAEL threshold of 50 dB L_{ASmax} set out in section 4 above would not be exceeded at any residential property following relaying of the track with long welded rail provided that welds were not located near to sensitive receptors, with a speed limit of 10mph. If under-ballast mat were laid in the vicinity of receptors less than 15m from the track a speed limit of 15 mph would achieve the same result, although this might necessitate the locomotive coasting.

For the East Suffolk Line the received levels of combined groundborne and airborne noise will depend on the location of welded joints in the rail relative to residential receptors. In locations where there are no welded joints within 25m of a property, the combined airborne and groundborne noise level at distances of 7m or more from the track centreline is unlikely to exceed 50 dB L_{ASmax} at train speeds no more than 20mph. Where there is a welded joint the equivalent distance is 10m. For residential receptors where the distance to the track centreline is only of the order of 3m, it will be possible to avoid exceeding the in-combination nighttime SOAEL if the speed is no more than 10mph and there are no rail joints or welds in the rails within 25m.

The boundary of the extent of nighttime LOAEL for groundborne noise is likely to be approxmately 25m from the track at 20mph.

In all cases the significant effect threshold for tactile vibration will not be exceeded in the absence of jointed track.

Because the groundborne noise thresholds for nighttime LOAEL, SOAEL and significant effects are expressed in terms of the maximum pass-by noise level, they are not affected by numbers of train movements, except that part of the rationale for setting SOAEL at a level higher than the significant effect threshold is the infrequency of the events. The LOAEL, SOAEL and significant effect thresholds for tactile vibration in VDV are affected by number of events, such that the VDV increases by just under 20% for every doubling of the number of movements in the day or night periods.

With regard to the daytime LOAEL and SOAEL expressed in terms of in-combination indoor $L_{Aeq\ 16h}$ levels. Provided that there is no rail joint or weld within 25m, the $L_{Aeq\ 16h}$ in-combination internal SOAEL is likely to be reached but not exceeded with three movements of SZC trains at 20 mph.

APPENDIX I

THE *FINDWAVE*® MODEL

A. INTRODUCTION

The wave equation in differential form is as follows

$$\mu\left(\frac{\partial^2\xi}{\partial x^2}+\frac{\partial^2\xi}{\partial y^2}+\frac{\partial^2\xi}{\partial z^2}\right)+(\lambda+\mu)\left(\frac{\partial^2\xi}{\partial x^2}+\frac{\partial^2\eta}{\partial x\partial y}+\frac{\partial^2\zeta}{\partial x\partial z}\right)=\rho\frac{\partial^2\xi}{\partial t^2} \quad (1)$$

for the *x* axis, with corresponding equations for the *y* and *z* axes, where *x, y, z* and ξ, η, ζ are displacements in three orthogonal axes; λ and μ are Lamé constants and ρ is the density. The Lamé constant μ is also known as the shear modulus, *G*. The Lamé constant λ is also known as the coefficient of dilatation and is given by

$$\lambda=\frac{2\sigma G}{(1-2\sigma)}$$

where σ is Poisson's ratio.

Equation (1) can be stated in finite difference form by replacing the differential operator with the approximation

$$\frac{\partial\xi}{\partial x}\approx (x[i][j][k] - x[i-1]\,[j][k])/\,\Delta x \quad (2)$$

For $\Delta x \rightarrow 0$ these two forms are identical.

For a homogeneous, isotropic medium with a finite value for Δx, Δy and Δz, elastic wave propagation can be computed using the finite difference substitution of equation (2)

Effectively, the process is as follows, for each axis, i, j and k. The example given is for axis i. Each point p(i,j,k) lies at the corner of a rectangular cell and is assigned a mass equal to one eighth of the sum of the eight contiguous cells as well as a displacement and velocity. The displacement and velocity is interpolated for each intermediate "virtual" point p(i+d,i+d,k+d) where d=0 or 0.5.

1) Compute pressure gradient
2) Compute shear force gradient
3) Accelerate p(i,j,k) by $\Delta v=F/\rho\,\Delta t$ where *F* is the sum of the force 1 & 2 and ρ is the density assigned to the point and *v* is the point velocity.
4) Displace p(i,j,k) by $\Delta x=\Delta v^*\Delta t$ where *x* is the point displacement and *t* is one time step.
5) repeat from step 1

The geometric part of wave propagation is completely represented by this process. Further terms are required to represent damping. Of several possible terms, the inclusion of a coefficient by which the velocity is multiplied produces a loss factor which decreases within increasing frequency (and gives rise to an excess attenuation per unit distance which is independent of frequency). A viscous damping term can be used, by including a force proportional to acceleration multiplied by a coefficient. However, many materials exhibit hysteretic damping, or damping with other types of frequency dependence. To model these effects it is necessary to include an algorithm which implements Boltzmann's strain history method where

$$s(t) = D_1 \varepsilon(t) - \int_0^{\infty} \varepsilon(t-\Delta t)\varphi(\Delta t)d(\Delta t)$$

where $\varphi(\Delta t) = \frac{D_2}{\tau} e^{-\Delta t/\tau}$ is an after-effect function, D_2 is a constant and τ is a relaxation time. D_1 is a modulus, *s(t)* is stress and $\varepsilon(t)$ is strain. By combining several after-effect functions with different values of D_2 and τ any relationship between loss factor and frequency may be represented. Note that in the frequency domain the integral has a real and imaginary part, with the result that the value of the modulus is reduced by the inclusion of the relaxation terms. Depending on the choice of the constants and relaxation times, the stiffness of a resilient element will be frequency-dependent, and the value of D_1 must be adjusted at the same time that D_2 and τ are selected to give the required dynamic stiffness. This method has been implemented in the version of *FINDWAVE®* used for this study.

B. BOUNDARIES

For modelling finite objects fully surrounded by space, the boundaries can be represented by assigning zero-valued elastic moduli to the space provided that the acoustic load of the air in an airspace can be neglected. If radiation into air is to be modelled, or if an infinite or semi-infinite medium such as the ground is required, it is necessary to minimise the effect of reflections from the boundaries. For a train tunnel, where distances to be modelled are small compared with the length of the train, the z-axis boundaries are dealt with by creating a model exactly one rail vehicle (or unit of several coupled rail vehicles) in length, and then connecting the ends of the model together to create an infinitely long train. This is done by copying the cell displacements and velocities from one end of the model to the other end at the end of each time-step.

For the other boundaries in the x- and y-axes, the potential problem of spurious reflections from model boundaries is overcome by the use of an impedance matching technique. This effectively assigns to the cells which are required to be non-reflective on the boundaries of the model the properties of a massless viscous damper such that

$$\frac{\eta K''}{\omega} = -\left(\rho c + \frac{D(\xi_o - \xi_{-1})}{\rho \Delta x v_0}\Delta t\right)$$

where η is the loss factor (dimensionless), K'' is the imaginary part of a complex spring stiffness in which the real part is zero, ω the angular frequency, ρc the characteristic impedance of the medium, ξ_0 and ξ_{-1} are the displacements of cell points 0 and –1 where the boundary is at cell 0, ρ is the density of the cell contents and v_0 is the velocity of cell 0. Over 95% absorption is achieved across the spectrum.

C. INPUT DATA

The only input data required for the model are the masses of each cell, plus the shear modulus and the compression modulus, and the loss factor. Otherwise, all secondary parameters such as wave speeds, impedances etc. are automatically generated by the finite difference algorithm. The only other input relates to methods of approximating actual structure shapes using the orthogonal grid.

The output of the model consists of a file containing the displacement and/or velocity of one or more selected cells.

The time steps used are of the order of 30 to 60 microseconds, and the model is run for either 16384 or 32768 steps to give a signal length of just under 1 second.

The resulting discrete time series can then be subjected to discrete fourier transformation to yield frequency spectra.

Note that, whereas in the acoustical analogy, the impedance of air varies little (except close to sources such as points), so that in most cases power is proportional to velocity squared, in elastic media, velocity transfer functions do not directly convey information about power transmission, and velocity at the receiver, in a low impedance medium, can be higher than velocity near the source, in a high impedance medium, even when there are power losses between the source and the receiver.

D. VALIDATION

The finite difference algorithm is validated by creating models of structures for which algebraic solutions are available and comparing the eigenfrequencies and decay rates. For Timoshenko beams, plates, thin and thick cylinders the eigenfrequencies are correctly predicted.

APPENDIX II

Class 66 Locomotive Parameters

Mass of No 1 bogie	25130 kg
Mass of No 2 bogie	25040 kg
Mass of traction motor	2722 kg
– axle hung with nose suspended off frame	
Mass of axle, gear and wheel assembly	2600 kg

Engine rpm:

Notch	rpm
1	272
2	343
3	490
4	568
5	651
6	756
7	820
8	902

Gear ratio 81:20 (81 teeth on bull wheel; 20 teeth on pinion)

Primary suspension:

Two coil springs each axle box, 35mm diameter Dw; 175mm dia Dm; 9 active coils (Na)

Stiffness, k=G Dw4/ Dm3Na

Assume shear modulus of spring steel G=78 GPa k= 2.43 MN/m

Assume zero damping for coil springs

Secondary suspension:

Four laminated rubber bearings per bogie – four 40mm thick rubber elements 335-395mm diameter between 5 laminae 395mm diameter 7mm thick.

Stiffness, k=5AGS2/Nt where N is the number of elements; A is effective plan area, S is shape factor = A/1.8tl where t is thickness and l is perimeter.

Assume shear modulus 0.5 MPa k= 3.6 MN/m

Assume damping 15% of critical damping for natural rubber

APPENDIX III

JNA wagon Parameters

O2-UK 4G 11:41 51%
greenbrier-europe.com

Measurements

Axle load	25.4 t / axle
Track gauge	1,435 mm
Loading gauge	W6a
Brake regime	UK
Brake type	GP (K)
Max. speed at 90,0 t	100 km/h (60 mph)
Max. speed at (unloaded)	120 km/h (75 mph)
Climate condition	T1
Rmin (coupled in train)	70.0 m
Length over buffers	13,970 mm
Tare weight	23.7 t
Payload	~ 77.9 t
Loading opening	2,470 x 12,758 mm
Internal height	1,890 mm
Material of box	Standard steel
Bogie type	LN25 (Axiom Rail)
Wheel diameter	840 mm
Bogie wheel base	2,000 mm

JNA 60 m³ | 4-axle open box wagon

24675	Vehicle_mass_per_wheel
4000000	Vehicle_secondary_suspension_stiffness
20000	Secondary_suspension_damping
2000	Sprung_mass_of_bogie_per_wheel
2e6	Stiffness_of_primary_suspension
10000	Primary_suspension_damping
1000	Unsprung_mass_per_wheel

APPENDIX IV

Results from noise and vibration survey Leiston Branch - Figures

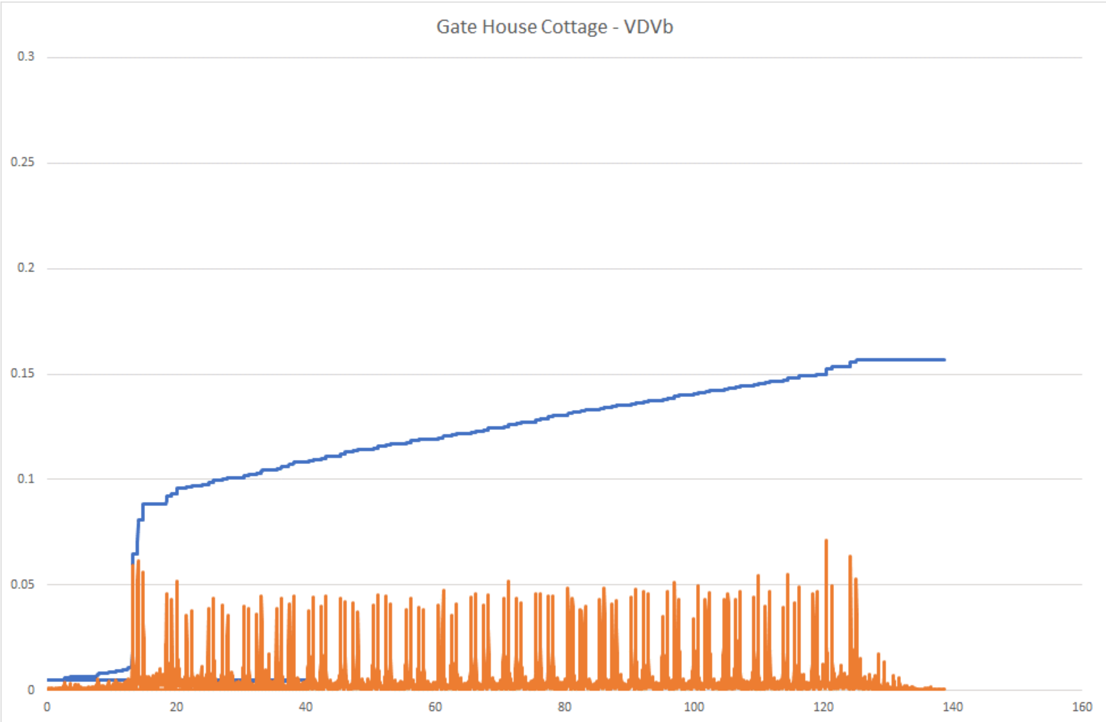


Figure 9 Measurement results at Gate House Cottage westbound - VDV_b <10 mph Class 66 leading

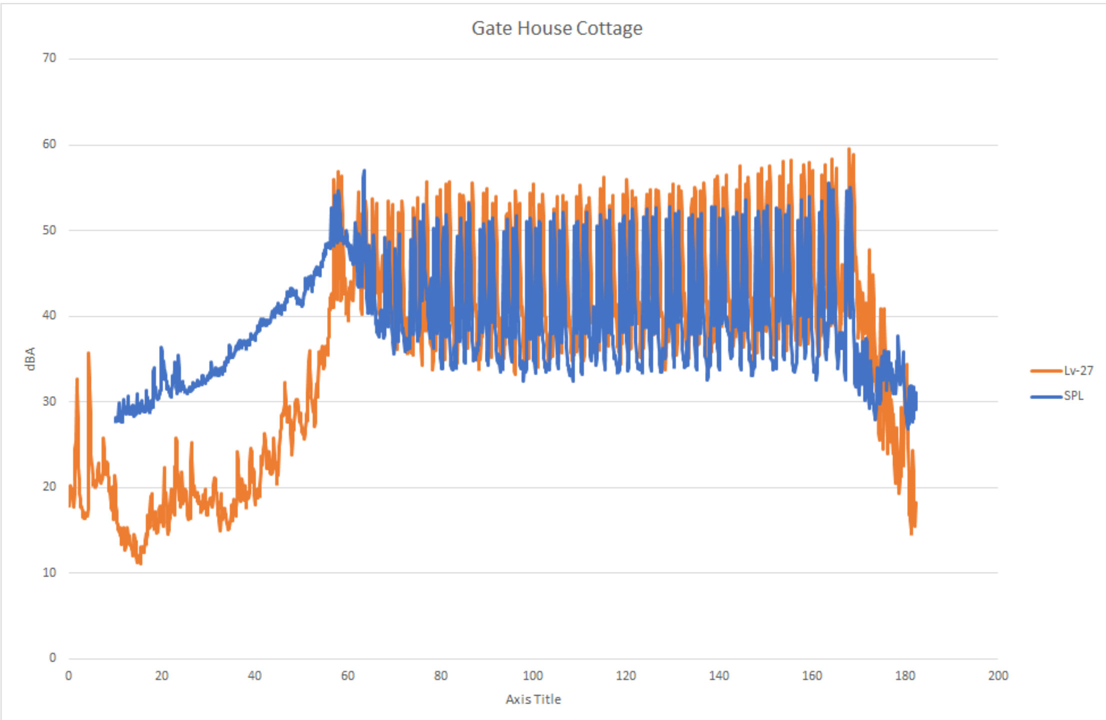


Figure 10 Measurement results at Gate House Cottage westbound – L_{Afmax} and Pseudo Noise Level <10 mph Class 66 leading

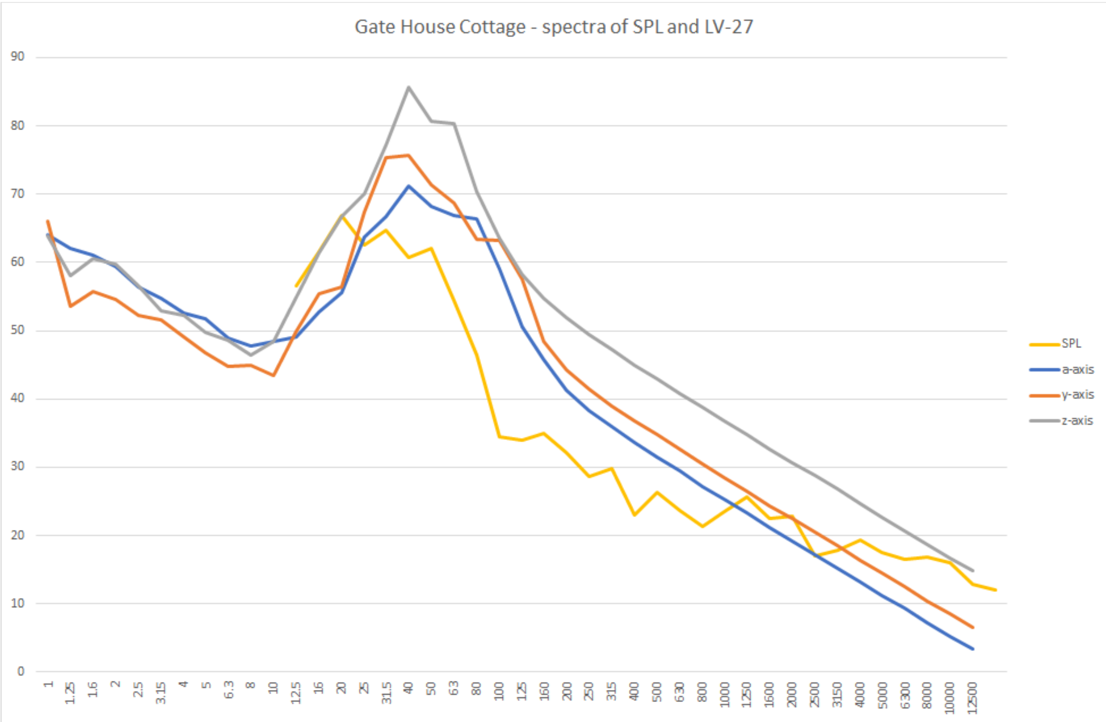


Figure 11 Measurement results at Gate House Cottage westbound – example spectra <10 mph Class 66 leading

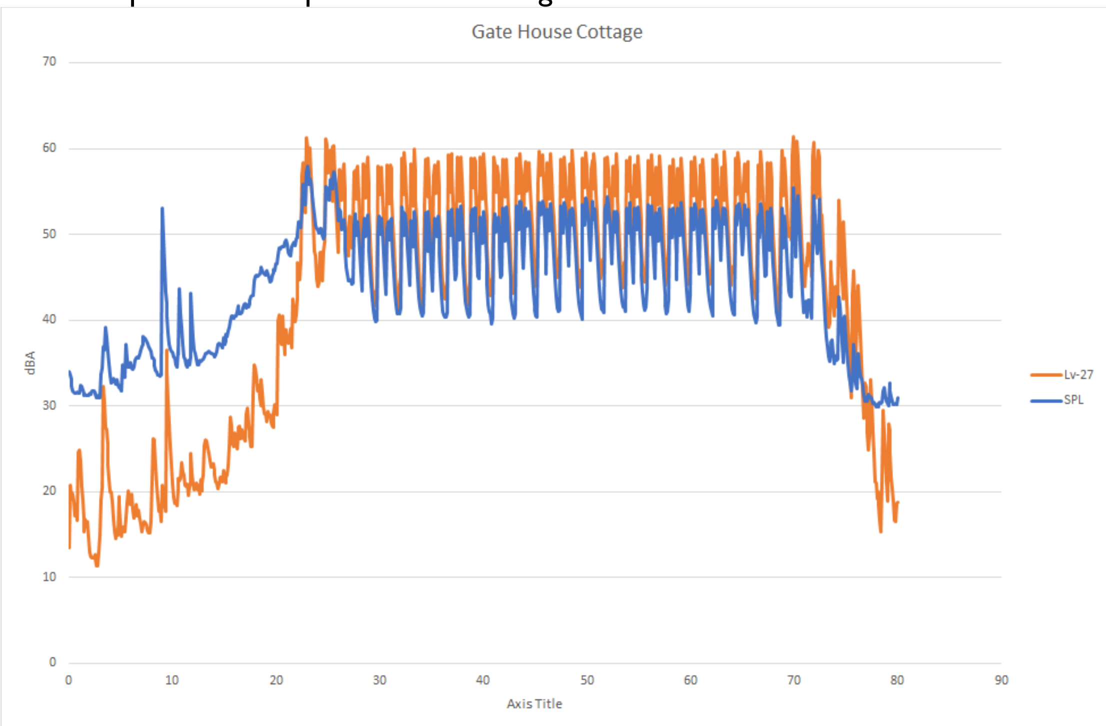


Figure 12 Measurement results at Gate House Cottage westbound – L_{Afmax} and Pseudo Noise 15 mph Class 66 leading

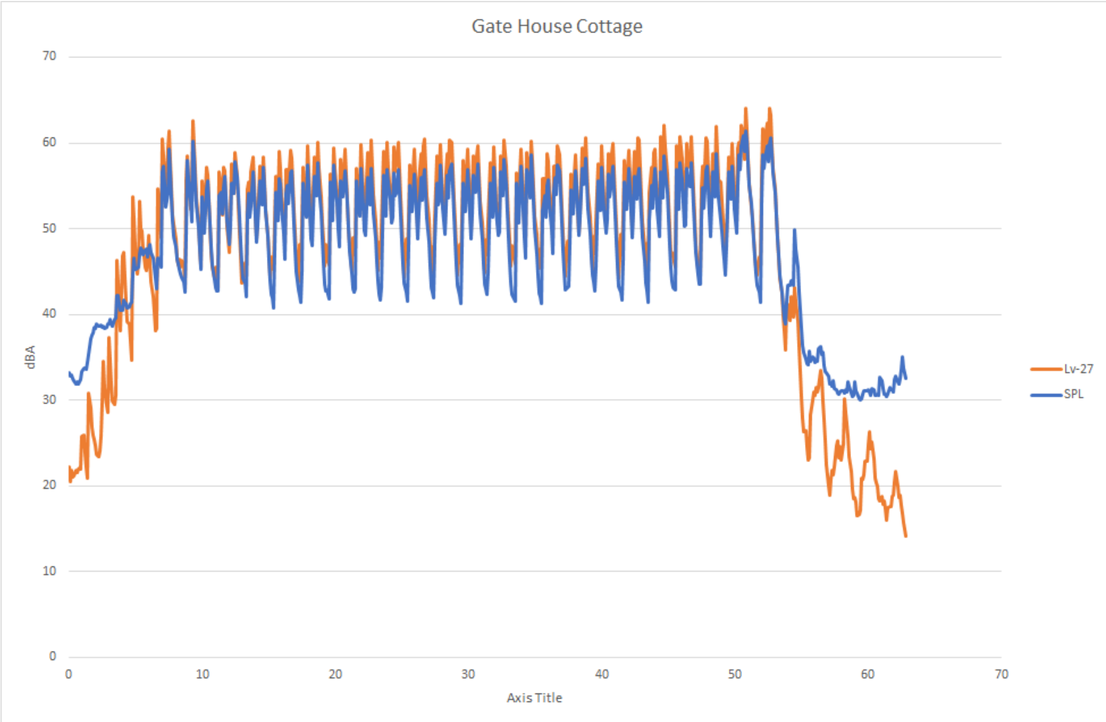


Figure 13 Measurement results at Gate House Cottage eastbound – L_{Afmax} and pseudo noise15 mph Class 68 leading

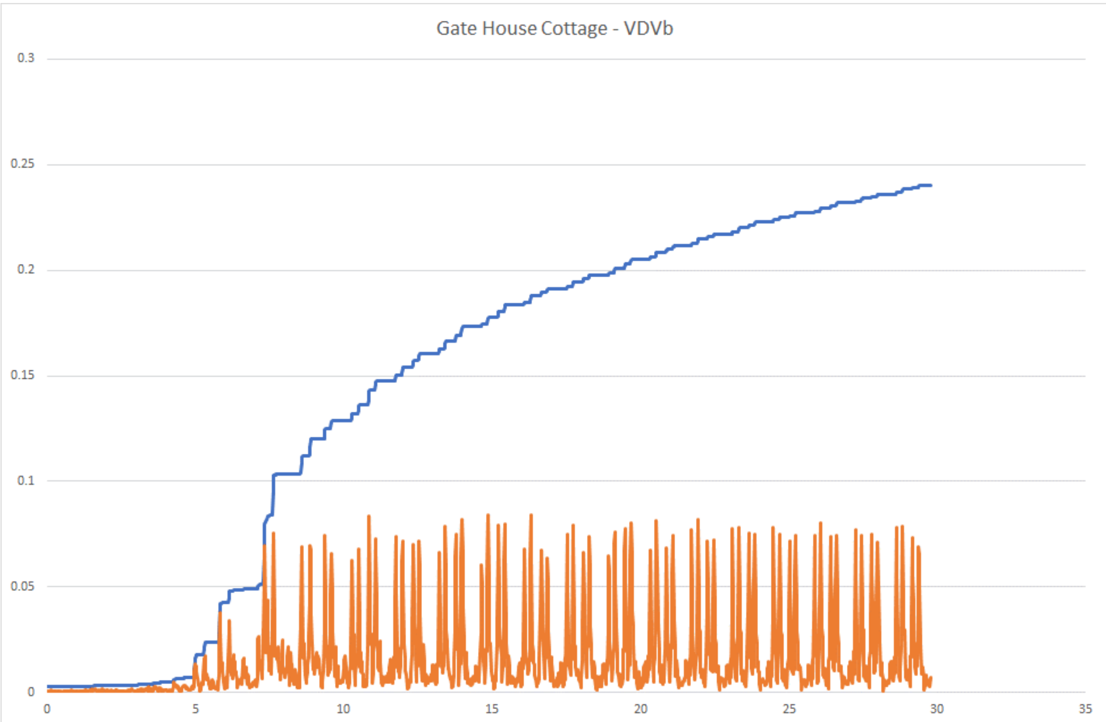


Figure 14 Measurement results at Gate House Cottage eastbound - VDV_b 20 mph Class 68 leading

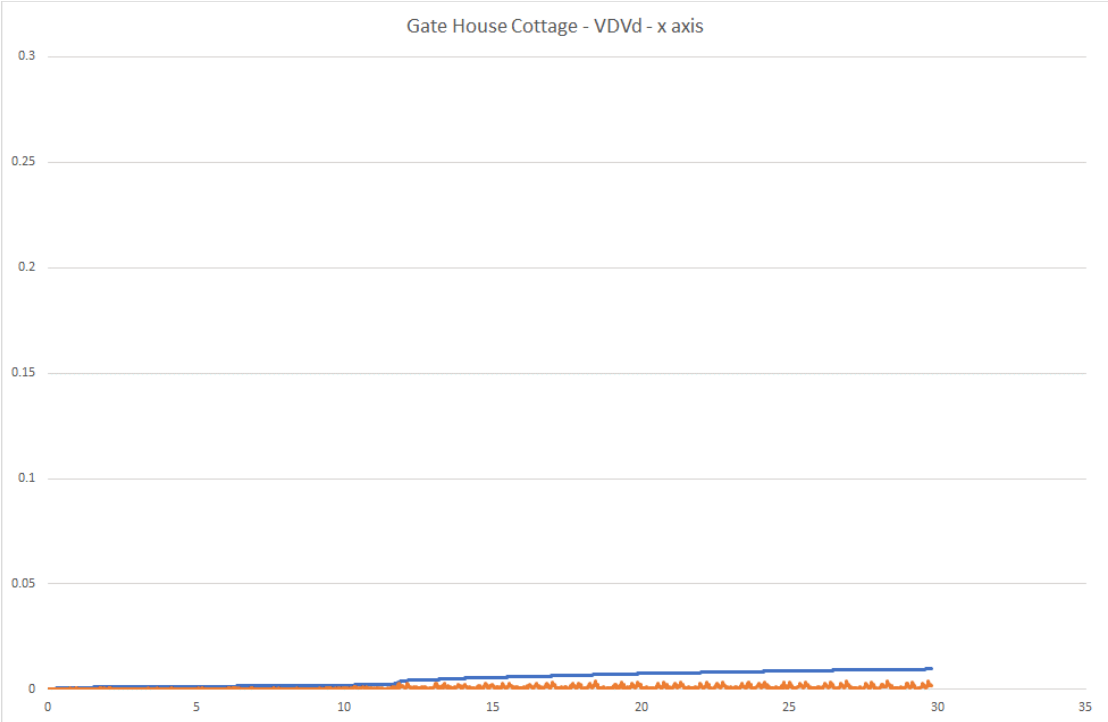


Figure 15 Measurement results at Gate House Cottage eastbound - VDV_d – x-axis 20 mph Class 68 leading

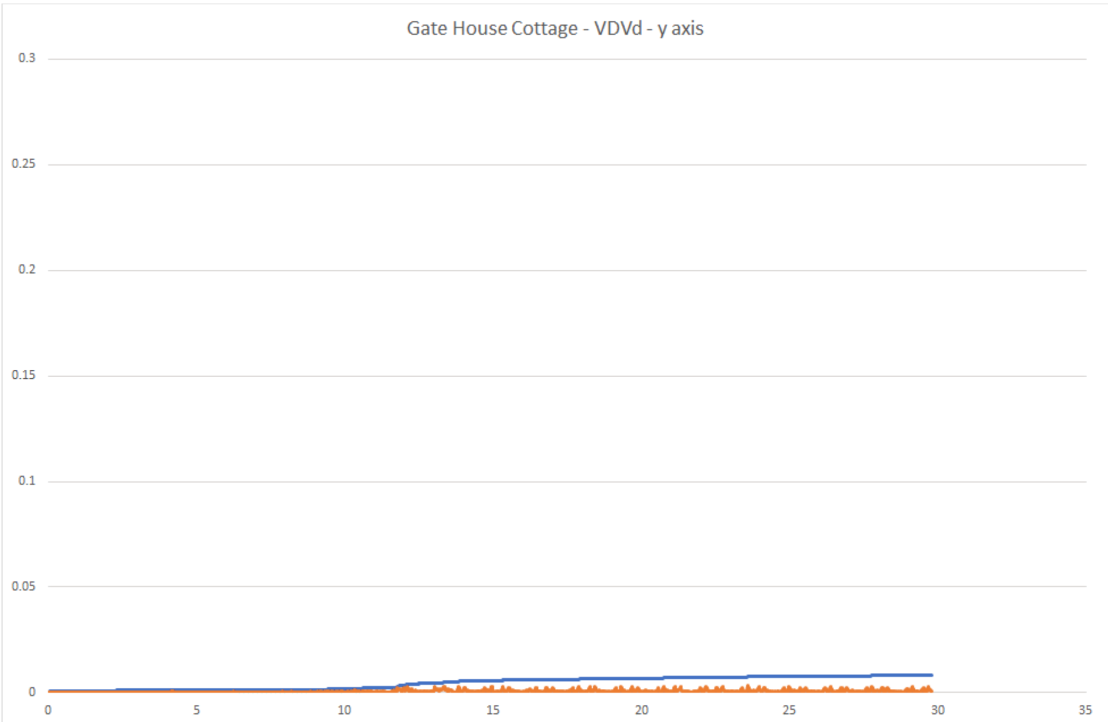


Figure 16 Measurement results at Gate House Cottage eastbound - VDV_d – y-axis 20 mph Class 68 leading

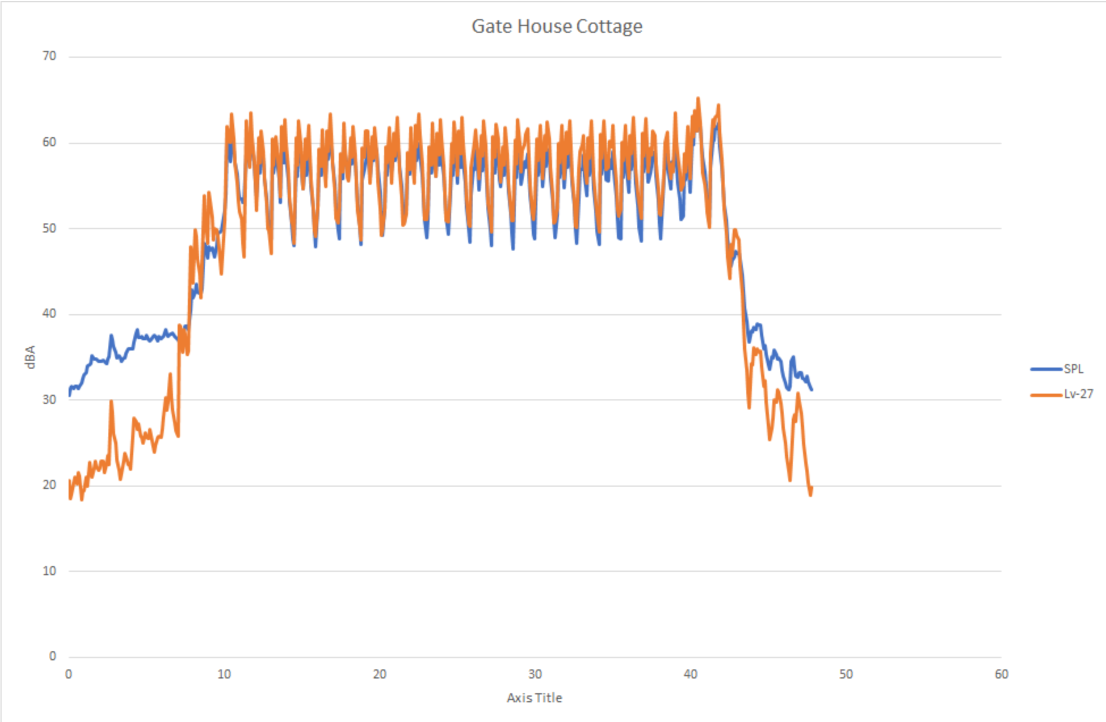


Figure 17 Measurement results at Gate House Cottage eastbound – SPL and Pseudo Noise 20 mph Class 68 leading

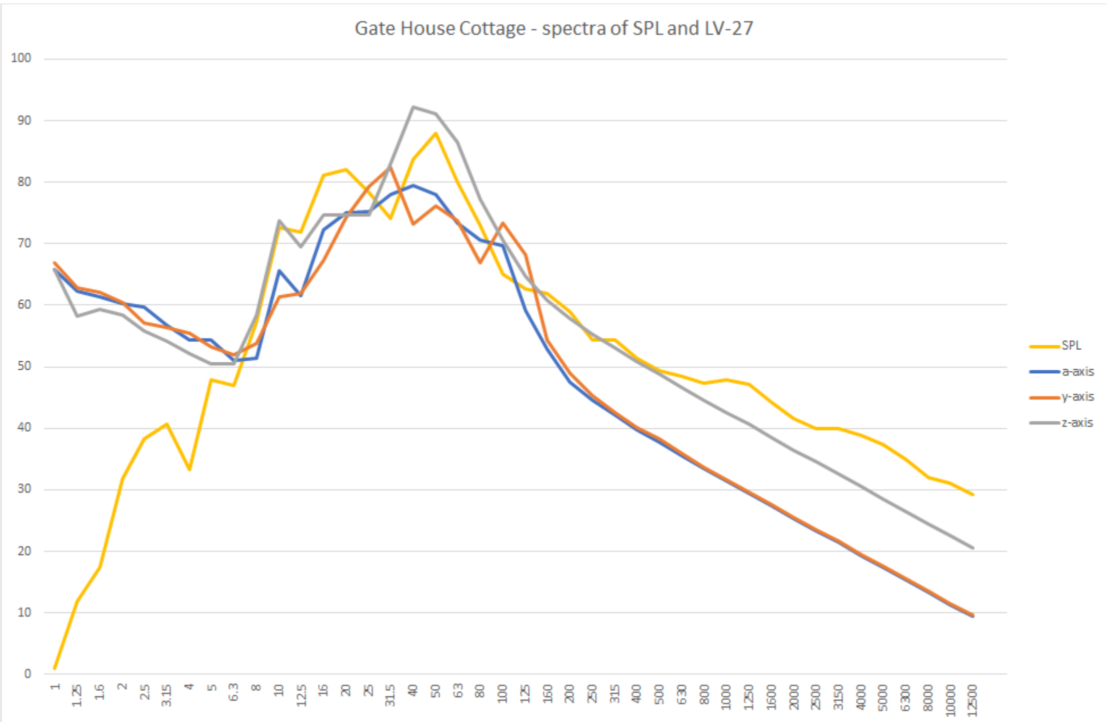


Figure 18 Measurement results at Gate House Cottage eastbound Spectra 20 mph Class 68 leading

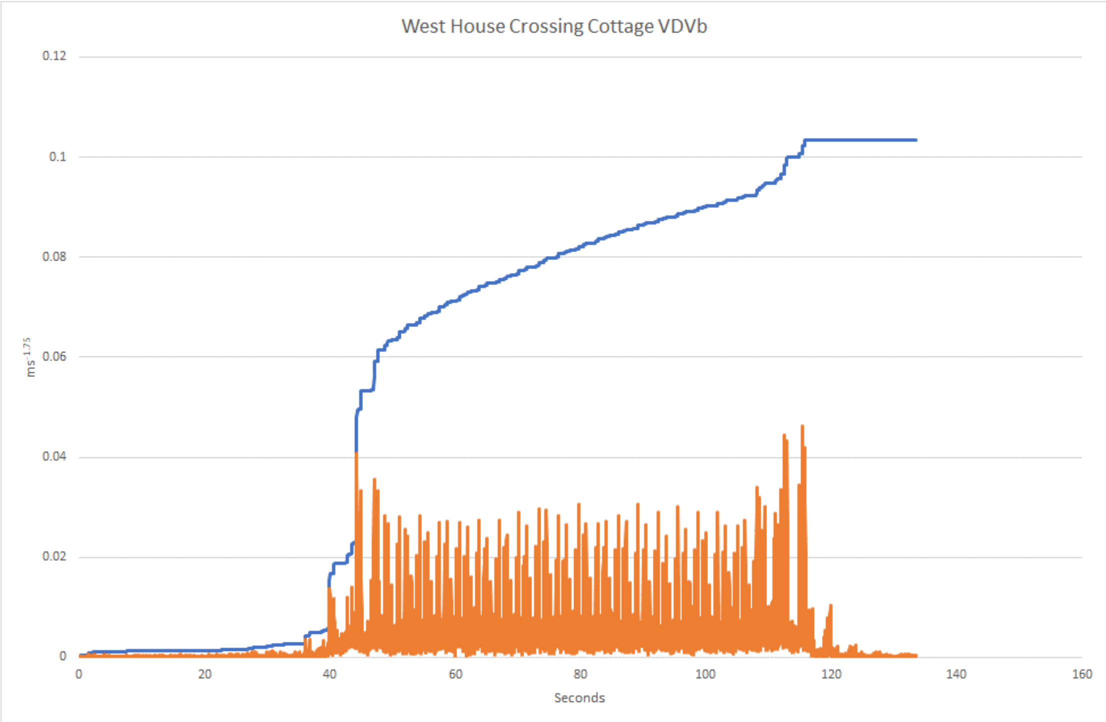


Figure 19 Measurement results at West House Crossing eastbound - VDV_b 10 mph Class 68 leading

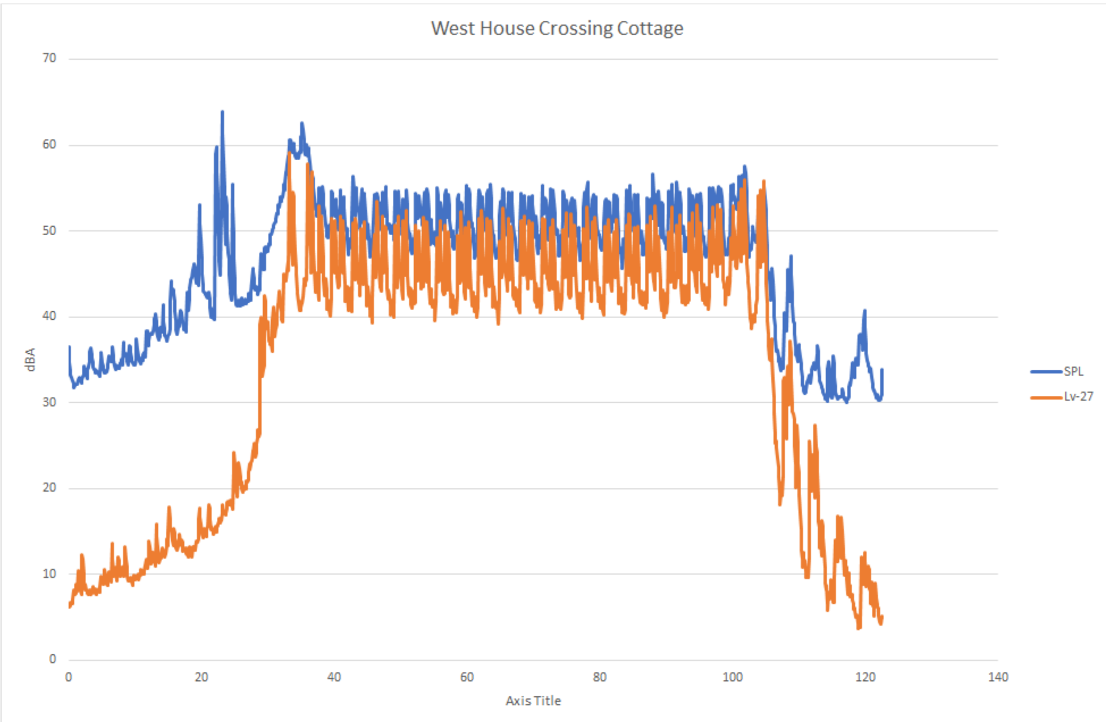


Figure 20 Measurement results at West House Crossing Cottage eastbound – L_{Afmax} and Pseudo Noise 10 mph Class 68 leading

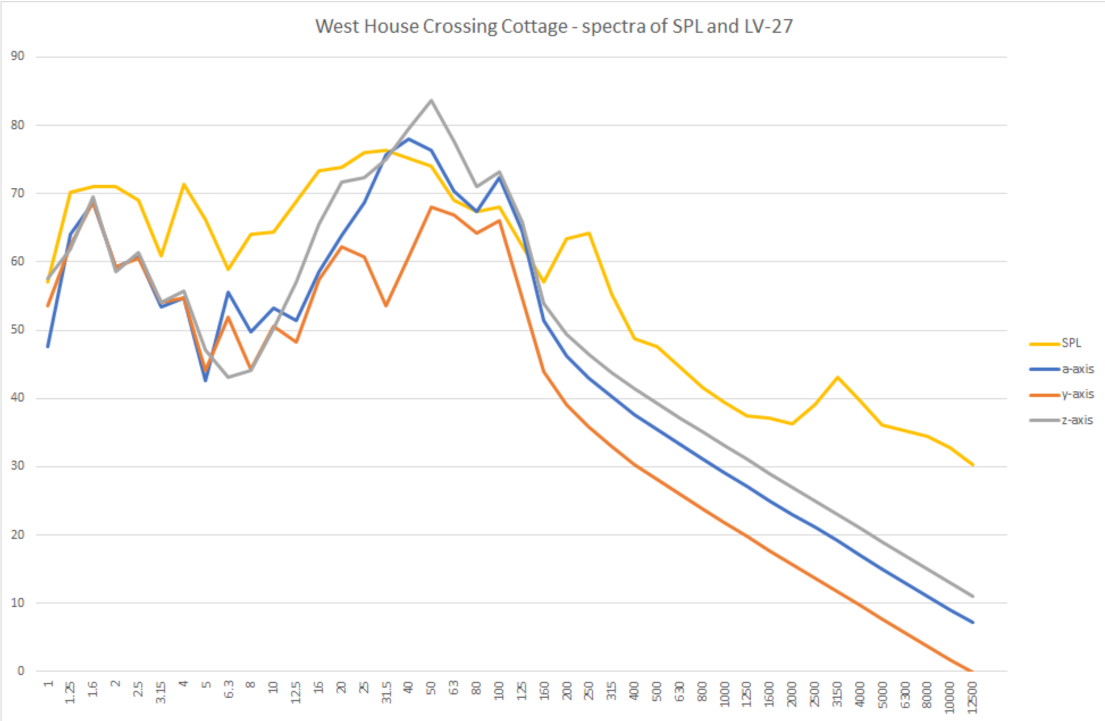


Figure 21 Measurement results at West House Crossing Cottage eastbound Spectra 10 mph Class 68 leading

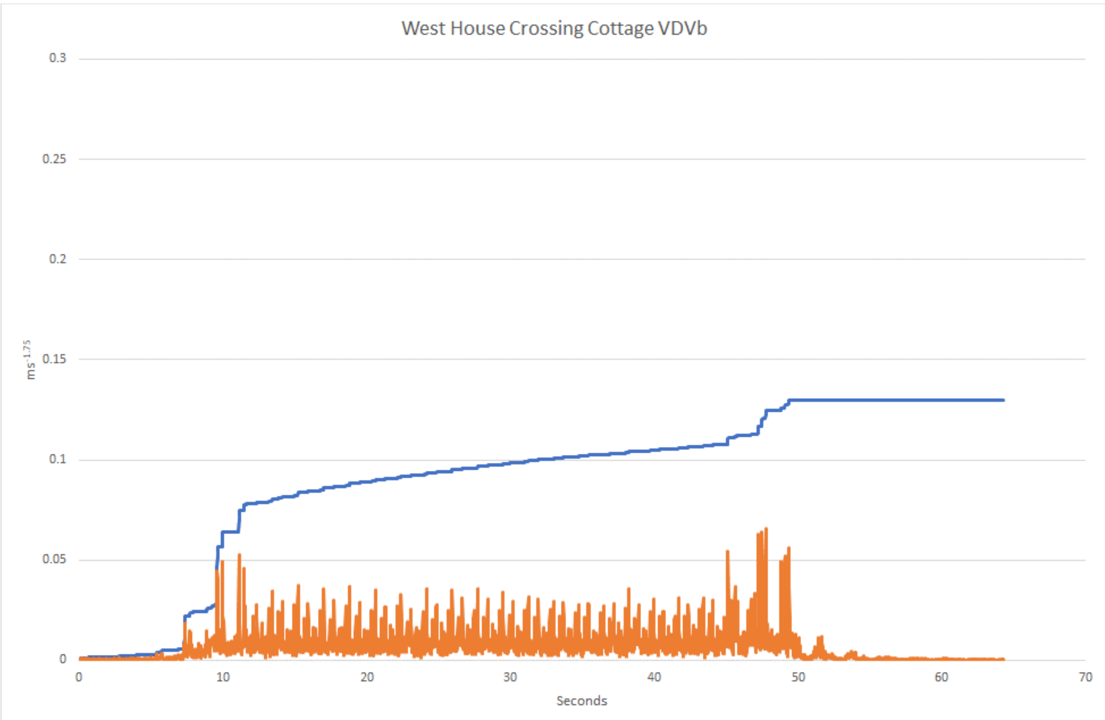


Figure 22 Measurement results at West House Crossing eastbound - VDV_b 20 mph Class 68 leading

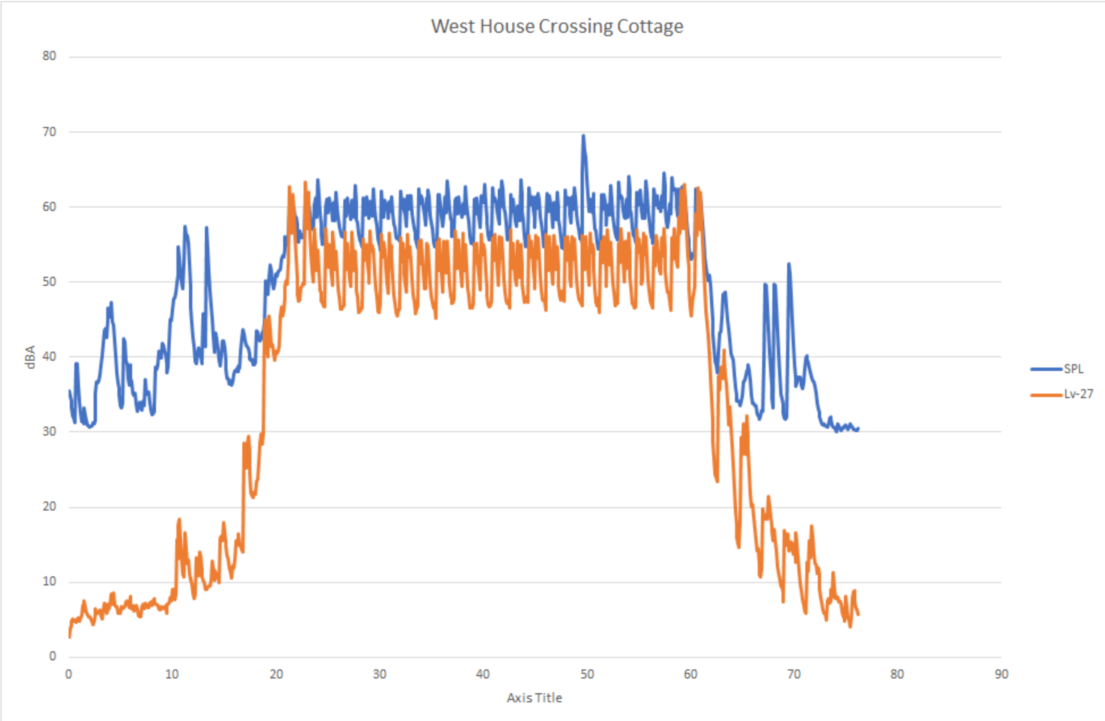


Figure 23 Measurement results at West House Crossing Cottage eastbound – L_{Afmax} and Pseudo Noise 20 mph Class 68 leading

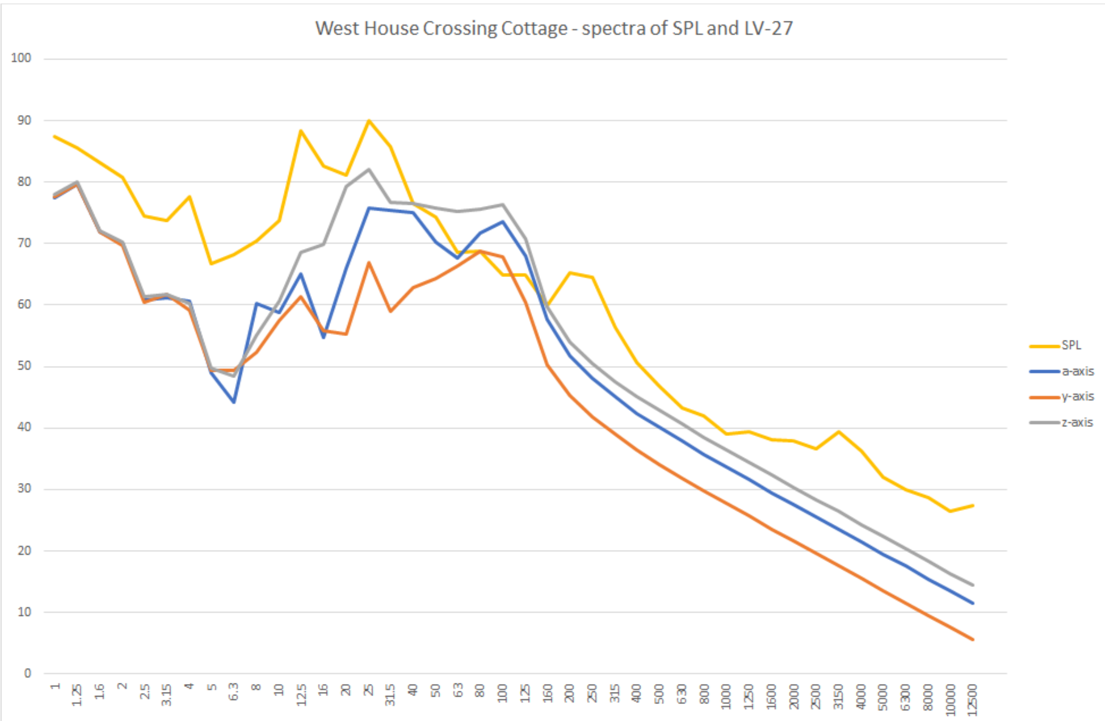


Figure 24 Measurement results at West House Crossing Cottage eastbound Spectra 10 mph Class 68 leading

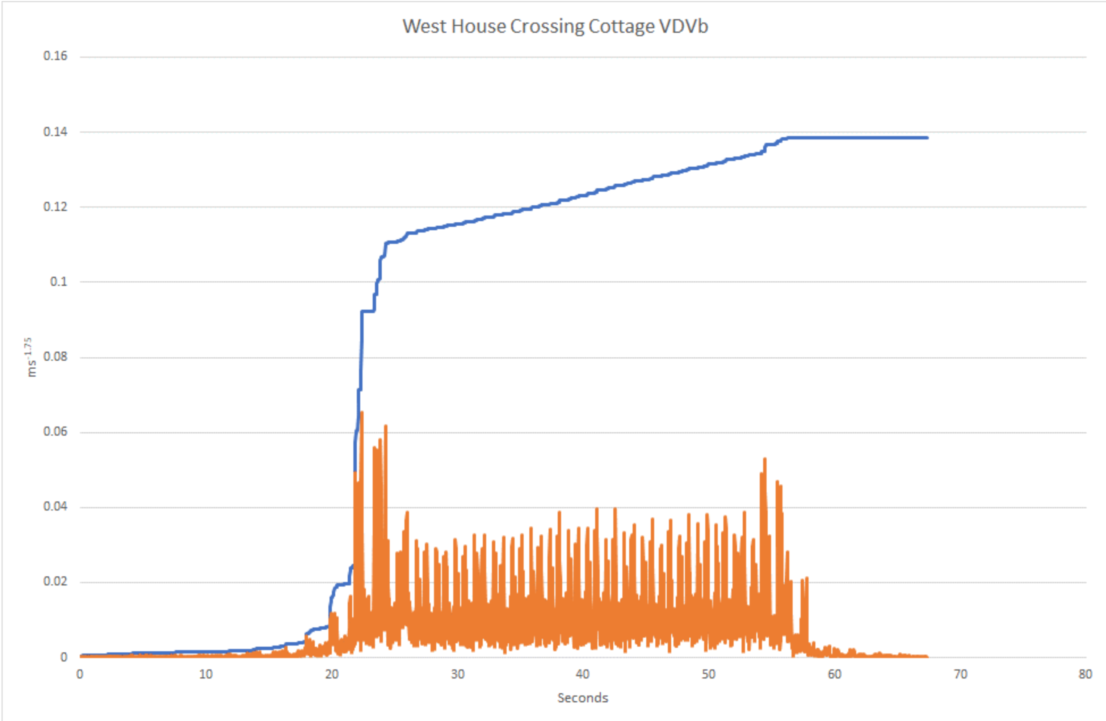


Figure 25 Measurement results at West House Crossing westbound - VDV_b 20 mph Class 66 leading

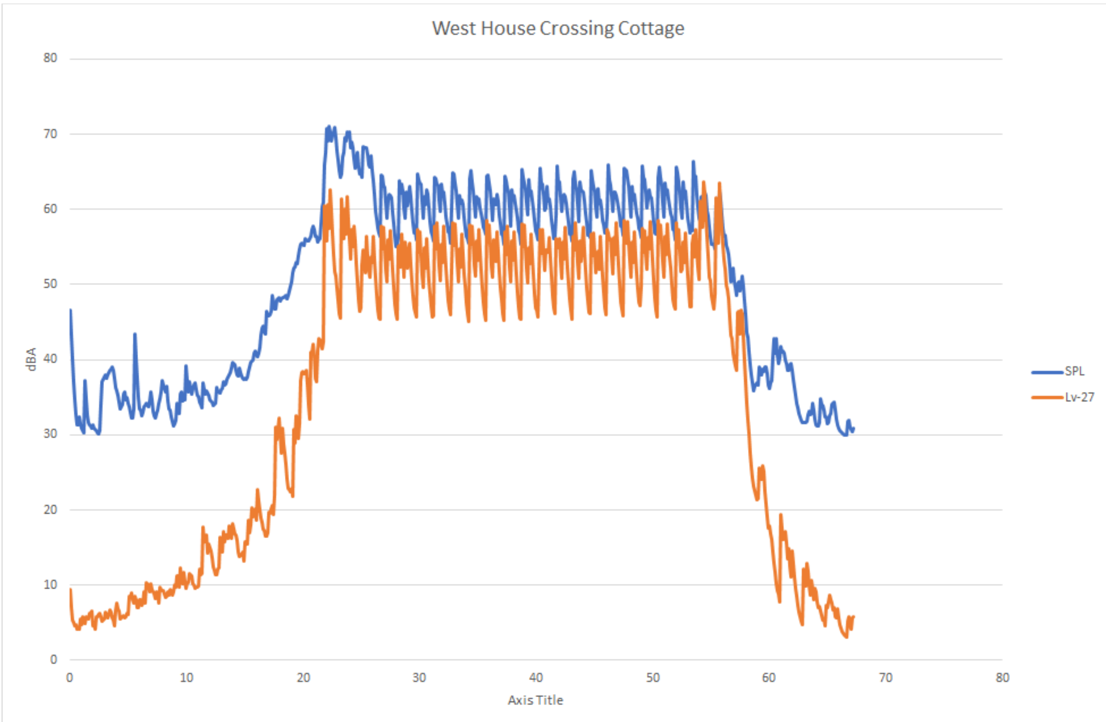


Figure 26 Measurement results at West House Crossing Cottage westbound – L_{Afmax} and Pseudo Noise 20 mph Class 66 leading

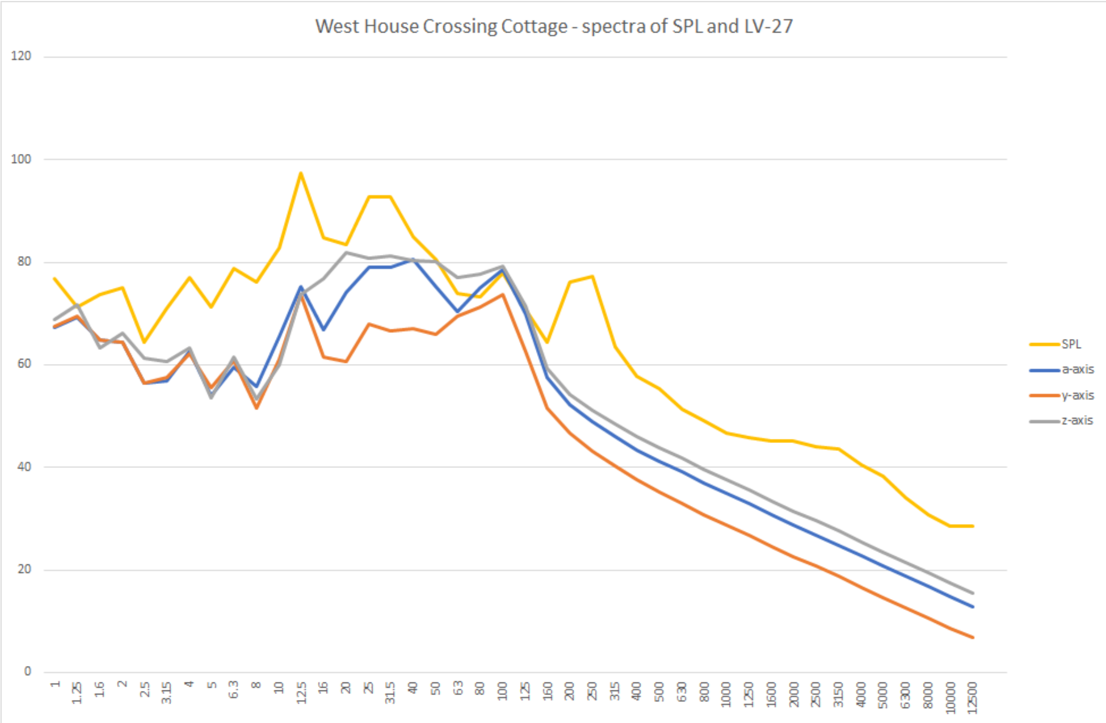


Figure 27 Measurement results at West House Crossing Cottage westbound Spectra 10 mph Class 66 leading

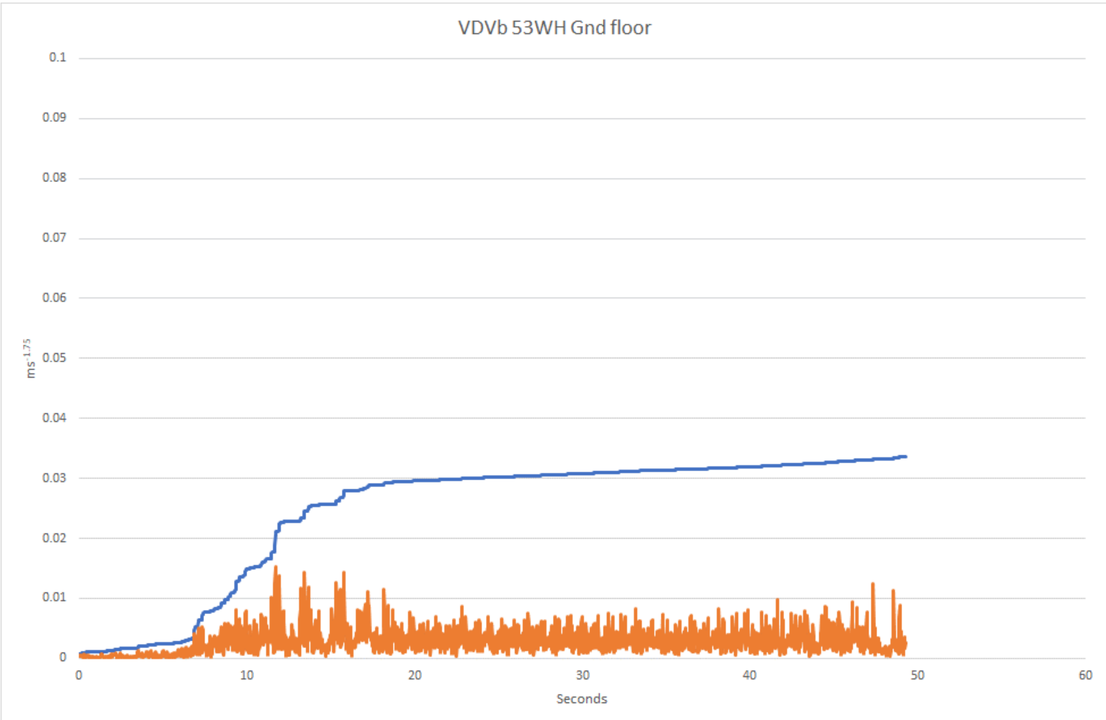


Figure 28 Measurement results at 53 Westward Ho Ground Floor westbound - VDV_b 20 mph Class 66 leading

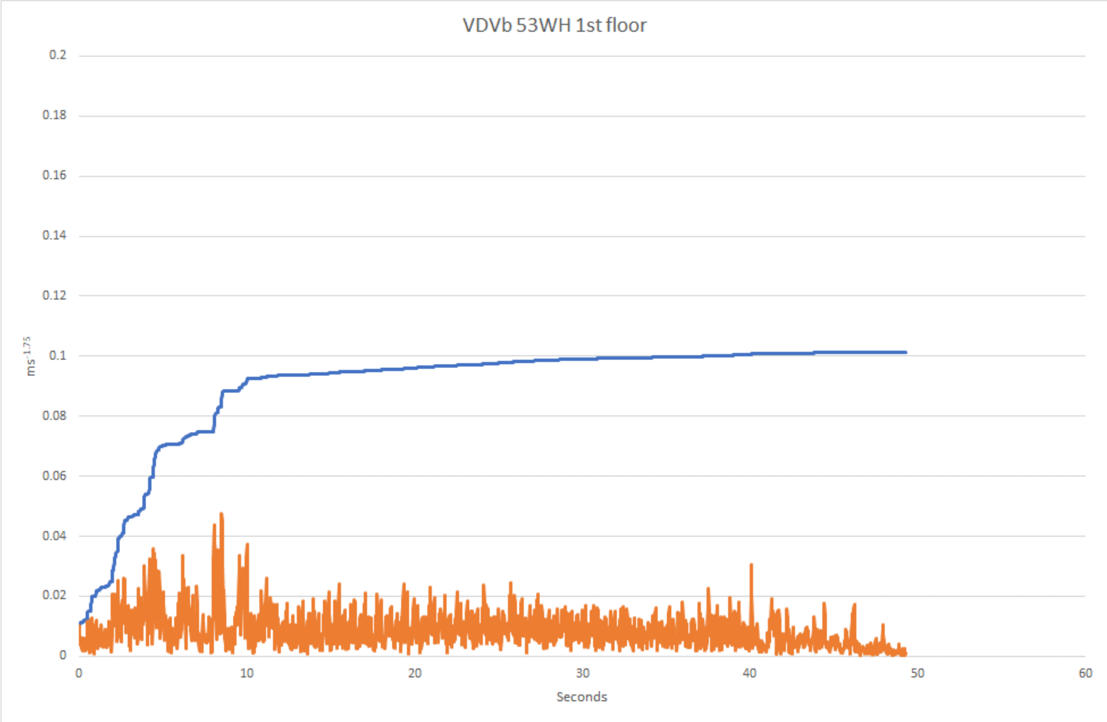


Figure 29 Measurement results at 53 Westward Ho First Floor westbound - VDV_b 20 mph Class 66 leading

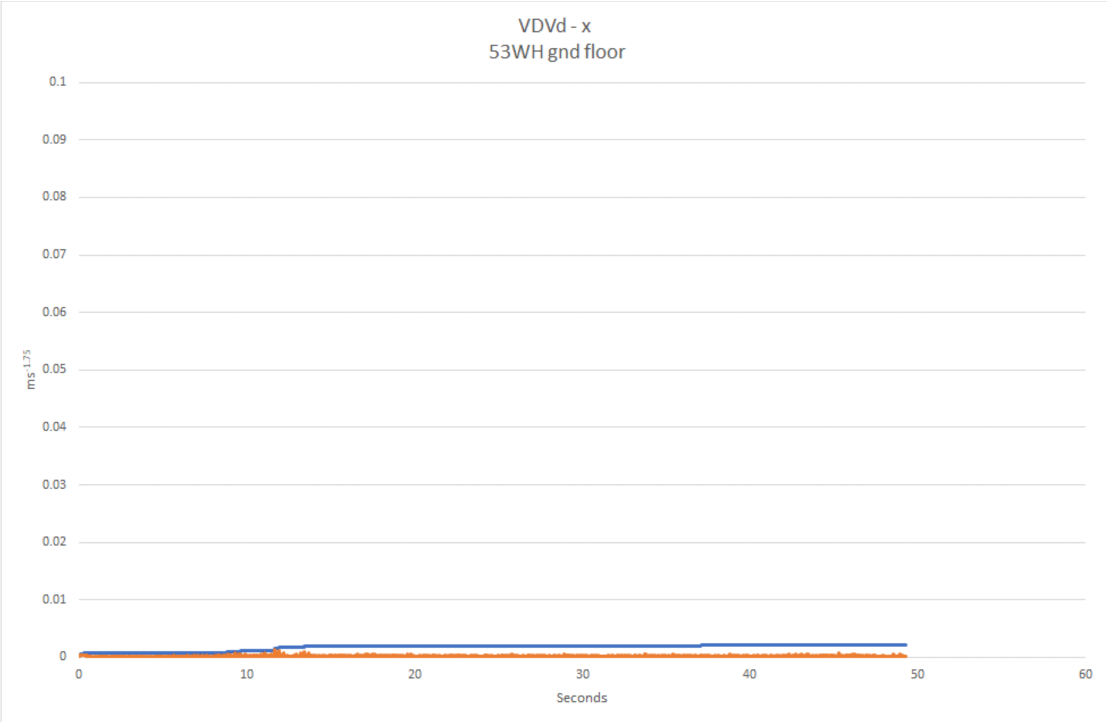


Figure 30 Measurement results at 53 Westward Ho Ground Floor westbound - VDV_d x-axis 20 mph Class 66 leading

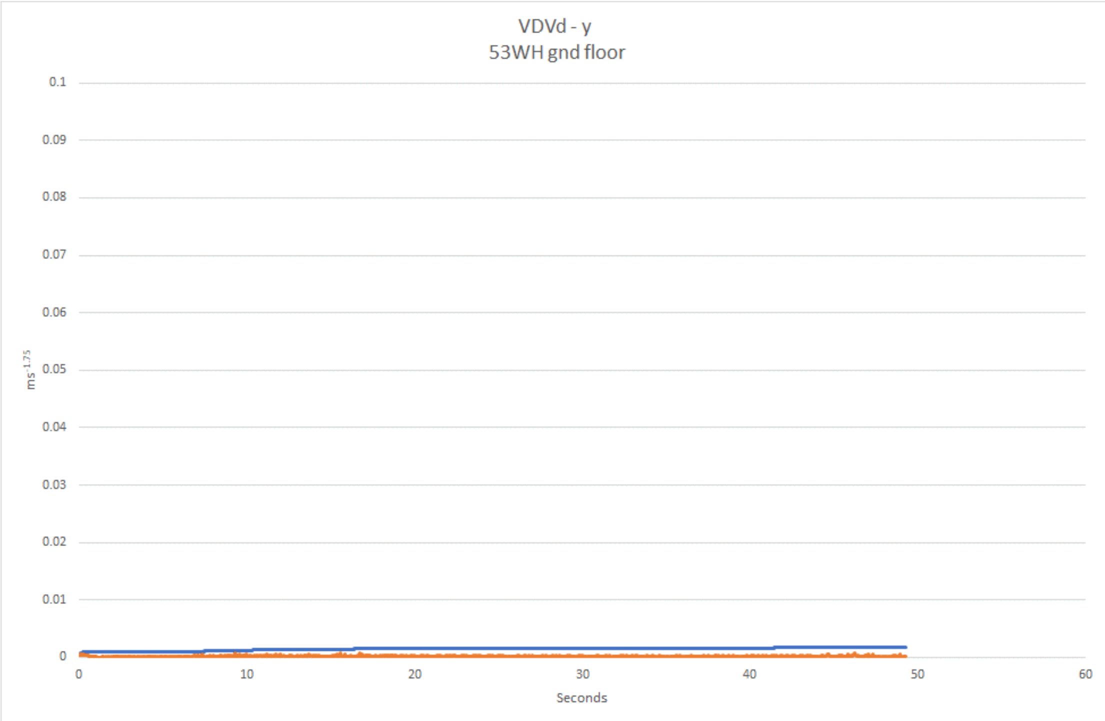


Figure 31 Measurement results at 53 Westward Ho Ground Floor westbound - VDV_b y-axis 20 mph Class 66 leading

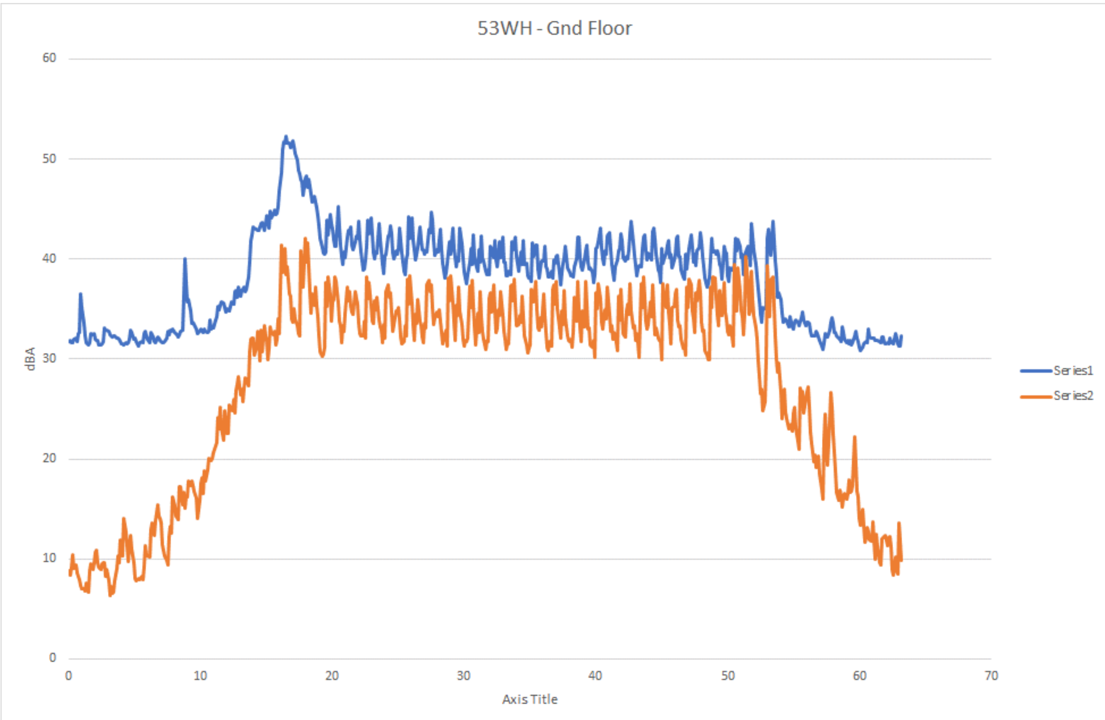


Figure 32 Measurement results at 53 Westward Ho Ground Floor westbound – L_{Afmax} and Pseudo Noise 20 mph Class 66 leading

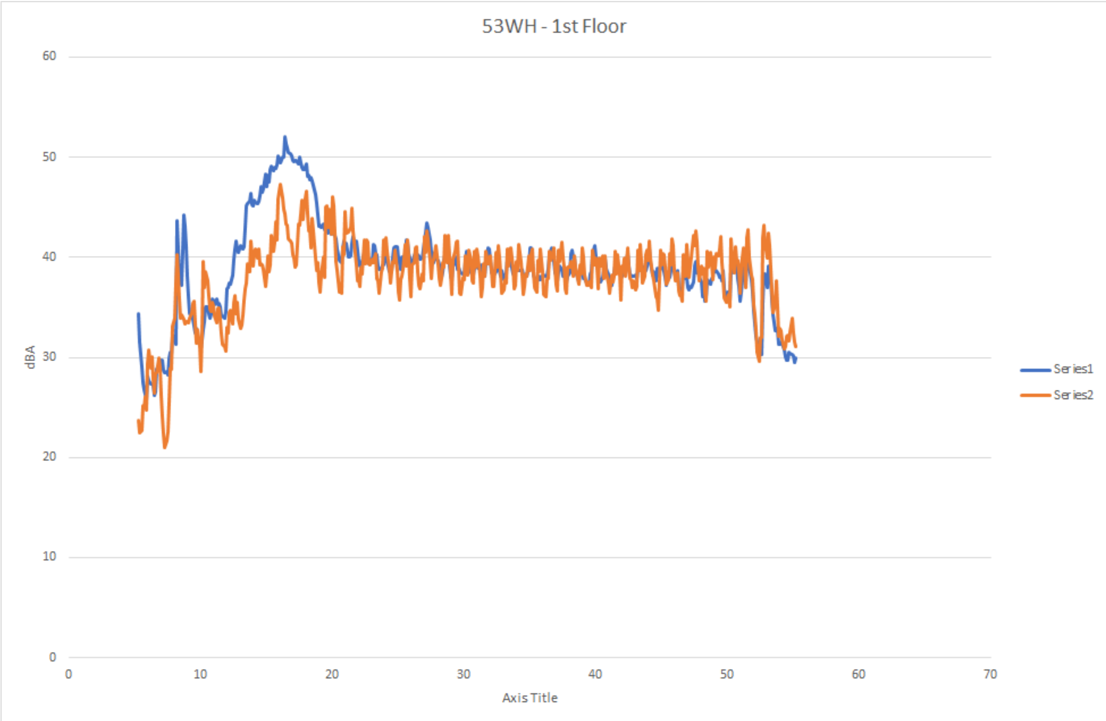


Figure 33 Measurement results at 53 Westward Ho First Floor westbound – L_{Afmax} and Pseudo Noise 20 mph Class 66 leading

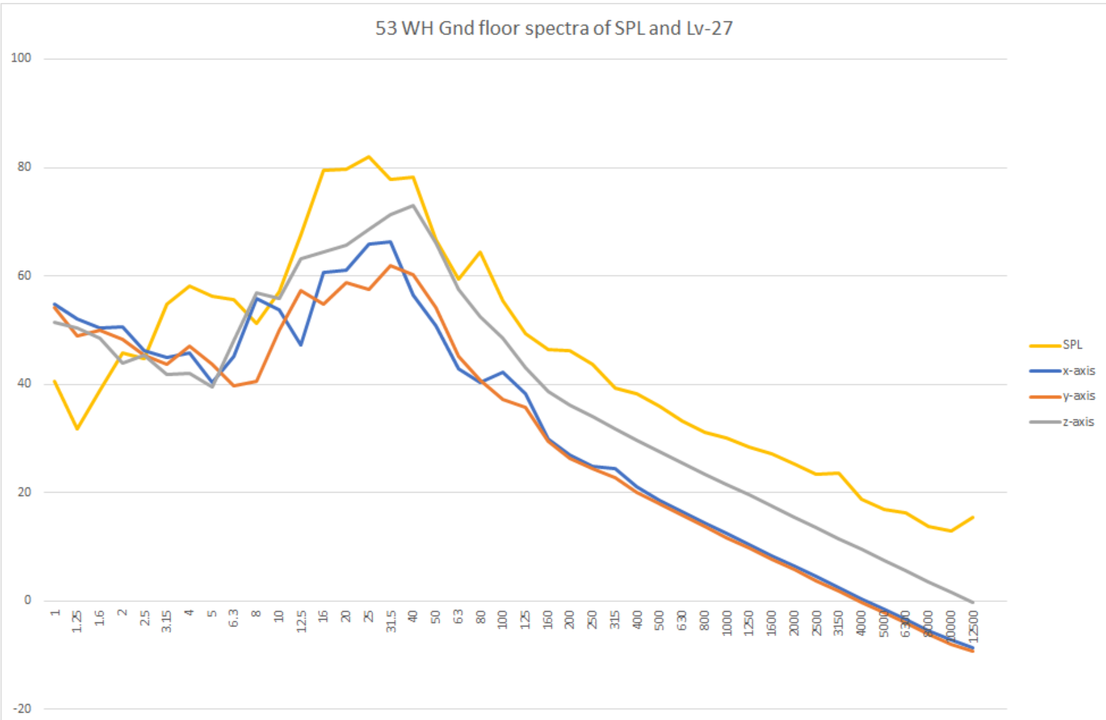


Figure 34 Measurement results at 53 Westward Ho westbound Spectra 20 mph Class 66 leading

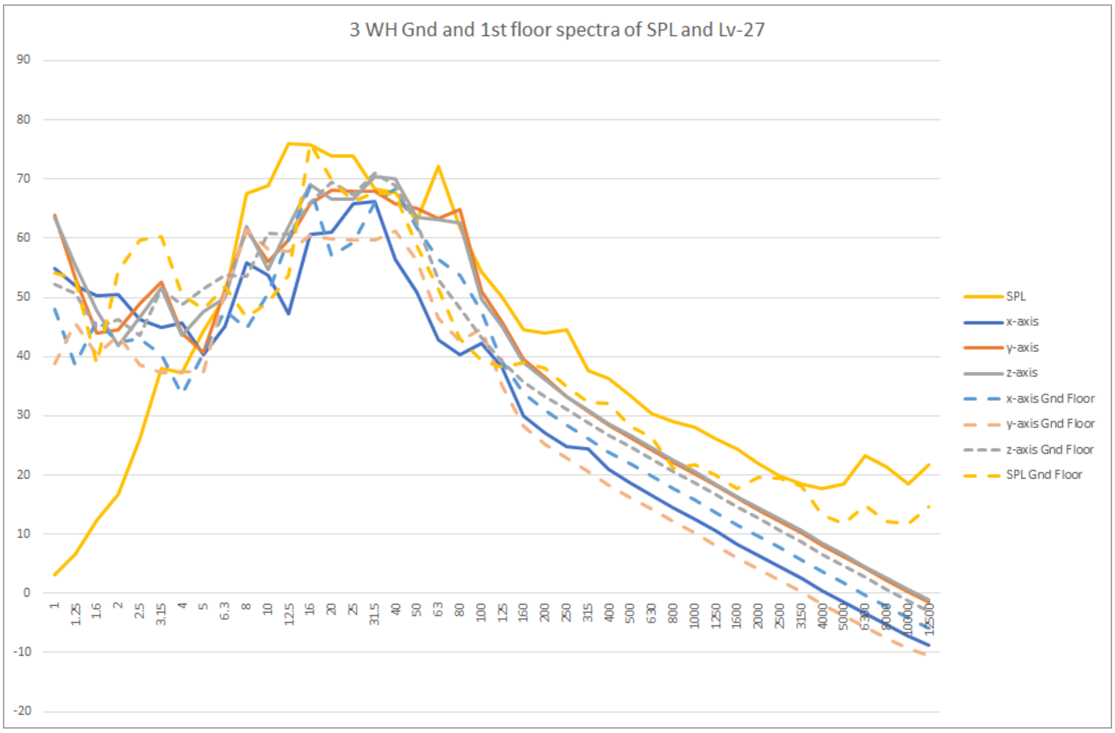


Figure 35 Measurement results at 53 Westward Ho westbound Spectra 20 mph Class 66 leading

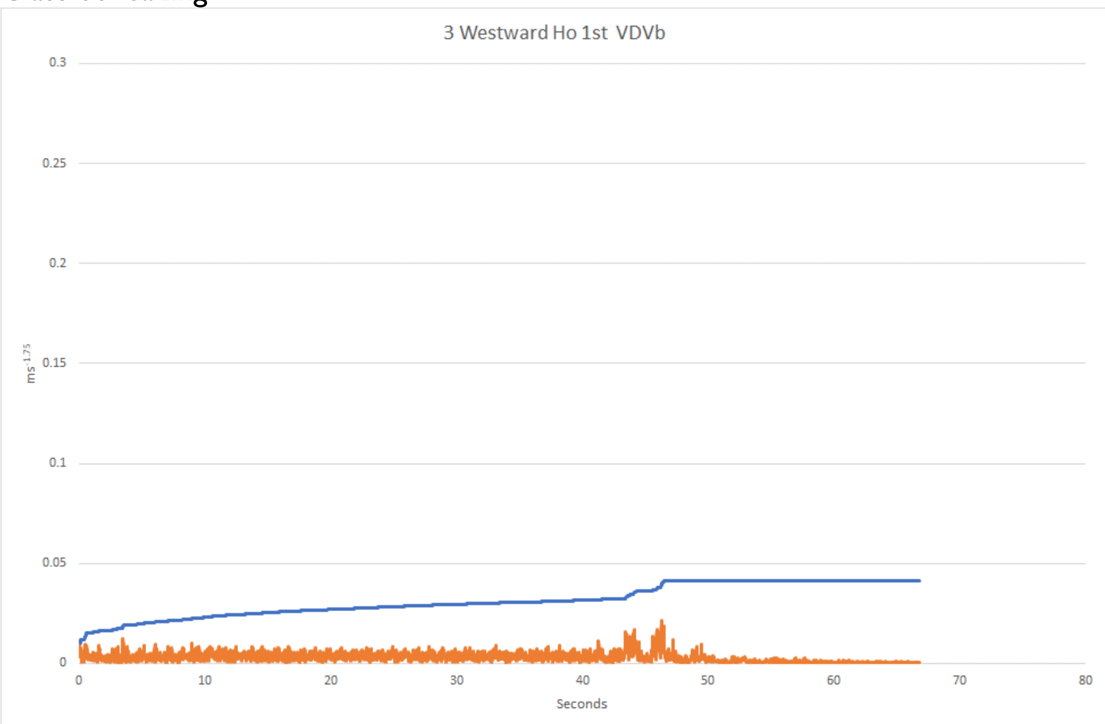


Figure 36 Measurement results at 3 Westward Ho First Floor eastbound - VDV_b 10 mph Class 68 leading

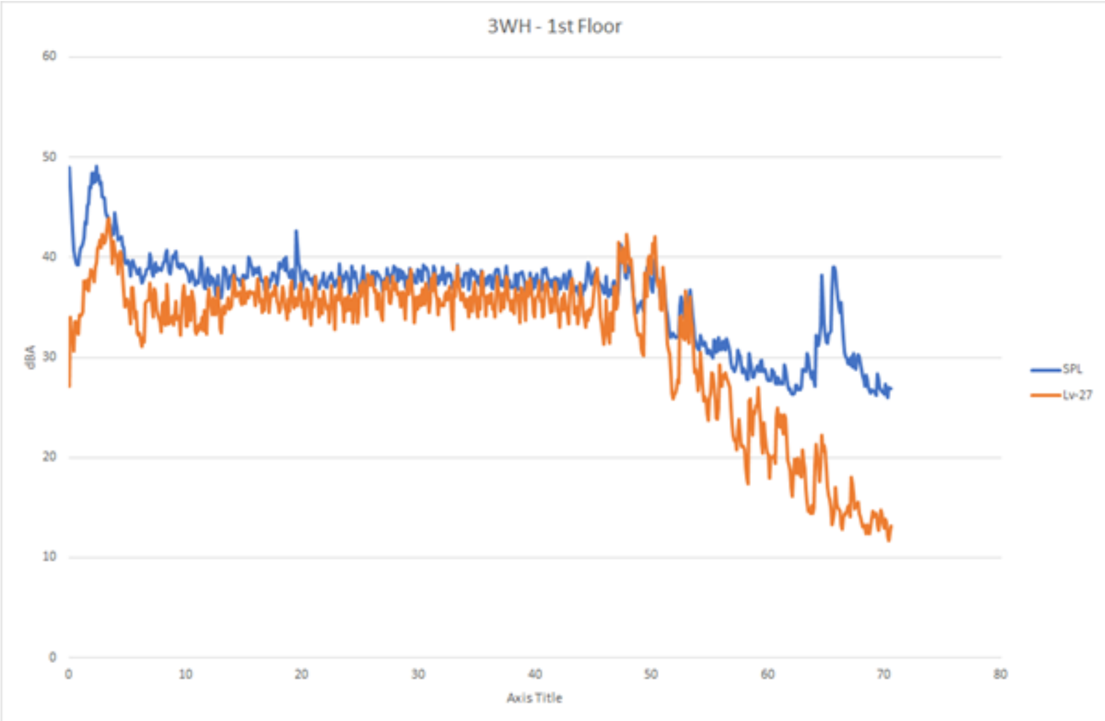


Figure 37 Measurement results at 3 Westward Ho First Floor eastbound – L_{Afmax} and Pseudo Noise 10 mph Class 68 leading

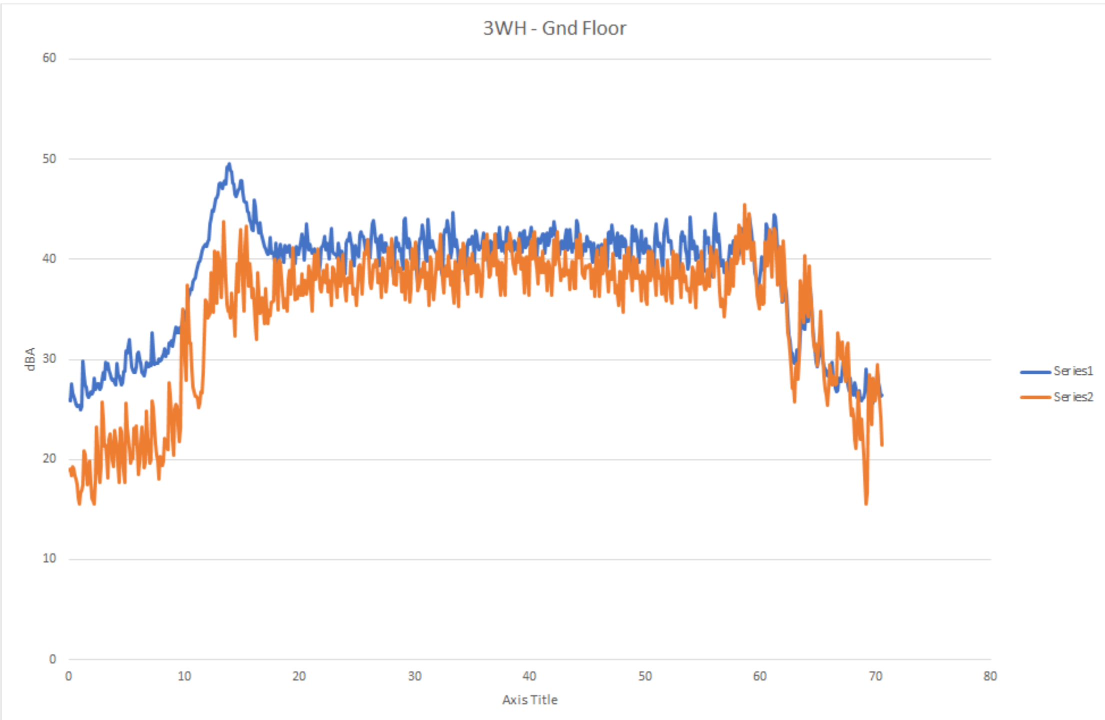


Figure 38 Measurement results at 3 Westward Ho Ground Floor eastbound – L_{Afmax} and Pseudo Noise 10 mph Class 68 leading

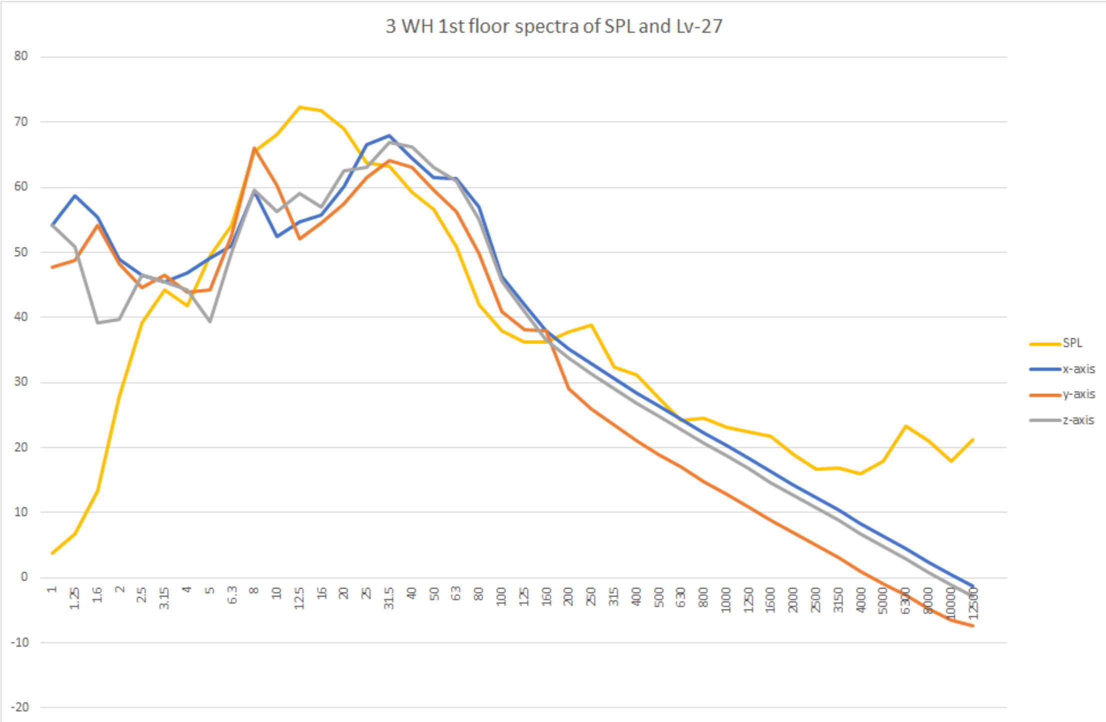


Figure 39 Measurement results at 3 Westward Ho First Floor eastbound Spectra 10 mph Class 68 leading

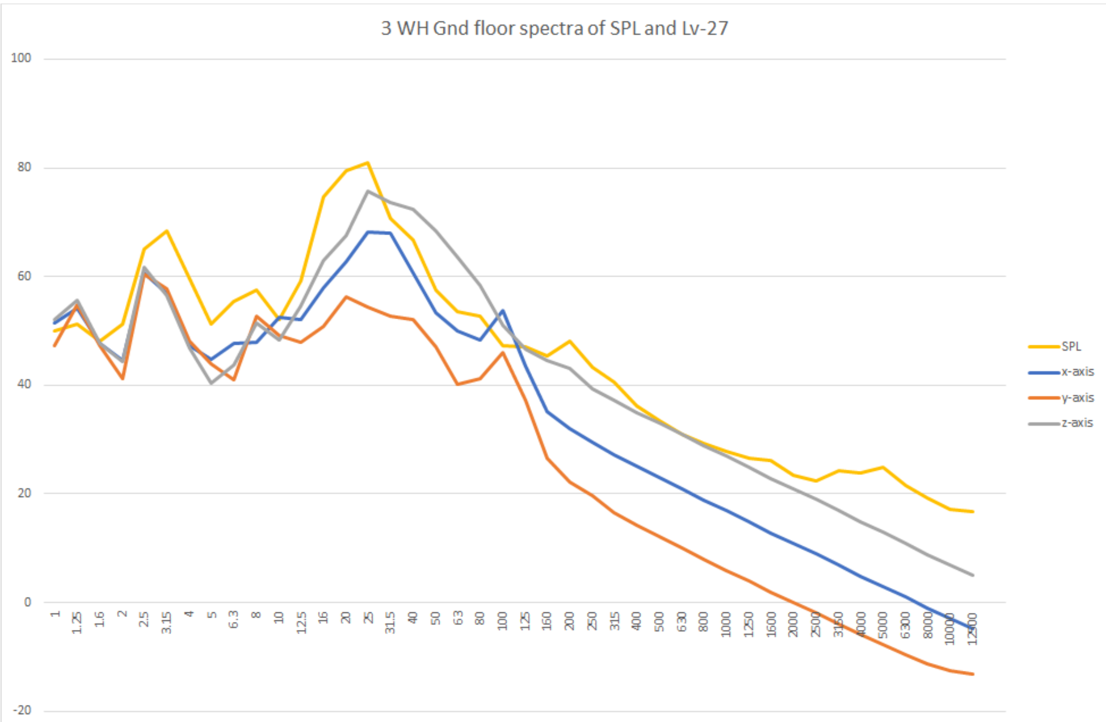


Figure 40 Measurement results at 3 Westward Ho Ground Floor eastbound Spectra 10 mph Class 68 leading

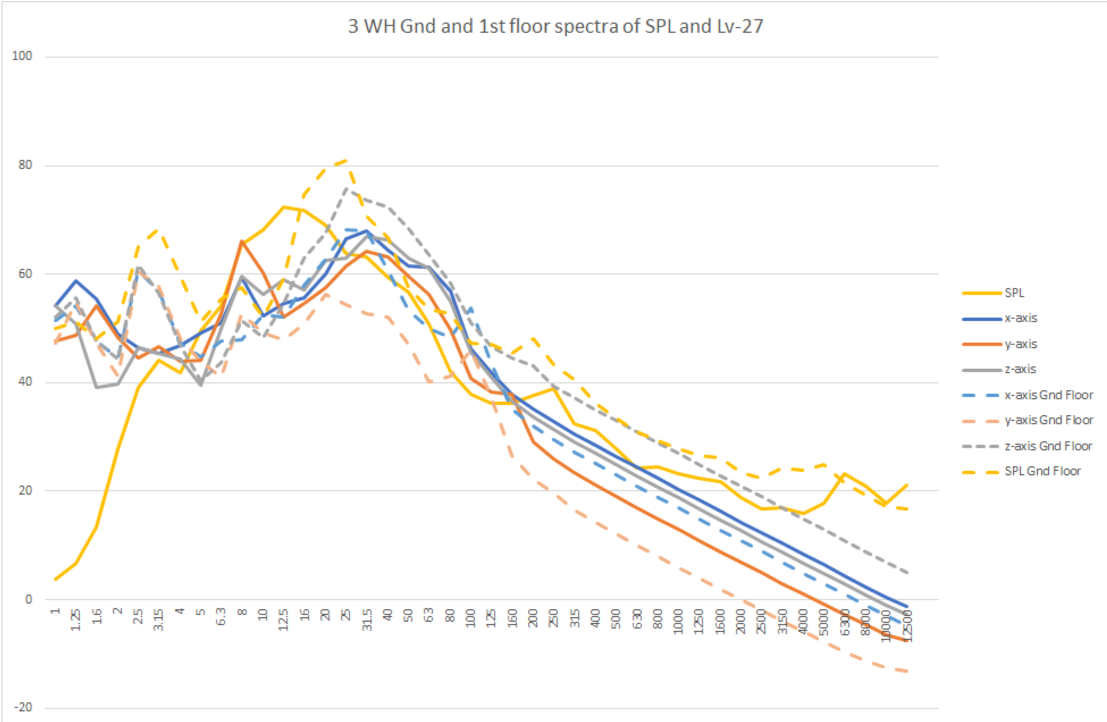


Figure 41 Measurement results at 3 Westward Ho Ground and First Floor eastbound Spectra 10 mph Class 68 leading

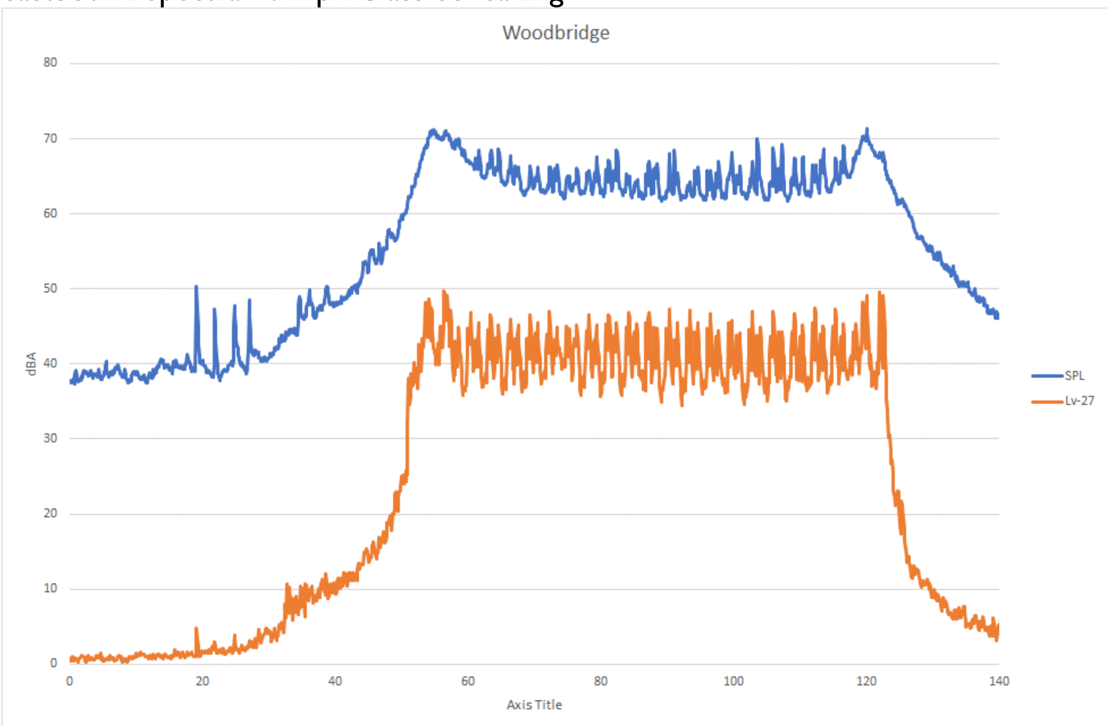


Figure 42 Measurement results at Woodbridge southbound – L_{Afmax} and Pseudo Noise 10 mph Class 66 leading

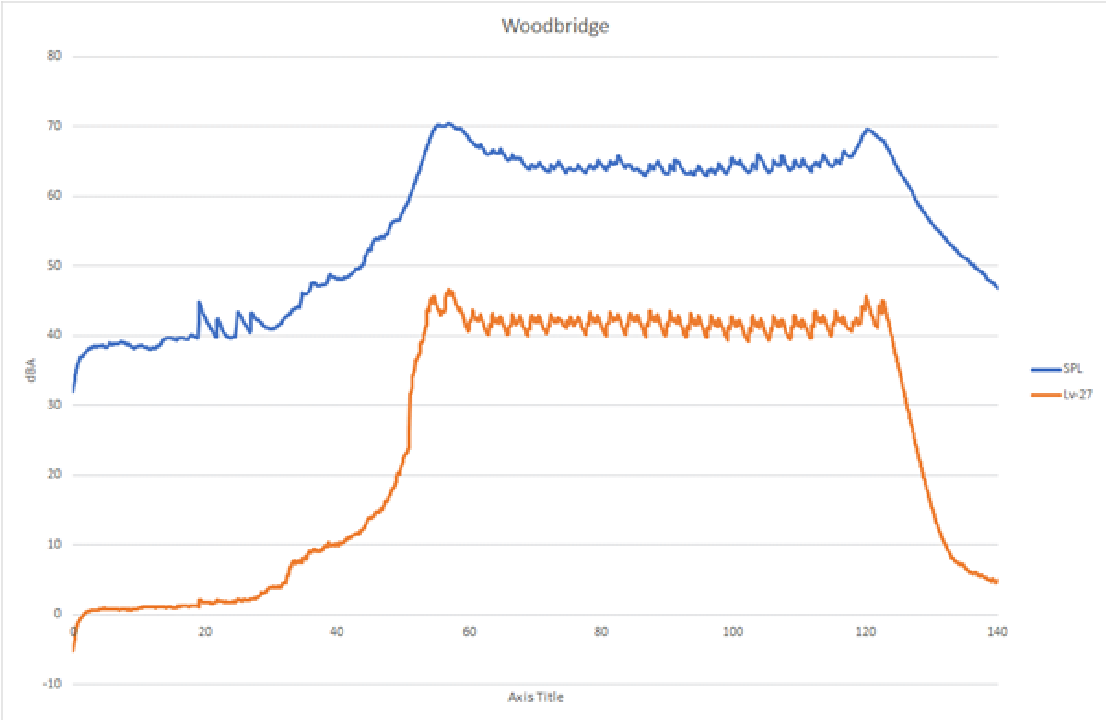


Figure 43 Measurement results at Woodbridge southbound – L_{ASmax} and Pseudo Noise 10 mph Class 66 leading

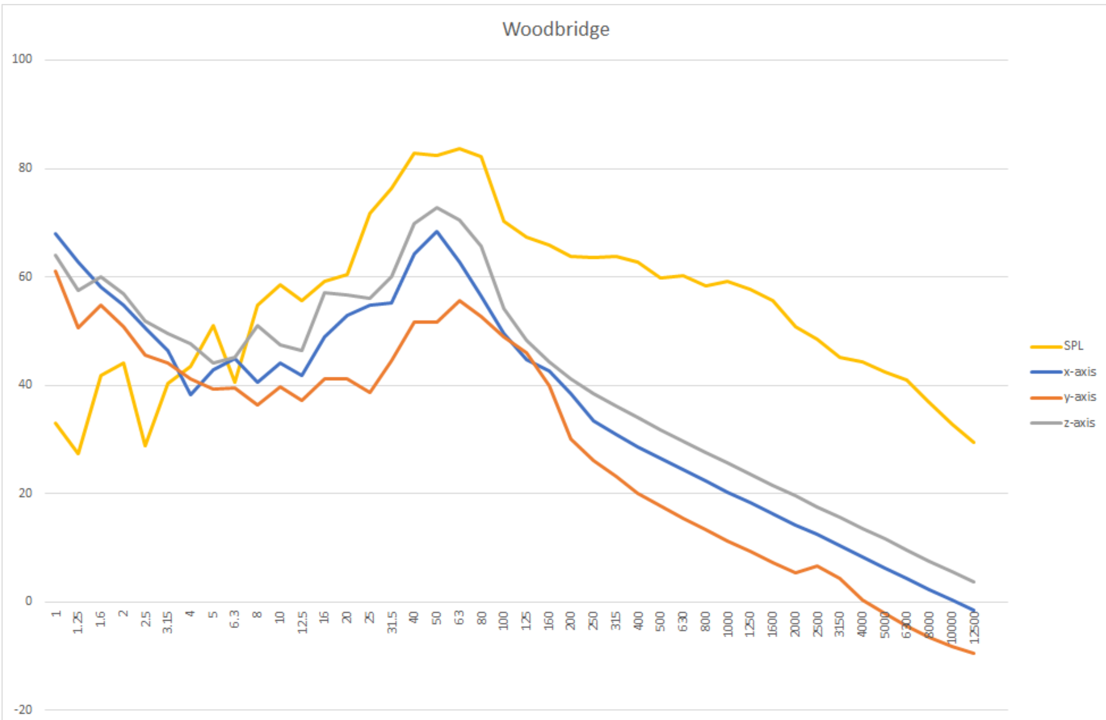


Figure 44 Measurement results at Woodbridge southbound Spectra 10 mph Class 66 leading

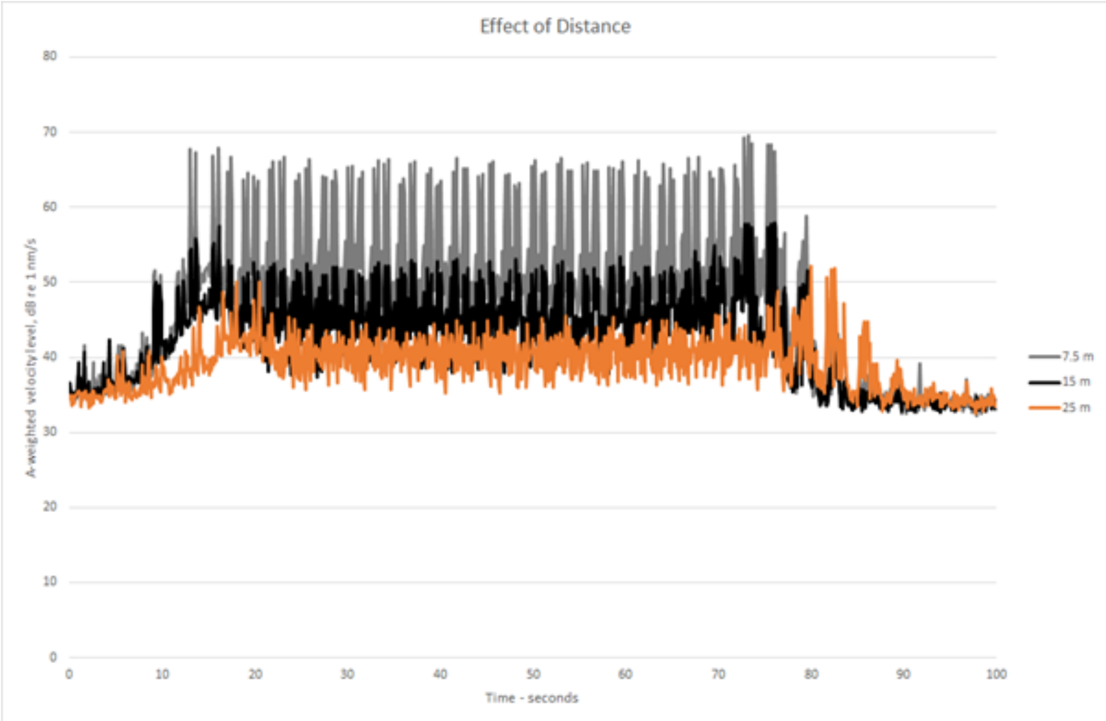


Figure 45 Measurement results at distances from the Leiston Branch near West House Crossing. 10 mph Class 66 leading

APPENDIX V

Under Ballast Mat

Under Ballast Mats

getzner
engineering a quiet future

1 | Functional Principle

Under ballast mats made of the Getzner materials Sylomer® and Sylodyn® limit the static and dynamic forces exerted on the ballast bed by railway operations.

The most important applications are:

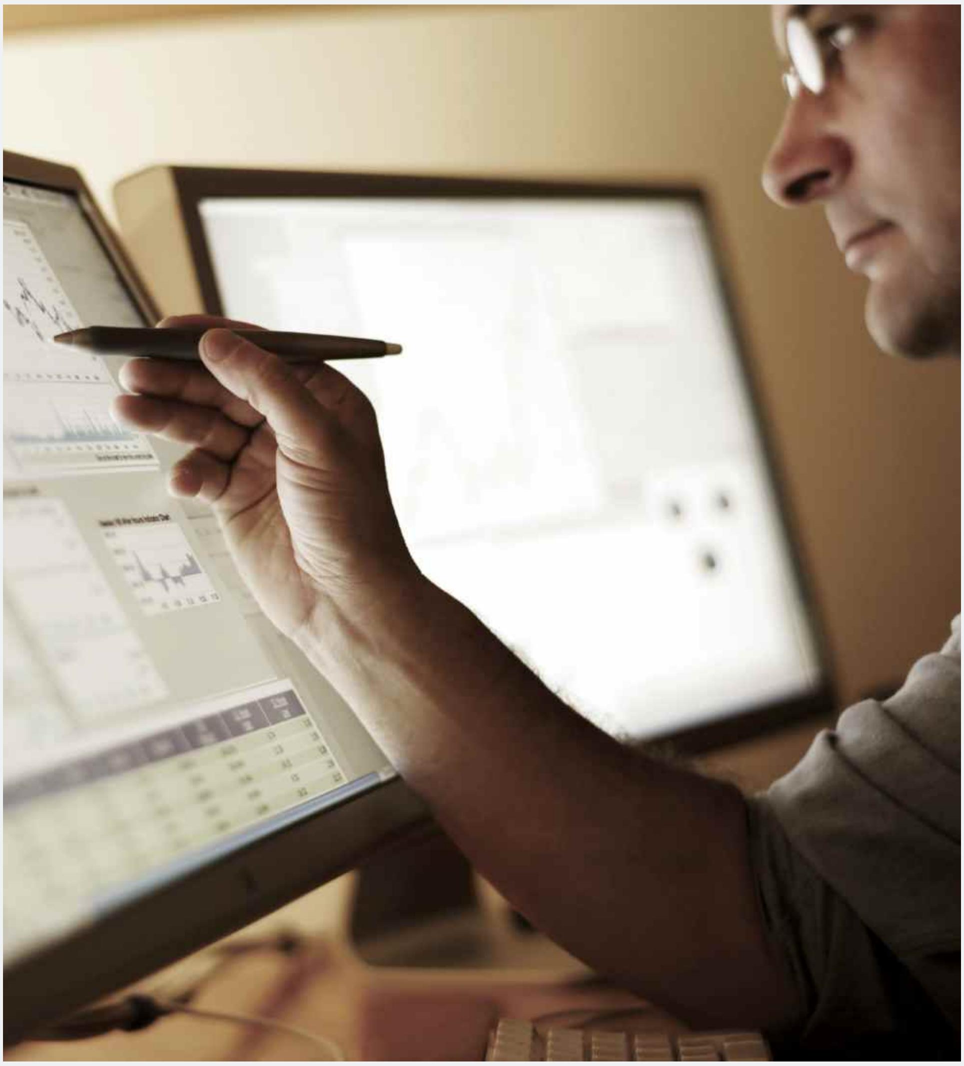
- Isolation of structure-borne noise on railway lines in densely populated regions: local transport railways and standard-gauge railways in the vicinity of buildings.
- Protection of structures and buildings sensitive to vibrations or with elevated vibration protection requirements such as concert halls, museums, hospitals, historic structures or vibration-sensitive laboratory, testing or measurement equipment.
- Reduction of the emission of secondary air-borne sound on bridge structures.
- Increased track geometry stability and reduction of ballast compression decrease the maintenance costs for heavily laden track sections.

Getzner under ballast mats have a multi-layer structure:

- Load distribution layer
  The top layer of the mats consists of a geotextile or fleece with high stretch and tear resistance. This layer deforms under the load of the ballast. The ballast rocks are embedded and their positions are stabilized by the increased contact surface. Forces introduced to the mat are distributed over the full area and transmitted to the underlying resilient layers.
- Resilient layer
  The resilient layer consists of microcellular polyurethane materials. The materials are volume-compressible, meaning that no profiles or cavities are required for shaping. Depending on the mat type, the resilient layer is comprised of one or two layers, each with a density specifically selected to yield the desired overall static and dynamic stiffness.

2 | Engineering Service

Getzner has developed a specialized computational model for the installation of under ballast mats that allows for reliable prediction of the achievable vibration reduction.



Multiple series of tests by various railway operators under a variety of test conditions have shown that Getzner's predictions correspond to the actual results. As part of Getzner's service to its customers, experts generate separate predictions for each application and mat type.

Additional examples of the comprehensive service offered by Getzner include the creation of CAD installation plans, specific calculation models for determining rail deflection, individual on-site construction support or installation instructions for the mats. The state-of-the-art testing laboratory helps make this possible.

In close cooperation with customers and various research and testing agencies, Getzner continuously modifies and tests its product selection. The engineers, product managers and physicists at Getzner are constantly focused on the rising expectations of the market and of customers.

Under ballast mats made of Sylomer® and Sylodyn® have proven their quality on operational track sections many times over the past few decades.

Tests and measurements are available from the following institutes (excerpt):

- **Chair and Testing Institute for Construction of Transport Routes at the Munich University of Technology**
- **TÜV Rhineland**, Cologne, Central Department of Vibration Technology and Vibration Protection
- **Deutsche Bahn**, Testing Institute
- **Arsenal Research**, Vienna
- **Müller BBM GmbH**, Planegg near Munich
- **ISMES Spa**, Bergamo, Italy
- **Institute for Road and Rail Transportation**, Berlin University of Technology
- **Prof. Peter Steinhauser**, Civil Engineer for Technical Physics, Vienna
- **Ruthishauser Engineering Office for Construction, Transportation and the Environment**, Zurich
- **EMPA**, Federal Materials Testing and Research Institute, Dübendorf
- **Fritsch, Chiari & Partner Ziviltechniker GmbH**, Vienna

Research and test reports are available upon request.

3 | Technical Product Information

Bedding modulus and static stiffness

The correct stiffness of a mat depends on the application, the superstructure design (ballast bed height, sleeper area and spacing, rail type) and the operating conditions (axle load, maximum speed).

The measure of stiffness is the bedding modulus, given in N/mm^3. This value is largely responsible for determining the rail deflection during train passes. If the recommendations are observed, the rail deflection is generally less than 3 mm and less than 1.5 mm for high-speed traffic.

Getzner determines the actual deflection in the individual case by calculating the bending line of the rails.

Effectiveness and insertion loss

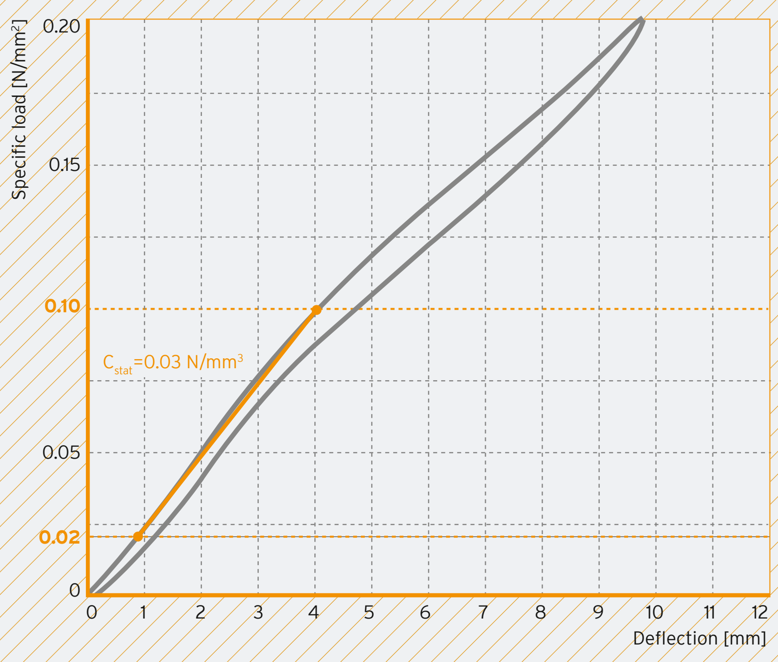
The effectiveness of a under ballast mat can be seen in the form of a reduced structure-borne sound level.

This measure is referred to as "insertion loss" and is indicated as the difference of 1/3-octave levels (cumulative level within a 1/3-octave frequency band) as a function of the 1/3-octave band center frequency. The effectiveness is not determined solely by the under ballast mat; rather, it results from the characteristics of the entire system – from the vehicle to the substructure.

The following parameters are particularly important:

- Unsprung mass of the bogie
- Dynamic stiffness, damping and mass of the ballast superstructure excluding the mat
- Dynamic stiffness and damping of the mat (depends on load, frequency and amplitude)
- Vibration resistance (impedance) of the substructure

Spring load deflection curve for Sylodyn® DN 335 under ballast mat



Prediction model

By considering the entire system and including the various structural factors, Getzner is able to apply a prediction model to calculate the effectiveness of a measure in advance.

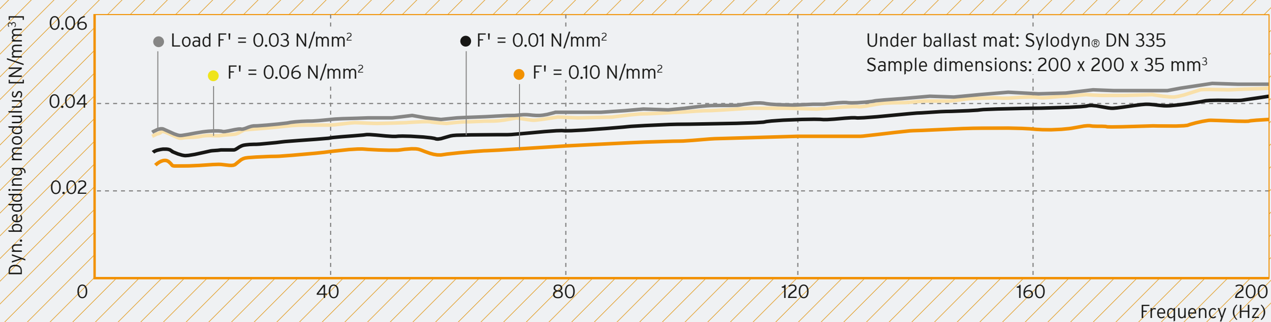
The model assumes that the "dynamic stiffness" and the "loss factor" are sufficient for a nearly complete description of the dynamic properties of the under ballast mat in the relevant load and frequency range.

Getzner under ballast mats satisfy this condition because the dynamic stiffness is only minimally dependent on frequency, load and amplitude. The under ballast mats are particularly effective in the frequency range corresponding to the wheel/rail superstructure resonance for a superstructure without mats. Depending on the bedding stiffness, this is between approx. 50 Hz and 80 Hz.

In most applications, the effectiveness in the frequency range under about 80 Hz is particularly important since these low-frequency vibrations are very strongly stimulated. Buildings and building elements can easily be stimulated within this frequency range, as can be seen in the natural vibration of ceilings and walls.

Due to the advanced technology of Getzner under ballast mats, the values for their effectiveness based on experience and prediction models are not applicable to other types of under ballast mats (examples: compact elastomer mats with profiling or interior cavities).

Load and frequency dependence of dynamic stiffness (from: Müller-BBM, Report No. 32242/12)



4 Long-Term Behavior

Long-term behavior under the harshest conditions

Getzner under ballast mats exhibit extremely high effectiveness even after years of exposure to operational loads. This has been proven by a study evaluating the long-term properties of Getzner under ballast mats.

After more than 16 years of operation and a daily load of roughly 150 000 tons, samples were removed from the superstructure and subjected to various tests. The test results showed that the under ballast mats still exhibited outstanding functionality. Despite more than 16 years of use, the under ballast mats from Getzner still had an impressive, constant stiffness behavior. In verification measurements on samples that had lain in silty subsoil for over 20 years, no contamination was found inside the mats.

Getzner under ballast mats retain their function even under extreme conditions. Environmental influences such as complete flooding, frost or heavy soiling of the ballast bed with sand or material worn away from the ballast rocks cannot affect the mats.

Quote from the test report by an external testing institute:

"... The Sylomer® B 851 under ballast mat superbly withstood the extremely high operating loads totalling over 760 million tons within a period of more than 16 years."

5 Installation Technology and Retrofitting

Delivery form and installation

Getzner manufactures under ballast mats in a uniform width of 1.50 m. The mat sheets are cut to the local track width before leaving the factory.

After being cut to size, the mats are rolled up and packaged. After the installation position has been marked on the mat, it is delivered directly to the construction site. Starting from a mat thickness of 35 or 40 millimeters, it is sometimes useful to deliver the mats in two separately rolled layers to allow for easier handling.

The mat rolls are distributed and laid out at the destination site according to their labeling. Any fine adaptations necessary are performed by inserting fitting blocks or by cutting the mats to the correct size and shape, which may be necessary in the area of curves.

The continuous further development of installation techniques by Getzner has now made it possible to thermally glue the upper layer of the individual mats and the fitting blocks together.

The mat covering is fully functional immediately after laying – in other words, even without the mats being bonded to the subsoil.

Rubber-tired construction vehicles can drive over the mat covering with no problems. If the mats are not covered with ballast immediately after laying, it is useful to secure the position of the mats through partial bonding with the subsoil (construction site traffic, incoming water). Getzner uses solvent-free adhesive, such as 2-component PUR adhesives, for this task. The bonding takes place so that any water that may have penetrated under the mats can flow or seep to the next drain inlet.

Requirements for the subsoil

Getzner under ballast mats lie on the subsoil with full surface contact. Because they are flexible and elastic in all directions, they largely adapt to the contour of the subsoil.

Since the mat optimally adapts to the subsoil beneath, sharp-edged recesses or bumps in the laying surface can damage the mats. Concrete decking must first be scraped or smoothed to an approximate evenness. No special measures are required for laying Getzner under ballast mats on subsoil of compressed gravel (sub-grade), on a cement-paved support layer or on a bitumen support layer.

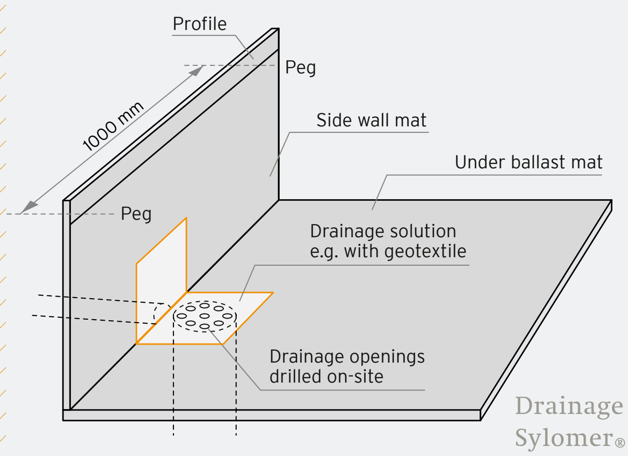
When existing track sections are retrofitted with mats, the laying surface frequently consists of old

ballast. In this case, it has proven effective to provide a load distribution layer on both sides of the mat.

If the mats are subject to constant and extensive water exposure, drainage mats can be laid under the mats in a linear arrangement. To avoid sound bridges in the area of the water channels, the grills or grates are covered with perforated under ballast mats; however, these can also be elastically supported themselves.

The Getzner under ballast mats delivery program naturally also includes detailed, written installation instructions as well as the adhesive required for laying. If the laying surface is coated with plastic (e.g. epoxy resin for steel bridges), no special measures are required.

Sylomer® and Sylodyn® are free of softening agents and other oils. If the under ballast mats are to be bonded, the subsoil must first be dry and swept clean.



Drainage principle: Sylomer® and Sylodyn® under ballast mats

Retrofitting existing track sections

Getzner under ballast mats are particularly valued in many retrofitting projects due to their low weight and easy installation.

Under ballast mats made of Sylomer® and Sylodyn® have also proven themselves well in sensitive areas with the highest requirements for vibration protection as well as under extreme structural conditions.

The retrofitting procedure from Getzner has been tested frequently in practice and ensures rapid construction progress. Because it is not necessary to remove the entire track panel, only short track closure times are required for the installation. Since it is not possible to adapt the size of the mats in advance, they must be cut on-site to the exact lengths required. They can be cut with simple, widely available carpet cutters.

If the signs of wear on the superstructure are not too extreme after years of operational loads without under ballast mats, it is naturally possible to reinstall all components. Rails, sleepers, rail fastenings and ballast do not have to be replaced, as is the case for other vibration-related refurbishment measures. Getzner trumps with economy and efficiency.

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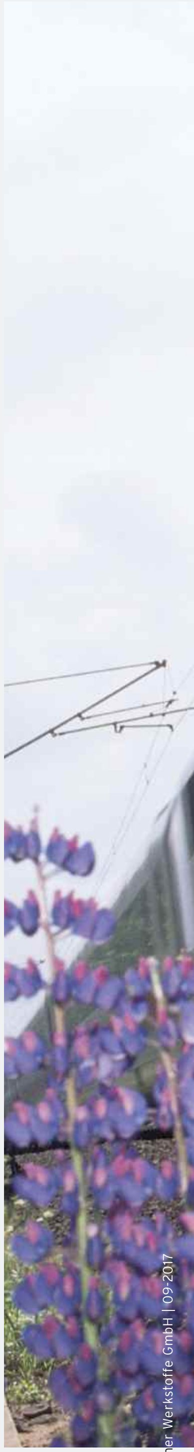

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APPENDIX VI
Instrumentation

Location:

3 Westward Ho 1st Floor, Gate House Cottage, former Council Car Park Woodbridge

Rion DA-20 Serial Number 35221732 Cal. Date 11-Apr-2019 Certificate No TCRT19/1288

PCB Piezotronics 356B18 tri-axial accelerometer Cal. Date 12-Apr-2019 Certificate No. TCRT19/1311

Brüel & Kjær 4291 Accelerometer calibrator Cal. Date 16-Apr-2019 Certificate No. TCRT19/1312

Rion NL-52 Sound Level Meter Serial number 00331831 UC-59 Serial No 04898 NH-25 Serial No 21782 Calibration Date 11-Apr-2019 Certificate No UCRT19/1457.

Rion NC-54 Sound Calibrator Calibration Date 11-Apr-2019 Certificate No UCRT19/1455

Location:

53 Westward Ho 1st Floor, West House Crossing Cottage

Rion DA-20 Serial Number 11160666 Cal. Date 14-Apr-2020 Certificate No TCRT20/1205

Rion PV-87 Accelerometer Serial No 23761 Cal. Date 17-Mar 2020 Certificate No 20/1169 (X-axis)
Rion PV-87 Accelerometer Serial No 23766 Cal. Date 17-Mar 2020 Certificate No 20/1167 (Y-axis)
Rion PV-87 Accelerometer Serial No 23754 Cal. Date 17-Mar 2020 Certificate No 20/1168 (Z-axis)

Rion Microphone UC-53A Serial Number 309255 Cal Date 19 May 2020 Calibration No UCRT20/1426

Rion Acoustic Calibrator NC-75 Serial Number 35292145 Cal Date 4 May 2020 Calibration No UCRT20/1387

Location:

3 Westward Ho Ground Floor

Rion DA-20 Serial Number 10770816 Cal. Date 12-Aug-2019 Certificate No TCRT19/1640

Rion PV-87 Accelerometer Serial No 54062 Cal. Date 05-Feb 2020 Certificate No 20/1072 (X-axis)
Rion PV-87 Accelerometer Serial No 54061 Cal. Date 05-Feb 2020 Certificate No 20/1071 (Y-axis)
Rion PV-87 Accelerometer Serial No 54039 Cal. Date 05-Feb 2020 Certificate No 20/1070 (Z-axis)

Rion Microphone UC-53A Serial Number 01284 Cal Date 19 May 2020 Calibration No UCRT20/1428

Rion Acoustic Calibrator NC-75 Serial Number 35292147 Cal Date 7 May 2020 Calibration No UCRT20/1404

Location:

53 Westward Ho Ground Floor

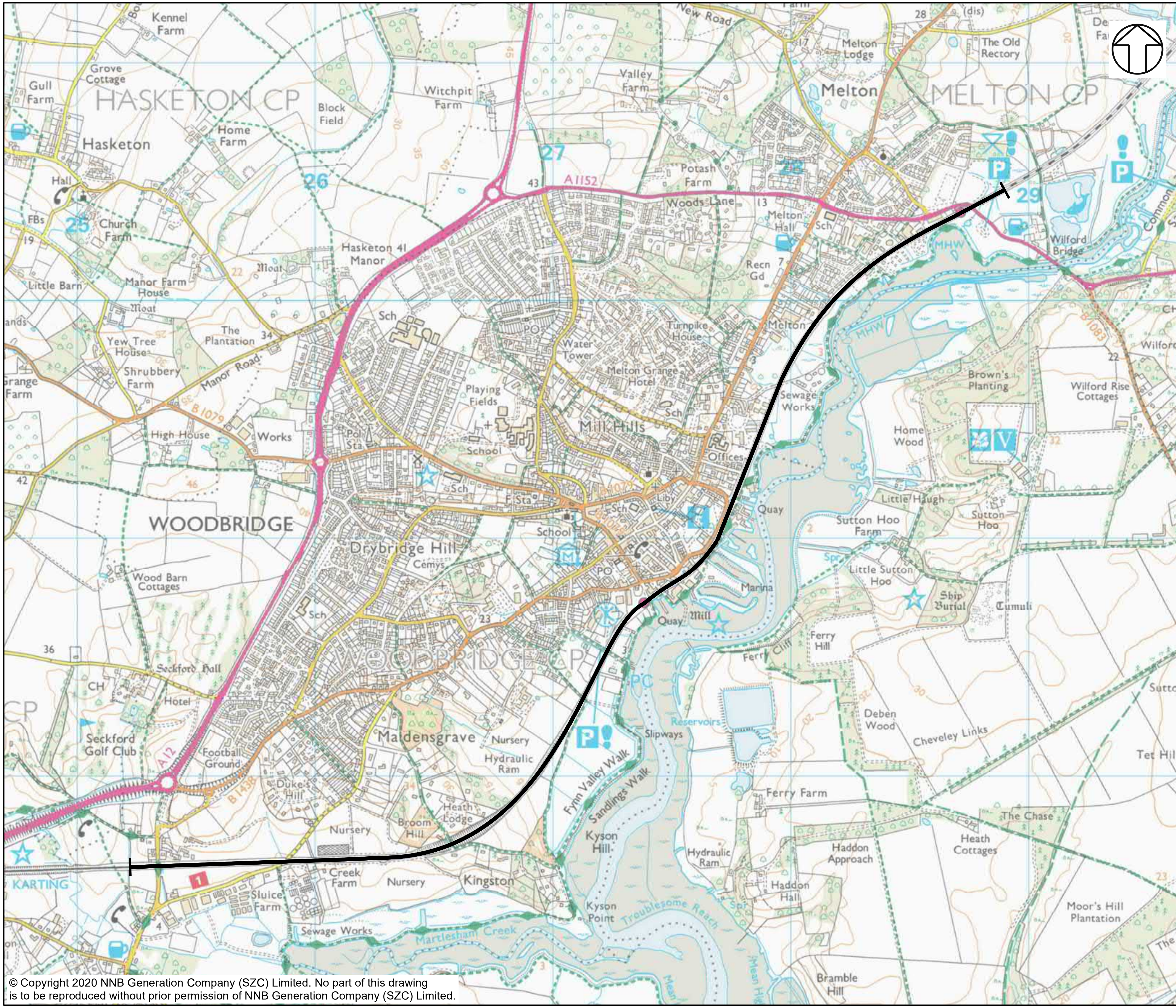
Rion DA-20 Serial Number 00460343 Cal. Date 16-Apr-2020 Certificate No TCRT20/1206

Rion PV-87 Accelerometer Serial No 23760 Cal. Date 08-Jan 2020 Certificate No 20/1011 (X-axis)
Rion PV-87 Accelerometer Serial No 23753 Cal. Date 08-Jan 2020 Certificate No 20/1014 (Y-axis)
Rion PV-87 Accelerometer Serial No 23759 Cal. Date 08-Jan 2020 Certificate No 20/1013 (Z-axis)

Rion Microphone UC-53A Serial Number 314072 Cal Date 15 April 2020 Calibration No UCRT20/1373

Rion Acoustic Calibrator NC-75 Serial Number 35292145 Cal Date 4 May 2020 Calibration No UCRT20/1387

APPENDIX 9.3.A.
APPENDIX C: SPEED LIMIT ZONES



NOTES

KEY

SPEED RESTRICTION

NOT PROTECTIVELY MARKED

SZC
edf ENERGY
CGN

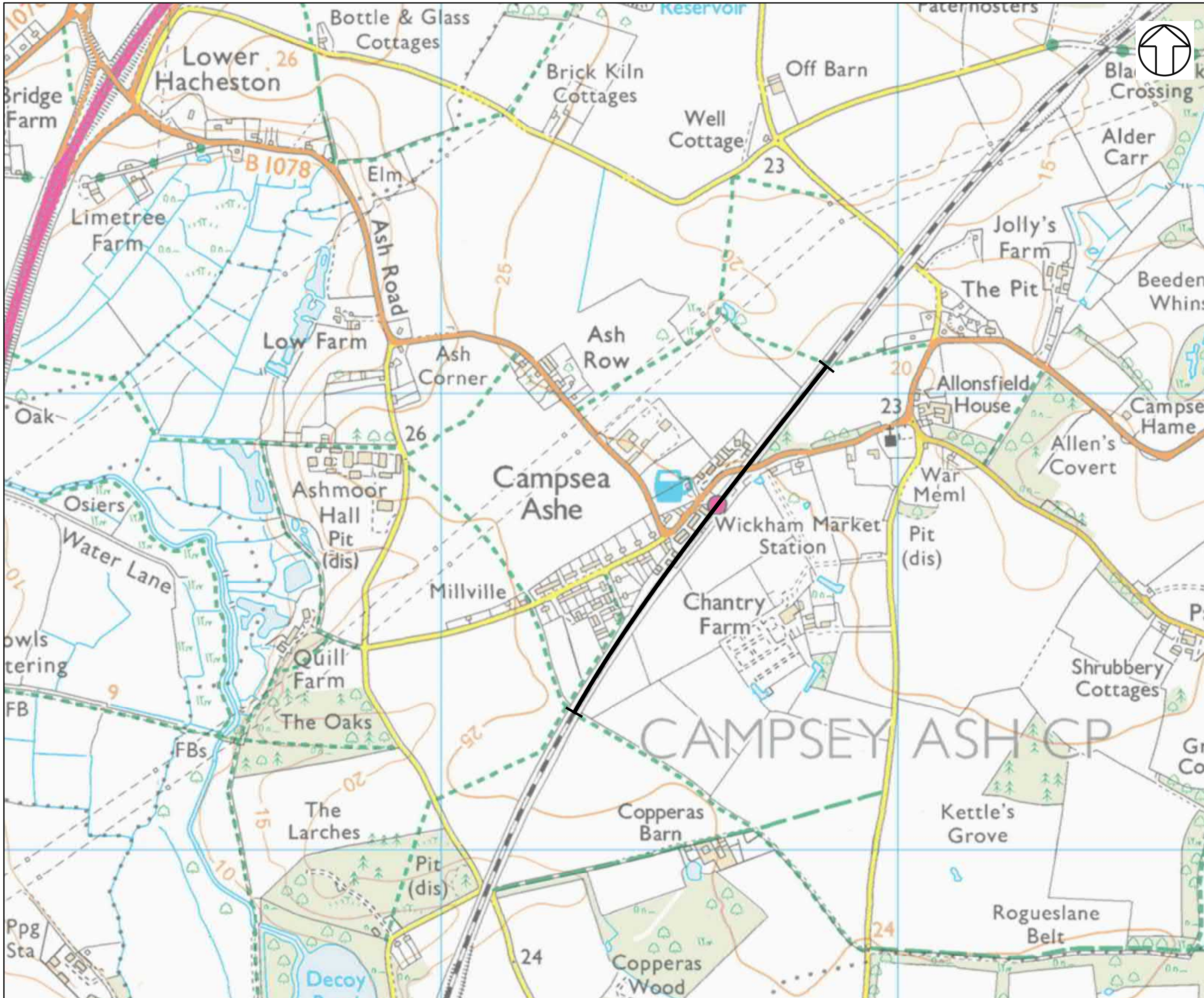
DOCUMENT:
SIZEWELL C
ENVIRONMENTAL STATEMENT
VOLUME 9
CHAPTER 4
NOISE AND VIBRATION

DRAWING TITLE:
MAP SHOWING LOCATION OF SPEED RESTRICTION IN WOODBRIDGE AND MELTON

DRAWING NO:
FIGURE 4.2

DATE:	DRAWN:	SCALE :
JAN 2020	J.W.	1:15,000 @A3

SCALE BAR
0 200 400 600 800 M



NOTES

KEY

SPEED RESTRICTION

NOT PROTECTIVELY MARKED

edF ENERGY SZC CGN

DOCUMENT:
SIZEWELL C
ENVIRONMENTAL STATEMENT
VOLUME 9
CHAPTER 4
NOISE AND VIBRATION

DRAWING TITLE:
MAP SHOWING LOCATION OF SPEED RESTRICTION IN CAMPSEA ASHE

DRAWING NO:
FIGURE 4.3

DATE:	DRAWN:	SCALE :
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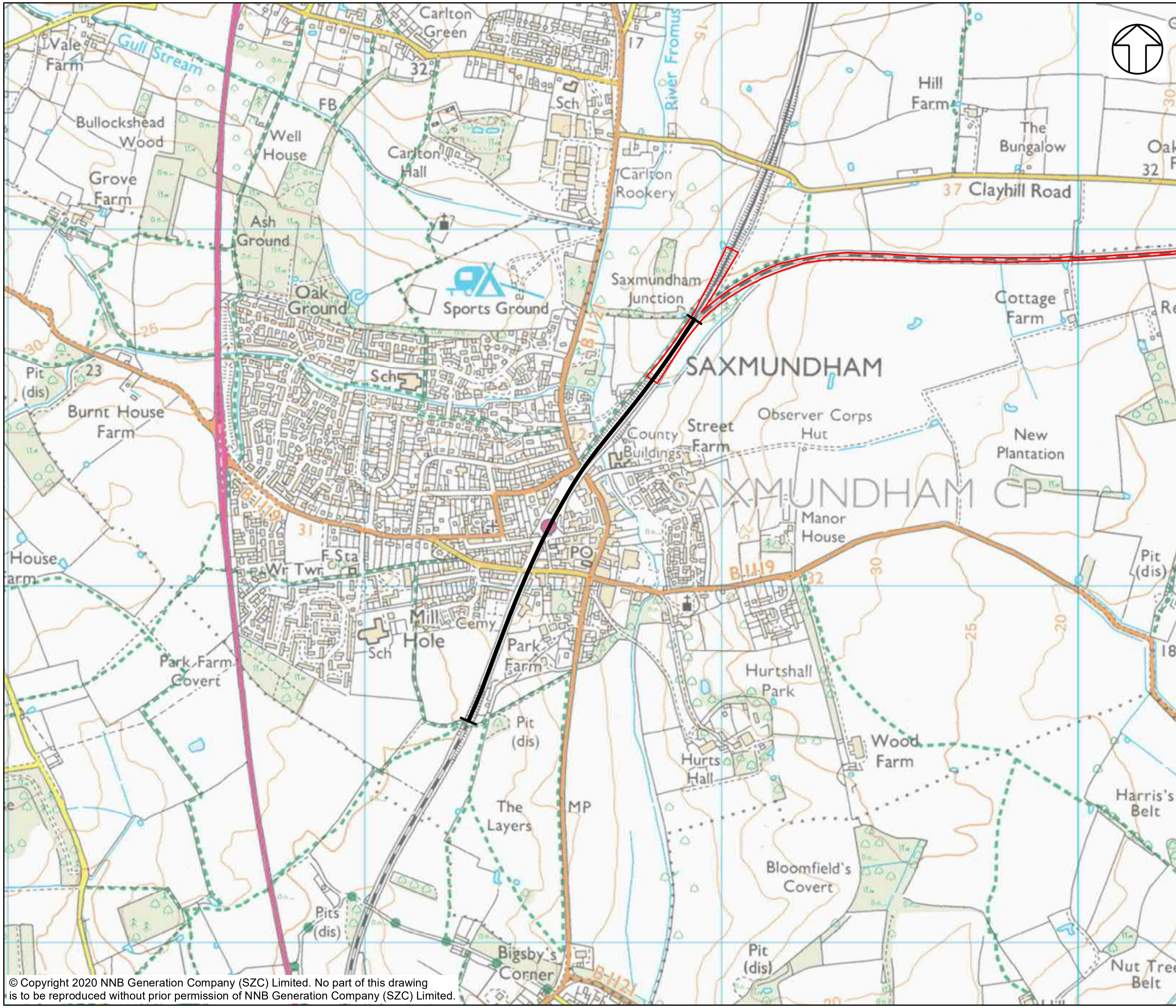

NOTES

KEY

SAXMUNDHAM TO LEISTON BRANCH LINE UPGRADES DEVELOPMENT SITE BOUNDARY

SPEED RESTRICTION

NOT PROTECTIVELY MARKED

DOCUMENT:
SIZEWELL C
ENVIRONMENTAL STATEMENT
VOLUME 9
CHAPTER 4
NOISE AND VIBRATION

DRAWING TITLE:
MAP SHOWING LOCATION OF SPEED RESTRICTION IN SAXMUNDHAM

DRAWING NO:
FIGURE 4.4

DATE:	DRAWN:	SCALE :
JAN 2020	J.W.	1:10,000 @A3

SCALE BAR
0 100 200 300 400 500 M

APPENDIX 9.3.A. APPENDIX D: LIST OF PROPERTIES CLOSE TO THE RAILWAY LINE

Table D1: Properties within 20m of railway line

Location	Address	Distance to nearest rail (m)
Within 5m of railway line		
SAXMUNDHAM	1 Albion Street, Saxmundham IP17 1BN	2.6
SAXMUNDHAM	Crossing Cottage, Kiln Lane South, Benhall, Saxmundham IP17 1HA	4.0
WOODBRIDGE	Unnamed property, Blackstock Crossing Road, Campsea Ashe, Woodbridge IP13 0QL	4.7
WOODBRIDGE	18 Talbot Walk, Station Road, Campsea Ashe, Woodbridge IP13 0QP	4.9
Between 5 and 7m of railway line		
WOODBRIDGE	16 Talbot Walk, Station Road, Campsea Ashe, Woodbridge IP13 0QP	5.3
WOODBRIDGE	17 Talbot Walk, Station Road, Campsea Ashe, Woodbridge IP13 0QP	5.6
SAXMUNDHAM	3 Albion Street, Saxmundham IP17 1BN	6.1
WOODBRIDGE	22 New Quay Court, Old Maltings Approach, Melton, Woodbridge IP12 1AN	6.2(1)

Location	Address	Distance to nearest rail (m)
WOODBRIDGE	21 New Quay Court, Old Maltings Approach, Melton, Woodbridge IP12 1AN	6.2(1)
WOODBRIDGE	20 New Quay Court, Old Maltings Approach, Melton, Woodbridge IP12 1AN	6.2(1)
WOODBRIDGE	2 New Quay Court, Old Maltings Approach, Melton, Woodbridge IP12 1AN	6.2(1)
WOODBRIDGE	19 New Quay Court, Old Maltings Approach, Melton, Woodbridge IP12 1AN	6.2(1)
WOODBRIDGE	18 New Quay Court, Old Maltings Approach, Melton, Woodbridge IP12 1AN	6.2(1)
WOODBRIDGE	17 New Quay Court, Old Maltings Approach, Melton, Woodbridge IP12 1AN	6.2(1)
WOODBRIDGE	5 Estuary Reach, Old Maltings Approach, Melton, Woodbridge IP12 1FN	6.3
WOODBRIDGE	1 Talbot Walk, Station Road, Campsea Ashe, Woodbridge IP13 0QP	6.4
WOODBRIDGE	Crossing Cottage, Ufford Road, Bromeswell, Woodbridge IP12 2QB	6.5
SAXMUNDHAM	Crossing Cottage, Benhall, Saxmundham IP17 1HZ	6.7
WOODBRIDGE	Swirly Cottage, 8 Lime Kiln Quay, Woodbridge IP12 1BD	6.8
Between 7 and 10m of railway line		

Location	Address	Distance to nearest rail (m)
SAXMUNDHAM	The Gatehouse, Farnham, Saxmundham IP17 1LY	8.7
WOODBRIDGE	19 Talbot Walk, Station Road, Campsea Ashe, Woodbridge IP13 0QP	9.7
SAXMUNDHAM	5 Albion Street, Saxmundham IP17 1BN	9.8
Between 10 and 14m of railway line		
WOODBRIDGE	2 Quayside Place, Quayside, Woodbridge IP12 1FA	10.3
WOODBRIDGE	9 Quayside Place, Quayside, Woodbridge IP12 1FA	10.4
WOODBRIDGE	1 Tide Mill Way, Woodbridge IP12 1BY	10.4
WOODBRIDGE	Blaxhall Hall Crossing, Little Glemham, Woodbridge IP13 0BP	10.7
SAXMUNDHAM	Station Cottage, Alma Place, Saxmundham IP17 1DN	10.9
WOODBRIDGE	15 Quayside Place, Quayside, Woodbridge IP12 1FA	10.9
WOODBRIDGE	2 Talbot Walk, Station Road, Campsea Ashe, Woodbridge IP13 0QP	11.4
SAXMUNDHAM	Greenland Grove Cottage, Farnham, Saxmundham IP17 1LY	11.5

Location	Address	Distance to nearest rail (m)
SAXMUNDHAM	2 Alma Place, Saxmundham IP17 1DN	11.5
SAXMUNDHAM	1 Alma Place, Saxmundham IP17 1DN	11.5
SAXMUNDHAM	3 Alma Place, Saxmundham IP17 1DN	11.8
SAXMUNDHAM	The Railway Barn, New Cut, Saxmundham IP17 1EH	12.0
SAXMUNDHAM	Chantry House Care Home, Chantry Rd, Saxmundham IP17 1DJ	12.1
WOODBRIDGE	6 Quayside Place, Quayside, Woodbridge IP12 1FA	12.4
WOODBRIDGE	The Chandlery, Lime Kiln Quay, Woodbridge IP12 1BD	12.6
SAXMUNDHAM	7 Albion Street, Saxmundham IP17 1BN	13.0
WOODBRIDGE	48a Deben Road, Woodbridge IP12 1AZ	13.0
SAXMUNDHAM	2 Albion Street, Saxmundham IP17 1BN	13.1
Between 14 and 20m of railway line		
WOODBRIDGE	20 Talbot Walk, Station Road, Campsea Ashe, Woodbridge IP13 0QP	14.1

Location	Address	Distance to nearest rail (m)
WOODBRIDGE	8 Quayside Place, Quayside, Woodbridge IP12 1FA	14.4
WOODBRIDGE	7 Quayside Place, Quayside, Woodbridge IP12 1FA	14.5
SAXMUNDHAM	45C High Street, Saxmundham IP17 1AJ	15.0
WOODBRIDGE	5 Quayside Place, Quayside, Woodbridge IP12 1FA	15.6
WOODBRIDGE	3 Talbot Walk, Station Road, Campsea Ashe, Woodbridge IP13 0QP	16.4
SAXMUNDHAM	4 Abbey Court, New Cut, Saxmundham IP17 1EH	17.6
WOODBRIDGE	49 Deben Road, Woodbridge IP12 1AZ	18.2
WOODBRIDGE	3 Quayside Place, Quayside, Woodbridge IP12 1FA	18.3
WOODBRIDGE	4 Quayside Place, Quayside, Woodbridge IP12 1FA	18.7

Notes:
(1) - the closest part of New Quay Court is 6.2m from the nearside line so there are likely to be three flats at that (plan) distance, one at each of the ground, first and second storeys.

APPENDIX 9.3.B WOODBRIDGE SURVEY RESULTS

SHARPS REDMORE

ACOUSTIC CONSULTANTS ▪ Established 1990

Report

ES Addendum Volume 3 Appendix 9.3.B

EDF – Sizewell C Power Station: Woodbridge Rail Noise and Vibration Survey Summary

Prepared by
Charlie Stafford-Roberts BSc (Hons) TechIOA MInstP

and

Clive Bentley BSc (Hons) CIEH MIEnvSc MIOA CEnv CSci

Date 8th December 2020

Project No 1212653

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Contents

Appendices

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of noise and vibration levels from trains passing through Woodbridge, with an emphasis on night time movements. The purpose of this survey is to provide information about the existing acoustic climate to assist with understanding the context in which the proposed additional rail movements would need to be considered.

1.2 This report provides a summary of all noise and vibration measurements taken up to the 1st November 2020.

1.3 The noise survey work began on 4th March 2020. A Type 1 sound level meter was installed at the location shown in Figure A1 in Appendix A. The microphone is in a free field location approximately 5 metres from the rail line at a height of 1.8m above ground. The meter is regularly serviced, and a calibration check carried out.

1.4 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

1.5 Vibration survey work began on 4th August 2020. A triaxial ground borne vibration level meter with a connected vibration pickup was installed at the location shown in Figure A2 in Appendix A. The vibration pickup is mounted to a DIN plate and was initially planted in a dug hole approximately 30cm below ground surface level. This was to minimise surface vibration effects being present in measurements. However, due to increasing bad weather, on the 1st October 2020, this vibration pickup and DIN plate were moved onto surface soil as the dug hole had begun to fill with water.

1.6 Levels of noise and vibration have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line. Using a combination of this information and an analysis of the measured levels, results have been interpreted to provide a summary of levels and the likely source which has resulted in those levels, where this is possible to determine.

1.7 RTT also provide further information about the trains passing along the line, such as the type of train, and the platform on which they pass through Woodbridge station. This allows for an investigation into the specific levels of noise and vibration caused by different types of train, which can then be linked to whether the train is accelerating or decelerating into Woodbridge station.

1.8 In October 2020, a trigger was set to record audio when L_{Amax} noise levels exceed 80dB. From these signals it has become possible to identify train movements passing the measurement location which are not captured by RTT. The type of these trains is not known, but they are likely to be single freight or passenger locomotives, or other engineering trains.

1.9 The monthly noise and vibration reports are attached to this summary report in appendices B and C respectively. These detail specific monthly measurements and give full night time data for key noise and vibration parameters. They also contain discrete monthly lists of trains as recorded by RTT and identified through other means.

2.0 Analysis of Night Time Noise Results

2.1 Noise Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period: long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 As can be seen in Figure A1, the microphone of the noise meter is placed at approximately 5m from the track edge. In this analysis, noise levels have been normalised to a distance of 10m to allow comparison with other reported source levels for train noise.

2.3 Due to equipment failures, some nights between 4th March 2020 and 1st November 2020 have not been recorded. Table 2.1 gives a summary of date ranges where night time data was obtained and where it was not. Date ranges are inclusive at both ends, with dates representing the night time period which began at 23:00 on that date and ended at 07:00 on the next date.

Table 2.1: Date ranges of recorded and not recorded noise data at Woodbridge

Night Time Noise Data Recorded	Night Time Noise Data Not Recorded
4th March 2020 – 24th April 2020	
	25th April 2020 – 3rd May 2020
4th May 2020 – 31st October 2020*	

*This measurement begun at 23:00 on the 31st December 2020 and ended at 07:00 on the 1st January 2021.

2.4 From Table 2.1 it can be calculated that noise measurements have been taken for 234-night time periods. There have been 9-night time periods where data was not recorded.

2.5 Using Real Time Trains, as well as measurement of audio signals, the number of trains measured across these 234-night time periods can be calculated and broken down by train types. This is shown in Table 2.2 where figures have been broken down by month.

Table 2.2: Number of different train types measured during recorded night time periods at Woodbridge by month.

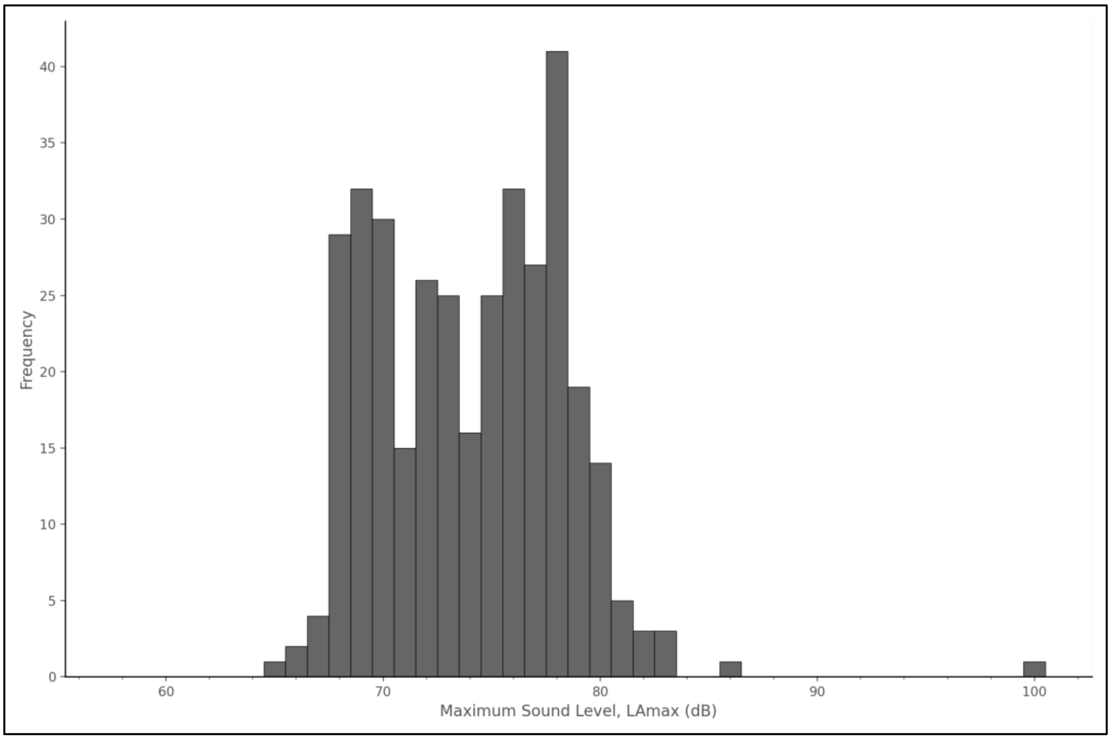
Month	Measured Nights	Type of Train and Total and Average Nightly Occurrence					
		Passenger		Non-Passenger		Unknown*	
		Total	Average	Total	Average	Total	Average
March	28	36	1.3	10	0.4	Not identifiable during these months as no audio signals	
April	24	36	1.5	18	0.75		
May	28	39	1.4	5	0.2		
June	30	41	1.4	2	0.1		
July	31	46	1.5	6	0.2		
August	31	43	1.4	17	0.5		
September	30	46	1.5	11	0.4		
October	31	64	2.1	35	1.3	8	0.3

*Unknown train types are those identified via audio recordings, which has only been possible for the 31-night periods between 1st October 2020 and 1st November 2020.

2.6 Table 2.2 shows that passenger trains were the most common, with between 1.3 and 2.1 per night depending on the month. Non-Passenger trains range in average occurrence from 0.1 to 1.3 per night, or roughly from one train every ten night to one train per night.

2.7 Figure 2.1 shows a histogram of the measured L_{Amax} noise levels for passenger trains, this allows the range of measured values, as well as the respective frequency of each L_{Amax} interval to be shown.

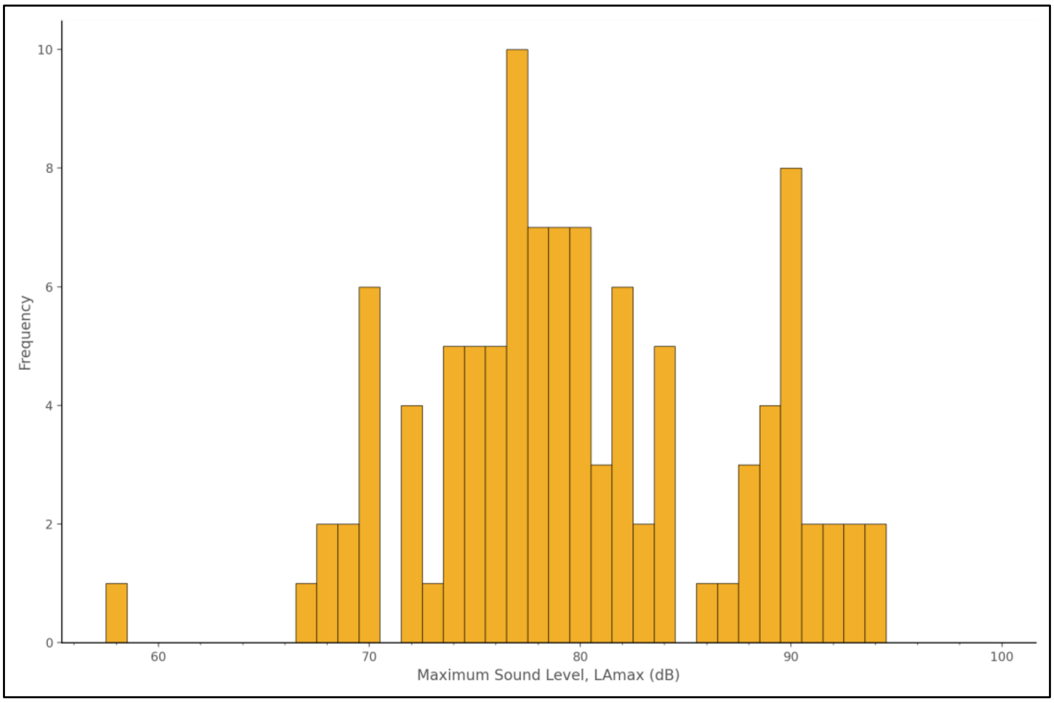
Figure 2.1: Histogram showing the Frequency of L_{Amax} measurements for passenger trains



2.8 Figure 2.1 shows that the distribution of measured maximum sound levels from passenger trains is generally bimodal, with a small shoulder off of the first peak. Measured values range from 65dB to 100dB.

2.9 Figure 2.2 shows a similar histogram of the measured L_{Amax} noise levels for non-passenger trains, this allows the range of measured values, as well as the respective number of each L_{Amax} interval to be shown.

Figure 2.2: Histogram showing the Frequency of L_{Amax} measurement for non-passenger trains



2.10 Figure 2.1 shows that the distribution of non-passenger train measurements is more widespread than that of passenger trains. The modal value is 77 dB L_{Amax} but 70 dB and 90dB are also frequently measured. Non-passenger trains L_{Amax} values have been measured ranging from 58 dB to 94 dB when normalised to 10m.

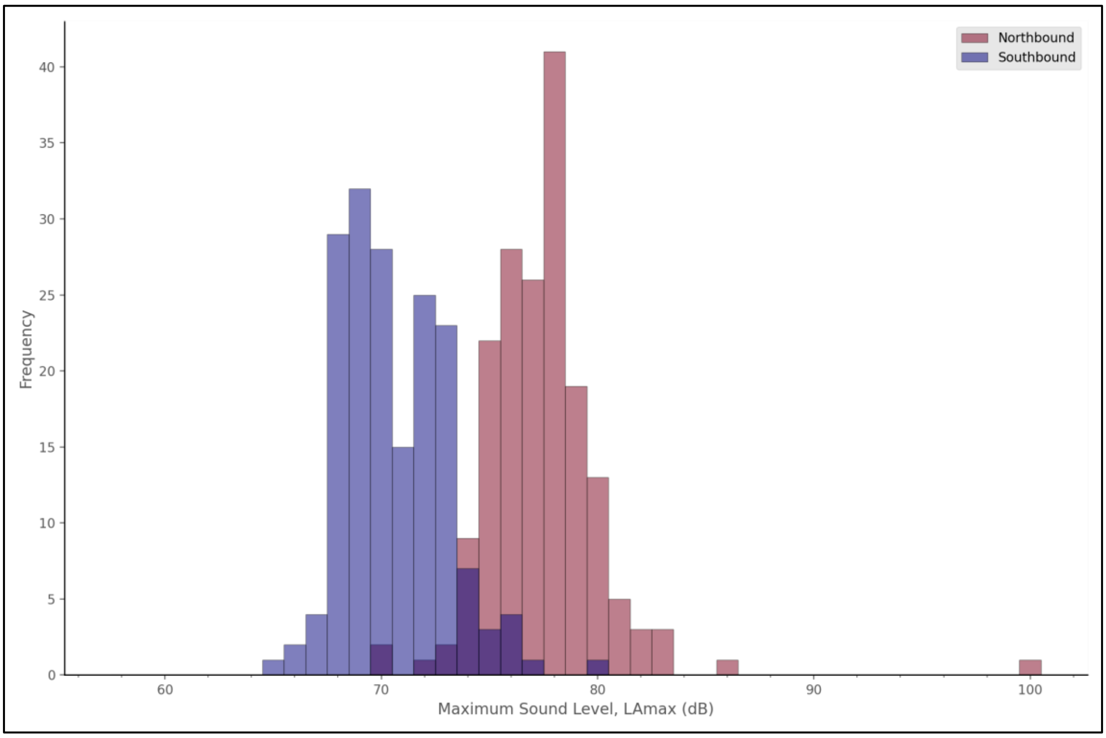
2.11 Table 2.3 gives a summary of the data shown in Figures 2.1 and 2.2.

Table 2.3: Summary of measured levels for trains measured at Woodbridge

Train Type	Range of L_{Amax} Levels (dB)	Modal L_{Amax} Value
Passenger	65 dB – 100 dB	78 dB
Non-Passenger	58 dB – 94 dB	77 dB

2.12 The bimodal distribution in passenger train measurements can be attributed to the direction of train travel. Figure 2.3 shows a histogram containing L_{Amax} levels separated by this.

Figure 2.3: Passenger Train L_{Amax} Values Separated by Direction of Travel at Woodbridge

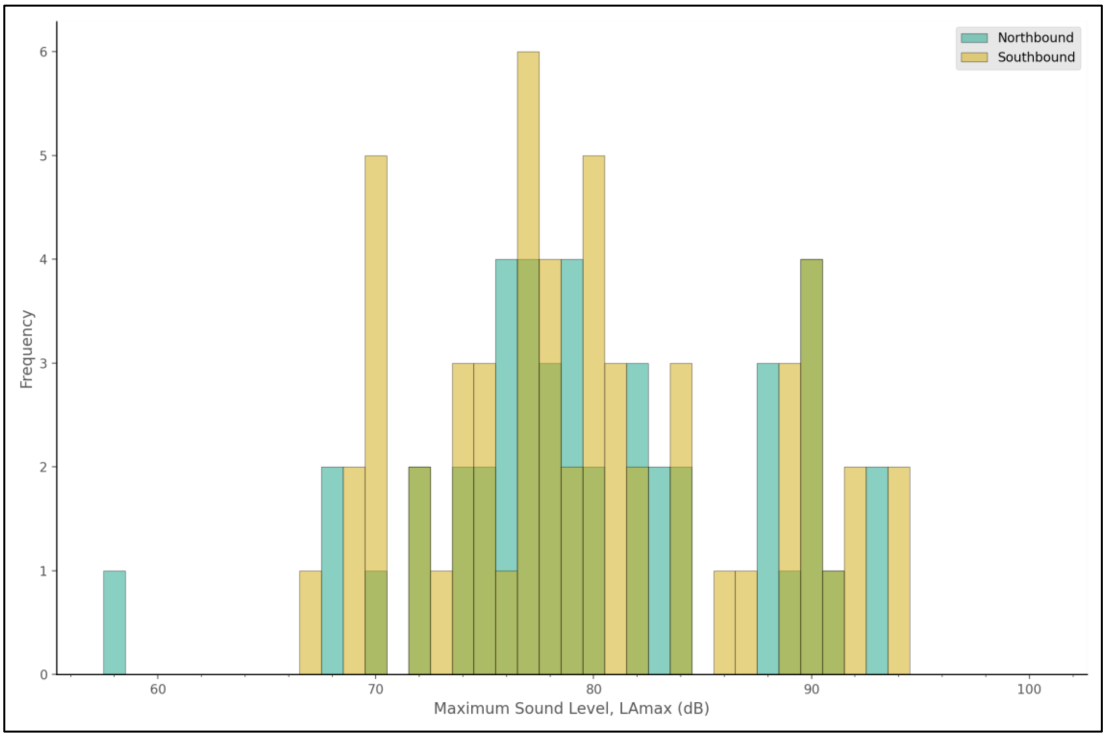


2.13 Woodbridge station is located south of the noise measurement position. As a result, trains travelling southbound are slowing into the station, while those travelling northbound are accelerating away from it. The higher sound levels recorded from northbound trains is due to the engine noise as the trains accelerate.

2.14 Figure 2.4 shows the same type of histogram, with sound levels separated by direction of travel for non-passenger trains.

2.15 Figure 2.4 shows that for non-passenger trains the measured levels are not generally attributed to direction of travel. This is likely because many non-passenger trains do not stop at Woodbridge station and therefore do not decelerate into or accelerate out of the station in the same way that passenger trains do.

Figure 2.4: Non-passenger Train L_{Amax} Values Separated by Direction of Travel at Woodbridge



2.16 In order to characterise the sound climate of the measurement location, the total number of 5-minute night time sample periods where different threshold levels are exceeded has been calculated. For each band, the lower level is inclusive while the upper level is exclusive, i.e. An L_{Amax} of 70 dB would fall into the 70-80 dB band.

2.17 Table 2.4 shows the total number of 5-minute exceedances for each band, as well as a count of the number which can be attributed to train passes. The L_{Amax} levels recorded have been normalised to 10m prior to calculating these numbers.

Table 2.4: Percentage of 5-minute exceedance events attributed to trains across entire 234-night survey

Band (L_{Amax}) at 10m	Number of Exceedance Events	Number Attributed to Trains	Percentage
60-70 dB	746	76	10%
70-80 dB	432	327	76%
80-90 dB	72	61	85%
90-100 dB	17	17	100%
100+ dB	1	1	100%

2.18 Table 2.4 shows that at the measurement position, L_{Amax} levels between 60-70 dB are common, with approximately 3 occurring per night. These are only attributed to trains 10% of the time. For levels greater than this, the proportion which are attributed to trains increases with the band levels. The majority of L_{Amax} levels greater than 70 dB in the area can be attributed to trains. Those that have not been attributed to trains are likely to have been caused by short engineering trains which are not recorded by RTT, aircrafts passing over the area, or by wildlife located very close to the microphone.

3.0 Analysis of Daytime Noise Results

3.1 As daytime noise levels due to trains is based on L_{eq} change, it is not necessary to examine the specific noise levels generated by different train types.

3.2 Table 3.1 shows the number of daytime trains recorded by RealTimeTrains to have passed through Woodbridge station between 4th March 2020 and the 31st October 2020. These are broken down by train type and month. Day is defined to be between 07:00-23:00.

Table 3.1: Number of Daytime Trains Recorded Passing Through Woodbridge Station from RealTimeTrains.

Month	Passenger		Non-Passenger
	Total	Average Per Day	Total
March	835	30*	1
April	853	28	5
May	848	27	6
June	875	29	4
July	937	30	19
August	922	30	18†
September	909	30	1
October	938	30	5
	7117		**65**

*This is an average taken for the 28-days between 4th March and 31st March 2020 (inclusive)

†6 Trains have been removed from this figure which were test trains for Sizewell and are not typical trains on the line.

3.3 Lower train totals recorded between March and June are likely a result of the Covid-19 pandemic and may not be representative of typical numbers of trains during these months.

4.0 Analysis of Night Time Vibration Results

4.1 Vibration Data was recorded with a sample rate of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing vibration levels over time.

4.2 As can be seen in Figure A2, the accelerometer of the vibration meter is placed at a distance of approximately 5m from the track edge. Measurements of vibration have not been normalised to 10m, as this is only possible if the ground conditions are precisely known. The X axis is orientated parallel to the train tracks while the Y axis is orientated perpendicular. The Z axis is aligned vertically.

4.3 Due to equipment failures, some nights between 4th August 2020 and 1st November 2020 have not been recorded. Table 3.1 gives a summary of date ranges where night time data was obtained and where it was not.

Table 4.1: Date ranges of recorded and not recorded noise data at Woodbridge

Night Time Vibration Data Recorded	Night Time Vibration Data Not Recorded
4th August 2020 – 16th August 2020	
	17th August 2020 – 1st September 2020
2nd September 2020 – 5th September 2020	
	6th September 2020 – 7th September 2020
8th September 2020 – 1st November 2020	

4.4 From Table 4.1 it can be calculated that vibration measurements have been taken for 72-night time periods. There have been 17-night time periods where data was not recorded.

4.5 Using Real Time Trains, as well as measurement of audio signals, the number of trains measured across these 72-night time periods can be calculated and broken down by train types. This is shown in Table 4.2 where figures have been broken down by month.

Table 4.2: Number of different train types measured during recorded night time periods at Woodbridge by month.

Month	Measured Nights	Type of Train and Total and Average Nightly Occurrence					
		Passenger		Non-Passenger		Unknown*	
		Total	Average	Total	Average	Total	Average
August	12	16	1.3	11	0.9	Not identifiable during these months as no audio signals	
September	29	42	1.4	11	0.4		
October	31	64	2.1	35	1.3	8	0.3

*Unknown train types are those identified via audio recordings, which has only been possible for the 31-night periods between 1st October 2020 and 1st November 2020.

4.6 Table 4.2 shows that passenger trains are the most common, with between 1.3 and 2.1 being measured per night depending on the month. Non-Passenger trains ranged in average occurrence from 0.4 to 1.3 per night, or roughly from one train every three nights to one train per night, whilst measurements were being taken.

PPV Measurements

4.7 As described in paragraph 1.4, the measurement position of the vibration meter pickup was moved from within a hole to the ground surface on the 1st October. Results from before and after this change have been separated in the following figures. August and September measurements represent those taken with the vibration pickup below surface level, and October measurements represent those taken with the vibration pickup at surface level.

4.8 Figures 4.1, 4.2 and 4.3 shows histograms of the measured PPV values in each axis for passenger trains, this allows the range of measured values, as well as the respective frequency of each PPV interval to be shown. The size of the bins in each Histogram has been set to 0.25mm/s and the X-axis limit have been set to the same for each figure to allow comparison between axes.

Figure 4.1: Histogram showing the Frequency of PPV measurements in the X-axis for passenger trains.

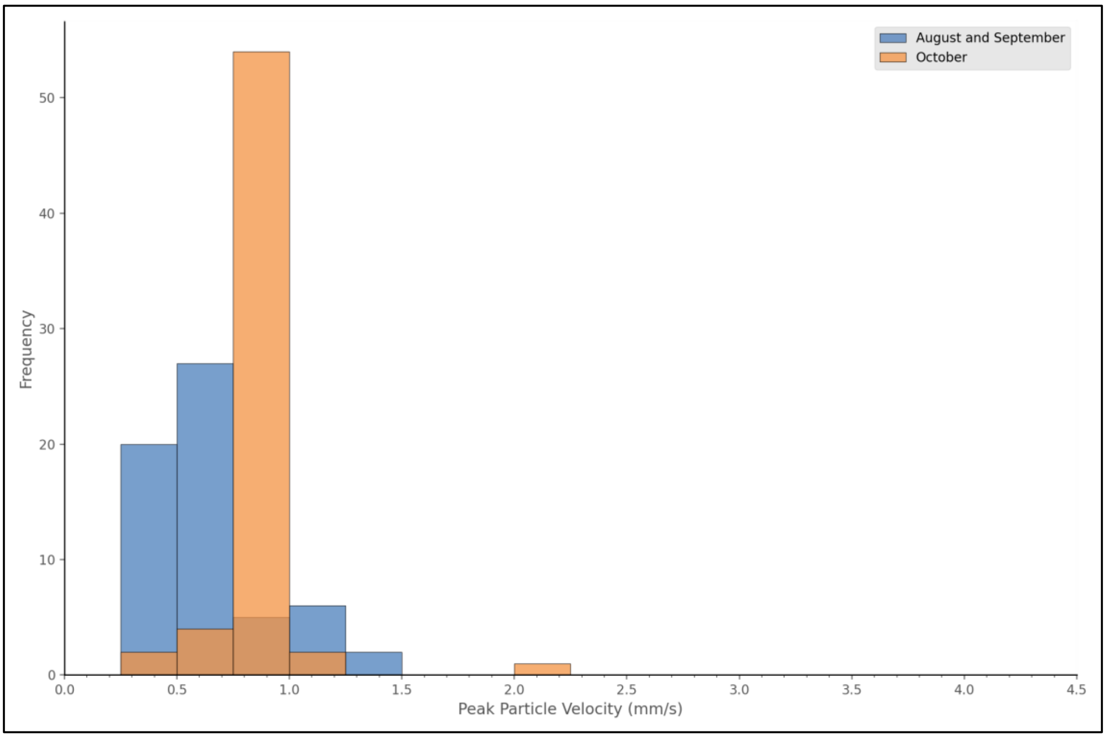


Figure 4.2: Histogram showing the Frequency of PPV measurements in the Y-axis for passenger trains

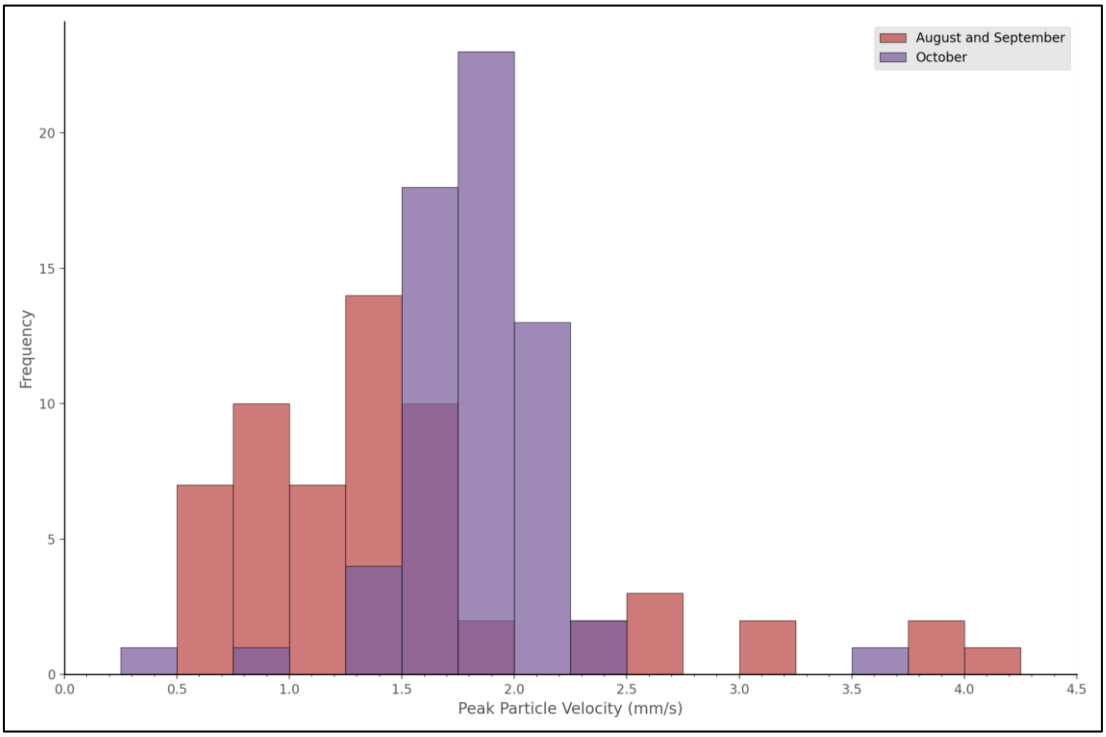
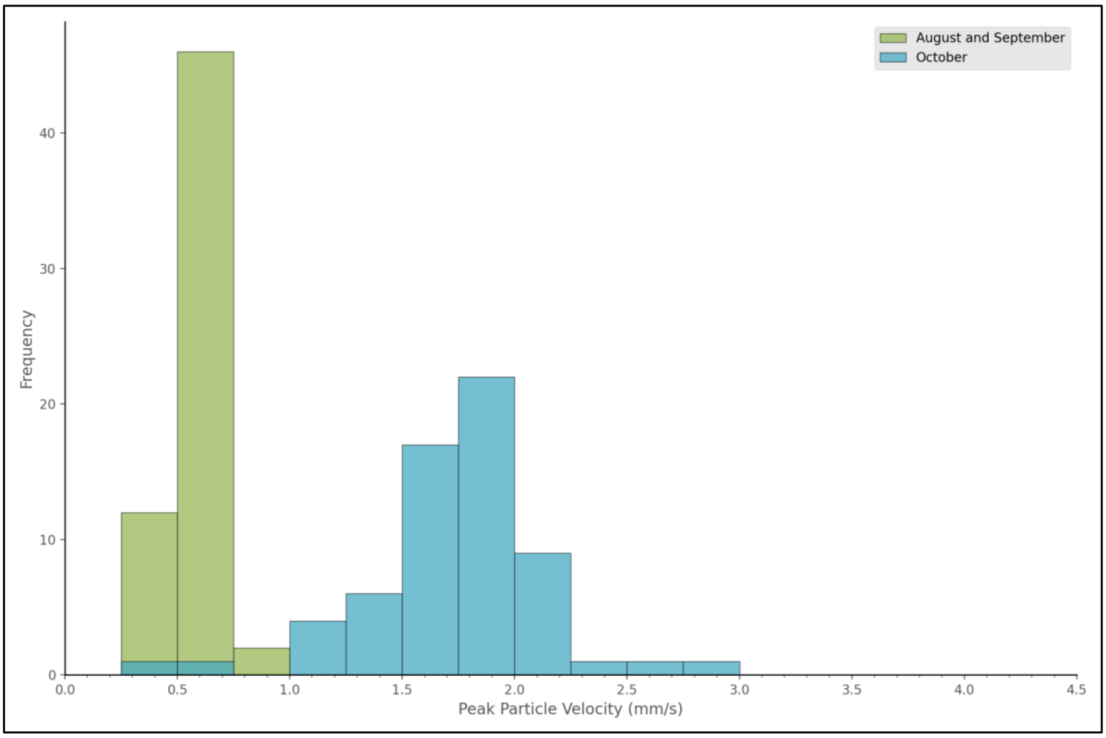


Figure 4.3: Histogram showing the Frequency of PPV measurements in the Z-axis for passenger trains



4.9 Comparison of these histograms shows that for passenger trains measured with the accelerometer placed below surface level, values in the Y-axis are typically higher than those in the X and Z axes. This axis represents vibrations from passenger trains with a direction perpendicular to that of travel.

4.10 PPV values measured below surface level in the X and Z axes tend to be more consistent and are considerably less spread than those in the Y axis.

4.11 For measurements taken on surface soil, PPV values in the X and Y axes due to passenger trains are similar, although slightly higher, to those measured below surface level. However, in the Z-axis, vibration taken levels on the surface are significantly higher than those recorded below surface level. Levels in this axis are also more widespread for measurements taken at surface level.

4.12 Figures 4.4, 4.5 and 4.6 shows histograms of the measured PPV values in each axis for non-passenger trains:

Figure 4.4: Histogram showing the Frequency of PPV measurements in the X-axis for non-passenger trains.

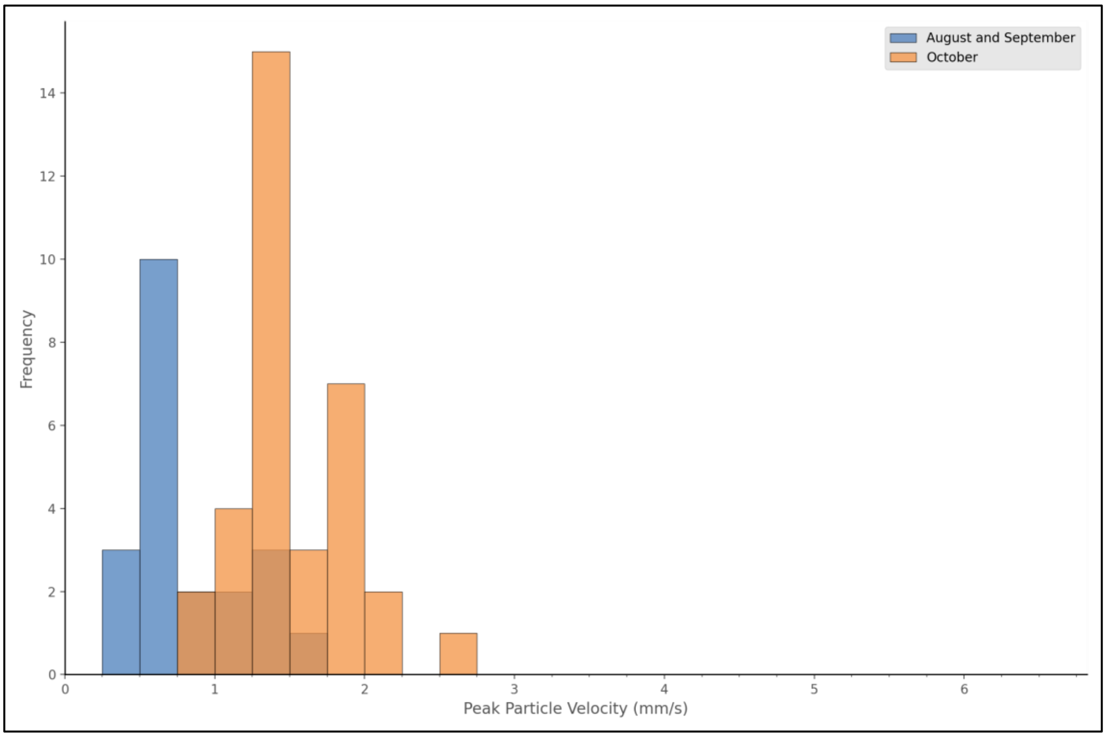


Figure 4.5: Histogram showing the Frequency of PPV measurements in the Y-axis for non-passenger trains.

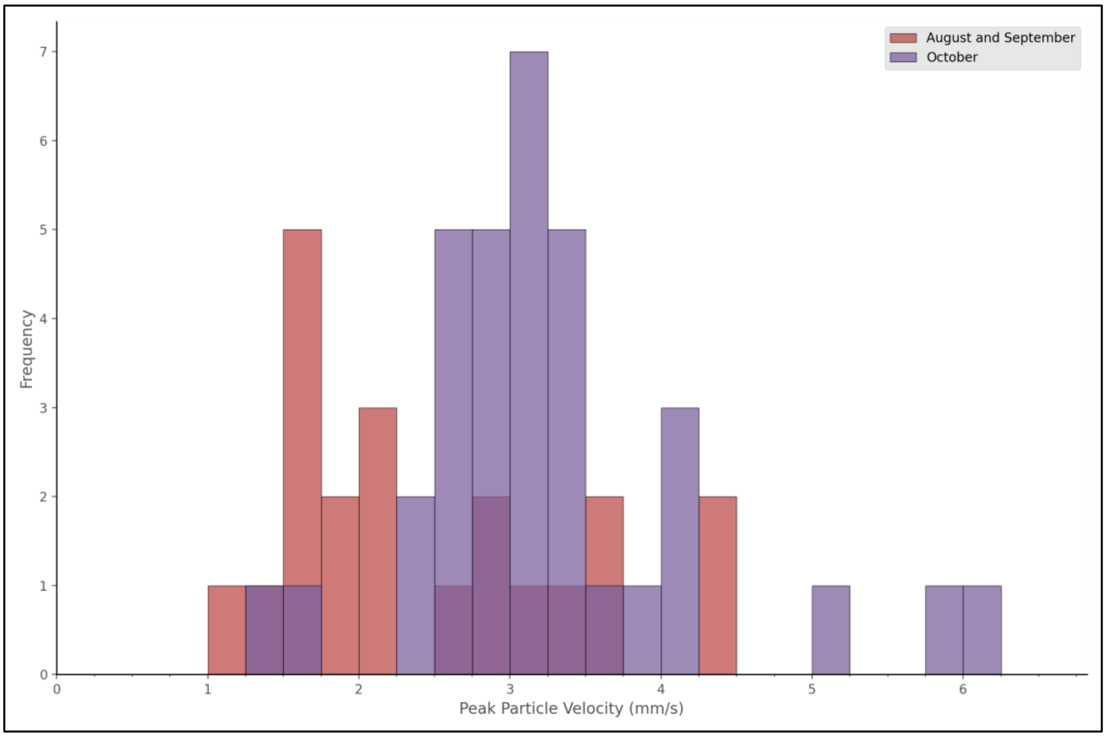
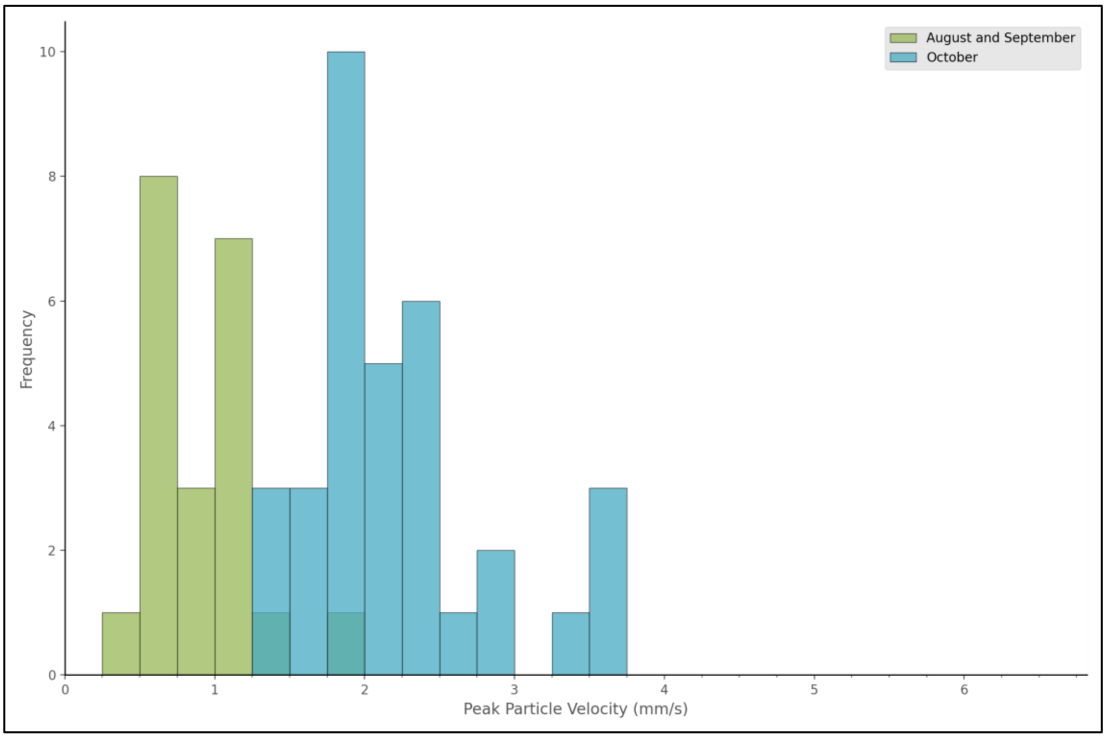


Figure 4.6: Histogram showing the Frequency of PPV measurements in the Z-axis for non-passenger trains measured with vibration pickup below surface level.



4.13 From Figures 4.4, 4.5 and 4.6 in all axes, PPV values due to non-passenger trains are higher than those measured for passenger trains.

4.14 Similarly to passenger trains, measurements taken with the vibration pickup on surface soil were higher than those taken below surface level. This difference is most prominent in the Z-axis.

4.15 Results for PPV, measured at 5m, are summarised in Table 4.3:

Table 4.3: Total measured PPV ranges and modal PPV ranges for passenger and non-passenger trains.

Train Type	Range of PPV Levels (mm/s)			Modal PPV Range (mm/s)		
	X	Y	Z	X	Y	Z
August and September						
Passenger	0.25-1.50	0.50-4.25	0.25-1.00	0.50-0.75	1.25-1.50	0.50-0.75
Non-Passenger	0.25-1.75	1.00-4.50	0.50-2.00	0.50-0.75	1.50-1.75	0.50-0.75
October						
Passenger	0.50-2.25	0.25-3.75	0.25-3.00	0.75-1.00	1.75-2.00	1.75-2.00
Non-Passenger	0.75-2.75	1.25-6.25	1.25-3.75	1.25-1.50	3.00-3.25	1.75-2.00

Vibration Dose Value (VDV) Measurements

4.16 For each measured night period, the total vibration dose value (VDV) measured at 5m was calculated. This has then been compared with the number of trains recorded to have passed the measurement position per night and presented in Figures 4.7 and 4.8, which are separated to reflect changes in vibration pickup position.

Figure 4.7: VDV against Number of Trains for All Measured Night Periods in August and September

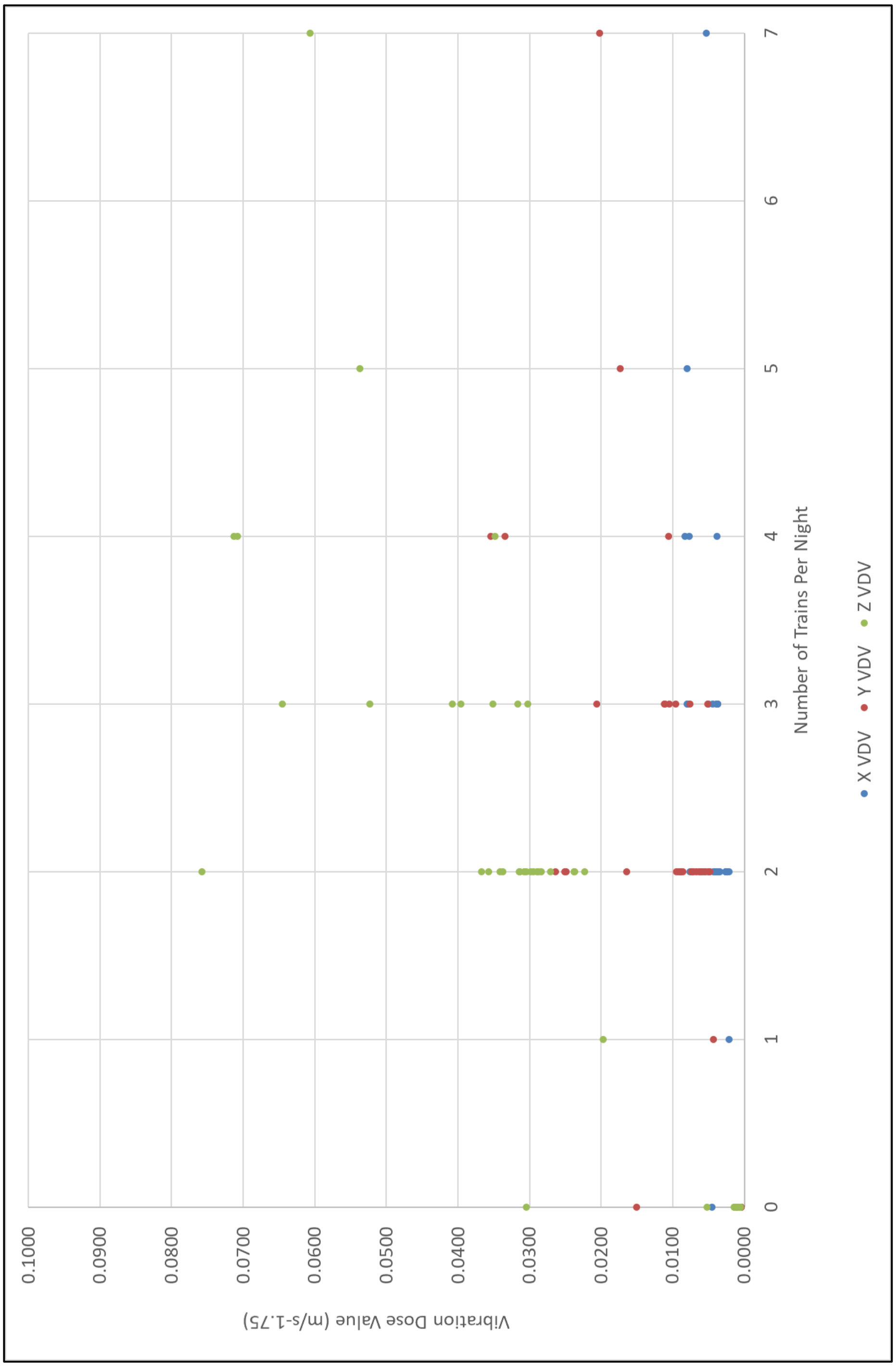
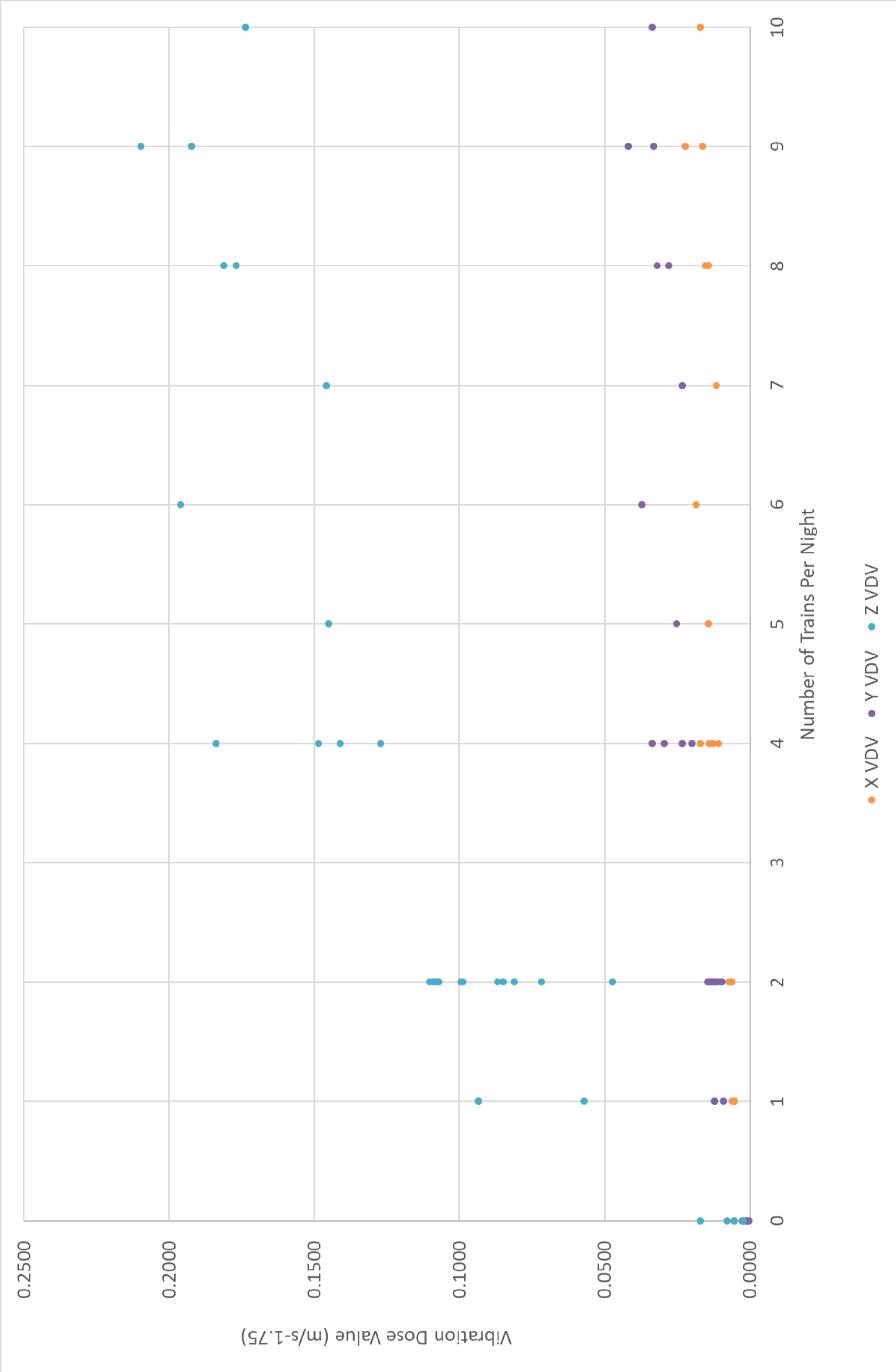


Figure 4.8: VDV against Number of Trains for All Measured Night Periods in October



4.17 VDV values measured in August and September are significantly lower than those measured in October. Across the entire measurement period however, VDVs are generally highest in the Z axis, and lowest in the X axis.

4.18 Weak trends can be seen in both figures for all axes however due to there being a relatively low number of data points, outliers are not always obvious. Trends in the data can generally be seen to follow that of a $y = x^{0.25}$ equation, which is expected as VDV is summed using the following equation:

$$VDV_{Total} = \left(VDV_1^4 + VDV_2^4 + \cdots + VDV_n^4\right)^{0.25}$$

4.19 Table 4.4 summarises the Vibration Dose values measured and gives a typical nightly value for each axis, derived from the arithmetic average.

Table 4.4: Summary of VDV Measurements by axis and month measured at 5m.

Month	VDV Range ($m/s^{-1.75}$)			Typical VDV ($m/s^{-1.75}$)		
	X	Y	Z	X	Y	Z
August	0.0012-0.0089	0.0012-0.0354	0.0012-0.0758	0.0056	0.0179	0.0409
September	0.0005-0.0080	0.0005-0.0206	0.0005-0.0646	0.0031	0.0070	0.0264
October	0.0006-0.0222	0.0005-0.0419	0.0024-0.2096	0.0094	0.0177	0.1100

5.0 Conclusion

5.1 For sound level measurements, passenger trains were recorded to pass the measurement position with an average frequency of 1.3-2.1 times per night, depending on month. L_{Amax} levels for these, normalised to 10m, were measured to be between 66dB-100dB, with 78dB being the modal L_{Amax} value.

5.2 Non-passenger trains were recorded to pass the measurement position with an average frequency of 0.1-1.3 times per night depending on month. These ranged in L_{Amax} from 58dB-94dB, with 77dB being the modal L_{Amax} value.

5.3 The distribution of noise measurements for passenger trains have been found to be bimodal, with this being attributed to direction of travel, with higher levels generally being recorded from trains travelling northbound (accelerating out of Woodbridge station). L_{Amax} levels from non-passenger trains have been shown to have no correlation with direction of travel, likely due to the fact that most pass-through Woodbridge station without stopping, and therefore do not accelerate or decelerate out of or into the station.

5.4 60-70dB $L_{Amax,5\ min}$ events have been shown to be common at the measurement interval, with many not being linked to trains. The majority of levels exceeding 70 dB in the area have been attributed to trains.

5.5 Vibration measurements measured at 5m have been shown in terms of PPV, with the Y axis generally measuring the highest levels of this parameter. Non-passenger trains have generally had higher PPV values measured in all axes during passes than passenger trains.

5.6 The location of the vibration pickup highly influenced measurements of both PPV and VDV, with measurements taken at surface level measuring higher than those taken 30cm below surface level.

5.7 The number of train passes in a night have been compared to vibration dose values measured at 5m, with trends being identified. Vibration dose values in all three axes have ranged in magnitude from approximately 0.0005 $m/s^{-1.75}$ to 0.2096 $m/s^{-1.75}$ depending on the number of trains in a night, the axis, and the position of the vibration pickup.

Appendix A

Plans Showing Monitoring Locations

Figure A1: Plan Showing Noise Monitoring Location

Figure A2: Plan Showing Vibration Monitoring Location

Appendix B

Monthly Noise Reports

SHARPS REDMORE

ACOUSTIC CONSULTANTS · Established 1990

Report

Project
EDF – Sizewell C Power Station: Woodbridge Rail noise survey monthly report

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Date 30th April 2020
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Contents

Appendices

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of noise levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing noise climate at night to assist with understanding the context in which the proposed additional rail movements at night would need to be considered.

1.2 The survey work began on 4th March 2020. A Type 1 sound level meter was installed at the location shown in Figure A1 in Appendix A. The microphone is in a free field location approximately 5 metres from the rail line at a height of 1.8m above ground. The meter is regularly serviced and a calibration check carried out.

1.3 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

1.4 Levels have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line and using a combination of this information and an analysis of the measured levels, results have been interpreted to provide a summary of levels and the likely source which has resulted in those levels, where this is possible to determine.

1.5 Results (LAeq and LAmax values) are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

1.6 This revision has been provided as full RTT data for the entire month was provided in September 2020. This allowed for more complete analysis of the measured results to be carried out. Screenshots of the website have been replaced with tabulated data for night time train movements during the month in Appendix C.

2.0 Analysis of survey results

2.1 Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 Raw data for night time in 5-minute periods has been provided in Appendix B.

2.3 Table 2.1 shows the $L_{Aeq,\ 8\text{-hour}}$ values and range of $L_{Amax,\ 5\ min}$ values measured throughout night time periods in March. Night is defined to be between 23:00-07:00 hours.

Table 2.1: Night time $L_{Aeq,\ 8\text{-hour}}$ values and $L_{Amax,\ 5\ min}$ ranges in March*

Date	Day	$L_{Aeq,\ 8\ hours}$	$L_{Amax,\ 5\ Min}$ Range	
			Min	Max
04/03/2020	Wednesday	44	32	83
05/03/2020	Thursday	59	37	99
06/03/2020	Friday	43	36	74
07/03/2020	Saturday	46	47	67
08/03/2020	Sunday	46	32	81
09/03/2020	Monday	47	39	84
10/03/2020	Tuesday	49	33	83
11/03/2020	Wednesday	50	49	84
12/03/2020	Thursday	47	45	85
13/03/2020	Friday	43	32	66
14/03/2020	Saturday	44	42	72
15/03/2020	Sunday	47	33	86
16/03/2020	Monday	45	34	81
17/03/2020	Tuesday	47	36	87
18/03/2020	Wednesday	51	32	84
19/03/2020	Thursday	46	34	84
20/03/2020	Friday	42	37	65
21/03/2020	Saturday	43	35	72
22/03/2020	Sunday	47	34	84
23/03/2020	Monday	47	34	82
24/03/2020	Tuesday	46	29	81
25/03/2020	Wednesday	47	30	82
26/03/2020	Thursday	47	30	81
27/03/2020	Friday	43	34	68
28/03/2020	Saturday	44	40	63
29/03/2020	Sunday	49	30	84
30/03/2020	Monday	49	29	83
31/03/2020	Tuesday	50	28	84

***Dates signify the date at the start of the night time period (I.e. 04/03/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.4 $L_{Aeq, 8\text{-hour}}$ values ranged from 42 dB to 59 dB throughout the month. Both the arithmetic and modal average $L_{Aeq, 8\text{-hour}}$ value for night time periods throughout the month was 47 dB.

2.5 An L_{Amax} level of 99 dB was measured during the night of the 5th of March. Analysis of one second sound level data indicates that this was likely due to a vehicle pass.

2.6 For each night in March, the number of times that L_{Amax} values exceeded 60 dB, 70 dB, 80 dB, 90 dB and 100 dB has been determined. Note that each exceedance event only falls into a single category, for example, an L_{Amax} level of 74 dB only falls into the 70 dB category, and not the 60 dB category.

2.7 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Tabulated logs of train movements through Woodbridge station, provided by www.realtimetrains.co.uk, are shown in Appendix C.

2.8 Table 2.2 shows the number of L_{Amax} exceedance events for each night. On these days the number of L_{Amax} events attributed to train movements is shown in brackets for each category.

Table 2.2: L_{Amax} exceedance events throughout March, and number of those attributed to train movements.

Date	Day	Level Exceedences (Attributed to Trains)				
		60 dB	70 dB	80 dB	90 dB	100 dB
04/03/2020	Wednesday	8 (0)	0 (0)	1 (1)	0 (0)	0 (0)
05/03/2020	Thursday	14 (0)	2 (2)	2 (2)	1 (1)	0 (0)
06/03/2020	Friday	13 (0)	1 (0)	0 (0)	0 (0)	0 (0)
07/03/2020	Saturday	29 (0)	0 (0)	0 (0)	0 (0)	0 (0)
08/03/2020	Sunday	11 (0)	2 (1)	2 (1)	0 (0)	0 (0)
09/03/2020	Monday	21 (0)	0 (0)	2 (2)	0 (0)	0 (0)
10/03/2020	Tuesday	11 (0)	7 (0)	2 (2)	0 (0)	0 (0)
11/03/2020	Wednesday	40 (0)	2 (1)	1 (1)	0 (0)	0 (0)
12/03/2020	Thursday	22 (0)	2 (1)	1 (1)	0 (0)	0 (0)
13/03/2020	Friday	14 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14/03/2020	Saturday	9 (0)	1 (0)	0 (0)	0 (0)	0 (0)
15/03/2020	Sunday	13 (0)	1 (1)	1 (1)	0 (0)	0 (0)
16/03/2020	Monday	9 (0)	1 (1)	1 (1)	0 (0)	0 (0)
17/03/2020	Tuesday	10 (0)	3 (1)	1 (1)	0 (0)	0 (0)
18/03/2020	Wednesday	12 (0)	4 (1)	1 (1)	0 (0)	0 (0)
19/03/2020	Thursday	12 (0)	2 (2)	1 (1)	0 (0)	0 (0)
20/03/2020	Friday	8 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21/03/2020	Saturday	14 (0)	1 (0)	0 (0)	0 (0)	0 (0)
22/03/2020	Sunday	14 (0)	3 (1)	1 (1)	0 (0)	0 (0)
23/03/2020	Monday	13 (0)	4 (2)	1 (1)	0 (0)	0 (0)
24/03/2020	Tuesday	5 (0)	1 (1)	1 (1)	0 (0)	0 (0)
25/03/2020	Wednesday	4 (0)	4 (2)	1 (1)	0 (0)	0 (0)
26/03/2020	Thursday	5 (0)	5 (4)	1 (1)	0 (0)	0 (0)
27/03/2020	Friday	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)
28/03/2020	Saturday	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
29/03/2020	Sunday	1 (0)	1 (1)	3 (3)	0 (0)	0 (0)
30/03/2020	Monday	5 (0)	2 (1)	3 (3)	0 (0)	0 (0)
31/03/2020	Tuesday	6 (0)	3 (1)	4 (4)	0 (0)	0 (0)
Total Exceedance Events		**330**	**52**	**31**	**1**	**0**

2.9 Table 2 shows that $L_{Amax,\ 5\ min}$ levels between 60-70 dB at the measurement point are common, with an arithmetic average of 12 per night. Exceedance events become increasingly rare as bands levels increase. There were no events where levels exceeded 100 dB during the month.

2.10 From Table 2, the percentage of exceedance events attributed to trains can be calculated for each band. These have been calculated for dates where RTT data was available. These are shown in Table 2.3.

Table 2.3: Percentage of exceedance events attributed to trains in March

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60 dB	330	0	0%
70 dB	52	24	46%
80 dB	31	30	97%
90 dB	1	0	0%

2.11 Table 2.3 shows that whilst common, no measured L_{Amax} levels between 60-70 dB were due to train passes in March. 46% of all L_{Amax} levels between 70-80 dB were attributed to trains whilst almost every exceedance of 80 dB was due to a train pass.

2.12 The noise sources causing the remaining exceedance events are unknown, however analysis of the one second traces from the sound level meter indicates that these are likely to have been caused by birds and other wildlife, or may have been due to occasional short engineering trains passing up and down the railway which are not recorded by RTT.

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing noise monitoring location

Appendix B

Graphs of Survey Results

Figure B1: 5-minute data from the 4th-8th of March 2020 – maximum levels from trains highlighted as red dots

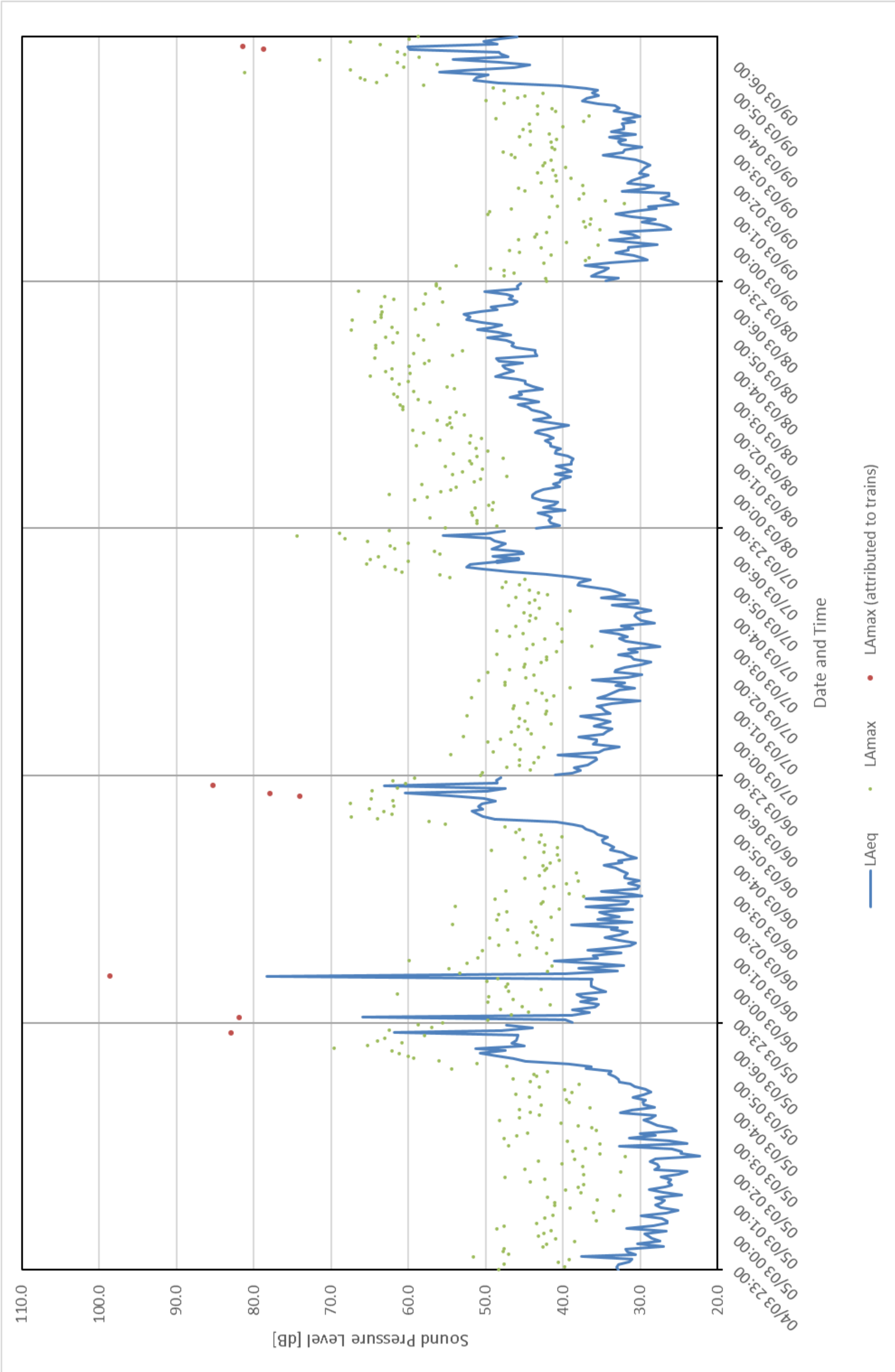


Figure B2: 5-minute data from the 9th-16th of March 2020 – maximum levels from trains highlighted as red dots

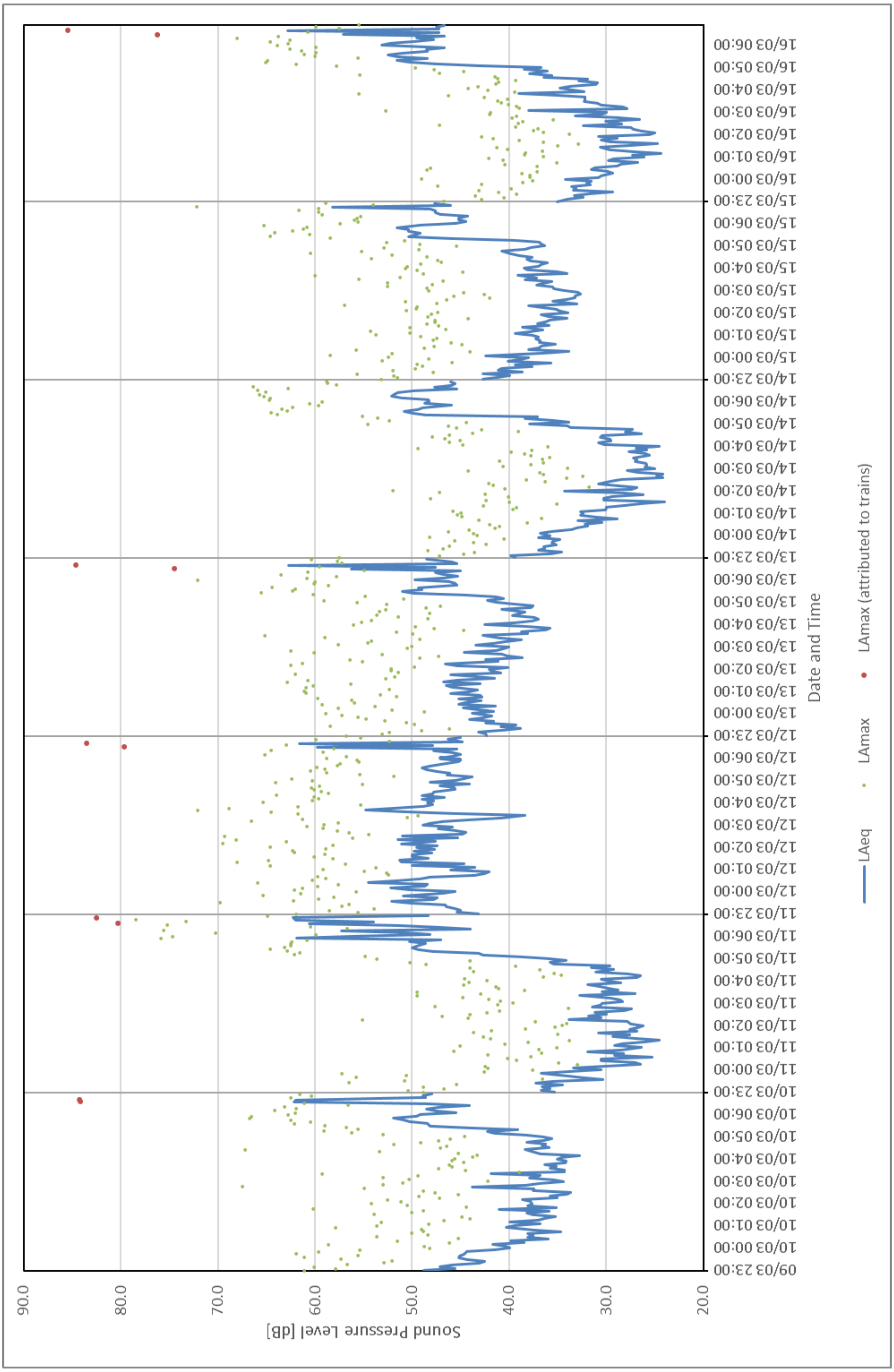


Figure B3: 5-minute data from the 16th-23rd of March 2020 – maximum levels from trains highlighted as red dots

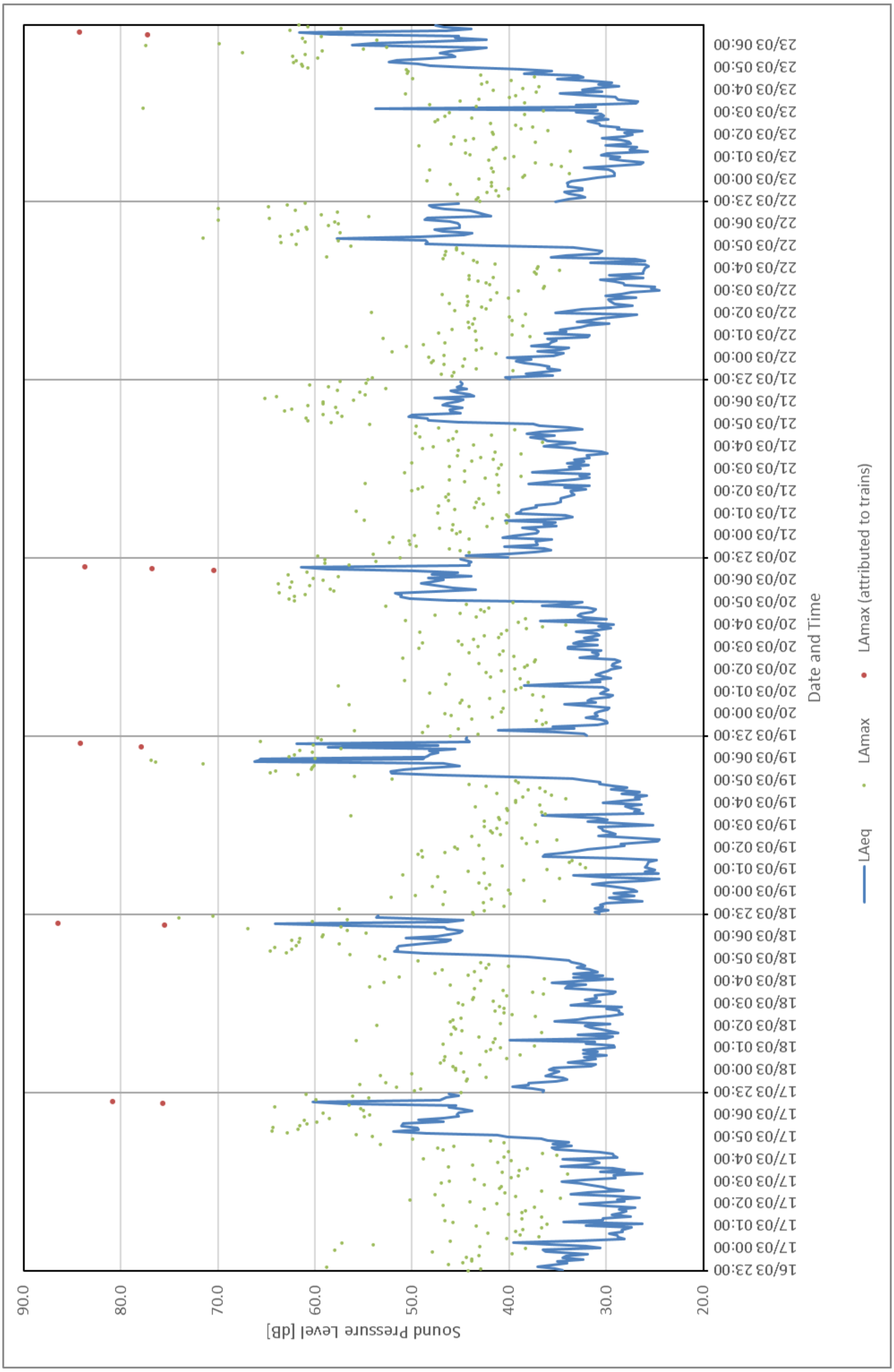


Figure B4: 5-minute data from the 23rd-30th of March 2020 – maximum levels from trains highlighted as red dots. Note: missing 29/03-01:00 due to British Summer Time.

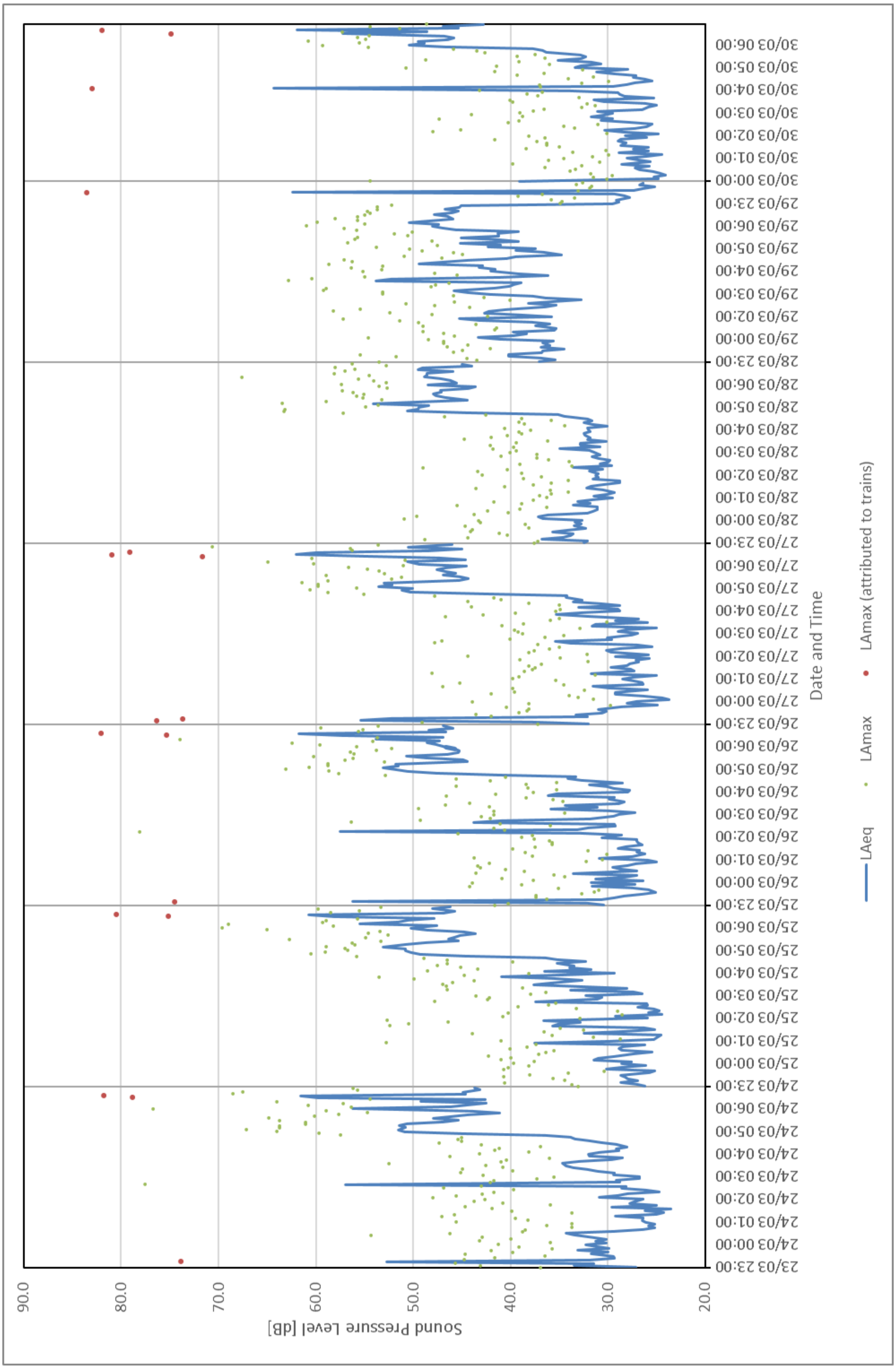
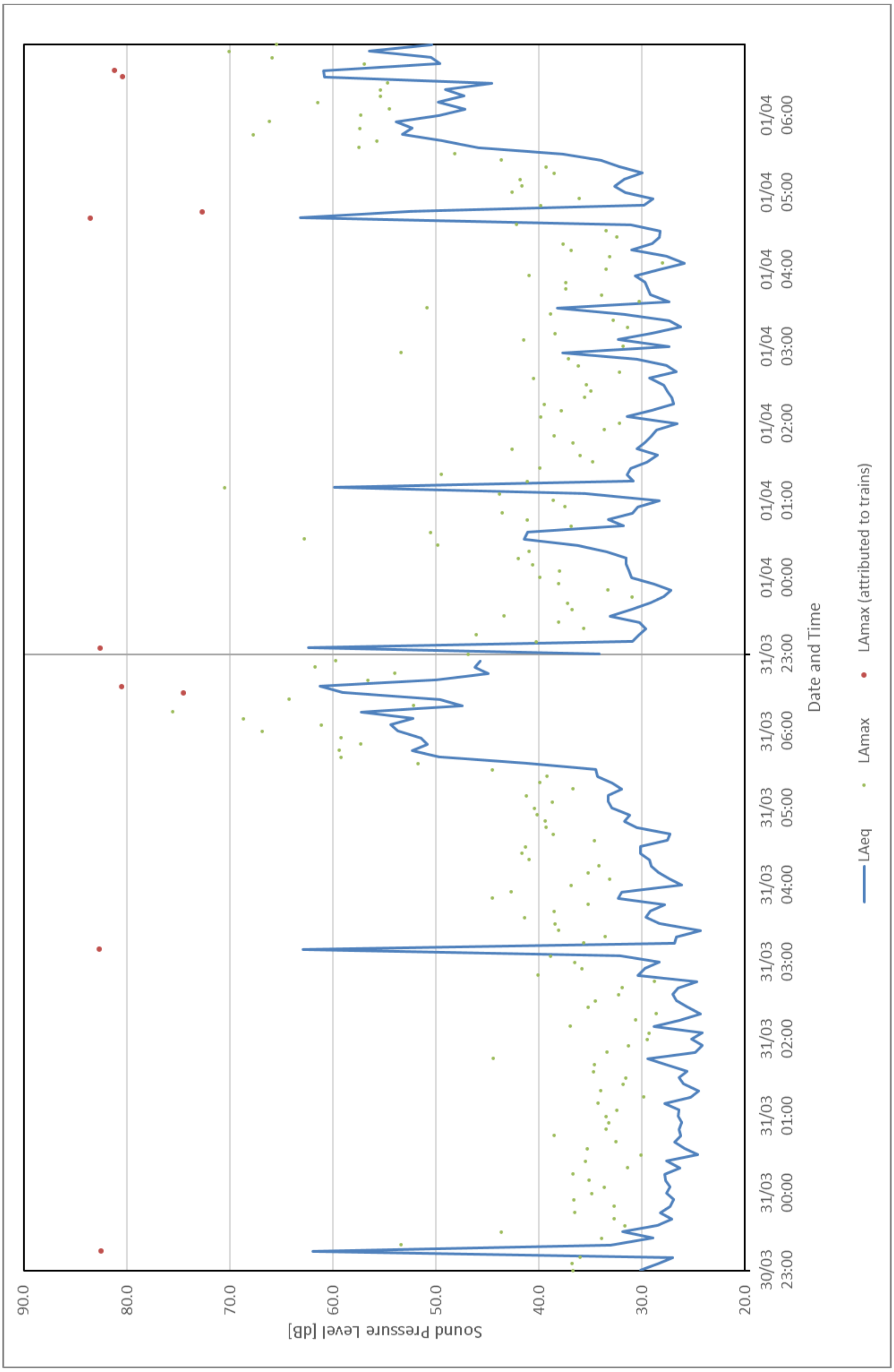


Figure B5: 5-minute data from the 30th March 2020 -1st of April 2020 – maximum levels from trains highlighted as red dots.



Appendix C

Real Time Trains data

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-03-04	06:32:00			LE
2020-03-04	06:55:17	06:56:11		LE
2020-03-05	06:36:55	06:39:42		LE
2020-03-05			23:13:18	ZZ
2020-03-06			00:29:39	ZZ
2020-03-06	06:31:28	06:33:42		LE
2020-03-06	06:36:53	06:38:29		LE
2020-03-09	06:36:17	06:36:56		LE
2020-03-09	06:35:08	06:37:06		LE
2020-03-10	06:37:56	06:38:48		LE
2020-03-11	06:51:13	06:51:49		LE
2020-03-11	06:35:21	06:52:02		LE
2020-03-12	06:33:01	06:35:07		LE
2020-03-12	06:35:52	06:38:01		LE
2020-03-13	06:33:31	06:34:50		LE
2020-03-13	06:38:33	06:40:00		LE
2020-03-16	06:33:35	06:35:08		LE
2020-03-16	06:41:24	06:42:23		LE
2020-03-17	06:33:15	06:35:06		LE
2020-03-17	06:35:47	06:37:25		LE
2020-03-18	06:32:25	06:34:33		LE
2020-03-18	06:35:17	06:36:57		LE
2020-03-19	06:33:10	06:35:14		LE
2020-03-19	06:37:00	06:38:05		LE
2020-03-20	06:32:45	06:34:53		LE
2020-03-20	06:35:35	06:37:12		LE
2020-03-23	06:32:19	06:34:36		LE
2020-03-23	06:34:43	06:37:51		LE
2020-03-23	23:20:00			ZZ
2020-03-24	06:32:43	06:34:52		LE
2020-03-24	06:34:30	06:36:37		LE
2020-03-25	06:33:05	06:35:11		LE
2020-03-25	06:35:18	06:36:55		LE
2020-03-25	23:15:00			ZZ
2020-03-26	06:33:16	06:35:27		LE
2020-03-26	06:34:45	06:35:55		LE
2020-03-26			23:17:22	ZZ
2020-03-27	06:34:35	06:35:07		LE
2020-03-27	06:35:10	06:36:56		LE
2020-03-29			23:12:43	ZZ
2020-03-30			04:07:19	ZZ
2020-03-30	06:34:29	06:35:02		LE
2020-03-30	06:41:02	06:42:53		LE
2020-03-31	03:13:31	23:15:03	01:14:17	ZZ
2020-03-31			03:13:35	ZZ
2020-03-31	06:33:22	06:35:16		LE

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-03-31	06:35:04	06:36:42		LE
2020-03-31	22:47:57*	23:01:47		ZZ
2020-04-01			04:47:14	ZZ
2020-04-01	06:34:45	06:35:28		LE
2020-04-01	06:35:26	06:37:33		LE

*Note this time falls outside of the defined night time period of 23:00-07:00, however is the time which the train is recorded to have arrived, departed or passed through Woodbridge Railway Station. This train passed the measurement location further down the track shortly after 23:00.

SHARPS REDMORE

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Report

Project
EDF – Sizewell C Power Station: Woodbridge Rail noise survey monthly report – April 2020

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Date 5th May 2020
Rev Date 19th October 2020

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Contents

Appendices

A. Plan showing noise monitoring location

B. Graphs of Survey Results

C. Real Time Train information

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of noise levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing noise climate at night to assist with understanding the context in which the proposed additional rail movements at night would need to be considered.

1.2 The survey work began on 4th March 2020. A Type 1 sound level meter was installed at the location shown in Figure A1 in Appendix A. The microphone is in a free field location approximately 5 metres from the rail line at a height of 1.8m above ground. The meter is regularly serviced and a calibration check carried out.

1.3 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

1.4 Levels have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line and using a combination of this information and an analysis of the measured levels, results have been interpreted to provide a summary of levels and the likely source which has resulted in those levels, where this is possible to determine.

1.5 Results (L_{Aeq} and L_{Amax} values) are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

1.6 This revision is necessary as full RTT data for the entire month was provided in September 2020. This has allowed for more complete analysis of the measured results to be carried out. Screenshots of the website have been replaced with tabulated data for night time train movements during the month in Appendix C.

2.0 Analysis of survey results

2.1 Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 Raw data for night time in 5-minute periods has been provided in Appendix B.

2.3 Table 2.1 shows the $L_{Aeq, 8\text{-hour}}$ values and range of L_{Amax} values measured throughout night time periods in April. Night is defined to be between 23:00-07:00 hours. No data was recorded for the nights of 25th to 31st due to an instrument fault, which was found and repaired on 4th May.

Table 2.1: Night time $L_{Aeq, 8\text{-hour}}$ values and L_{Amax} ranges in April*

Date	Day	$L_{Aeq, 8\ hours}$	$L_{AMax, 5\ Min}$ Range	
			Min	Max
01/04/2020	Wednesday	48	33	86
02/04/2020	Thursday	46	32	85
03/04/2020	Friday	42	34	69
04/04/2020	Saturday	43	33	75
05/04/2020	Sunday	47	33	86
06/04/2020	Monday	52	35	90
07/04/2020	Tuesday	51	33	90
08/04/2020	Wednesday	55	29	90
09/04/2020	Thursday	44	30	69
10/04/2020	Friday	42	33	71
11/04/2020	Saturday	46	30	86
12/04/2020	Sunday	51	40	89
13/04/2020	Monday	46	28	85
14/04/2020	Tuesday	46	31	83
15/04/2020	Wednesday	47	31	85
16/04/2020	Thursday	48	36	84
17/04/2020	Friday	45	34	83
18/04/2020	Saturday	43	28	83
19/04/2020	Sunday	46	33	84
20/04/2020	Monday	47	37	86
21/04/2020	Tuesday	49	35	82
22/04/2020	Wednesday	50	36	88
23/04/2020	Thursday	48	29	84
24/04/2020	Friday	48	30	76

***Dates signify the date at the start of the night time period (I.e. 01/04/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.4 $L_{Aeq, 8\text{-hour}}$ values ranged from 42 dB to 55 dB throughout the month. The arithmetic average $L_{Aeq, 8\text{-hour}}$ value for night time periods throughout the month was 47 dB.

2.5 For each night in April, the number of times that L_{Amax} values exceeded 60 dB, 70 dB, 80 dB, 90 dB and 100 dB has been determined. Note that each exceedance event only falls into a single category, for example, an L_{Amax} level of 74 dB only falls into the 70 dB category, and not the 60 dB category.

2.6 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Tabulated logs of night time train movements through Woodbridge station, provided by www.realtimetrains.co.uk, are shown in Appendix C.

2.7 Table 2.2 shows the number of L_{Amax} exceedance events for each night. On these days the number of L_{Amax} events attributed to train movements is shown in brackets for each category.

Table 2.2: L_{Amax} exceedance events throughout April, and number of those attributed to train movements.

Date	Day	Level Exceedences (Attributed to Trains)				
		60dB	70dB	80dB	90dB	100dB
01/04/2020	Wednesday	10 (1)	1 (1)	2 (2)	0 (0)	0 (0)
02/04/2020	Thursday	7 (0)	2 (2)	2 (2)	0 (0)	0 (0)
03/04/2020	Friday	7 (0)	0 (0)	0 (0)	0 (0)	0 (0)
04/04/2020	Saturday	10 (0)	1 (0)	0 (0)	0 (0)	0 (0)
05/04/2020	Sunday	8 (0)	1 (1)	1 (1)	0 (0)	0 (0)
06/04/2020	Monday	10 (0)	2 (1)	4 (4)	0 (0)	0 (0)
07/04/2020	Tuesday	7 (0)	2 (1)	2 (2)	0 (0)	0 (0)
08/04/2020	Wednesday	10 (0)	2 (1)	4 (4)	0 (0)	0 (0)
09/04/2020	Thursday	15 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10/04/2020	Friday	10 (0)	2 (0)	0 (0)	0 (0)	0 (0)
11/04/2020	Saturday	13 (0)	0 (0)	1 (1)	0 (0)	0 (0)
12/04/2020	Sunday	10 (0)	5 (4)	2 (2)	0 (0)	0 (0)
13/04/2020	Monday	6 (0)	1 (1)	1 (1)	0 (0)	0 (0)
14/04/2020	Tuesday	7 (0)	3 (2)	1 (1)	0 (0)	0 (0)
15/04/2020	Wednesday	12 (0)	2 (1)	2 (1)	0 (0)	0 (0)
16/04/2020	Thursday	9 (0)	5 (1)	2 (1)	0 (0)	0 (0)
17/04/2020	Friday	11 (0)	1 (0)	2 (0)	0 (0)	0 (0)
18/04/2020	Saturday	10 (0)	1 (0)	1 (0)	0 (0)	0 (0)
19/04/2020	Sunday	7 (0)	2 (1)	1 (1)	0 (0)	0 (0)
20/04/2020	Monday	9 (0)	2 (1)	2 (1)	0 (0)	0 (0)
21/04/2020	Tuesday	11 (0)	4 (3)	1 (1)	0 (0)	0 (0)
22/04/2020	Wednesday	6 (0)	4 (1)	3 (3)	0 (0)	0 (0)
23/04/2020	Thursday	10 (0)	5 (1)	1 (1)	0 (0)	0 (0)
24/04/2020	Friday	14 (0)	2 (0)	0 (0)	0 (0)	0 (0)
Total Exceedance Events		**229**	**50**	**35**	**0**	**0**

2.8 Table 2 shows that L_{Amax} levels between 60-70 dB at the measurement point are common, with an average of 10 per night. Exceedance events become increasingly rare as bands levels increase. There were no events where levels exceeded 90 dB during the month.

2.9 From Table 2, the percentage of exceedance events attributed to trains can be calculated for each band. These have been calculated for dates where RTT data was available. These are shown in Table 2.3.

Table 2.3: Percentage of exceedance events attributed to trains between 10-24st April

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	229	1	0%
70dB	50	23	46%
80dB	35	29	83%
90dB	0	0	N/A

2.10 Table 2.3 shows that, whilst common, only 1 measured L_{Amax} levels between 60-70 dB was due to train pass events between 1st-24th April. 46% of all L_{Amax} levels between 70-80 dB were attributed to trains whilst 83% of 80 dB exceedance events were due to a train pass.

2.11 The noise source causing the remaining cases is unknown, however analysis of the one second traces from the sound level meter indicates that these are likely to have been caused by birds and other wildlife, or may have been due to occasional short engineering trains passing up and down the railway which are not recorded on RTT.

2.12 Table 2.4 shows the lifetime statistics for exceedance events recorded at the measurement point.

Table 2.4: Total number of exceedance events and those attributed to trains measured from March 2020 onwards

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	559	1	0%
70dB	102	47	46%
80dB	66	59	89%
90dB	1	0	0%
100dB	0	0	N/A

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing noise monitoring location

Appendix B

Graphs of Survey Results

Figure B1: 5-minute data from the 1st-6th of April 2020 – maximum levels from trains highlighted as red dots

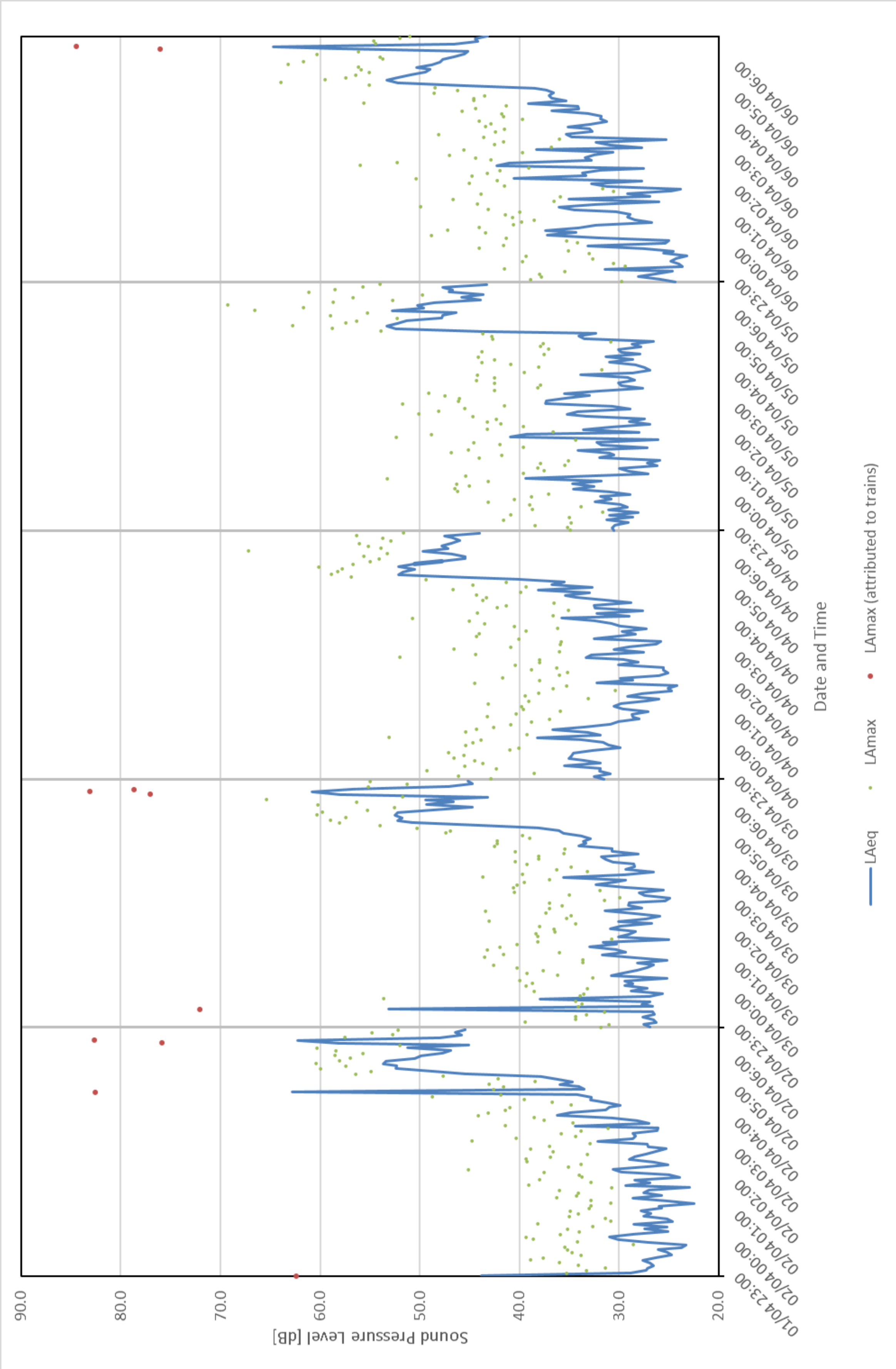


Figure B2: 5-minute data from the 6th-13th of April 2020 – maximum levels from trains highlighted as red dots

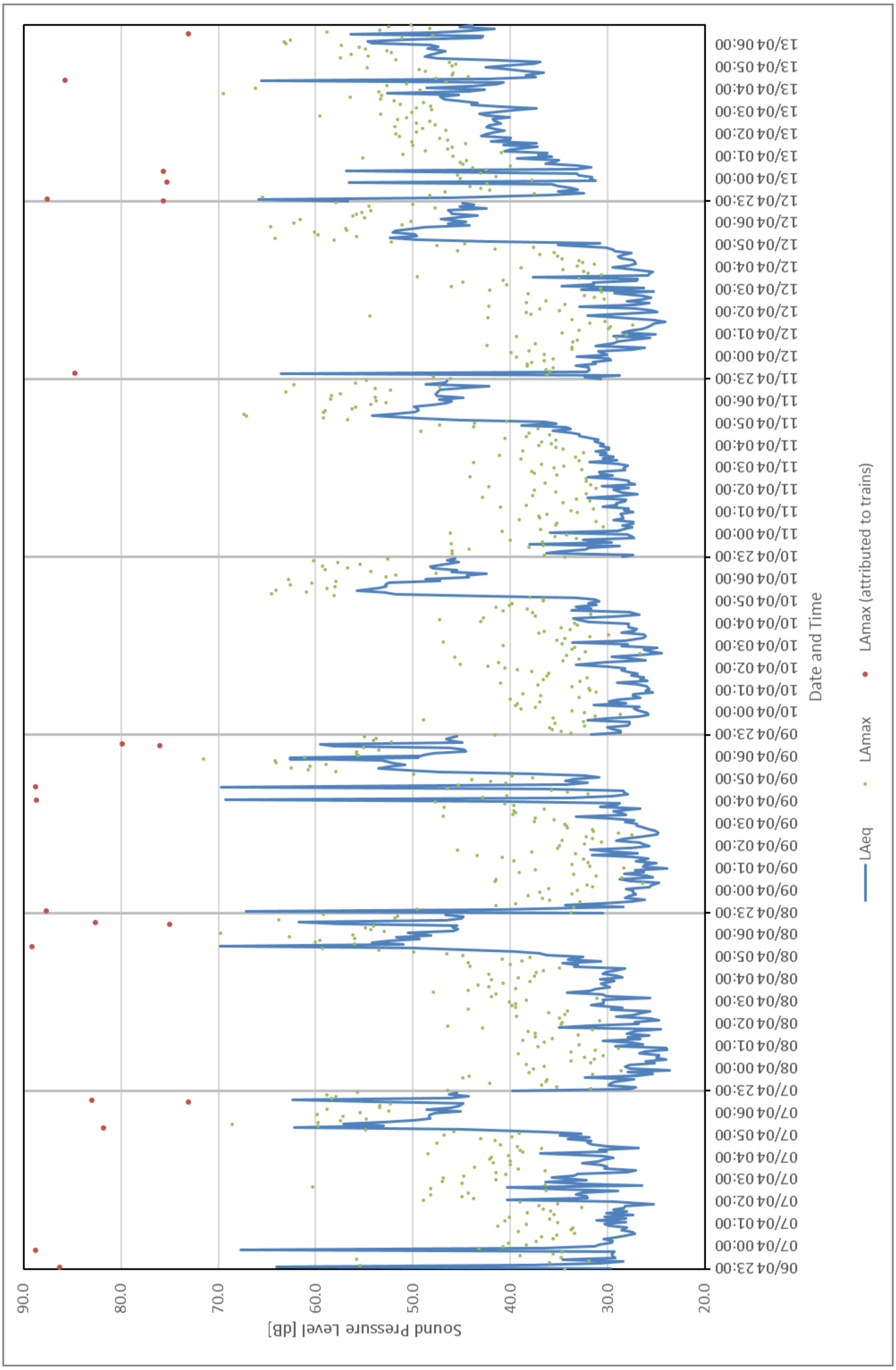


Figure B3: 5-minute data from the 13th-20th of April 2020 – maximum levels from trains highlighted as red dots

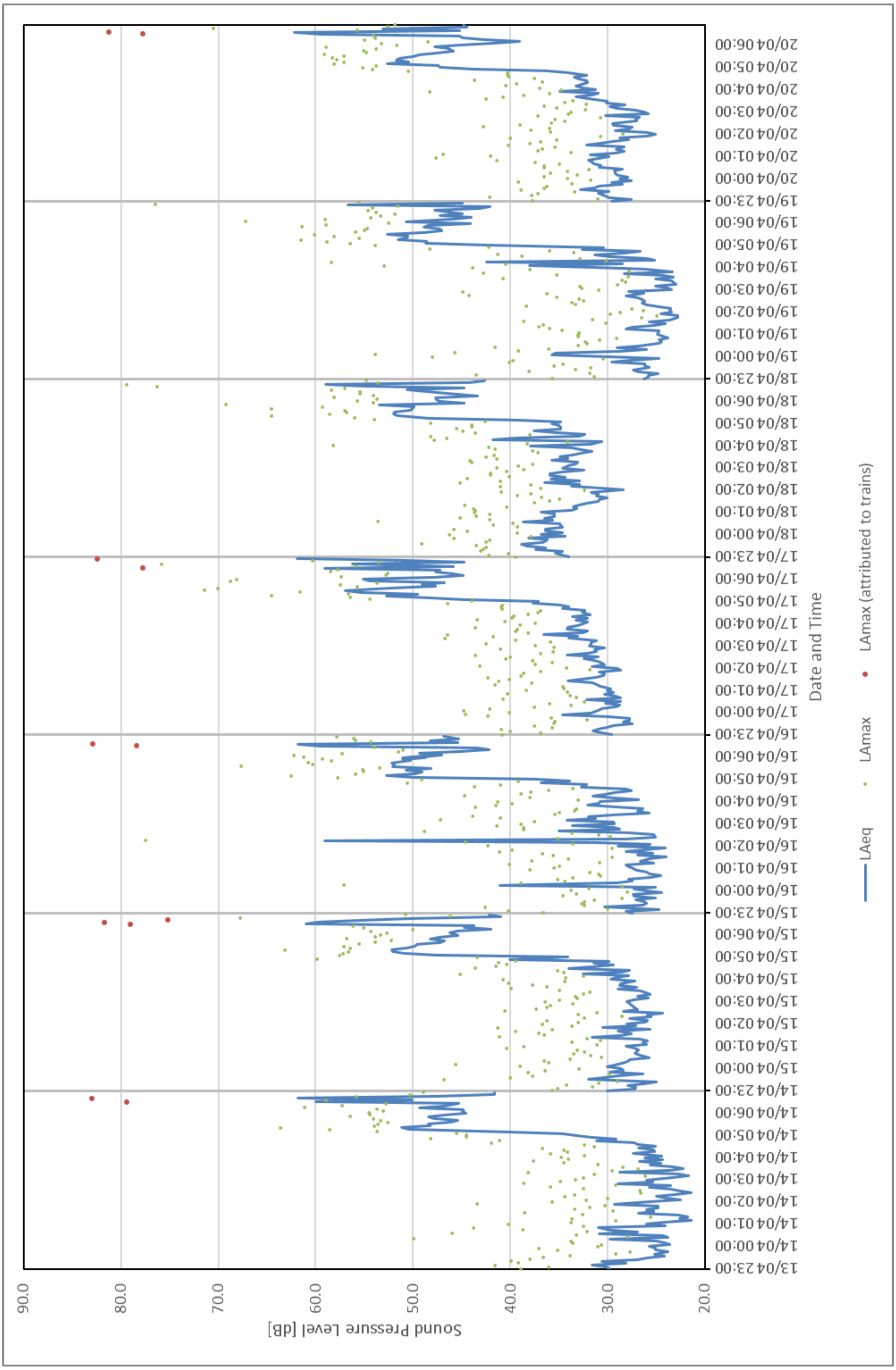
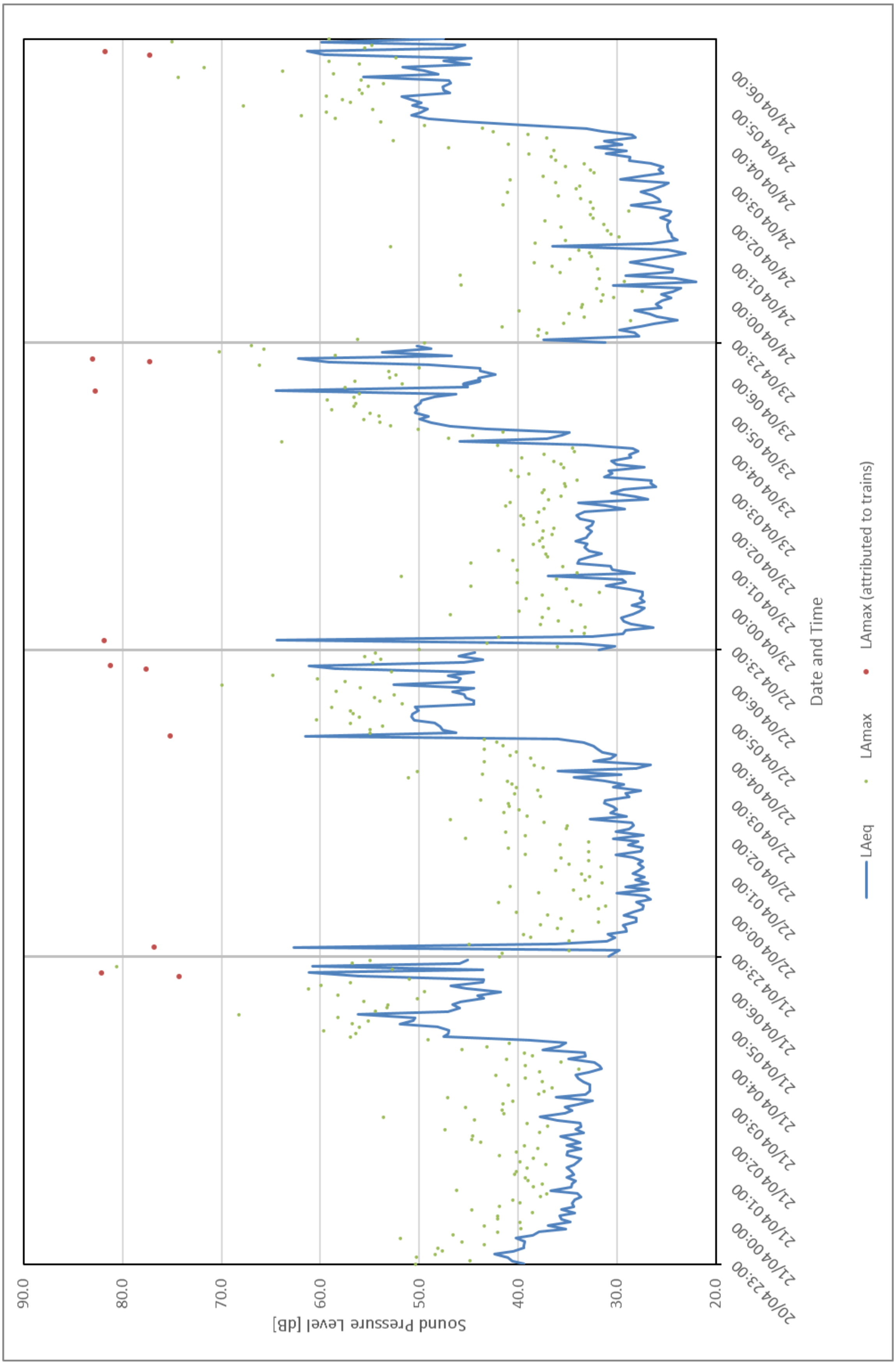


Figure B4: 5-minute data from the 20th-24th of April 2020 – maximum levels from trains highlighted as red dots.



Appendix C

Real Time Trains data

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-04-01	06:34:45	06:35:28		LE
2020-04-01	06:35:26	06:37:33		LE
2020-04-01	22:42:30*	22:57:07*		ZZ
2020-04-02			04:58:57	ZZ
2020-04-02	06:33:38	06:34:58		LE
2020-04-02	06:36:25	06:37:48		LE
2020-04-02			23:39:34	ZZ
2020-04-03	06:33:41	06:34:36		LE
2020-04-03	06:34:35	06:37:56		LE
2020-04-06	06:32:41	06:34:57		LE
2020-04-06	06:35:23	06:37:31		LE
2020-04-06			22:59:12*	ZZ
2020-04-06	23:17:36	23:49:28		ZZ
2020-04-07			05:26:12	ZZ
2020-04-07	06:32:59	06:34:50		LE
2020-04-07	06:35:25	06:37:29		LE
2020-04-08			05:36:01	ZZ
2020-04-08	06:33:11	06:35:32		LE
2020-04-08	06:35:34	06:37:55		LE
2020-04-08			23:06:55	ZZ
2020-04-09			04:09:01	ZZ
2020-04-09			04:45:10	ZZ
2020-04-09	06:32:33	06:34:49		LE
2020-04-09		06:37:27		LE
2020-04-11		23:13:00		ZZ
2020-04-12	06:57:18	06:58:27		LE
2020-04-12			23:04:53	LE
2020-04-12		23:07:04		ZZ
2020-04-12			23:55:47	LE
2020-04-13			00:26:27	LE
2020-04-13			04:27:46	ZZ
2020-04-13	06:32:32	06:34:45		LE
2020-04-14	06:32:27	06:34:38		LE
2020-04-14	06:38:55	06:40:15		LE
2020-04-15	06:32:25	06:34:56		LE
2020-04-15	06:34:55	06:37:54		LE
2020-04-16	06:32:14	06:34:48		LE
2020-04-16	06:34:46	06:37:31		LE
2020-04-17	06:33:10	06:34:46		LE
2020-04-17	06:53:36	06:54:50		LE
2020-04-20	06:33:00	06:34:59		LE
2020-04-20	06:35:33	06:37:11		LE
2020-04-21	06:32:55	06:35:13		LE
2020-04-21	06:35:25	06:37:12		LE
2020-04-21	23:00:52	23:16:34		ZZ
2020-04-22	04:48:00	04:49:21		ZZ

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-04-22	06:32:40	06:34:46		LE
2020-04-22	06:35:21	06:36:50		LE
2020-04-22	22:59:49	23:14:07		ZZ
2020-04-23	05:50:42	05:51:13		ZZ
2020-04-23	06:32:11	06:34:11		LE
2020-04-23	06:35:51	06:38:01		LE
2020-04-24	06:32:38	06:35:05		LE
2020-04-24	06:34:46	06:36:51		LE
2020-04-27	06:33:08	06:34:58		LE
2020-04-27	06:38:42	06:40:18		LE
2020-04-28	06:43:37	06:44:20		LE
2020-04-28	06:35:28	06:44:35		LE
2020-04-29	06:35:21	06:37:30		LE
2020-04-30	06:34:51	06:35:28		LE
2020-04-30	06:35:11	06:36:44		LE
2020-04-30			23:12:47	ZZ
2020-05-01			00:21:04	ZZ
2020-05-01	06:32:54	06:35:01		LE

*Note this time falls outside of the defined night period of 23:00-07:00, however is the time which the train is recorded to have arrived, departed or passed through Woodbridge Railway Station. This train passed the measurement location further down the track shortly before/after this time.

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Report

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Contents

Appendices

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of noise levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing noise climate at night to assist with understanding the context in which the proposed additional rail movements at night would need to be considered.

1.2 The survey work began on 4th March 2020. A Type 1 sound level meter was installed at the location shown in Figure A1 in Appendix A. The microphone is in a free field location approximately 5 metres from the rail line at a height of 1.8m above ground. The meter is regularly serviced and a calibration check carried out.

1.3 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

1.4 Levels have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line and using a combination of this information and an analysis of the measured levels, results have been interpreted to provide a summary of levels and the likely source which has resulted in those levels, where this is possible to determine.

1.5 Results (L_{Aeq} and L_{Amax} values) are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

1.6 This revision is necessary as full RTT data for the entire month was provided in September 2020. This has allowed for more complete analysis of the measured results to be carried out. Screenshots of the website have been replaced with tabulated data for night time train movements during the month in Appendix C.

2.0 Analysis of survey results

2.1 Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 Raw data for night time in 5-minute periods has been provided in Appendix B.

2.3 Table 2.1 shows the $L_{Aeq, 8\text{-}hour}$ values and range of L_{Amax} values measured throughout night time periods in May. Night is defined to be between 23:00-07:00 hours. No data was recorded for the nights of 1st to 4th May 2020 due to an instrument fault, which was found and rectified on 4th May.

Table 2.1: Night time $L_{Aeq, 8\text{-}hour}$ values and L_{Amax} ranges in May*

Date	Day	$L_{Aeq, 8 hours}$	$L_{AMax, 5 Min}$ Range	
			Min	Max
04/05/2020	Monday	46	36	80
05/05/2020	Tuesday	53	32	94
06/05/2020	Wednesday	48	31	82
07/05/2020	Thursday	52	34	91
08/05/2020	Friday	46	31	77
09/05/2020	Saturday	45	30	76
10/05/2020	Sunday	49	44	87
11/05/2020	Monday	50	30	90
12/05/2020	Tuesday	50	30	89
13/05/2020	Wednesday	51	30	88
14/05/2020	Thursday	47	32	82
15/05/2020	Friday	42	32	76
16/05/2020	Saturday	44	30	80
17/05/2020	Sunday	48	33	84
18/05/2020	Monday	47	32	81
19/05/2020	Tuesday	51	32	88
20/05/2020	Wednesday	48	32	86
21/05/2020	Thursday	47	33	83
22/05/2020	Friday	42	31	75
23/05/2020	Saturday	45	37	81
24/05/2020	Sunday	48	27	89
25/05/2020	Monday	48	30	86
26/05/2020	Tuesday	47	32	86
27/05/2020	Wednesday	48	29	82
28/05/2020	Thursday	59	31	99
29/05/2020	Friday	43	36	81
30/05/2020	Saturday	51	33	93
31/05/2020	Sunday	46	31	84

***Dates signify the date at the start of the night time period (I.e. 05/05/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.4 $L_{Aeq, 8\text{-}hour}$ values ranged from 42 dB to 59 dB throughout the month. The arithmetic average $L_{Aeq, 8\text{-}hour}$ value for night time periods throughout the month was 48 dB.

2.5 For each night in May, the number of times that L_{Amax} values exceeded 60 dB, 70 dB, 80 dB, 90 dB and 100 dB has been determined. Note that each exceedance event only falls into a single category, for example, an L_{Amax} level of 74 dB only falls into the 70 dB category, and not the 60 dB category.

2.6 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Tabulated logs of night time train movements through Woodbridge station, provided by www.realtimetrains.co.uk, are shown in Appendix C.

2.7 Table 2.2 overleaf, shows the number of L_{Amax} exceedance events for each night. On these days the number of L_{Amax} events attributed to train movements is shown in brackets for each category.

Table 2.2: L_{Amax} exceedance events throughout May, and number of those attributed to train movements

Date	Day	Level Exceedances (Attributed to Trains)				
		60dB	70dB	80dB	90dB	100dB
04/05/2020	Monday	13 (0)	3 (2)	0 (0)	0 (0)	0 (0)
05/05/2020	Tuesday	19 (0)	4 (1)	2 (1)	1 (1)	0 (0)
06/05/2020	Wednesday	17 (0)	8 (1)	1 (1)	0 (0)	0 (0)
07/05/2020	Thursday	21 (0)	2 (1)	1 (1)	1 (1)	0 (0)
08/05/2020	Friday	18 (0)	3 (0)	0 (0)	0 (0)	0 (0)
09/05/2020	Saturday	18 (0)	2 (0)	0 (0)	0 (0)	0 (0)
10/05/2020	Sunday	13 (0)	4 (1)	1 (1)	0 (0)	0 (0)
11/05/2020	Monday	16 (0)	5 (1)	4 (1)	0 (0)	0 (0)
12/05/2020	Tuesday	9 (0)	5 (2)	2 (2)	0 (0)	0 (0)
13/05/2020	Wednesday	13 (0)	3 (1)	2 (2)	0 (0)	0 (0)
14/05/2020	Thursday	19 (0)	2 (1)	1 (1)	0 (0)	0 (0)
15/05/2020	Friday	13 (0)	2 (0)	0 (0)	0 (0)	0 (0)
16/05/2020	Saturday	22 (0)	3 (0)	0 (0)	0 (0)	0 (0)
17/05/2020	Sunday	15 (0)	4 (1)	2 (1)	0 (0)	0 (0)
18/05/2020	Monday	11 (0)	7 (1)	1 (1)	0 (0)	0 (0)
19/05/2020	Tuesday	16 (0)	4 (1)	3 (1)	0 (0)	0 (0)
20/05/2020	Wednesday	13 (0)	4 (1)	1 (1)	0 (0)	0 (0)
21/05/2020	Thursday	16 (0)	4 (1)	1 (1)	0 (0)	0 (0)
22/05/2020	Friday	13 (0)	2 (0)	0 (0)	0 (0)	0 (0)
23/05/2020	Saturday	11 (0)	6 (1)	1 (0)	0 (0)	0 (0)
24/05/2020	Sunday	5 (0)	5 (1)	1 (1)	0 (0)	0 (0)
25/05/2020	Monday	11 (0)	2 (1)	1 (1)	0 (0)	0 (0)
26/05/2020	Tuesday	9 (0)	4 (1)	2 (1)	0 (0)	0 (0)
27/05/2020	Wednesday	18 (0)	4 (0)	2 (2)	0 (0)	0 (0)
28/05/2020	Thursday	15 (0)	1 (1)	2 (2)	1 (1)	0 (0)
29/05/2020	Friday	16 (0)	1 (0)	1 (0)	0 (0)	0 (0)
30/05/2020	Saturday	18 (0)	2 (0)	1 (0)	1 (0)	0 (0)
31/05/2020	Sunday	10 (0)	4 (1)	1 (1)	0 (0)	0 (0)
Total Exceedance Events		**408**	**100**	**34**	**4**	**0**

2.8 Table 2.2 shows that L_{Amax} levels between 60-70 dB at the measurement point are common, with an average of 15 per night. Exceedance events become increasingly rare as bands levels increase. There were four events where levels exceeded 90 dB during the month.

2.9 From Table 2.2, the percentage of exceedance events attributed to trains can be calculated for each band. These have been calculated for dates where RTT data was available. These are shown in Table 2.3 overleaf.

Table 2.3: Percentage of exceedance events attributed to trains between 5-31st May

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	408	0	0%
70dB	100	21	21%
80dB	34	23	68%
90dB	4	3	75%
100dB	0	0	N/A

2.10 Table 2.3 shows that, whilst common, none of the measured L_{Amax} levels between 60-70 dB were due to train pass by events between 5 and 31st May 2020. Approximately 21% of all L_{Amax} levels between 70-80 dB and 68% between 80-90 dB were attributed to trains, whilst 3 out of the 4 exceedance events over 90 dB L_{Amax} were due to a train pass.

2.11 The noise source causing the remaining cases is unknown, however analysis of the one second traces from the sound level meter indicates that these are likely to have been caused by birds and other wildlife, or may have been due to occasional short engineering trains passing up and down the railway which are not recorded on RTT.

2.12 Table 2.4 shows the lifetime statistics for exceedance events recorded at the measurement point.

Table 2.4: Total number of exceedance events and those attributed to trains measured from March 2020 onwards

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	967	1	0%
70dB	202	68	34%
80dB	100	82	82%
90dB	5	3	60%
100dB	0	0	N/A

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing noise monitoring location

Appendix B

Graphs of Survey Results

Figure B1: 5-minute data from the 4th-11th of May 2020 – maximum levels from trains highlighted as red dots

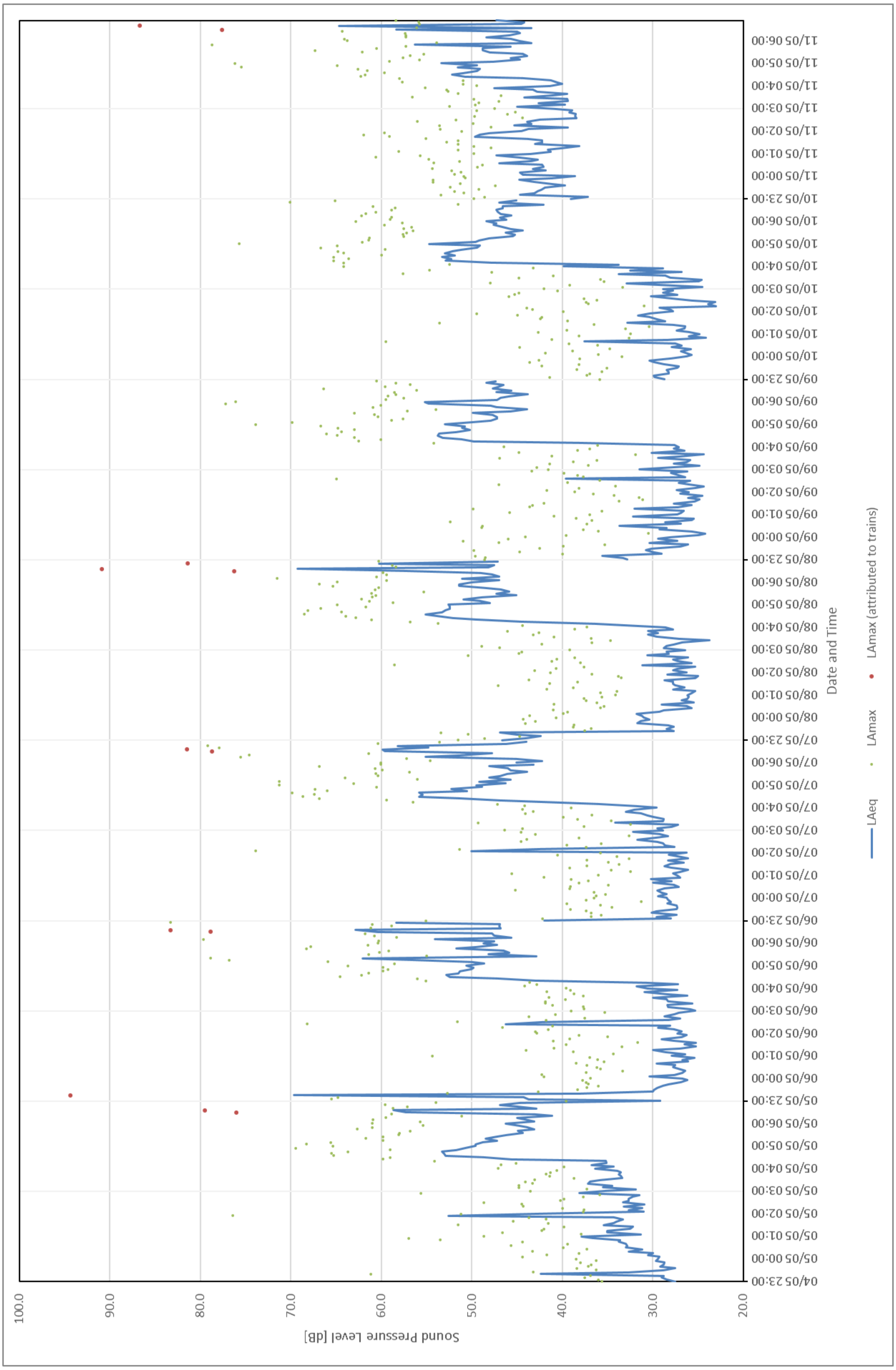


Figure B2: 5-minute data from the 11th-18th of May 2020 – maximum levels from trains highlighted as red dots

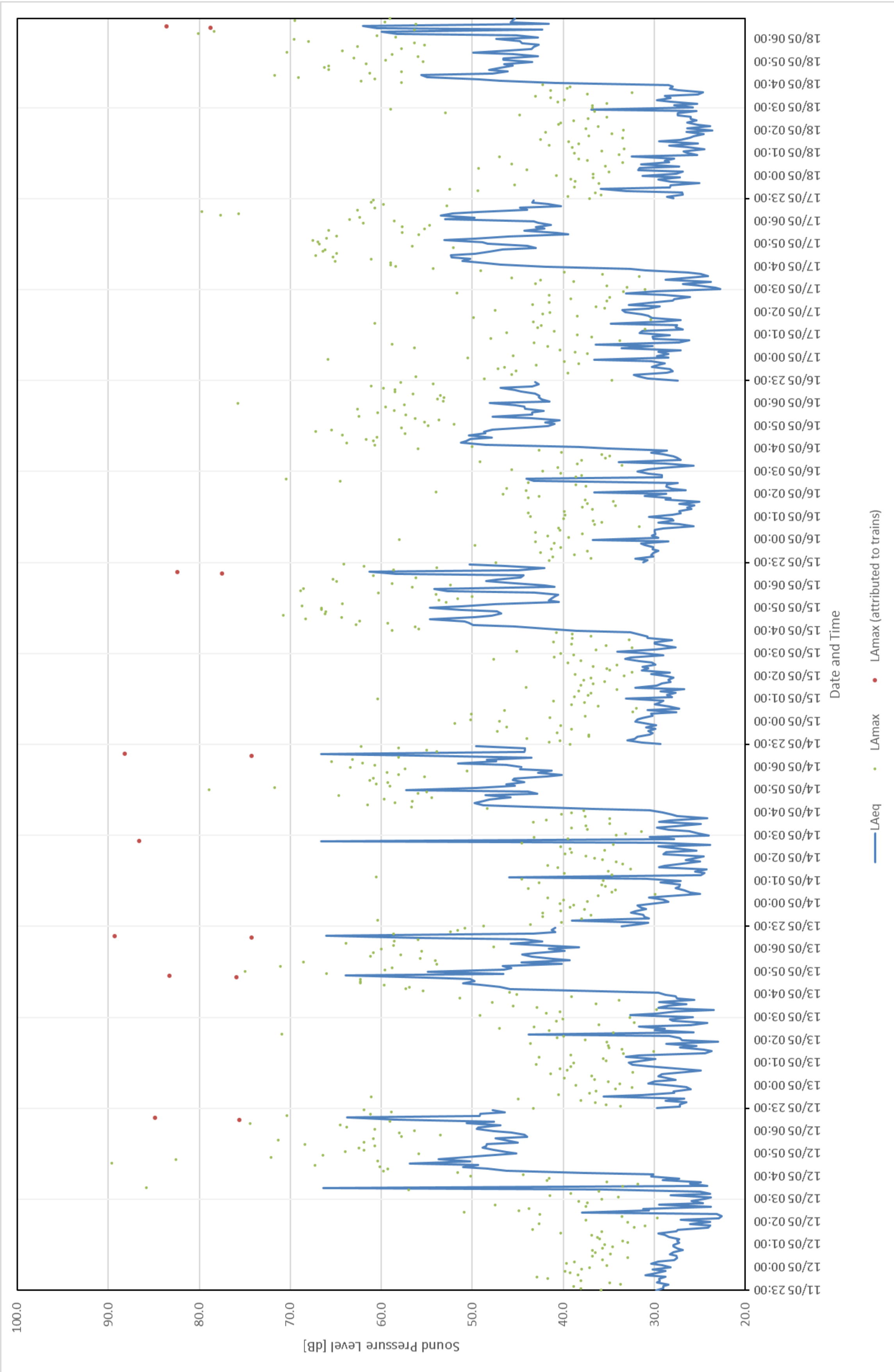


Figure B3: 5-minute data from the 18th-25th of May 2020 – maximum levels from trains highlighted as red dots

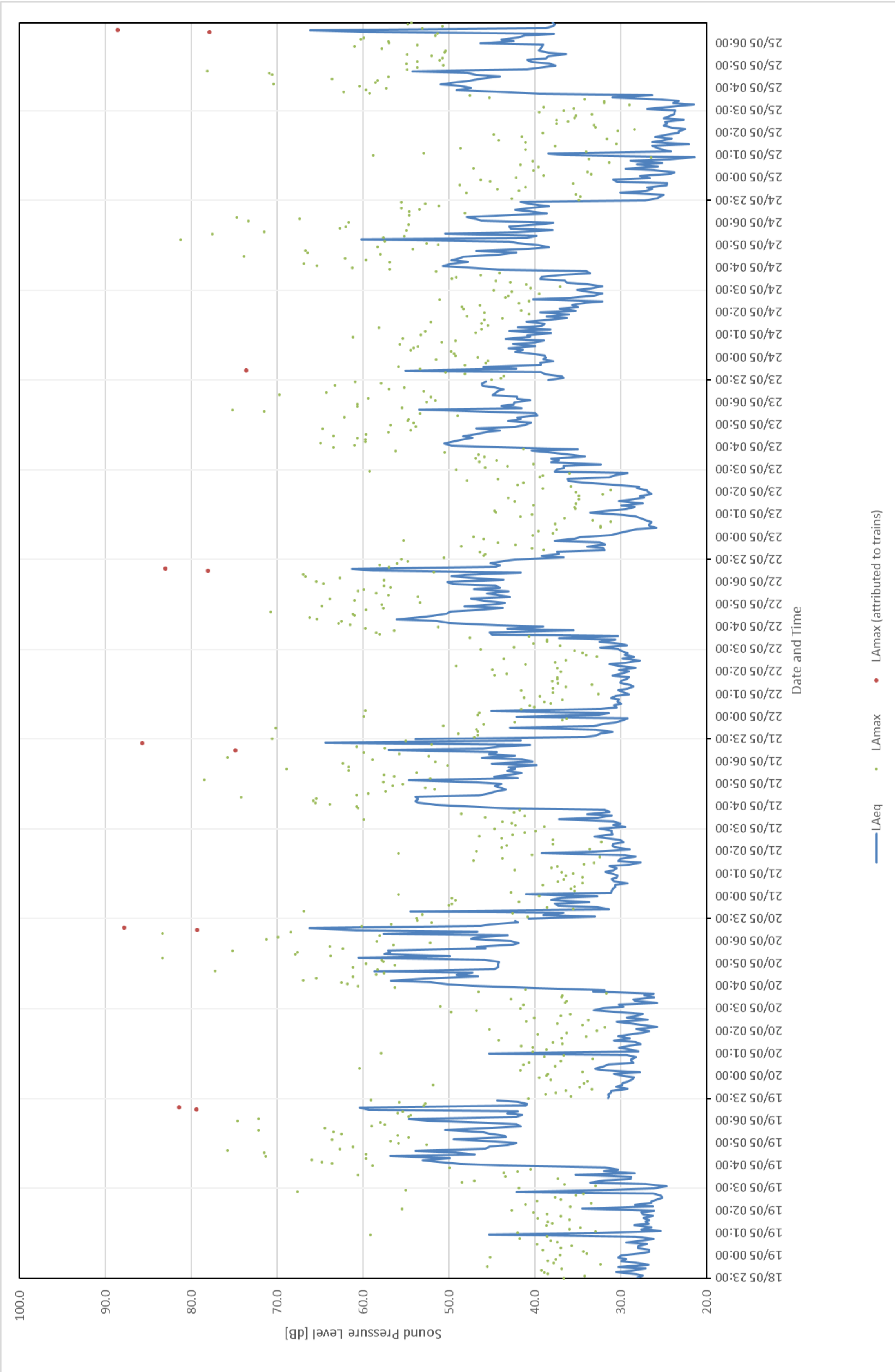
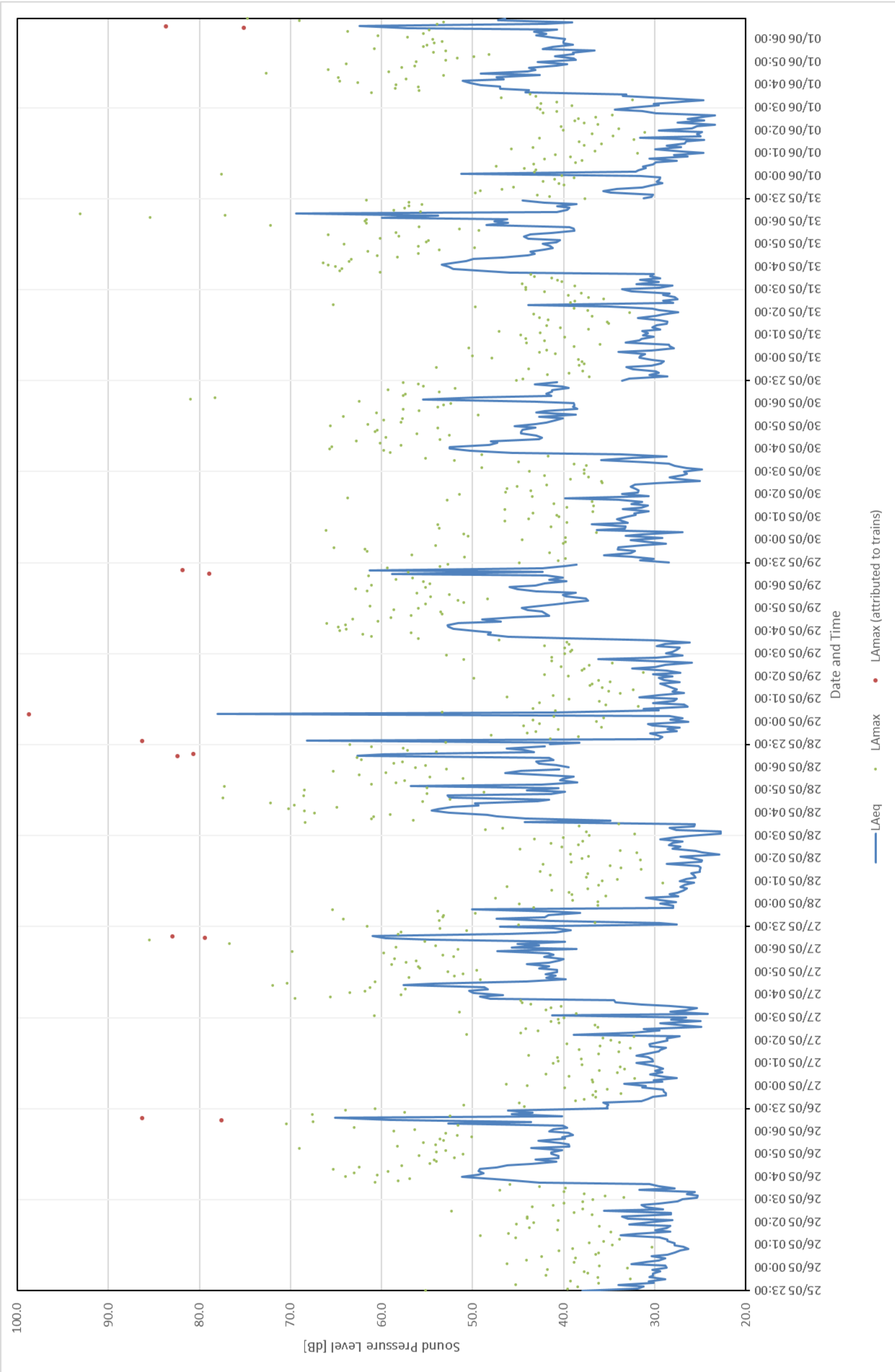


Figure B4: 5-minute data from the 22nd-28th of May 2020 – maximum levels from trains highlighted as red dots.



Appendix C

Real Time Trains data

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-05-05	06:33:13	06:35:24		LE
2020-05-05	06:36:14	06:37:10		LE
2020-05-05	23:02:42	23:07:49		ZZ
2020-05-05	23:23:14			ZZ
2020-05-06	06:32:51	06:35:04		LE
2020-05-06	06:34:55	06:36:30		LE
2020-05-06	23:04:21			ZZ
2020-05-07	06:32:50	06:35:03		LE
2020-05-07	06:36:30	06:37:14		LE
2020-05-08	06:32:18	06:34:57		LE
2020-05-08	06:49:12	06:51:27		LE
2020-05-11	06:33:01	06:35:03		LE
2020-05-11	06:36:05	06:38:05		LE
2020-05-12	06:33:16	06:34:55		LE
2020-05-12	06:35:22	06:37:09		LE
2020-05-13			04:53:13	ZZ
2020-05-13	06:32:49	06:34:58		LE
2020-05-13	06:35:21	06:36:56		LE
2020-05-14			02:49:34	ZZ
2020-05-14	06:33:31	06:35:12		LE
2020-05-14	06:35:40	06:37:28		LE
2020-05-15	06:32:36	06:34:51		LE
2020-05-15	06:35:29	06:37:49		LE
2020-05-18	06:33:02	06:35:20		LE
2020-05-18	06:34:57	06:36:59		LE
2020-05-19	06:32:44	06:34:42		LE
2020-05-19	06:35:29	06:37:30		LE
2020-05-20	06:32:14	06:34:45		LE
2020-05-20	06:34:52	06:37:06		LE
2020-05-21	06:33:36	06:35:41		LE
2020-05-21	06:50:46	06:51:39		LE
2020-05-22	06:32:23	06:34:42		LE
2020-05-22	06:34:56	06:36:36		LE
2020-05-23	23:31:10	23:32:10		LE
2020-05-25	06:34:54	06:35:16		LE
2020-05-25	06:36:03	06:37:16		LE
2020-05-26	06:33:23	06:35:15		LE
2020-05-26	06:35:22	06:36:51		LE
2020-05-27	06:32:23	06:34:47		LE
2020-05-27	06:35:38	06:37:00		LE
2020-05-28	06:32:21	06:34:31		LE
2020-05-28	06:34:51	06:37:07		LE
2020-05-28			23:13:17	ZZ
2020-05-29			00:19:26	ZZ
2020-05-29	06:32:24	06:34:52		LE
2020-05-29	06:40:55	06:41:58		LE

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-06-01	06:32:58	06:35:05		LE
2020-06-01	06:34:48	06:36:52		LE

SHARPS REDMORE

ACOUSTIC CONSULTANTS ▪ Established 1990

Report

Project
EDF – Sizewell C Power Station: Woodbridge Rail noise survey monthly report – June 2020

Prepared by

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and

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Date 2nd July 2020
Rev Date 19th October 2020

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1.3 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

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1.5 Results (L_{Aeq} and L_{Amax} values) are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

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2.0 Analysis of survey results

2.1 Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 Raw data for night time in 5-minute periods has been provided in Appendix B.

2.3 Table 2.1 overleaf shows the $L_{Aeq,\ 8\text{-hour}}$ values and range of L_{Amax} values measured throughout night time periods in June. Night is defined to be between 23:00-07:00 hours.

Table 2.1: Night time $L_{Aeq, 8\text{-}hour}$ values and L_{Amax} ranges in June*

Date	Day	$L_{Aeq, 8 hours}$	$L_{AMax, 5 Min}$ Range	
			Min	Max
01/06/2020	Monday	46	32	84
02/06/2020	Tuesday	47	33	84
03/06/2020	Wednesday	48	31	87
04/06/2020	Thursday	53	34	92
05/06/2020	Friday	42	35	77
06/06/2020	Saturday	43	36	78
07/06/2020	Sunday	46	37	85
08/06/2020	Monday	46	30	82
09/06/2020	Tuesday	44	32	83
10/06/2020	Wednesday	46	29	85
11/06/2020	Thursday	46	29	83
12/06/2020	Friday	41	29	79
13/06/2020	Saturday	41	29	68
14/06/2020	Sunday	49	31	83
15/06/2020	Monday	50	30	85
16/06/2020	Tuesday	46	30	84
17/06/2020	Wednesday	52	32	85
18/06/2020	Thursday	45	32	83
19/06/2020	Friday	40	33	68
20/06/2020	Saturday	43	30	80
21/06/2020	Sunday	46	32	86
22/06/2020	Monday	45	31	79
23/06/2020	Tuesday	44	30	83
24/06/2020	Wednesday	46	31	86
25/06/2020	Thursday	54	30	95
26/06/2020	Friday	42	36	76
27/06/2020	Saturday	42	43	62
28/06/2020	Sunday	44	38	81
29/06/2020	Monday	46	43	82
30/06/2020	Tuesday	45	35	83

***Dates signify the date at the start of the night time period (I.e. 01/06/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.4 $L_{Aeq, 8\text{-}hour}$ values ranged from 40 dB to 54 dB throughout the month. The arithmetic average $L_{Aeq, 8\text{-}hour}$ value for night time periods throughout the month was 46 dB.

2.5 For each night in June, the number of times that L_{Amax} values exceeded 60 dB, 70 dB, 80 dB, 90 dB and 100 dB has been determined. Note that each exceedance event only falls into a single category, for example, an L_{Amax} level of 74 dB only falls into the 70 dB category, and not the 60 dB category.

2.6 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Tabulated logs of night time train movements through Woodbridge station, provided by www.realtimetrains.co.uk, are shown in Appendix C.

2.7 Table 2.2 below, shows the number of L_{Amax} exceedance events for each night. The number of L_{Amax} events attributed to train movements is shown in brackets for each category.

Table 2.2: L_{Amax} exceedance events throughout June, and number of those attributed to train movements.

Date	Day	Level Exceedences (Attributed to Trains)				
		60dB	70dB	80dB	90dB	100dB
01/06/2020	Monday	8 (0)	2 (1)	1 (1)	0 (0)	0 (0)
02/06/2020	Tuesday	14 (0)	2 (1)	1 (0)	0 (0)	0 (0)
03/06/2020	Wednesday	11 (0)	2 (2)	1 (1)	0 (0)	0 (0)
04/06/2020	Thursday	22 (0)	3 (1)	3 (1)	1 (1)	0 (0)
05/06/2020	Friday	17 (0)	1 (0)	0 (0)	0 (0)	0 (0)
06/06/2020	Saturday	17 (0)	5 (0)	0 (0)	0 (0)	0 (0)
07/06/2020	Sunday	9 (0)	4 (1)	1 (1)	0 (0)	0 (0)
08/06/2020	Monday	15 (0)	2 (2)	1 (1)	0 (0)	0 (0)
09/06/2020	Tuesday	11 (0)	1 (0)	1 (1)	0 (0)	0 (0)
10/06/2020	Wednesday	7 (0)	1 (1)	1 (1)	0 (0)	0 (0)
11/06/2020	Thursday	13 (0)	1 (1)	1 (1)	0 (0)	0 (0)
12/06/2020	Friday	15 (0)	1 (0)	0 (0)	0 (0)	0 (0)
13/06/2020	Saturday	13 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14/06/2020	Sunday	12 (0)	1 (1)	3 (1)	0 (0)	0 (0)
15/06/2020	Monday	7 (0)	1 (1)	4 (1)	0 (0)	0 (0)
16/06/2020	Tuesday	10 (0)	1 (1)	2 (1)	0 (0)	0 (0)
17/06/2020	Wednesday	31 (0)	3 (0)	4 (2)	0 (0)	0 (0)
18/06/2020	Thursday	7 (0)	2 (1)	1 (1)	0 (0)	0 (0)
19/06/2020	Friday	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20/06/2020	Saturday	6 (0)	2 (0)	0 (0)	0 (0)	0 (0)
21/06/2020	Sunday	9 (0)	0 (0)	1 (1)	0 (0)	0 (0)
22/06/2020	Monday	12 (0)	1 (1)	0 (0)	0 (0)	0 (0)
23/06/2020	Tuesday	9 (0)	0 (0)	1 (1)	0 (0)	0 (0)
24/06/2020	Wednesday	5 (0)	2 (1)	1 (1)	0 (0)	0 (0)
25/06/2020	Thursday	8 (0)	3 (1)	1 (1)	1 (1)	0 (0)
26/06/2020	Friday	8 (0)	2 (0)	0 (0)	0 (0)	0 (0)
27/06/2020	Saturday	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)
28/06/2020	Sunday	2 (0)	1 (1)	1 (1)	0 (0)	0 (0)
29/06/2020	Monday	11 (0)	1 (1)	1 (1)	0 (0)	0 (0)
30/06/2020	Tuesday	14 (0)	1 (1)	1 (1)	0 (0)	0 (0)
Total Exceedance Events		**328**	**46**	**32**	**2**	**0**

2.8 Table 2.2 shows that L_{Amax} levels between 60-70 dB at the measurement point are common, with an average of 10 per night. Exceedance events become increasingly rare as bands levels increase. There were two events where levels exceeded 90 dB during the month.

2.9 From Table 2.2, the percentage of exceedance events attributed to trains can be calculated for each band. These have been calculated for dates where RTT data was available. These are shown in Table 2.3.

Table 2.3: Percentage of exceedance events attributed to trains between 1-30th June.

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	328	0	0%
70dB	46	20	43%
80dB	32	21	66%
90dB	2	2	100%
100dB	0	0	N/A

2.10 Table 2.3 shows that, whilst common, none of the measured L_{Amax} levels between 60-70 dB were due to train pass by events between 1 and 30th June 2020. 43% of all L_{Amax} levels between 70-80 dB were attributed to trains whilst 66% of 80 dB exceedance events were due to a train pass. Both maximum sound level events over 90 dB were attributed to trains.

2.11 The noise source causing the remaining cases is unknown, however analysis of the one second traces from the sound level meter indicates that these are likely to have been caused by birds and other wildlife, or may have been due to occasional short engineering trains passing up and down the railway which are not recorded on RTT.

2.12 Table 2.4 shows the lifetime statistics for exceedance events recorded at the measurement point.

Table 2.4: Total number of exceedance events and those attributed to trains measured from March 2020 onwards

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	1295	1	0%
70dB	248	88	35%
80dB	132	103	78%
90dB	7	5	71%
100dB	0	0	N/A

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing noise monitoring location

Appendix B

Graphs of Survey Results

Figure B1: 5-minute data from the 1st-8th of June 2020 – maximum levels from trains highlighted as red dots

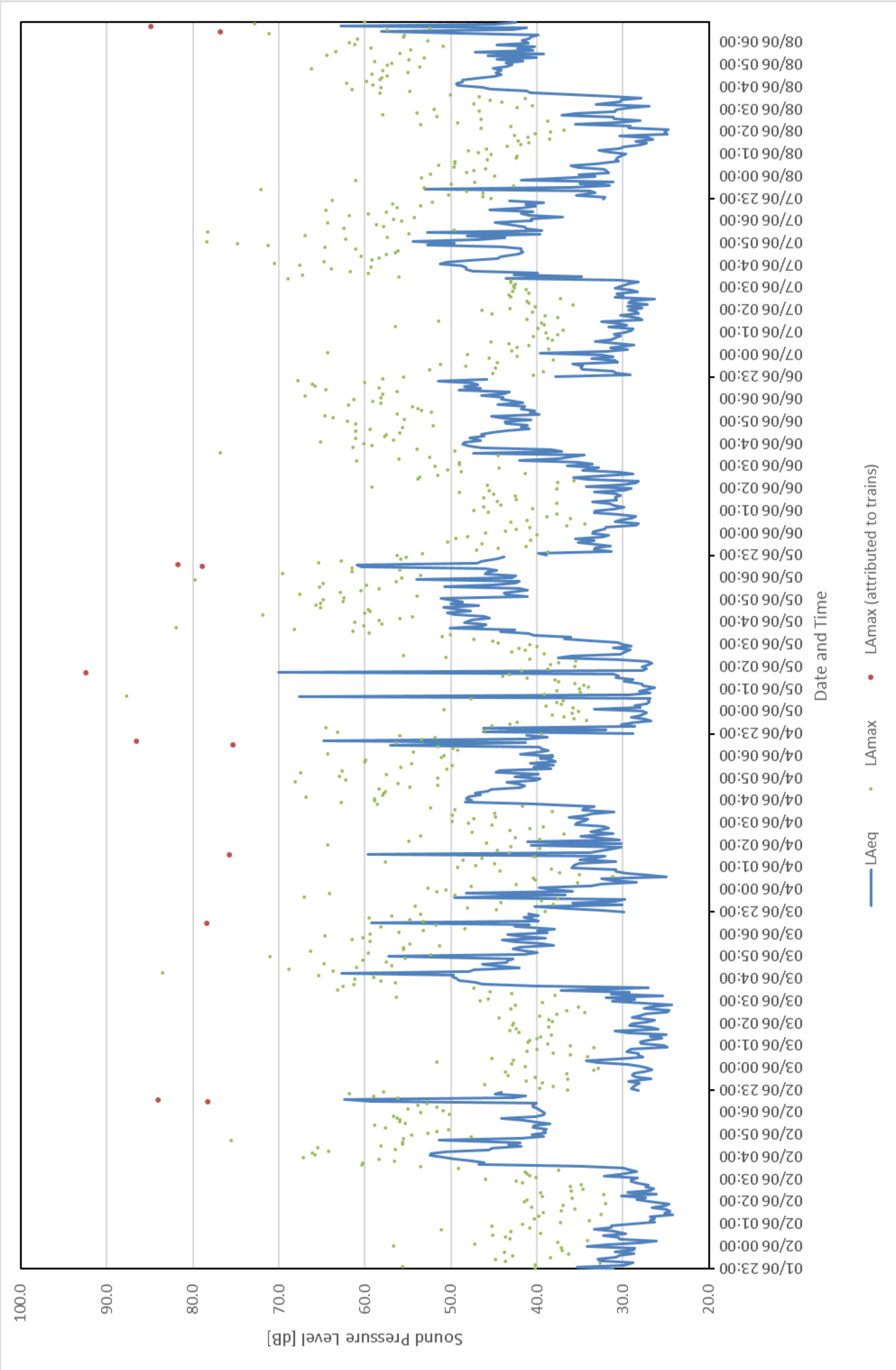


Figure B2: 5-minute data from the 8th-15th of June 2020 – maximum levels from trains highlighted as red dots

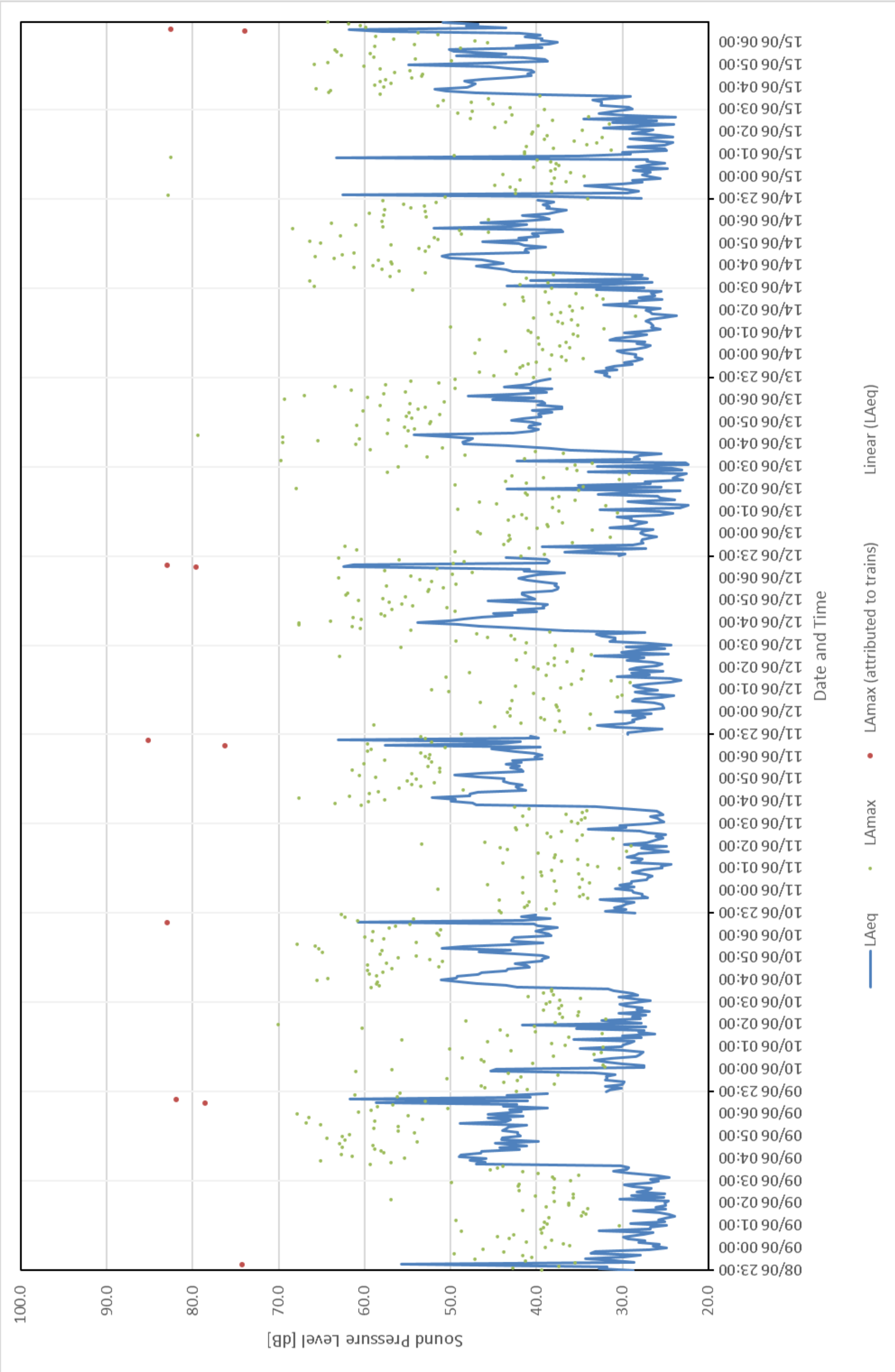


Figure B3: 5-minute data from the 15th-22nd of June 2020 – maximum levels from trains highlighted as red dots

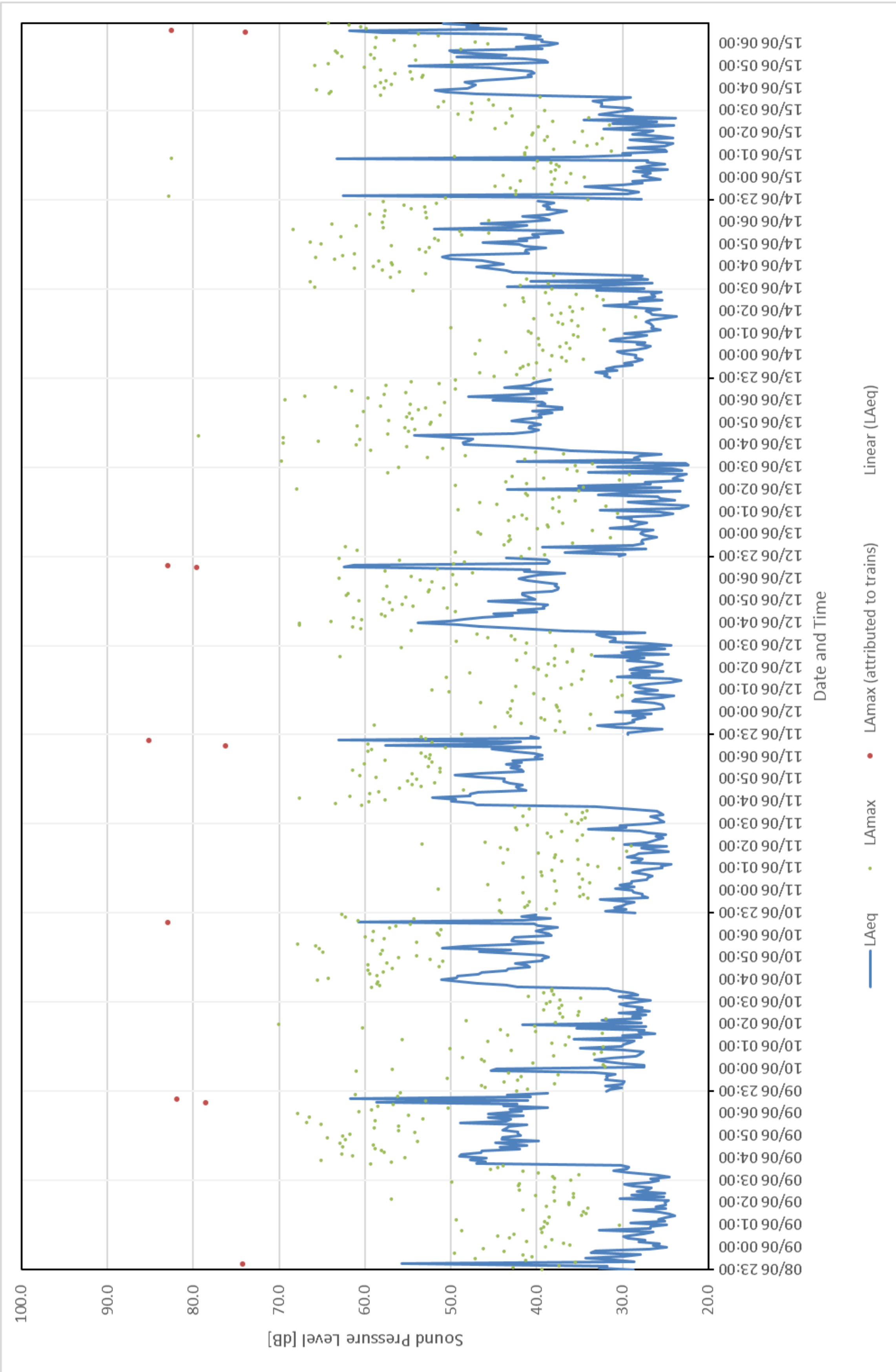


Figure B4: 5-minute data from the 22nd-29th of June 2020 – maximum levels from trains highlighted as red dots.

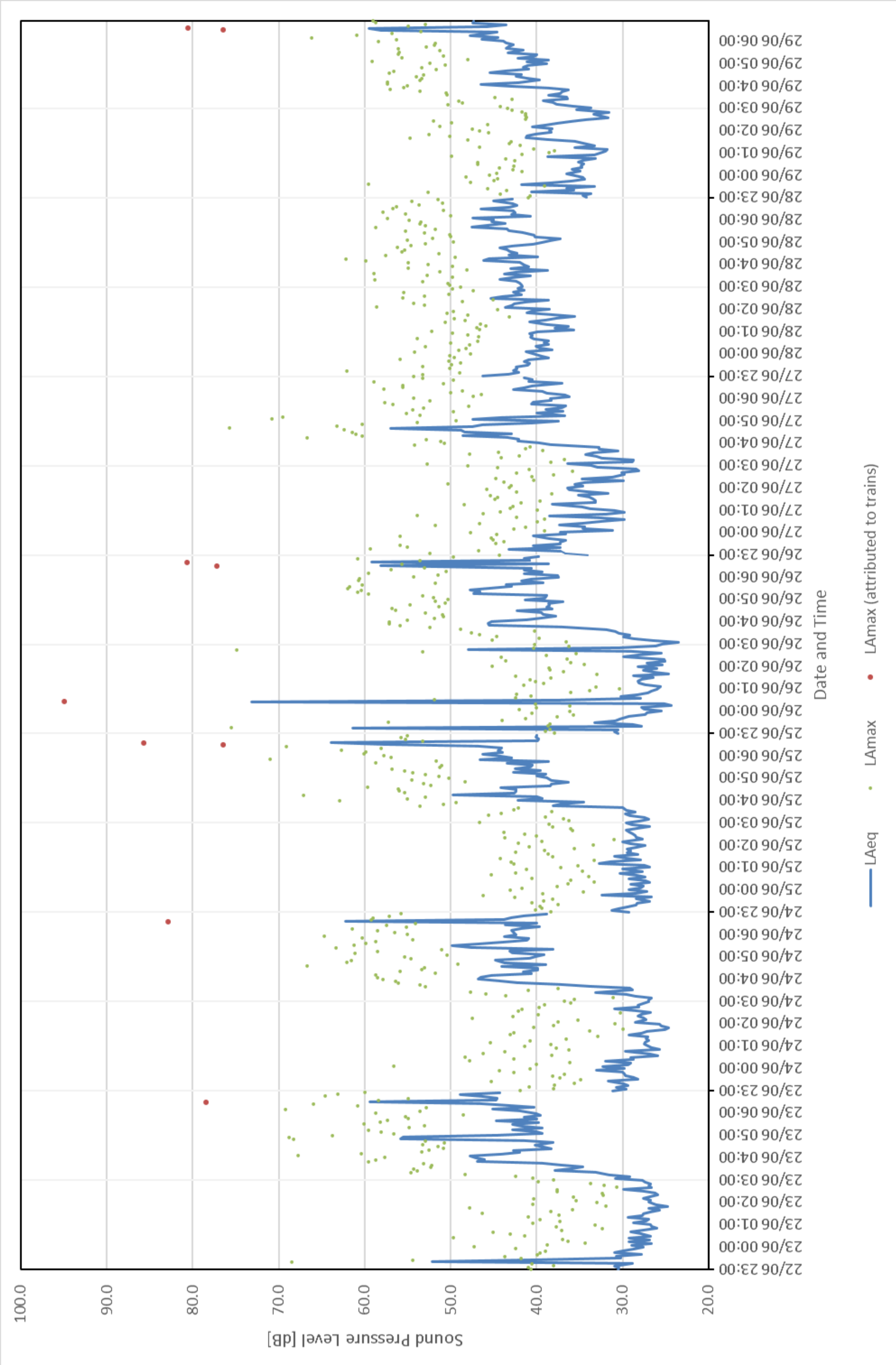
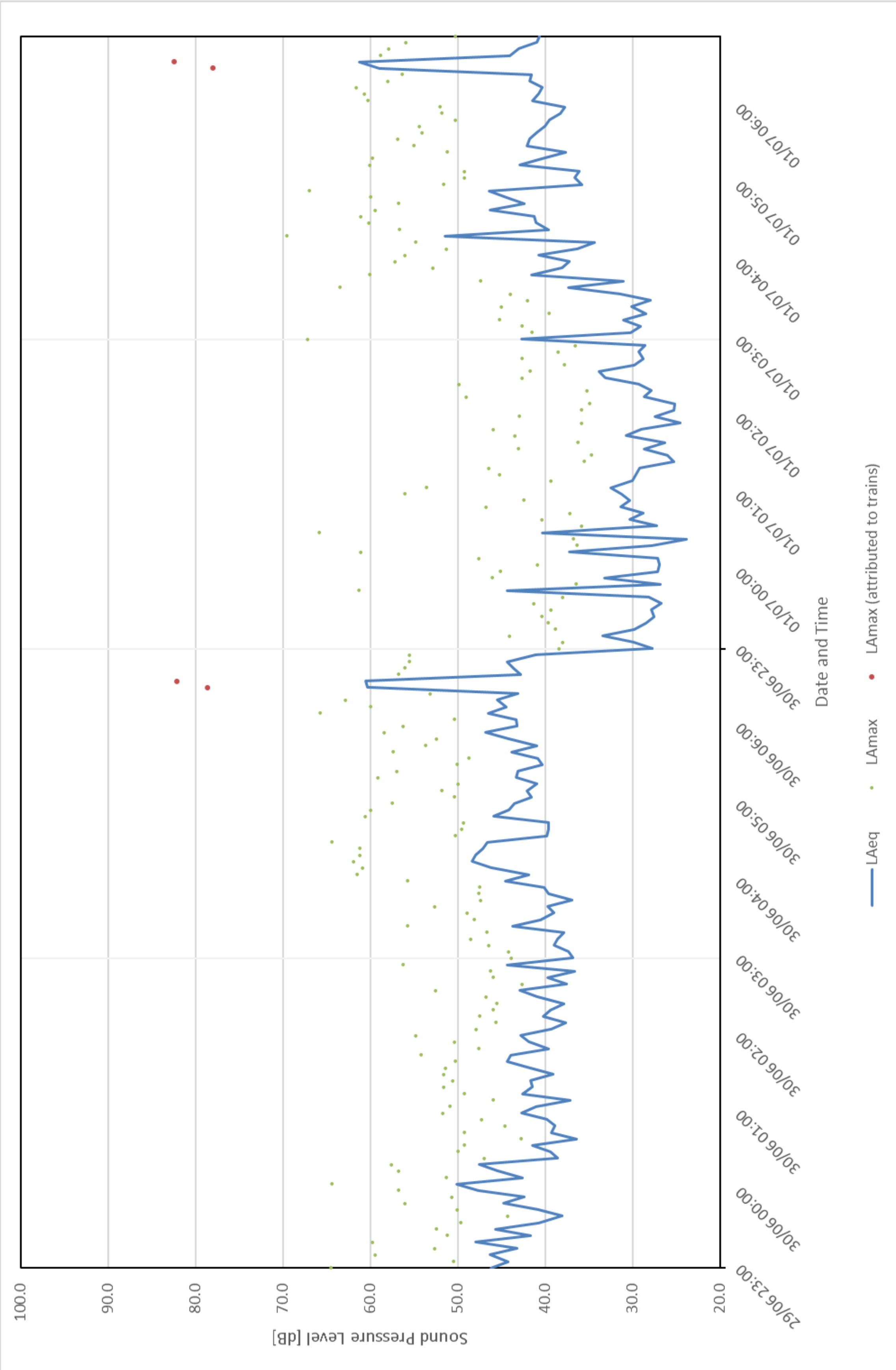


Figure B5: 5-minute data from the 29th June – 1st July 2020 – maximum levels from trains highlighted as red dots.



Appendix C

Real Time Trains data

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-06-01	06:32:58	06:35:05		LE
2020-06-01	06:34:48	06:36:52		LE
2020-06-02	06:33:00	06:34:50		LE
2020-06-02	06:34:45	06:36:57		LE
2020-06-03	06:32:40	06:35:02		LE
2020-06-04			01:41:01	ZZ
2020-06-04	06:33:00	06:35:12		LE
2020-06-04	06:36:51	06:38:27		LE
2020-06-05	01:37:00	01:45:04		ZZ
2020-06-05	06:34:27	06:35:10		LE
2020-06-05	06:35:10	06:37:05		LE
2020-06-07	23:31:27	23:32:05		LE
2020-06-08	06:32:37	06:35:04		LE
2020-06-08	06:42:52	06:43:39		LE
2020-06-08	23:18:57	23:19:20		LE
2020-06-09	06:32:52	06:35:08		LE
2020-06-09	06:38:01	06:39:29		LE
2020-06-10	06:35:27	06:37:14		LE
2020-06-11	06:32:39	06:34:45		LE
2020-06-11	06:42:59	06:44:10		LE
2020-06-12	06:32:26	06:34:41		LE
2020-06-12	06:35:06	06:36:53		LE
2020-06-15	06:33:49	06:35:35		LE
2020-06-15	06:35:39	06:37:26		LE
2020-06-16	06:32:31	06:34:53		LE
2020-06-16	06:41:22	06:42:46		LE
2020-06-17	06:33:11	06:34:55		LE
2020-06-17	06:35:45	06:37:42		LE
2020-06-18	06:32:44	06:34:53		LE
2020-06-18	06:35:35	06:37:28		LE
2020-06-19	06:33:04	06:34:52		LE
2020-06-19	06:37:54	06:38:44		LE
2020-06-22	06:34:48	06:36:59		LE
2020-06-23	06:33:04	06:35:07		LE
2020-06-24	06:34:58	06:36:59		LE
2020-06-25	06:33:38	06:35:25		LE
2020-06-25	06:35:24	06:37:04		LE
2020-06-26	06:36:06	06:36:45		LE
2020-06-26	06:34:55	06:38:24		LE
2020-06-29	06:32:27	06:34:37		LE
2020-06-29	06:35:13	06:36:37		LE
2020-06-30	06:32:37	06:34:50		LE
2020-06-30	06:35:48	06:36:52		LE
2020-07-01	06:32:31	06:34:43		LE
2020-07-01	06:35:36	06:36:54		LE

SHARPS REDMORE

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Report

Project
EDF – Sizewell C Power Station: Woodbridge Rail noise survey monthly report – July 2020

Prepared by
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Date 19th August 2020
Rev Date 19th October 2020

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Contents

Appendices

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of noise levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing noise climate at night to assist with understanding the context in which the proposed additional rail movements at night would need to be considered.

1.2 The survey work began on 4th March 2020. A Type 1 sound level meter was installed at the location shown in Figure A1 in Appendix A. The microphone is in a free field location approximately 5 metres from the rail line at a height of 1.8m above ground. The meter is regularly serviced and a calibration check carried out.

1.3 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

1.4 Levels have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line and using a combination of this information and an analysis of the measured levels, results have been interpreted to provide a summary of levels and the likely source which has resulted in those levels, where this is possible to determine.

1.5 Results (L_{Aeq} and L_{Amax} values) are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

1.6 This revision is necessary as full RTT data for the entire month was provided in September 2020. This has allowed for more complete analysis of the measured results to be carried out. Screenshots of the website have been replaced with tabulated data for night time train movements during the month in Appendix C.

2.0 Analysis of survey results

2.1 Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 Raw data for night time in 5-minute periods has been provided in Appendix B.

2.3 Table 2.1 overleaf shows the $L_{Aeq,\ 8h}$ values and range of L_{Amax} values measured throughout night time periods in July. Night is defined to be between 23:00-07:00 hours.

Table 2.1: Night time $L_{Aeq, 8\text{-}hour}$ values and L_{Amax} ranges in July*

Date	Day	$L_{Aeq, 8 hours}$	$L_{AMax, 5 Min}$ Range	
			Min	Max
01/07/2020	Wednesday	44	33	82
02/07/2020	Thursday	44	30	82
03/07/2020	Friday	45	46	68
04/07/2020	Saturday	52	45	88
05/07/2020	Sunday	47	46	85
06/07/2020	Monday	46	34	87
07/07/2020	Tuesday	45	37	82
08/07/2020	Wednesday	46	37	84
09/07/2020	Thursday	44	33	81
10/07/2020	Friday	38	35	69
11/07/2020	Saturday	37	31	71
12/07/2020	Sunday	44	33	82
13/07/2020	Monday	47	36	82
14/07/2020	Tuesday	46	31	83
15/07/2020	Wednesday	45	34	84
16/07/2020	Thursday	44	32	82
17/07/2020	Friday	38	36	71
18/07/2020	Saturday	37	35	71
19/07/2020	Sunday	46	33	85
20/07/2020	Monday	47	35	86
21/07/2020	Tuesday	45	34	83
22/07/2020	Wednesday	46	37	87
23/07/2020	Thursday	56	36	94
24/07/2020	Friday	37	37	63
25/07/2020	Saturday	37	34	81
26/07/2020	Sunday	43	37	82
27/07/2020	Monday	45	35	82
28/07/2020	Tuesday	44	35	81
29/07/2020	Wednesday	45	35	82
30/07/2020	Thursday	50	37	91
31/07/2020	Friday	37	35	71

***Dates signify the date at the start of the night time period (I.e. 01/07/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.4 $L_{Aeq, 8h}$ values ranged from 37 dB to 56 dB throughout the month. The arithmetic average $L_{Aeq, 8h}$ value for night time periods throughout the month was 44 dB.

2.5 For each night in July, the number of times that L_{Amax} values exceeded 60 dB, 70 dB, 80 dB, 90 dB and 100 dB has been determined. Note that each exceedance event only falls into a single category, for example, an L_{Amax} level of 74 dB only falls into the 70 dB category, and not the 60 dB category.

2.6 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Tabulated logs of night time train movements through Woodbridge station, provided by www.realtimetrains.co.uk, are shown in Appendix C.

2.7 Table 2.2 below, shows the number of L_{Amax} exceedance events for each night. The number of L_{Amax} events attributed to train movements is shown in brackets for each category.

Table 2.2: L_{Amax} exceedance events throughout July, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)				
		60dB	70dB	80dB	90dB	100dB
01/07/2020	Wednesday	8 (0)	3 (1)	1 (1)	0 (0)	0 (0)
02/07/2020	Thursday	6 (0)	2 (1)	1 (1)	0 (0)	0 (0)
03/07/2020	Friday	9 (0)	0 (0)	0 (0)	0 (0)	0 (0)
04/07/2020	Saturday	23 (0)	0 (0)	2 (1)	0 (0)	0 (0)
05/07/2020	Sunday	8 (0)	1 (1)	1 (1)	0 (0)	0 (0)
06/07/2020	Monday	2 (0)	1 (1)	1 (1)	0 (0)	0 (0)
07/07/2020	Tuesday	5 (0)	2 (1)	2 (1)	0 (0)	0 (0)
08/07/2020	Wednesday	11 (0)	1 (1)	1 (1)	0 (0)	0 (0)
09/07/2020	Thursday	5 (0)	1 (1)	1 (1)	0 (0)	0 (0)
10/07/2020	Friday	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11/07/2020	Saturday	5 (0)	1 (0)	0 (0)	0 (0)	0 (0)
12/07/2020	Sunday	1 (0)	3 (1)	1 (1)	0 (0)	0 (0)
13/07/2020	Monday	10 (0)	6 (1)	1 (1)	0 (0)	0 (0)
14/07/2020	Tuesday	2 (0)	2 (1)	2 (2)	0 (0)	0 (0)
15/07/2020	Wednesday	0 (0)	2 (1)	1 (1)	0 (0)	0 (0)
16/07/2020	Thursday	5 (0)	1 (1)	1 (1)	0 (0)	0 (0)
17/07/2020	Friday	4 (0)	1 (0)	0 (0)	0 (0)	0 (0)
18/07/2020	Saturday	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)
19/07/2020	Sunday	1 (0)	2 (1)	1 (1)	0 (0)	0 (0)
20/07/2020	Monday	0 (0)	2 (2)	2 (1)	0 (0)	0 (0)
21/07/2020	Tuesday	5 (0)	2 (1)	1 (1)	0 (0)	0 (0)
22/07/2020	Wednesday	8 (0)	2 (1)	2 (1)	0 (0)	0 (0)
23/07/2020	Thursday	1 (0)	1 (1)	2 (2)	1 (1)	0 (0)
24/07/2020	Friday	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
25/07/2020	Saturday	3 (0)	2 (0)	1 (0)	0 (0)	0 (0)
26/07/2020	Sunday	2 (0)	1 (1)	1 (1)	0 (0)	0 (0)
27/07/2020	Monday	5 (0)	1 (1)	1 (1)	0 (0)	0 (0)
28/07/2020	Tuesday	6 (0)	5 (1)	1 (1)	0 (0)	0 (0)
29/07/2020	Wednesday	4 (0)	3 (1)	1 (1)	0 (0)	0 (0)
30/07/2020	Thursday	4 (0)	4 (1)	3 (2)	1 (0)	0 (0)
31/07/2020	Friday	3 (0)	1 (0)	0 (0)	0 (0)	0 (0)
Total Exceedance Events		**153**	**54**	**32**	**2**	**0**

2.8 Table 2.2 shows that L_{Amax} levels between 60-70 dB at the measurement point are common, with an average of 5 per night. Exceedance events become increasingly rare as bands levels increase. There were two events where levels exceeded 90dB during the month.

2.9 From Table 2.2, the percentage of exceedance events attributed to trains can be calculated for each band. These have been calculated for dates where RTT data was available. These are shown in Table 2.3.

Table 2.3: Percentage of exceedance events attributed to trains between 1-31st July.

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	153	0	0%
70dB	54	23	43%
80dB	32	26	81%
90dB	2	1	50%
100dB	0	0	N/A

2.10 Table 2.3 shows that, whilst common, none of the measured L_{Amax} levels between 60-70 dB were due to train pass by events between 1 and 31st July 2020. 43% of all L_{Amax} levels between 70-80 dB were attributed to trains whilst 81% of 80 dB exceedance events were due to a train pass. One of the maximum sound events over 90 dB was attributed to a train.

2.11 The noise source causing the remaining cases is unknown, however analysis of the one second traces from the sound level meter indicates that these are likely to have been caused by birds and other wildlife, or may have been due to occasional short engineering trains passing up and down the railway which are not recorded on RTT.

2.12 Table 2.4 shows the lifetime statistics for exceedance events recorded at the measurement point.

Table 2.4: Total number of exceedance events and those attributed to trains measured from March 2020 onwards

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	1448	1	0%
70dB	302	111	37%
80dB	164	129	79%
90dB	9	6	67%
100dB	0	0	N/A

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing noise monitoring location

Appendix B

Graphs of Survey Results

Figure B1: 5-minute data from the 1st-6th of July 2020 – maximum levels from trains highlighted as red dots

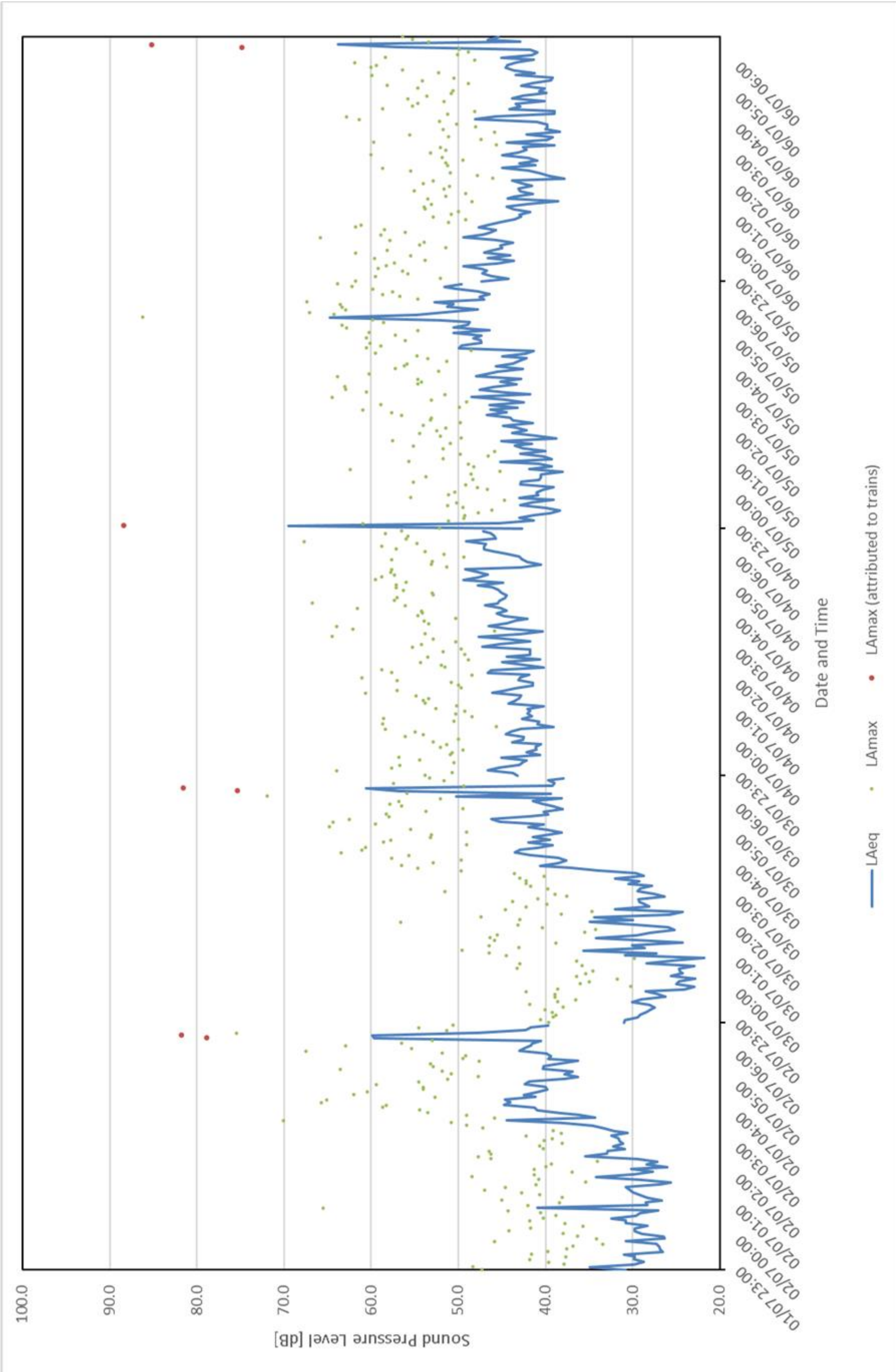


Figure B2: 5-minute data from the 6th-13th of July 2020 – maximum levels from trains highlighted as red dots

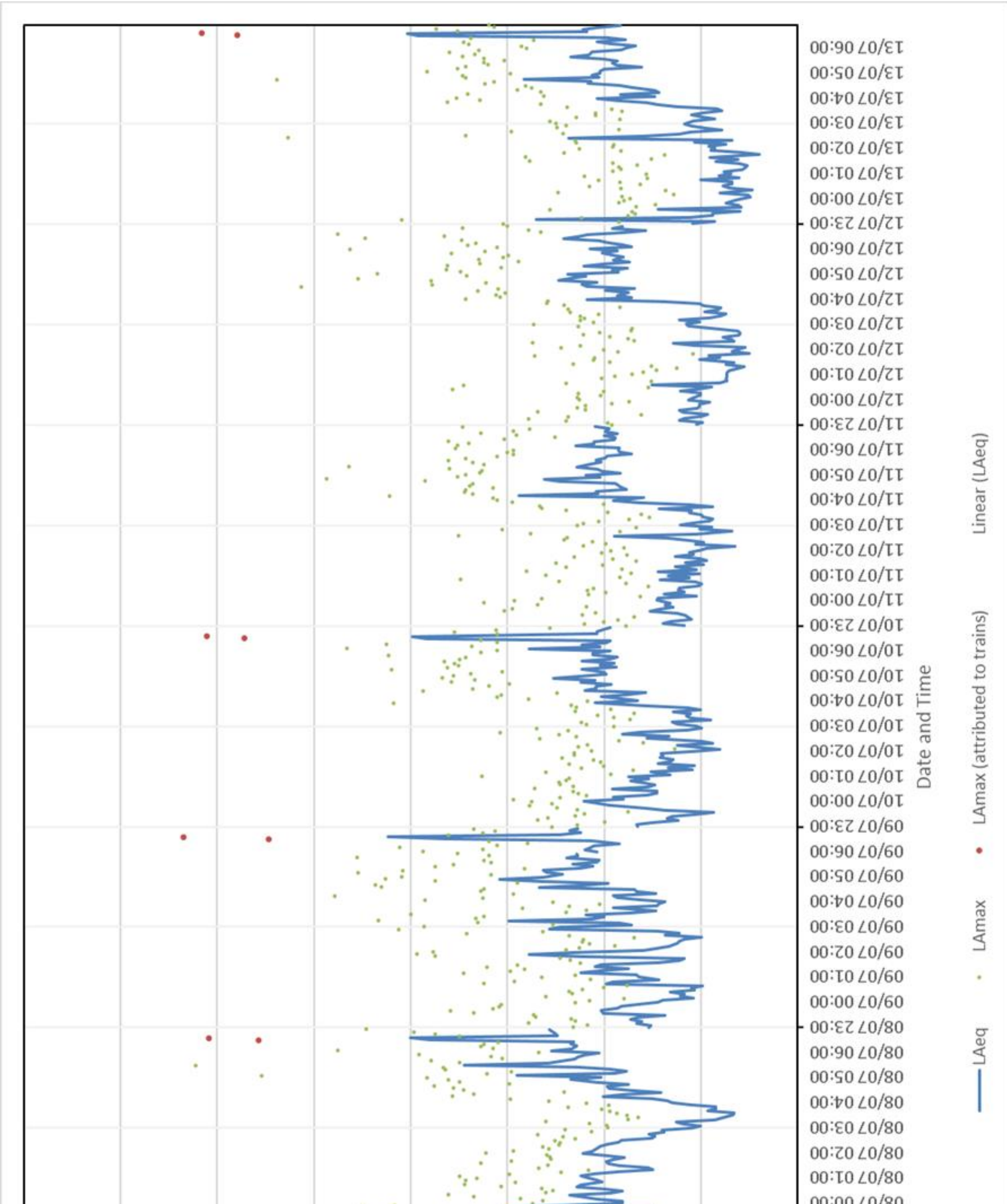


Figure B3: 5-minute data from the 13th-20th of July 2020 – maximum levels from trains highlighted as red dots

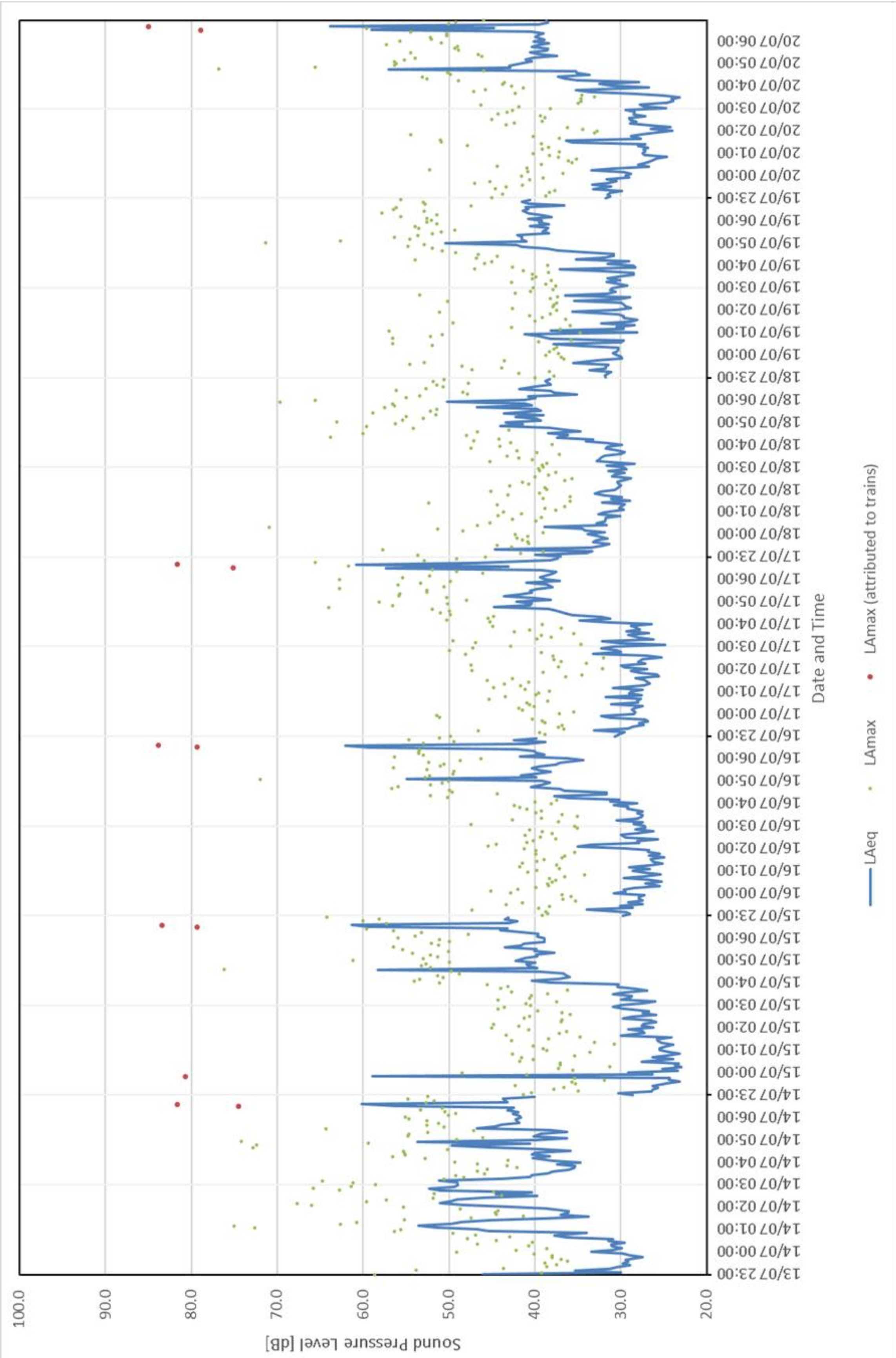


Figure B4: 5-minute data from the 20th-27th of July 2020 – maximum levels from trains highlighted as red dots.

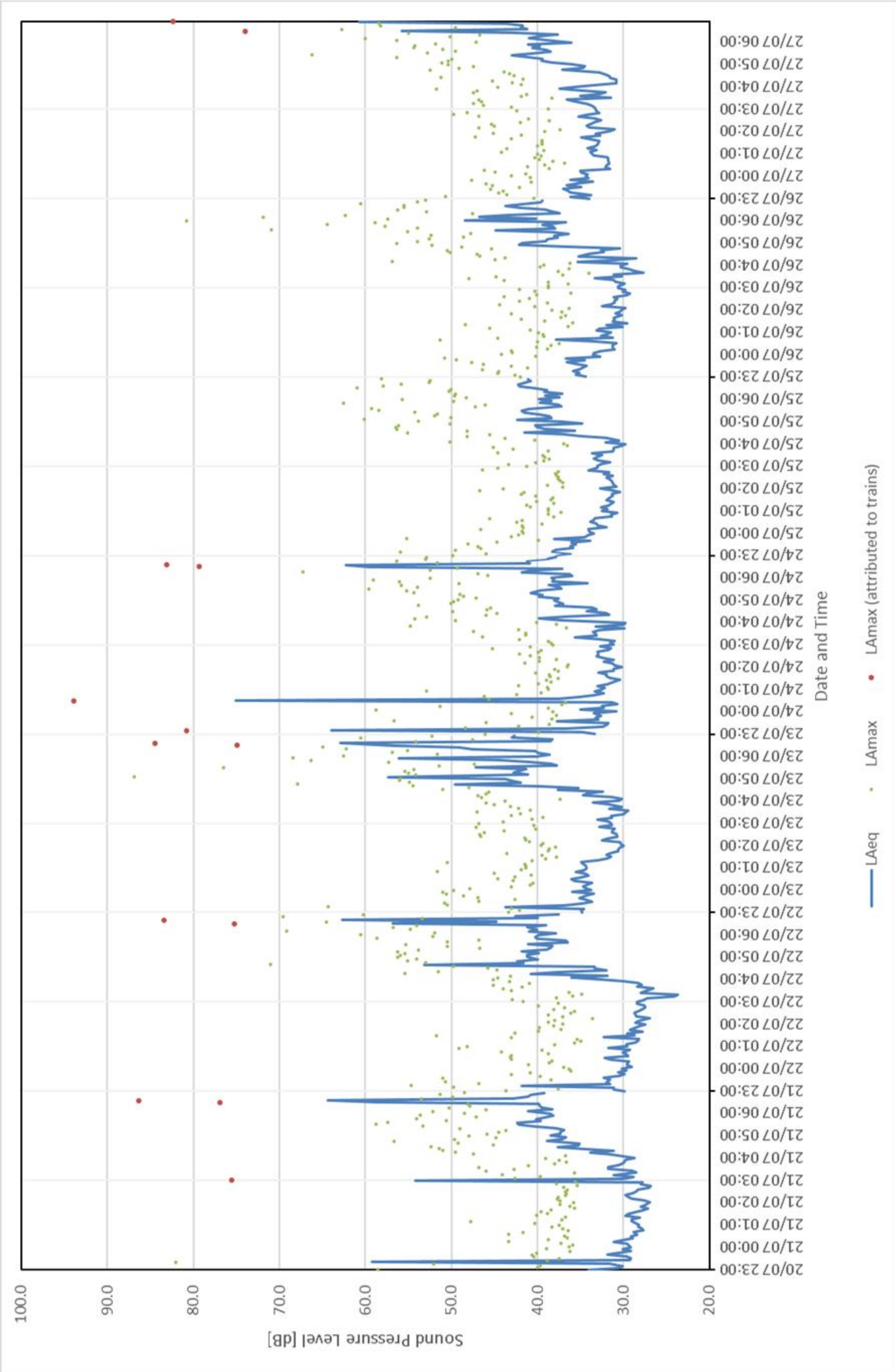
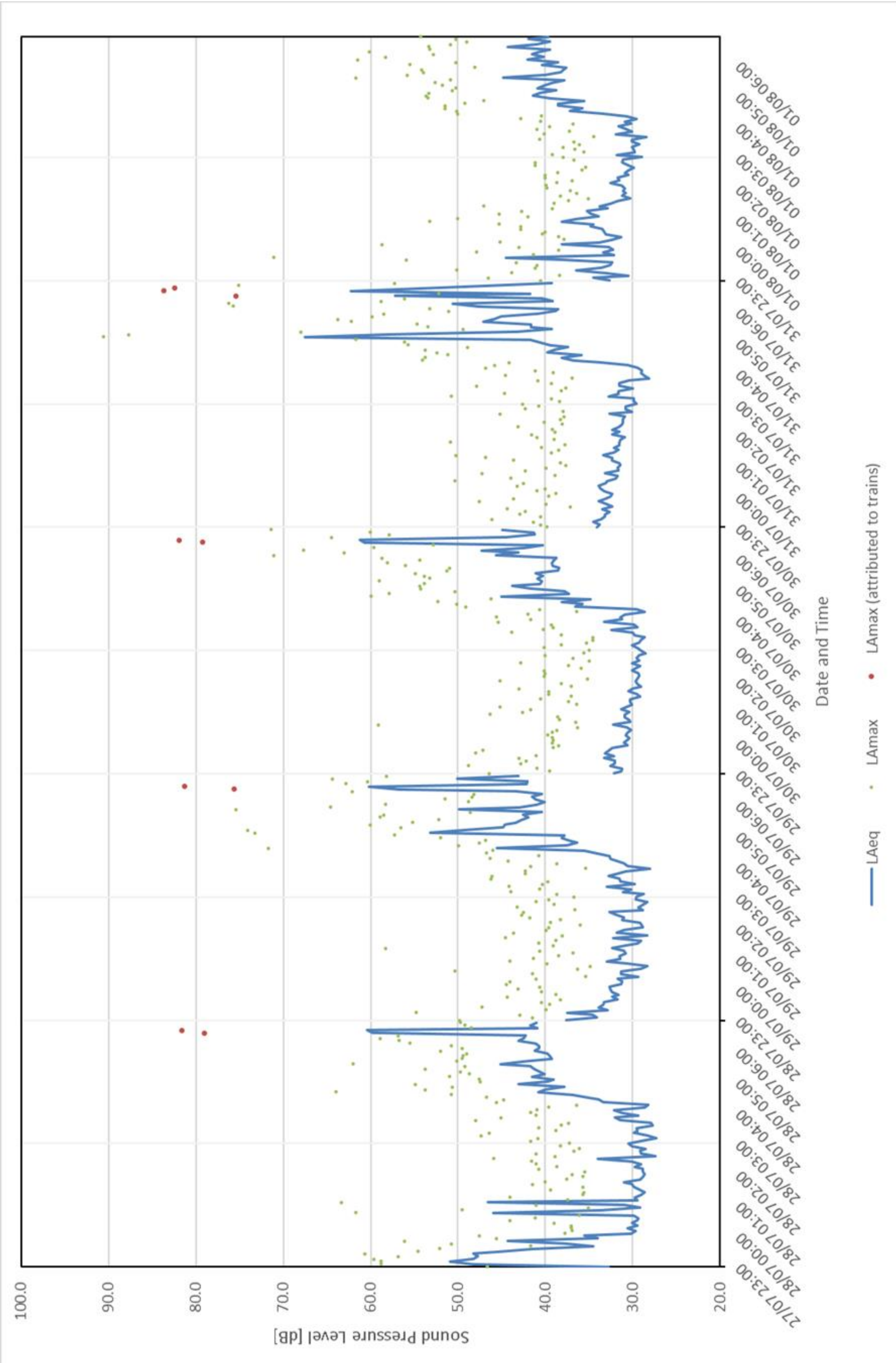


Figure B5: 5-minute data from the 27th July - 1st August 2020 – maximum levels from trains highlighted as red dots.



Appendix C

Real Time Trains Data

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-07-02	06:32:30	06:34:54		LE
2020-07-02	06:35:31	06:37:50		LE
2020-07-03	06:32:27	06:34:43		LE
2020-07-03	06:35:39	06:37:03		LE
2020-07-04	22:47:21	23:04:19		ZZ
2020-07-06			06:38:45	LE
2020-07-06	06:39:39	06:41:06		LE
2020-07-07	06:32:56	06:34:57		LE
2020-07-07	06:34:56	06:36:46		LE
2020-07-08	06:33:11	06:34:09		LE
2020-07-08	06:35:29	06:37:28		LE
2020-07-09	06:33:31	06:34:27		LE
2020-07-09	06:34:53	06:36:55		LE
2020-07-10	06:32:43	06:34:47		LE
2020-07-10	06:35:04	06:36:31		LE
2020-07-13	06:32:51	06:35:00		LE
2020-07-13	06:35:00	06:37:03		LE
2020-07-14	06:32:54	06:34:31		LE
2020-07-14	06:35:11	06:36:55		LE
2020-07-14			23:41:32	ZZ
2020-07-15			04:39:38	ZZ
2020-07-15	06:32:26	06:34:44		LE
2020-07-15	06:36:33	06:37:47		LE
2020-07-16	06:33:11	06:34:49		LE
2020-07-16	06:35:13	06:37:06		LE
2020-07-17	06:32:57	06:34:55		LE
2020-07-17	06:35:23	06:38:00		LE
2020-07-20	06:33:16	06:35:31		LE
2020-07-20	06:40:34	06:42:14		LE
2020-07-21			03:06:28	ZZ
2020-07-21	06:33:02	06:35:11		LE
2020-07-21	06:34:46	06:37:08		LE
2020-07-22	06:32:23	06:34:46		LE
2020-07-22	06:37:13	06:38:54		LE
2020-07-23	06:33:41	06:35:06		LE
2020-07-23	06:36:17	06:37:15		LE
2020-07-23			23:15:08	ZZ
2020-07-24			00:29:03	ZZ
2020-07-24	06:32:51	06:34:55		LE
2020-07-24	06:35:31	06:37:30		LE
2020-07-27	06:33:00	06:35:30		LE
2020-07-27	06:55:36	06:56:48		LE
2020-07-28	06:38:18	06:38:49		LE
2020-07-28	06:34:53	06:40:56		LE
2020-07-29	06:32:36	06:34:41		LE
2020-07-29	06:35:10	06:36:47		LE

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-07-30	06:32:48	06:34:51		LE
2020-07-30	06:35:18	06:37:15		LE
2020-07-31	06:32:39	06:35:17		LE
2020-07-31	06:35:33	06:38:07		LE

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Report

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Appendices

A. Plan showing noise monitoring location

B. Graphs of Survey Results

C. Real Time Train information

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of noise levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing noise climate at night to assist with understanding the context in which the proposed additional rail movements at night would need to be considered.

1.2 The survey work began on 4th March 2020. A Type 1 sound level meter was installed at the location shown in Figure A1 in Appendix A. The microphone is in a free field location approximately 5 metres from the rail line at a height of 1.8m above ground. The meter is regularly serviced, and a calibration check carried out.

1.3 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

1.4 Levels have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line and using a combination of this information and an analysis of the measured levels, results have been interpreted to provide a summary of levels and the likely source which has resulted in those levels, where this is possible to determine.

1.5 Results (L_{Aeq} and L_{Amax} values) are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

1.6 This revision is necessary to provide an updated version of the lifetime statistics shown in table 2.4. This is due to realtimetrains.co.uk providing full data for the months preceding this report, and as a result, a more complete analysis has been provided for previous reports. As a result, the number of exceedance events attributed to trains has increased.

2.0 Analysis of survey results

2.1 Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 Raw data for night time in 5-minute periods has been provided in Appendix B.

2.3 Table 2.1 overleaf shows the $L_{Aeq, 8h}$ values and range of L_{Amax} values measured throughout night time periods in August. Night is defined to be between 23:00-07:00 hours.

Table 2.1: Night time $L_{Aeq, 8\text{-}hour}$ values and L_{Amax} ranges in August*

Date	Day	$L_{Aeq, 8 hours}$	$L_{AMax, 5 Min}$ Range	
			Min	Max
01/08/2020	Saturday	35	35	63
02/08/2020	Sunday	45	34	86
03/08/2020	Monday	45	32	85
04/08/2020	Tuesday	47	42	84
05/08/2020	Wednesday	45	32	85
06/08/2020	Thursday	48	33	85
07/08/2020	Friday	35	30	59
08/08/2020	Saturday	36	35	62
09/08/2020	Sunday	44	35	83
10/08/2020	Monday	51	34	86
11/08/2020	Tuesday	51	35	86
12/08/2020	Wednesday	43	33	81
13/08/2020	Thursday	46	37	82
14/08/2020	Friday	50	34	85
15/08/2020	Saturday	38	32	74
16/08/2020	Sunday	42	29	81
17/08/2020	Monday	48	35	81
18/08/2020	Tuesday	44	33	83
19/08/2020	Wednesday	45	38	86
20/08/2020	Thursday	49	34	83
21/08/2020	Friday	47	41	80
22/08/2020	Saturday	39	40	70
23/08/2020	Sunday	46	36	94
24/08/2020	Monday	45	34	81
25/08/2020	Tuesday	56	58	84
26/08/2020	Wednesday	49	34	88
27/08/2020	Thursday	45	36	85
28/08/2020	Friday	39	32	69
29/08/2020	Saturday	41	41	67
30/08/2020	Sunday	45	33	84
31/08/2020	Monday	43	29	84

***Dates signify the date at the start of the night time period (I.e. 01/07/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.4 $L_{Aeq, 8h}$ values ranged from 35 dB to 56 dB throughout the month. The arithmetic average $L_{Aeq, 8h}$ value for night time periods throughout the month was 45 dB.

2.5 For each night in August, the number of times that L_{Amax} values exceeded 60 dB, 70 dB, 80 dB, 90 dB and 100 dB has been determined. Note that each exceedance event only falls into a single category, for example, an L_{Amax} level of 74 dB only falls into the 70 dB category, and not the 60 dB category.

2.6 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Data from this site has been provided for all days in August. Appendix C contains a table showing all night time trains logged by www.realtimetrains.co.uk during the month.

2.7 Table 2.2 below, shows the number of L_{Amax} exceedance events for each night. All dates had RTT data available. The number of L_{Amax} events attributed to train movements is shown in brackets for each category.

2.8 Throughout the night of the 25th August, there were consistent elevated levels compared to a typical night. The source of these raised levels is not known however appears to be artificially generated noise due to its generally consistent level. The raised night time levels can be seen on the chart presented in Appendix B

2.9 This source produced a large quantity of 60 dB exceedance events as well as some 70 dB events. It was however still possible to attribute exceedance events to trains despite the generally raised sound levels.

Table 2.2: L_{Amax} exceedance events throughout August, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)				
		60dB	70dB	80dB	90dB	100dB
01/08/2020	Saturday	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)
02/08/2020	Sunday	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)
03/08/2020	Monday	4 (0)	1 (1)	1 (1)	0 (0)	0 (0)
04/08/2020	Tuesday	1 (0)	2 (1)	2 (2)	0 (0)	0 (0)
05/08/2020	Wednesday	5 (0)	2 (2)	1 (1)	0 (0)	0 (0)
06/08/2020	Thursday	1 (0)	4 (2)	4 (3)	0 (0)	0 (0)
07/08/2020	Friday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
08/08/2020	Saturday	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
09/08/2020	Sunday	4 (0)	2 (1)	1 (1)	0 (0)	0 (0)
10/08/2020	Monday	4 (0)	2 (2)	3 (3)	0 (0)	0 (0)
11/08/2020	Tuesday	1 (0)	3 (3)	2 (2)	0 (0)	0 (0)
12/08/2020	Wednesday	2 (0)	1 (1)	1 (1)	0 (0)	0 (0)
13/08/2020	Thursday	6 (0)	6 (1)	1 (1)	0 (0)	0 (0)
14/08/2020	Friday	2 (0)	1 (0)	2 (2)	0 (0)	0 (0)
15/08/2020	Saturday	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)
16/08/2020	Sunday	2 (0)	1 (1)	1 (1)	0 (0)	0 (0)
17/08/2020	Monday	0 (0)	4 (4)	1 (1)	0 (0)	0 (0)
18/08/2020	Tuesday	5 (0)	3 (1)	1 (1)	0 (0)	0 (0)
19/08/2020	Wednesday	1 (0)	1 (1)	1 (1)	0 (0)	0 (0)
20/08/2020	Thursday	5 (0)	2 (2)	1 (1)	0 (0)	0 (0)
21/08/2020	Friday	2 (0)	0 (0)	1 (1)	0 (0)	0 (0)
22/08/2020	Saturday	4 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23/08/2020	Sunday	7 (0)	1 (1)	1 (1)	1 (0)	0 (0)
24/08/2020	Monday	7 (0)	1 (1)	1 (1)	0 (0)	0 (0)
25/08/2020	Tuesday	67 (0)	22 (1)	1 (1)	0 (0)	0 (0)
26/08/2020	Wednesday	5 (0)	1 (1)	3 (3)	0 (0)	0 (0)
27/08/2020	Thursday	2 (0)	2 (1)	1 (1)	0 (0)	0 (0)
28/08/2020	Friday	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
29/08/2020	Saturday	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)
30/08/2020	Sunday	4 (0)	1 (1)	1 (1)	0 (0)	0 (0)
31/08/2020	Monday	2 (0)	2 (1)	2 (1)	0 (0)	0 (0)
Total Exceedance Events		**154**	**67**	**35**	**1**	**0**

2.10 Table 2.2 shows that L_{Amax} levels between 60-70 dB at the measurement point are common, with an average of 5 per night. Exceedance events become increasingly rare as bands levels increase. There was only one event where levels exceeded 90 dB during the month.

2.11 From Table 2.2, the percentage of exceedance events attributed to trains can be calculated for each band. These are shown in Table 2.3.

Table 2.3: Percentage of exceedance events attributed to trains between 1-31st August

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	154	0	0%
70dB	67	31	46%
80dB	35	33	94%
90dB	1	0	0%
100dB	0	0	N/A

2.12 Table 2.3 shows that, whilst common, none of the measured L_{Amax} levels between 60-70 dB were due to train pass by events between 1 and 31st August 2020. Approximately 46% of all L_{Amax} levels between 70-80 dB were attributed to trains whilst 94% of 80 dB exceedance events were due to a train pass. There was one 90 dB event which could not be attributed to a train pass.

2.13 The noise source causing the remaining cases is unknown, however analysis of the one second traces from the sound level meter indicates that these are likely to have been caused by birds and other wildlife, or may have been due to occasional short engineering trains passing up and down the railway which are not recorded on RTT.

2.14 Table 2.4 shows the lifetime statistics for exceedance events recorded at the measurement point.

Table 2.4: Total number of exceedance events and those attributed to trains measured from March 2020 onwards

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	1602	1	0%
70dB	369	142	38%
80dB	199	162	81%
90dB	10	6	60%
100dB	0	0	N/A

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing noise monitoring location

Appendix B

Graphs of Survey Results

Figure B1: 5-minute data from the 1st-3rd of August 2020 – maximum levels from trains highlighted as red dots

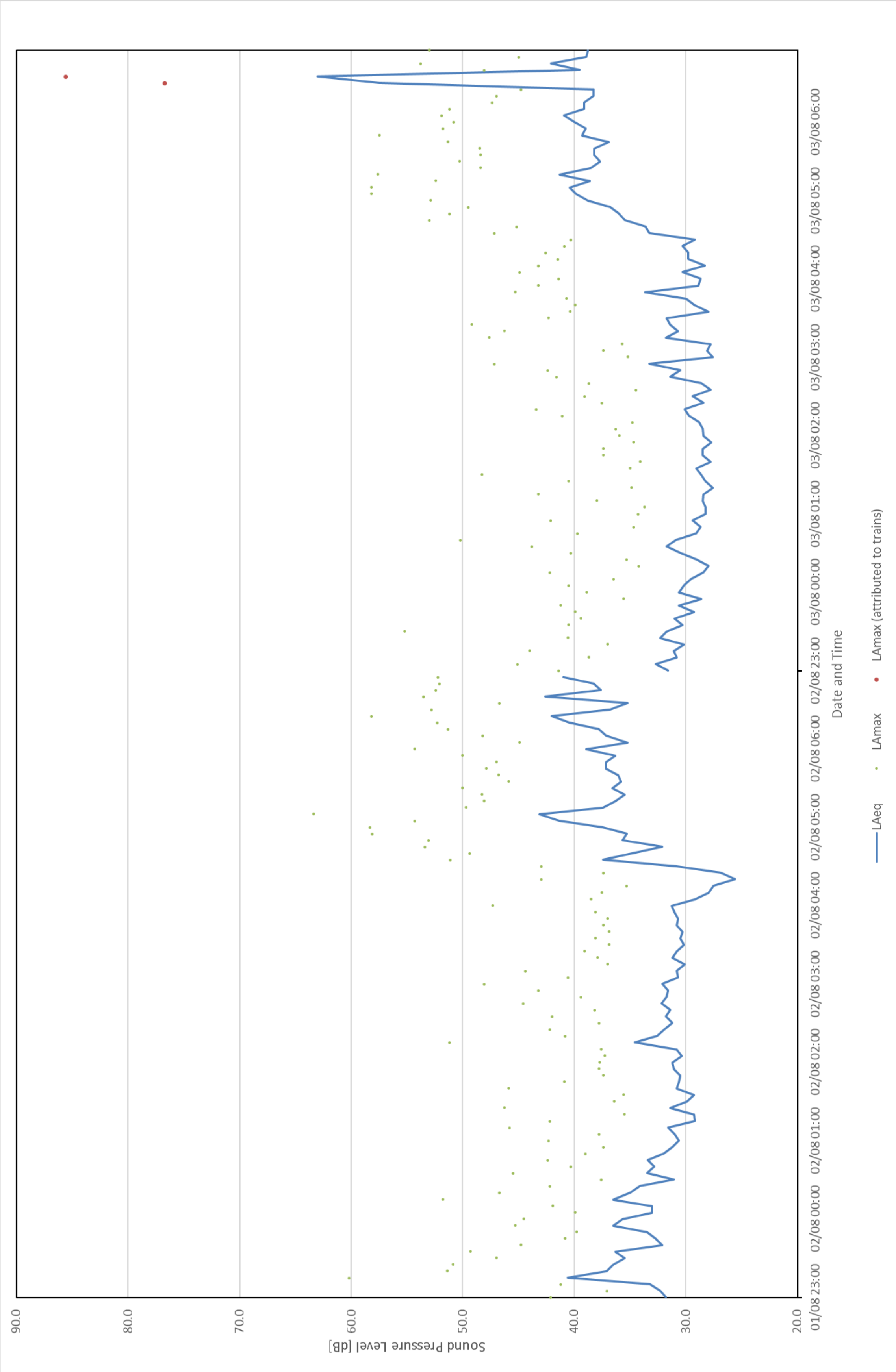


Figure B2: 5-minute data from the 3rd-10th of August 2020 – maximum levels from trains highlighted as red dots

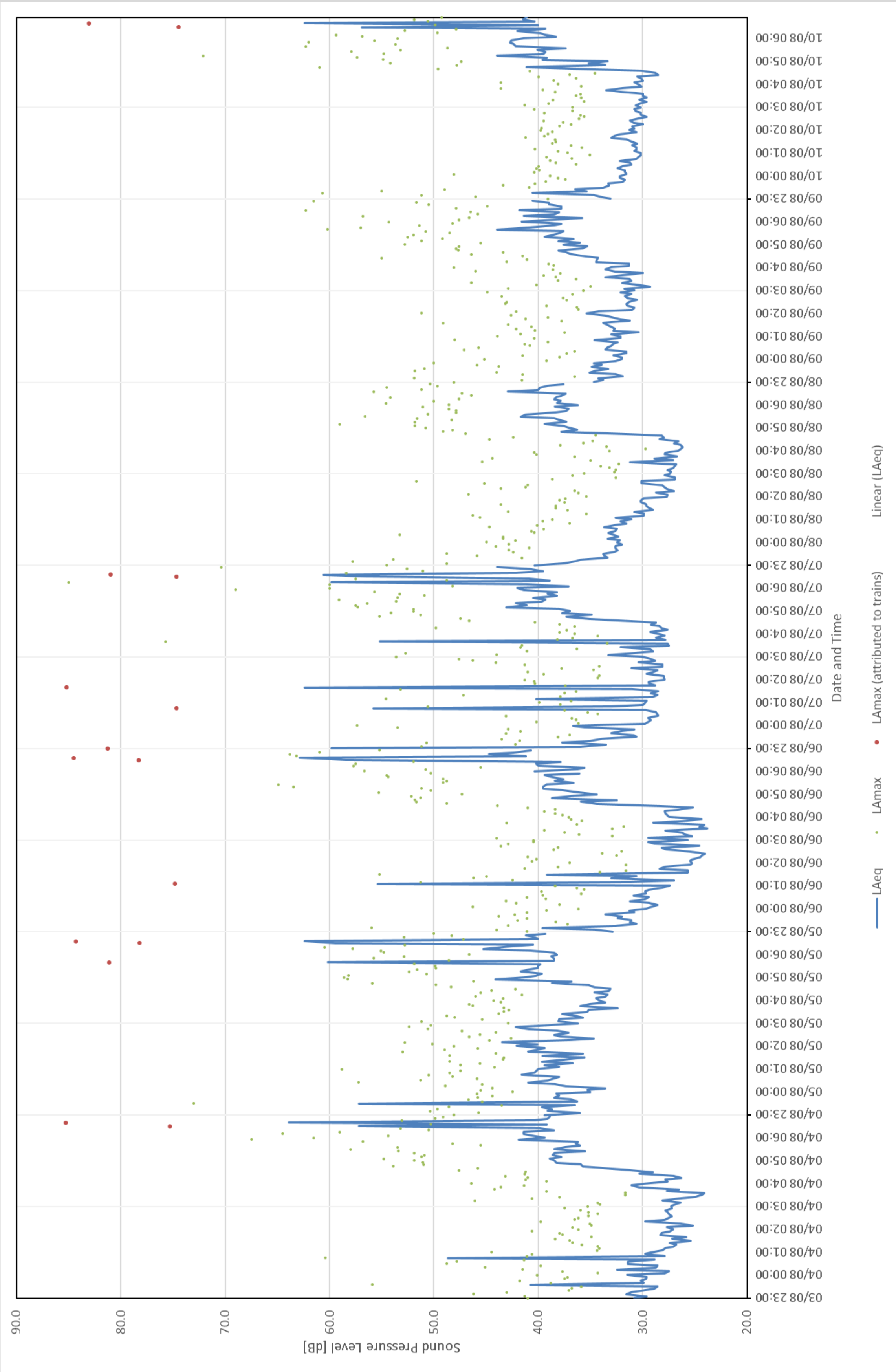


Figure B3: 5-minute data from the 10th-17th of August 2020 – maximum levels from trains highlighted as red dots

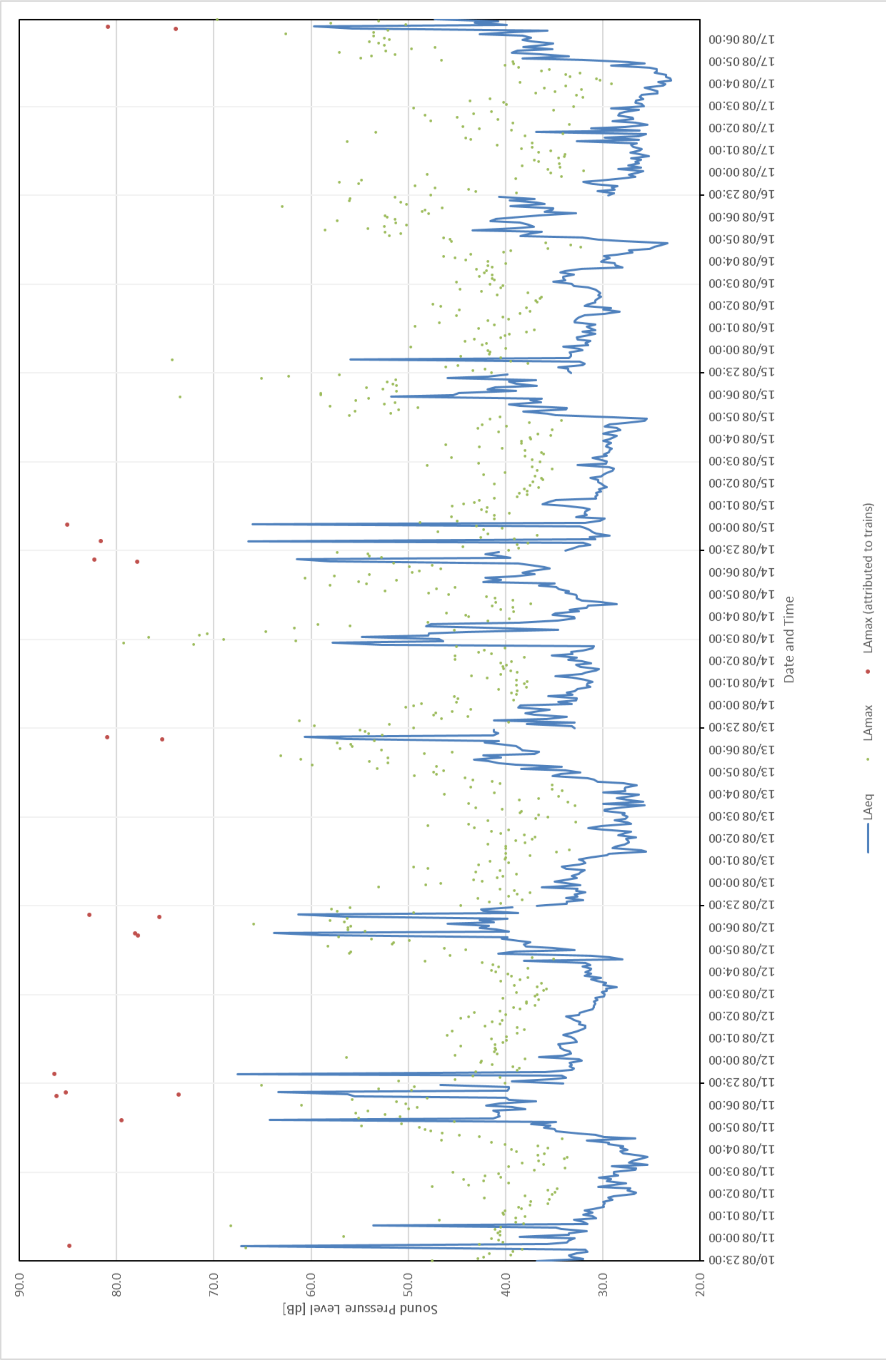


Figure B4: 5-minute data from the 17th-24th of August 2020 – maximum levels from trains highlighted as red dots.

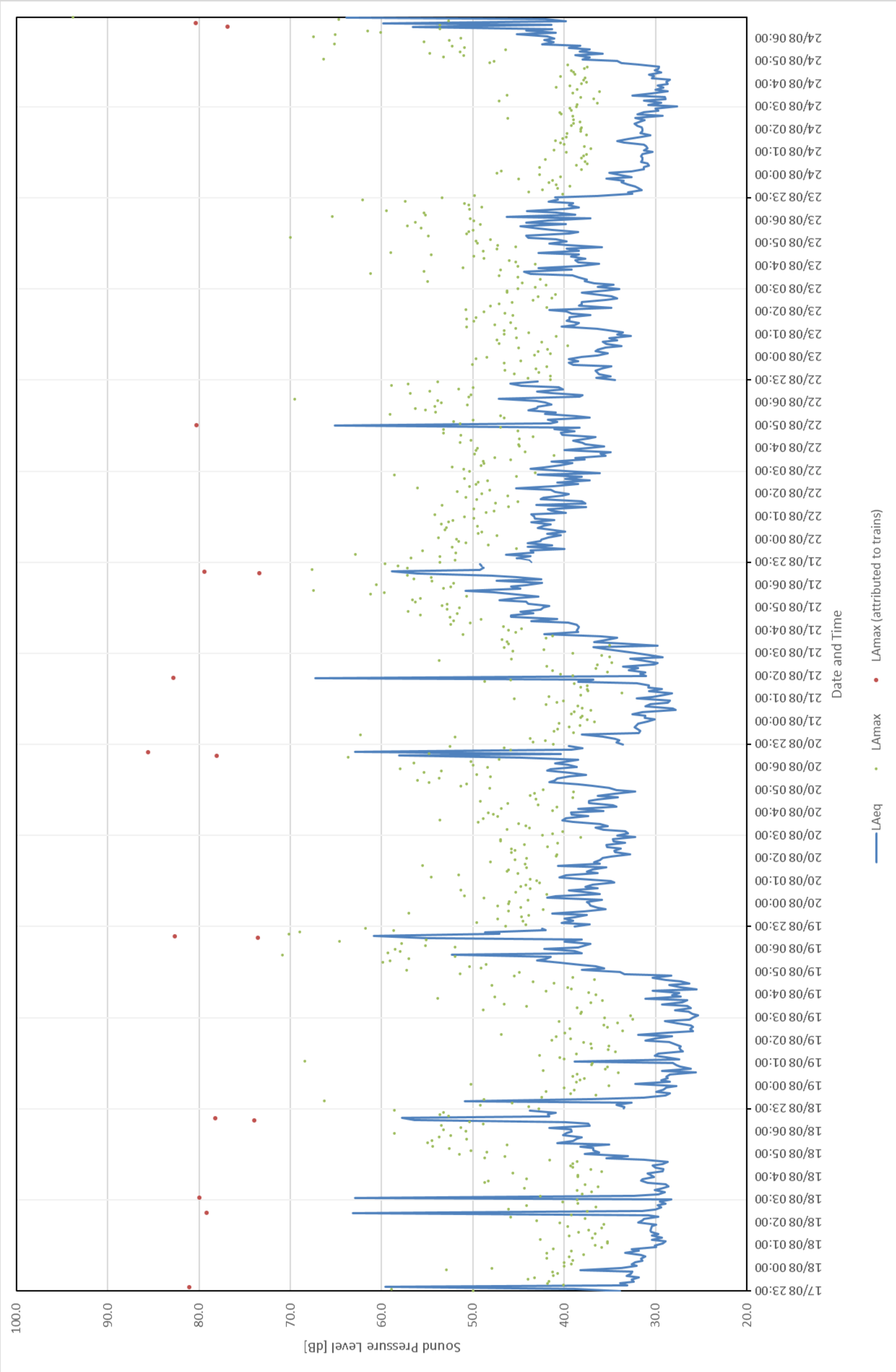
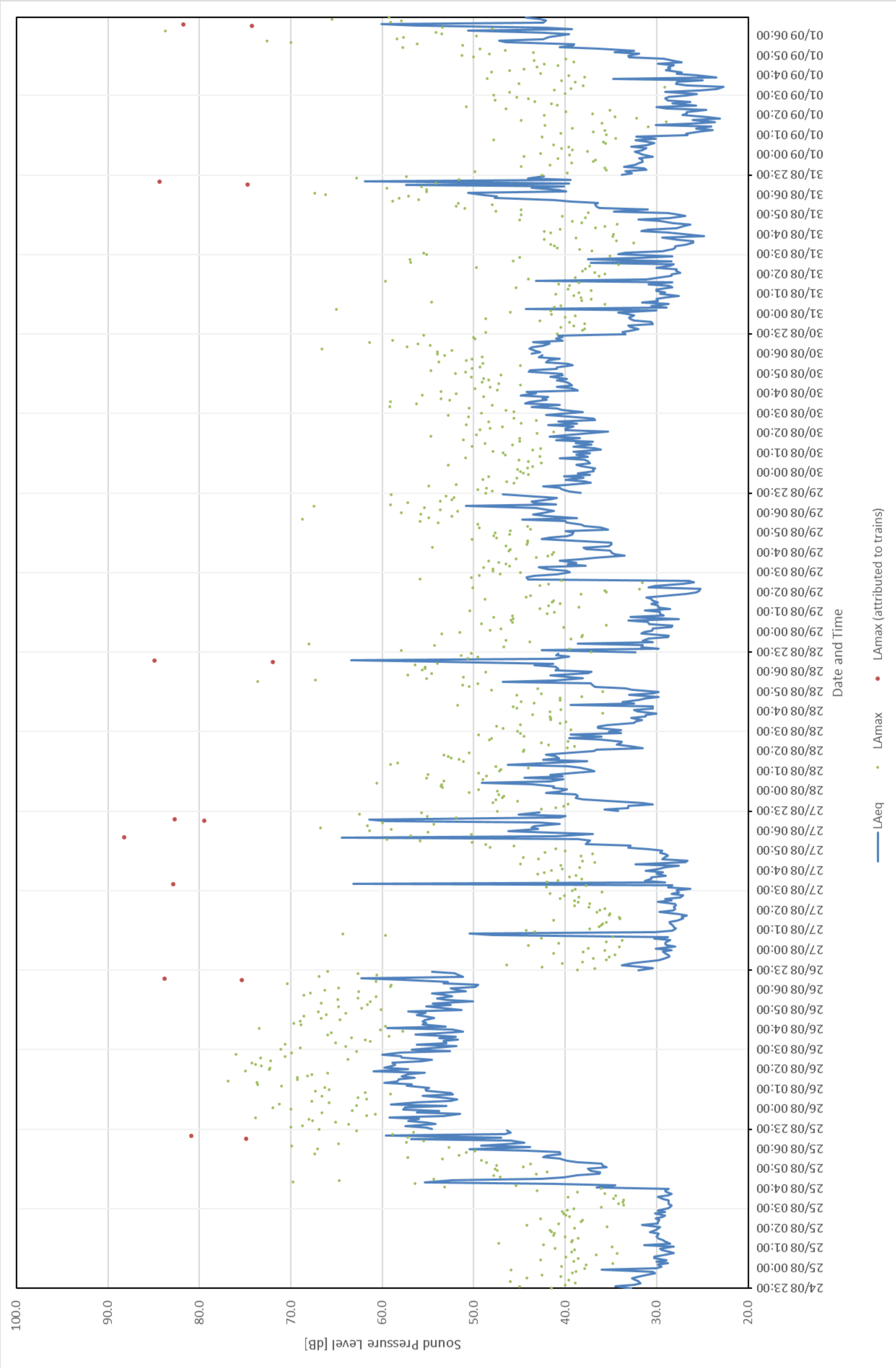


Figure B5: 5-minute data from the 24th-31st of August 2020 – maximum levels from trains highlighted as red dots.



Appendix C

Real Time Trains Data – Night Time Trains

Table C1: Woodbridge Station Night Time Train Passes, data provided by www.realtimetrains.co.uk.

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-08-03	06:33:22	06:35:00		LE
2020-08-03	06:35:18	06:37:10		LE
2020-08-04	06:36:36	06:37:25		LE
2020-08-04	06:35:34	06:39:21		LE
2020-08-05	05:37:00	05:39:00		ZZ
2020-08-05	06:32:30	06:34:47		LE
2020-08-05	06:35:47	06:37:01		LE
2020-08-06			01:11:16	ZZ
2020-08-06	06:33:03	06:34:58		LE
2020-08-06	06:34:52	06:36:46		LE
2020-08-06			22:59:00*	ZZ
2020-08-07			00:52:04	ZZ
2020-08-07			01:37:00	ZZ
2020-08-07	06:32:22	06:34:52		LE
2020-08-07	06:34:37	06:36:34		LE
2020-08-10	06:32:28	06:35:06		LE
2020-08-10	06:38:20	06:39:43		LE
2020-08-10	23:29:41	23:40:53		ZZ
2020-08-11	05:25:51	05:25:58		ZZ
2020-08-11	06:32:58	06:34:46		LE
2020-08-11	06:35:58	06:37:24		LE
2020-08-11	23:12:33	23:22:50		ZZ
2020-08-12	05:47:06	05:47:28		ZZ
2020-08-12	06:32:42	06:34:48		LE
2020-08-12	06:35:28	06:37:11		LE
2020-08-13	06:33:22	06:35:24		LE
2020-08-13	06:34:53	06:36:43		LE
2020-08-14	06:33:43	06:34:32		LE
2020-08-14	06:35:48	06:37:10		LE
2020-08-14	23:07:33	23:22:36		ZZ
2020-08-15	23:34:52	00:07:14		ZZ
2020-08-17	06:32:43	06:35:00		LE
2020-08-17	06:35:18	06:36:59		LE
2020-08-17	23:09:01	23:09:57		LE
2020-08-18	02:28:06	02:28:44		ZZ
2020-08-18	03:09:57	03:10:21		ZZ
2020-08-18	06:32:44	06:34:52		LE
2020-08-18	06:35:46	06:37:22		LE
2020-08-19	06:32:33	06:35:12		LE
2020-08-19	06:35:15	06:36:59		LE
2020-08-20	06:32:56	06:34:59		LE
2020-08-20	06:38:39	06:40:06		LE
2020-08-21	01:37:17	01:53:08		ZZ

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-08-21	06:33:12	06:35:28		LE
2020-08-21	06:35:43	06:37:05		LE
2020-08-22	05:03:59	05:04:52		ZZ
2020-08-24	06:33:30	06:35:18		LE
2020-08-24	06:38:07	06:39:35		LE
2020-08-25	06:32:48	06:34:40		LE
2020-08-25	06:38:20	06:39:06		LE
2020-08-26	06:33:00	06:35:07		LE
2020-08-26	06:35:37	06:37:04		LE
2020-08-27			03:16:00	ZZ
2020-08-27			05:45:00	ZZ
2020-08-27	06:32:00			LE
2020-08-27	06:35:00	06:37:00		LE
2020-08-28	06:32:25	06:34:40		LE
2020-08-28	06:35:13	06:36:54		LE
2020-08-31	06:32:52	06:35:06		LE
2020-08-31	06:40:01	06:41:48		LE
2020-09-01	06:33:17	06:34:50		LE
2020-09-01	06:35:26	06:37:32		LE

*Note this time falls outside of the defined night time period of 23:00-07:00, however is the time which the train is recorded to have passed through Woodbridge Railway Station. This train passed the measurement location further down the track shortly after 23:00.

SHARPS REDMORE

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Report

Project
EDF – Sizewell C Power Station: Woodbridge Rail noise survey monthly report – September 2020

Prepared by
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and

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Contents

Appendices

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of noise levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing noise climate at night to assist with understanding the context in which the proposed additional rail movements at night would need to be considered.

1.2 The survey work began on 4th March 2020. A Type 1 sound level meter was installed at the location shown in Figure A1 in Appendix A. The microphone is in a free field location approximately 5 metres from the rail line at a height of 1.8m above ground. The meter is regularly serviced, and a calibration check carried out.

1.3 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

1.4 Levels have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line and using a combination of this information and an analysis of the measured levels, results have been interpreted to provide a summary of levels and the likely source which has resulted in those levels, where this is possible to determine.

1.5 Results (L_{Aeq} and L_{Amax} values) are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

2.0 Analysis of survey results

2.1 Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 Raw data for night time in 5-minute periods has been provided in Appendix B.

2.3 Table 2.1 overleaf shows the $L_{Aeq, 8h}$ values and range of L_{Amax} values measured throughout night time periods in the Month. Night is defined to be between 23:00-07:00 hours.

Table 2.1: Night time $L_{Aeq, 8\text{-}hour}$ values and L_{Amax} ranges in September*

Date	Day	$L_{Aeq, 8 hours}$	$L_{AMax, 5 Min}$ Range	
			Min	Max
01/09/2020	Tuesday	44	30	83
02/09/2020	Wednesday	45	41	84
03/09/2020	Thursday	44	38	84
04/09/2020	Friday	39	31	71
05/09/2020	Saturday	37	31	67
06/09/2020	Sunday	45	33	84
07/09/2020	Monday	45	34	84
08/09/2020	Tuesday	44	33	83
09/09/2020	Wednesday	44	34	83
10/09/2020	Thursday	44	30	83
11/09/2020	Friday	39	37	78
12/09/2020	Saturday	37	39	71
13/09/2020	Sunday	44	35	84
14/09/2020	Monday	46	37	85
15/09/2020	Tuesday	48	33	84
16/09/2020	Wednesday	49	36	85
17/09/2020	Thursday	57	31	95
18/09/2020	Friday	34	35	59
19/09/2020	Saturday	34	33	66
20/09/2020	Sunday	42	37	81
21/09/2020	Monday	42	40	80
22/09/2020	Tuesday	41	34	80
23/09/2020	Wednesday	56	35	106
24/09/2020	Thursday	51	33	88
25/09/2020	Friday	52	47	86
26/09/2020	Saturday	51	51	73
27/09/2020	Sunday	41	36	75
28/09/2020	Monday	45	32	85
29/09/2020	Tuesday	43	27	84
30/09/2020	Wednesday	48	43	89

***Dates signify the date at the start of the night time period (I.e. 01/09/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.4 $L_{Aeq, 8h}$ values ranged from 34 dB to 57 dB throughout the month. The arithmetic average $L_{Aeq, 8h}$ value for night time periods throughout the month was 44 dB.

2.5 For each night in, the number of times that L_{Amax} values exceeded 60 dB, 70 dB, 80 dB, 90 dB and 100 dB has been determined. Note that each exceedance event only falls into a single category, for example, an L_{Amax} level of 71 dB only falls into the 70 dB category, and not the 60 dB category.

2.6 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Data from this site has been provided for all days in the Month. Appendix C contains a table showing all night time trains logged by www.realtimetrains.co.uk during the month.

2.7 Table 2.2 below, shows the number of L_{Amax} exceedance events for each night. All dates had RTT data available. The number of L_{Amax} events attributed to train movements is shown in brackets for each category.

2.8 Throughout the nights of the 25th and 26th September, there were consistent elevated levels compared to a typical night. The source of these raised levels is not known however appears to be artificially generated noise due to its generally consistent level. The raised night time levels can be seen on the chart presented in Appendix B

2.9 This source produced a large quantity of 60 dB exceedance events as well as some 70 dB events. It was however still possible to attribute exceedance events to trains despite the generally raised sound levels.

Table 2.2: L_{Amax} exceedance events throughout the Month, and number of those attributed to train movements.

Date	Day	Level Exceedences (Attributed to Trains)				
		60dB	70dB	80dB	90dB	100dB
01/09/2020	Tuesday	4 (0)	2 (1)	1 (1)	0 (0)	0 (0)
02/09/2020	Wednesday	2 (0)	1 (1)	1 (1)	0 (0)	0 (0)
03/09/2020	Thursday	2 (0)	1 (1)	1 (1)	0 (0)	0 (0)
04/09/2020	Friday	7 (0)	1 (0)	0 (0)	0 (0)	0 (0)
05/09/2020	Saturday	5 (0)	0 (0)	0 (0)	0 (0)	0 (0)
06/09/2020	Sunday	5 (0)	2 (1)	1 (1)	0 (0)	0 (0)
07/09/2020	Monday	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)
08/09/2020	Tuesday	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)
09/09/2020	Wednesday	6 (0)	1 (1)	1 (1)	0 (0)	0 (0)
10/09/2020	Thursday	3 (0)	2 (1)	1 (1)	0 (0)	0 (0)
11/09/2020	Friday	4 (0)	1 (0)	0 (0)	0 (0)	0 (0)
12/09/2020	Saturday	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)
13/09/2020	Sunday	2 (0)	2 (1)	1 (1)	0 (0)	0 (0)
14/09/2020	Monday	2 (0)	2 (1)	2 (2)	0 (0)	0 (0)
15/09/2020	Tuesday	0 (0)	1 (1)	3 (2)	0 (0)	0 (0)
16/09/2020	Wednesday	3 (0)	1 (1)	3 (3)	0 (0)	0 (0)
17/09/2020	Thursday	0 (0)	6 (1)	4 (4)	2 (2)	0 (0)
18/09/2020	Friday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19/09/2020	Saturday	2 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20/09/2020	Sunday	3 (0)	1 (1)	1 (1)	0 (0)	0 (0)
21/09/2020	Monday	2 (0)	1 (1)	1 (1)	0 (0)	0 (0)
22/09/2020	Tuesday	1 (0)	2 (2)	0 (0)	0 (0)	0 (0)
23/09/2020	Wednesday	4 (0)	1 (1)	1 (1)	0 (0)	1 (1)
24/09/2020	Thursday	5 (0)	2 (1)	3 (3)	0 (0)	0 (0)
25/09/2020	Friday	56 (0)	4 (2)	3 (3)	0 (0)	0 (0)
26/09/2020	Saturday	63 (0)	9 (0)	0 (0)	0 (0)	0 (0)
27/09/2020	Sunday	1 (0)	1 (1)	0 (0)	0 (0)	0 (0)
28/09/2020	Monday	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)
29/09/2020	Tuesday	0 (0)	2 (1)	1 (1)	0 (0)	0 (0)
30/09/2020	Wednesday	7 (0)	1 (1)	1 (1)	0 (0)	0 (0)
Total Exceedance Events		**190**	**51**	**33**	**2**	**1**

2.10 Table 2.2 shows that L_{Amax} levels between 60-70 dB at the measurement point are common, with an average of 3 per night (excluding 25th and 26th). Exceedance events become increasingly rare as bands levels increase. There was only one event where levels exceeded 100 dB during the month.

2.11 From Table 2.2, the percentage of exceedance events attributed to trains can be calculated for each band. These have been calculated for dates where RTT data was available. These are shown in Table 2.3.

Table 2.3: Percentage of exceedance events attributed to trains during the Month

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	190	0	0%
70dB	51	25	49%
80dB	33	32	97%
90dB	2	2	100%
100dB	1	1	100%

2.12 Table 2.3 shows that, whilst common, none of the measured L_{Amax} levels between 60-70 dB were due to train pass by events. Approximately 49% of 70-80 dB and 97% of 80-90 dB L_{Amax} levels were attributed to trains. All L_{Amax} values exceeding 90dB were due to a train pass.

2.13 The noise source causing the remaining cases is unknown, however analysis of the one second traces from the sound level meter indicates that these are likely to have been caused by birds and other wildlife, or may have been due to occasional short engineering trains passing up and down the railway which are not recorded on RTT.

2.14 Table 2.4 shows the lifetime statistics for exceedance events recorded at the measurement point.

Table 2.4: Total number of exceedance events and those attributed to trains measured from March 2020 onwards

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	1792	1	0%
70dB	420	167	40%
80dB	232	194	84%
90dB	12	8	67%
100dB	1	1	100%

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing noise monitoring location

Appendix B

Graphs of Survey Results

Figure B1: 5-minute data from the 1st-7th of September 2020 – maximum levels from trains highlighted as red dots

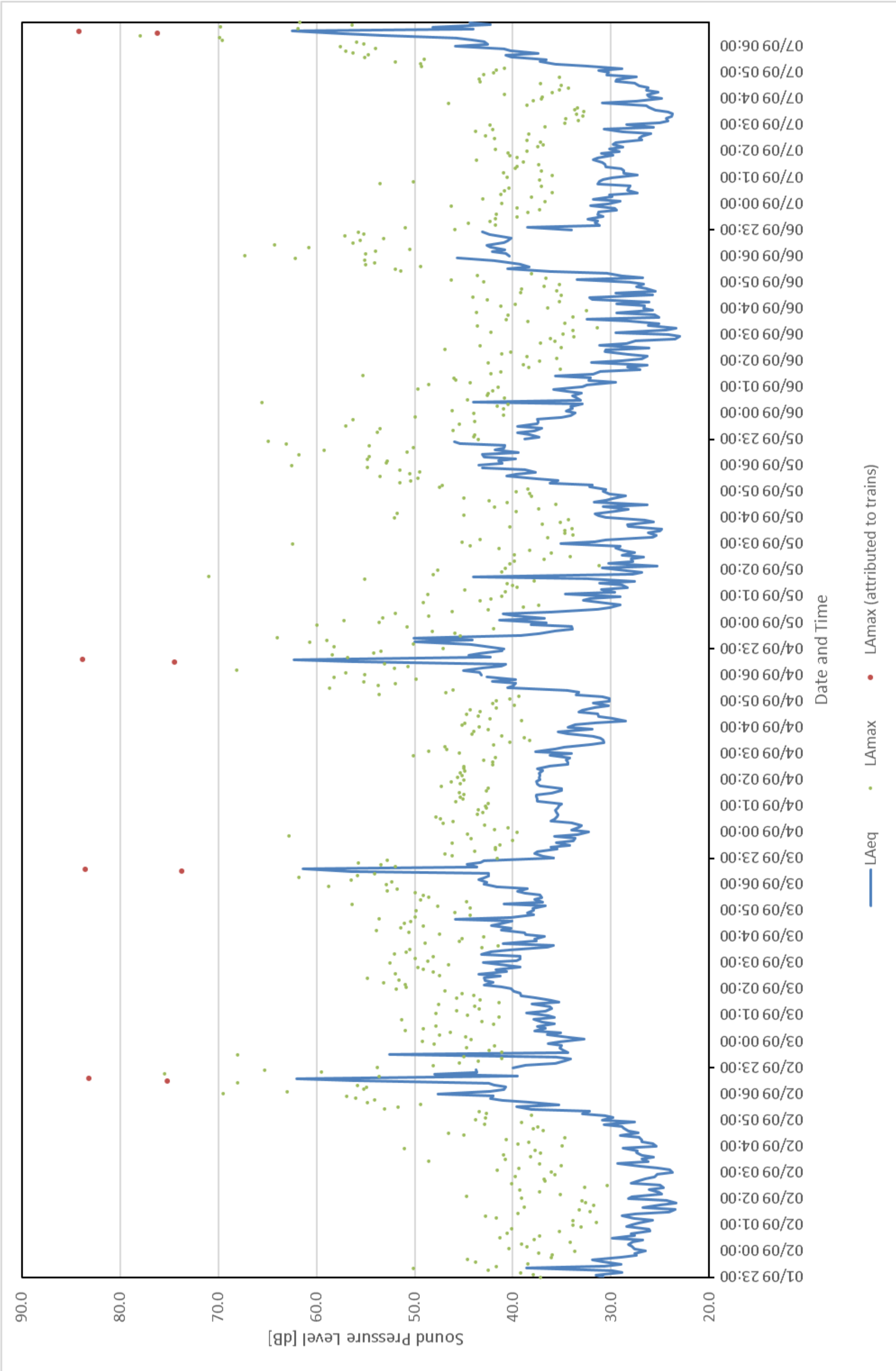


Figure B2: 5-minute data from the 7th-14th of September 2020 – maximum levels from trains highlighted as red dots

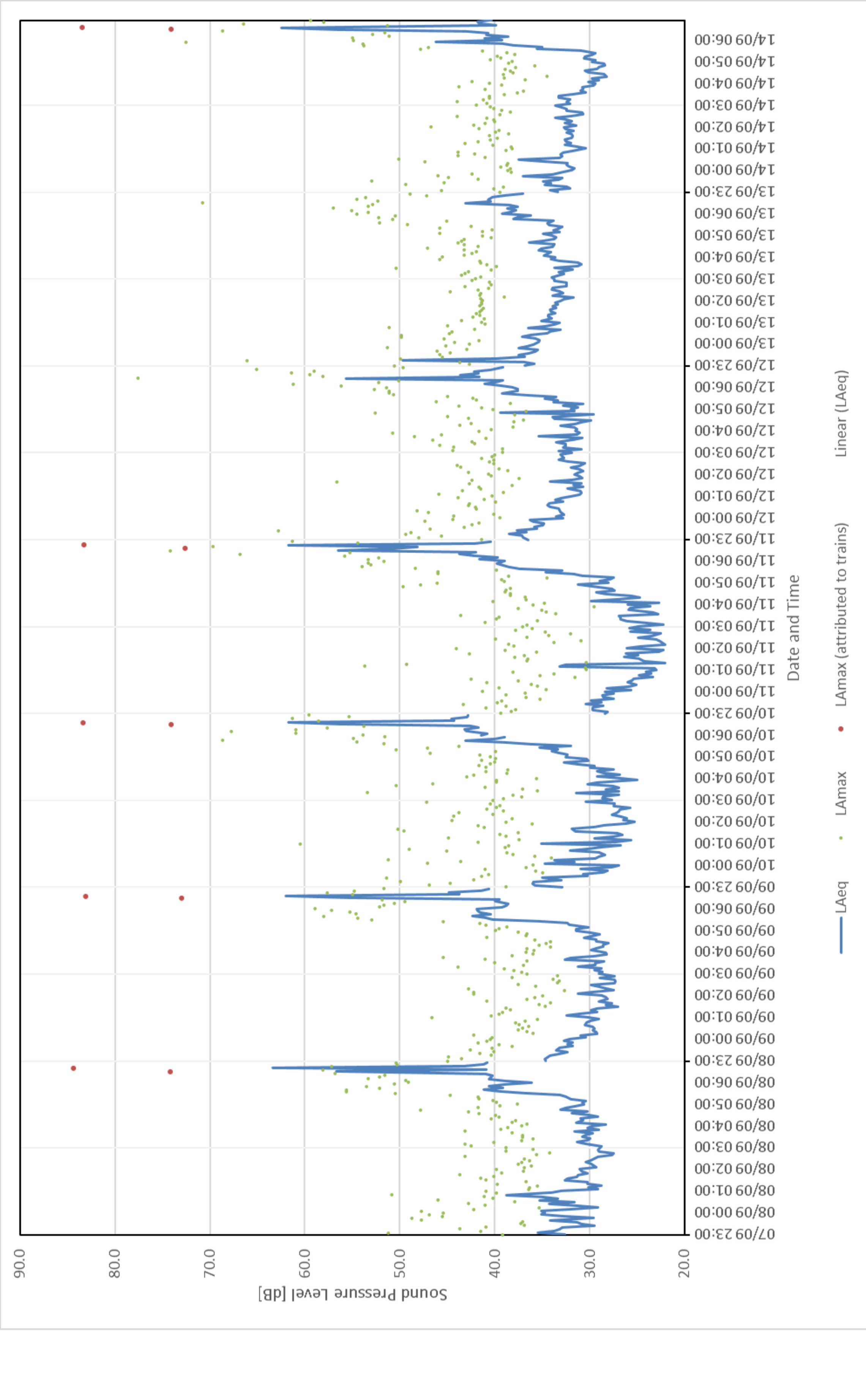


Figure B3: 5-minute data from the 14th-21st of September 2020 – maximum levels from trains highlighted as red dots

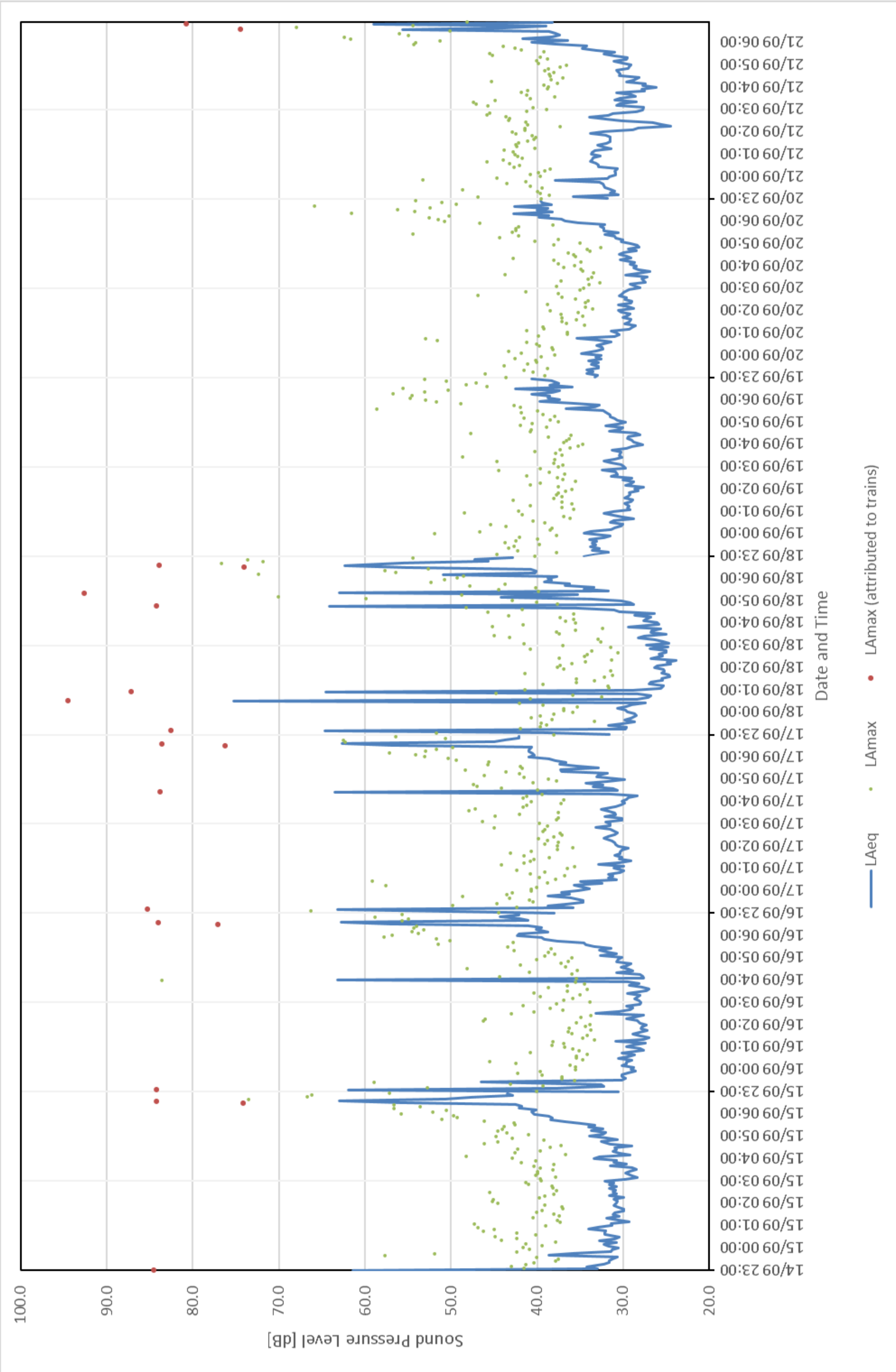


Figure B4: 5-minute data from the 21st-28th of September 2020 – maximum levels from trains highlighted as red dots.

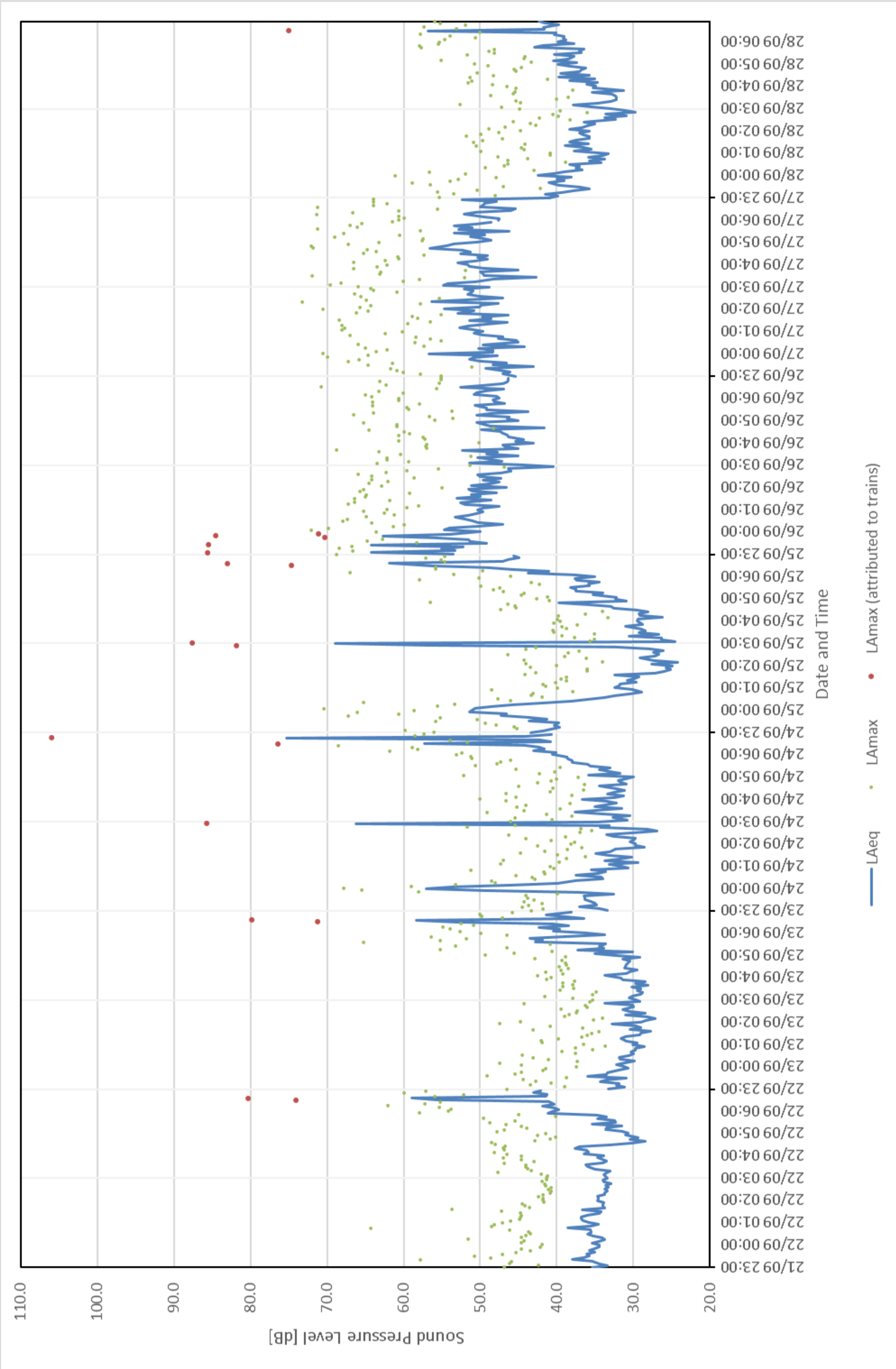
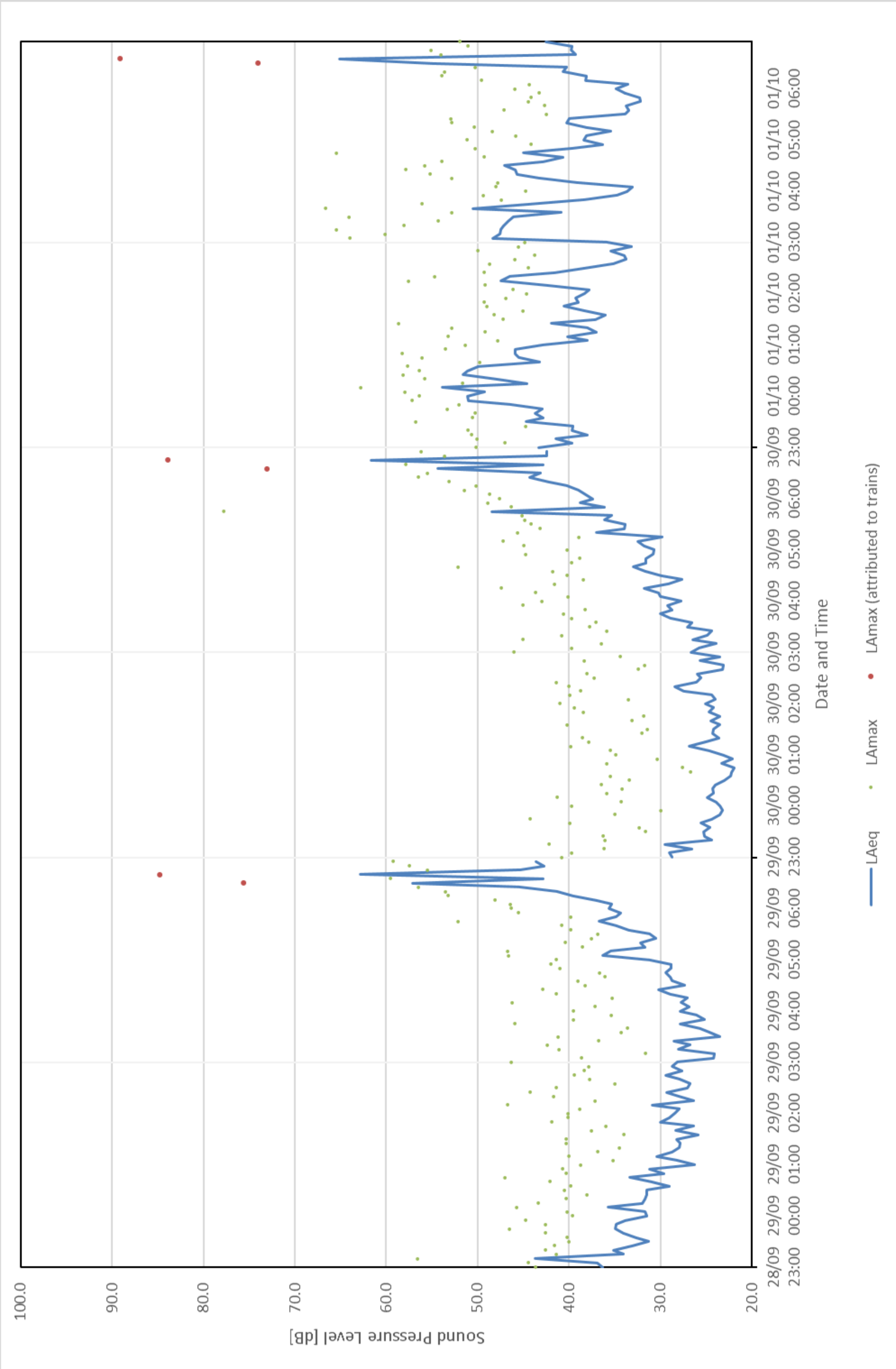


Figure B5: 5-minute data from the 28th-30th of September 2020 – maximum levels from trains highlighted as red dots.



Appendix C

Real Time Trains Data – Night Time Trains

Table C1: Woodbridge Station Night Time Train Passes, data provided by www.realtimetrains.co.uk.

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-09-02	06:32:45	06:35:10		LE
2020-09-02	06:35:06	06:36:59		LE
2020-09-03	06:32:25	06:34:59		LE
2020-09-03	06:35:34	06:37:08		LE
2020-09-04	06:33:05	06:35:26		LE
2020-09-04	06:35:19	06:37:02		LE
2020-09-07	06:32:29	06:34:52		LE
2020-09-07	06:36:00	06:36:59		LE
2020-09-08	06:32:33	06:34:43		LE
2020-09-08	06:38:01	06:39:07		LE
2020-09-09	06:32:53	06:34:47		LE
2020-09-09	06:35:15	06:37:13		LE
2020-09-10	06:32:58	06:34:54		LE
2020-09-10	06:35:29	06:37:15		LE
2020-09-11	06:32:53	06:35:13		LE
2020-09-11	06:43:21	06:44:45		LE
2020-09-14	06:33:23	06:34:58		LE
2020-09-14	06:34:57	06:36:51		LE
2020-09-14			22:57:17	ZZ
2020-09-15	06:33:39	06:34:43		LE
2020-09-15	06:35:53	06:37:19		LE
2020-09-15			23:01:32	ZZ
2020-09-16	06:33:30	06:35:21		LE
2020-09-16	06:34:15	06:36:32		LE
2020-09-16			23:04:06	ZZ
2020-09-17			04:30:12	ZZ
2020-09-17	06:32:39	06:35:03		LE
2020-09-17	06:34:59	06:37:01		LE
2020-09-17			23:13:26	ZZ
2020-09-18			00:27:46	ZZ
2020-09-18			00:46:00	ZZ
2020-09-18			04:48:36	ZZ
2020-09-18			05:25:05	ZZ
2020-09-18	06:35:32	06:36:08		LE
2020-09-18	06:35:42	06:37:21		LE
2020-09-21	06:41:58	06:42:41		LE
2020-09-21	06:35:10	06:50:20		LE
2020-09-22	06:32:39	06:34:46		LE
2020-09-22	06:35:12	06:37:12		LE
2020-09-23	06:32:46	06:34:56		LE
2020-09-23	06:35:21	06:37:29		LE
2020-09-24			02:58:42	ZZ
2020-09-24	06:36:07	06:36:52		LE

2020-09-24	06:43:07	06:44:21		LE
2020-09-25	02:46:11	02:57:17		ZZ
2020-09-25	06:35:22	06:36:10		LE
2020-09-25	06:35:27	06:37:21		LE
2020-09-25	23:01:04	23:03:38		LE
2020-09-25			23:27:14	LE
2020-09-25			23:50:11	LE
2020-09-28	06:32:49	06:35:04		LE
2020-09-29	06:33:35	06:34:57		LE
2020-09-29	06:37:22	06:38:58		LE
2020-09-30	06:41:58	06:42:40		LE
2020-09-30	06:35:56	06:45:52		LE
2020-10-01	06:33:30	06:34:58		LE
2020-10-01	06:35:58	06:37:32		LE

*Note this time falls outside of the defined night time period of 23:00-07:00, however is the time which the train is recorded to have passed through Woodbridge Railway Station. This train passed the measurement location further down the track shortly after 23:00.

SHARPS REDMORE

ACOUSTIC CONSULTANTS ▪ Established 1990

Report

Project
EDF – Sizewell C Power Station: Woodbridge Rail noise survey monthly report – October 2020

Prepared by
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Date 19th November 2020

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Contents

Appendices

This report has been prepared with all reasonable skill, care and diligence commensurate with an acoustic consultancy practice under the terms and brief agreed with our client at that time. Sharps Redmore provides no duty or responsibility whatsoever to any third party who relies upon its content, recommendations or conclusions.

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of noise levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing noise climate at night to assist with understanding the context in which the proposed additional rail movements at night would need to be considered.

1.2 The survey work began on 4th March 2020. A Type 1 sound level meter was installed at the location shown in Figure A1 in Appendix A. The microphone is in a free field location approximately 5 metres from the rail line at a height of 1.8m above ground. The meter is regularly serviced, and a calibration check carried out.

1.3 The meter is set to record levels at a one second resolution to enable individual events giving rise to maximum levels to be analysed in detail. This makes it possible to identify whether individual events giving rise to a significant maximum noise level are likely to have been due to a train movement or some other source (such as a bird near to the microphone).

1.4 Levels have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line and using a combination of this information and an analysis of the measured levels, results have been interpreted to provide a summary of levels and the likely source which has resulted in those levels, where this is possible to determine.

1.5 Results (L_{Aeq} and L_{Amax} values) are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

2.0 Analysis of survey results

2.1 Data was recorded with a sample rate of 1 second. L_{Amax} data has then been processed to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing sound levels over time.

2.2 On the 1st October 2020, a trigger level of 80dB L_{Amax} was set to record audio signals of events exceeding this sound level between 23:00-07:00. This was done to determine the cause of these events when they cannot be attributed to a train recorded by Real Time Trains.

2.3 Raw data for night time in 5-minute periods has been provided in Appendix B.

2.5 Table 2.1 overleaf shows the $L_{Aeq, 8h}$ values and range of L_{Amax} values measured throughout night time periods in October. Night is defined to be between 23:00-07:00 hours.

Table 2.1: Night time $L_{Aeq, 8\text{-}hour}$ values and L_{Amax} ranges in October*

Date	Day	$L_{Aeq, 8 hours}$	$L_{AMax, 5 Min}$ Range	
			Min	Max
01/10/2020	Thursday	46	33	83
02/10/2020	Friday	41	38	64
03/10/2020	Saturday	49	39	85
04/10/2020	Sunday	50	32	86
05/10/2020	Monday	46	38	84
06/10/2020	Tuesday	45	40	85
07/10/2020	Wednesday	46	38	82
08/10/2020	Thursday	43	32	82
09/10/2020	Friday	36	34	70
10/10/2020	Saturday	46	34	78
11/10/2020	Sunday	60	32	96
12/10/2020	Monday	43	33	82
13/10/2020	Tuesday	44	34	83
14/10/2020	Wednesday	45	34	84
15/10/2020	Thursday	54	30	91
16/10/2020	Friday	35	34	54
17/10/2020	Saturday	31	32	54
18/10/2020	Sunday	42	31	81
19/10/2020	Monday	56	35	96
20/10/2020	Tuesday	46	33	82
21/10/2020	Wednesday	58	41	95
22/10/2020	Thursday	47	32	83
23/10/2020	Friday	62	34	99
24/10/2020	Saturday	43	32	77
25/10/2020	Sunday	59	31	96
26/10/2020	Monday	59	32	96
27/10/2020	Tuesday	61	35	101
28/10/2020	Wednesday	59	36	96
29/10/2020	Thursday	61	41	98
30/10/2020	Friday	62	38	98
31/10/2020	Saturday	43	33	76

***Dates signify the date at the start of the night time period (I.e. 01/09/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.6 $L_{Aeq, 8h}$ values ranged from 31 dB to 62 dB throughout the month. The arithmetic average $L_{Aeq, 8h}$ value for night time periods throughout the month was 49 dB.

2.7 For each night in October, the number of times that L_{Amax} values exceeded 60 dB, 70 dB, 80 dB, 90 dB and 100 dB has been determined. Note that each exceedance event only falls into a single category, for example, an L_{Amax} level of 71 dB only falls into the 70 dB category, and not the 60 dB category.

2.8 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Data from this site has been provided for all days in the month. Appendix C contains a table showing all night time trains logged by www.realtimetrains.co.uk during the month.

2.9 Alongside the data from RTT, audio recordings have been used to attribute trains to raised sound levels. During October, three trains which were not recorded by RTT were identified from audio signals. Three further trains which were not recorded by RTT were also identified by fine resolution analysis and comparison of noise and vibration data. These trains have been inserted into appendix C and are highlighted to show they were not recorded by RTT but were instead identified via other methods.

2.10 Table 2.2 below, shows the number of L_{Amax} exceedance events for each night. All dates had RTT data available. The number of L_{Amax} events attributed to train movements is shown in brackets for each category.

Table 2.2: L_{Amax} exceedance events throughout October, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)				
		60dB	70dB	80dB	90dB	100dB
01/10/2020	Thursday	1 (0)	1 (1)	1 (1)	0 (0)	0 (0)
02/10/2020	Friday	3 (0)	0 (0)	0 (0)	0 (0)	0 (0)
03/10/2020	Saturday	20 (0)	2 (0)	1 (1)	0 (0)	0 (0)
04/10/2020	Sunday	2 (0)	2 (1)	4 (4)	0 (0)	0 (0)
05/10/2020	Monday	8 (0)	3 (1)	1 (1)	0 (0)	0 (0)
06/10/2020	Tuesday	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)
07/10/2020	Wednesday	7 (0)	1 (1)	1 (1)	0 (0)	0 (0)
08/10/2020	Thursday	0 (0)	1 (1)	2 (2)	0 (0)	0 (0)
09/10/2020	Friday	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10/10/2020	Saturday	4 (0)	2 (2)	0 (0)	0 (0)	0 (0)
11/10/2020	Sunday	0 (0)	2 (1)	2 (2)	2 (2)	0 (0)
12/10/2020	Monday	2 (0)	2 (1)	1 (1)	0 (0)	0 (0)
13/10/2020	Tuesday	1 (0)	2 (1)	1 (1)	0 (0)	0 (0)
14/10/2020	Wednesday	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)
15/10/2020	Thursday	1 (0)	3 (2)	1 (1)	1 (1)	0 (0)
16/10/2020	Friday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17/10/2020	Saturday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18/10/2020	Sunday	0 (0)	1 (1)	1 (1)	0 (0)	0 (0)
19/10/2020	Monday	3 (0)	1 (1)	2 (2)	1 (1)	0 (0)
20/10/2020	Tuesday	7 (0)	2 (1)	1 (1)	0 (0)	0 (0)
21/10/2020	Wednesday	4 (0)	2 (2)	2 (2)	2 (2)	0 (0)
22/10/2020	Thursday	1 (0)	1 (1)	3 (3)	0 (0)	0 (0)
23/10/2020	Friday	4 (0)	0 (0)	4 (4)	2 (2)	0 (0)
24/10/2020	Saturday	6 (0)	4 (1)	0 (0)	0 (0)	0 (0)
25/10/2020	Sunday	4 (0)	2 (2)	3 (3)	2 (2)	0 (0)
26/10/2020	Monday	2 (0)	3 (3)	5 (5)	2 (2)	0 (0)
27/10/2020	Tuesday	3 (0)	3 (2)	3 (3)	1 (1)	1 (1)
28/10/2020	Wednesday	5 (0)	2 (2)	5 (5)	2 (2)	0 (0)
29/10/2020	Thursday	2 (0)	4 (4)	5 (5)	2 (2)	0 (0)
30/10/2020	Friday	3 (0)	2 (2)	4 (4)	3 (3)	0 (0)
31/10/2020	Saturday	2 (0)	1 (1)	0 (0)	0 (0)	0 (0)
Total Exceedance Events		**96**	**51**	**55**	**20**	**1**

2.11 Table 2.2 shows that L_{Amax} levels between 60-70 dB at the measurement point are common, with an average of 3 per night. Generally, exceedance events become increasingly rare as bands levels increase, however during this month there was a higher level of 80 dB exceedance events than 70 dB. There was only one event where levels exceeded 100 dB during the month.

2.12 From Table 2.2, the percentage of exceedance events attributed to trains can be calculated for each band. These are shown in Table 2.3.

Table 2.3: Percentage of exceedance events attributed to trains during October

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	96	0	0%
70dB	51	37	73%
80dB	55	55	100%
90dB	20	20	100%
100dB	1	1	100%

2.13 Table 2.3 shows that, whilst common, none of the measured L_{Amax} levels between 60-70 dB were due to train pass by events during the month. Approximately 73% of 70-80 dB L_{Amax} levels were attributed to trains. All L_{Amax} values exceeding 80dB were due to a train pass.

2.14 The noise source causing the remaining cases is unknown, however analysis of the one second traces from the sound level meter indicates that these are likely to have been caused by birds and other wildlife or may have been due to occasional short engineering trains passing up and down the railway which are not recorded on RTT.

2.15 It is important to note that the use of the audio trigger has allowed 100% of L_{Amax} events exceeding 80dB to be attributed to trains, whereas in previous months this was not possible. Comparison with vibration results has also allowed train movements to be identified in lower bands too. These new methods of train identification have the effect of raising the percentage of level exceedances attributed to trains for this month compared to previous months.

2.16 Table 2.4 shows the lifetime statistics for exceedance events recorded at the measurement point.

Table 2.4: Total number of exceedance events and those attributed to trains measured from March 2020 onwards

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
60dB	1888	1	0%
70dB	471	206	44%
80dB	287	249	87%
90dB	32	28	88%
100dB	2	2	100%

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing noise monitoring location

Appendix B

Graphs of Survey Results

Figure B1: 5-minute data from the 1st-5th of October 2020 – maximum levels from trains highlighted as red dots

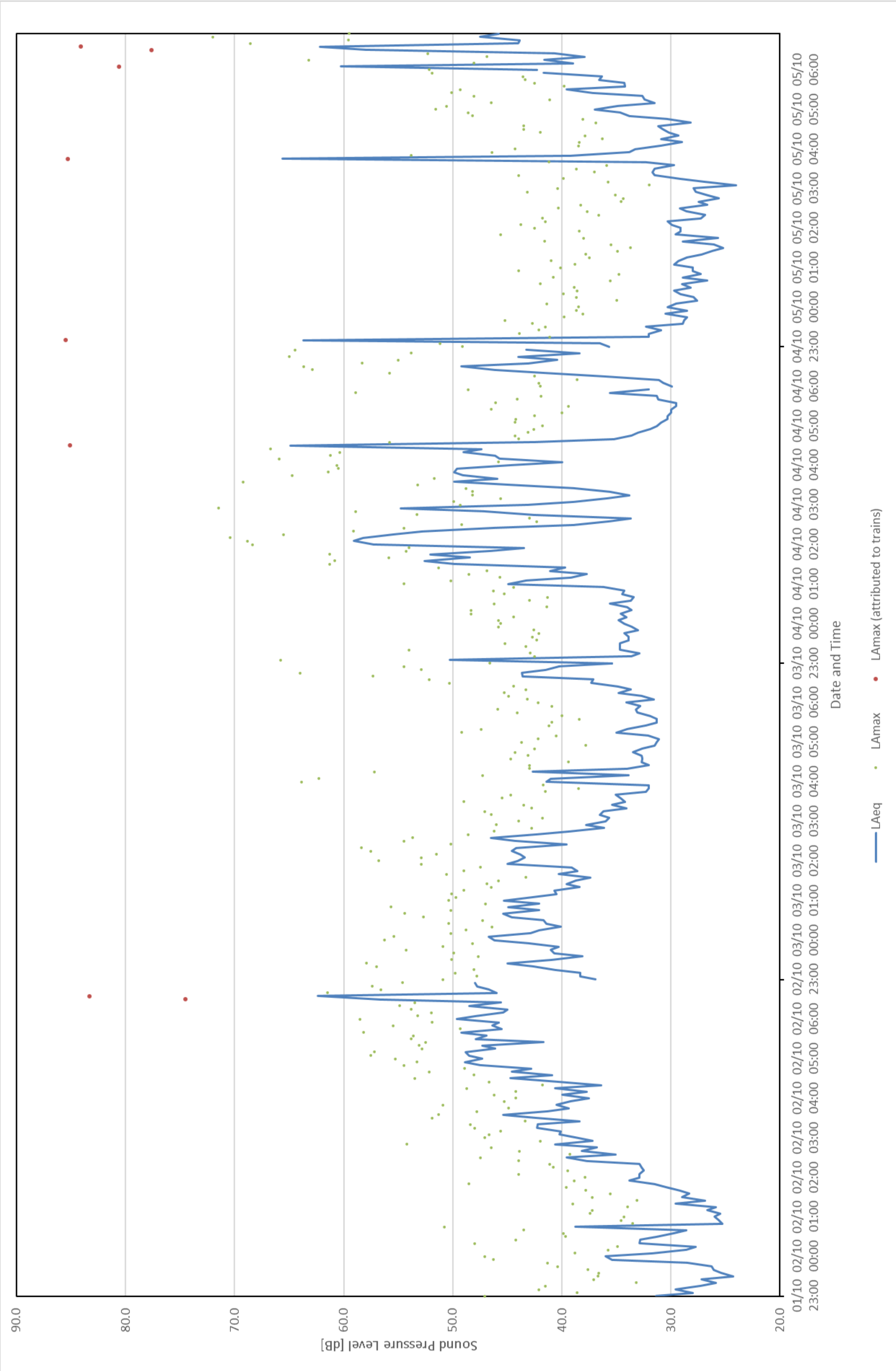


Figure B2: 5-minute data from the 5th-12th of October 2020 – maximum levels from trains highlighted as red dots

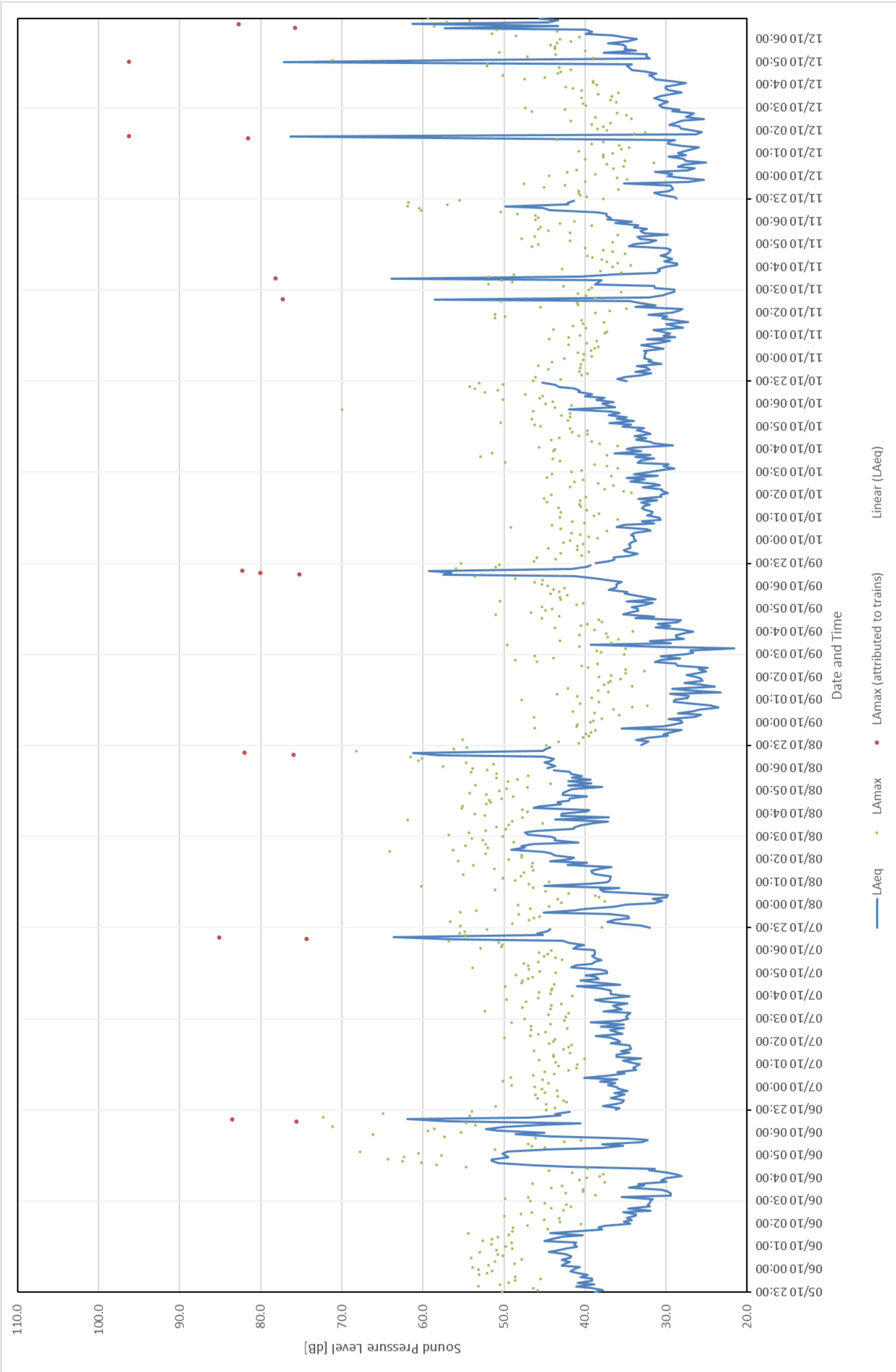


Figure B3: 5-minute data from the 12th-19th of October 2020 – maximum levels from trains highlighted as red dots

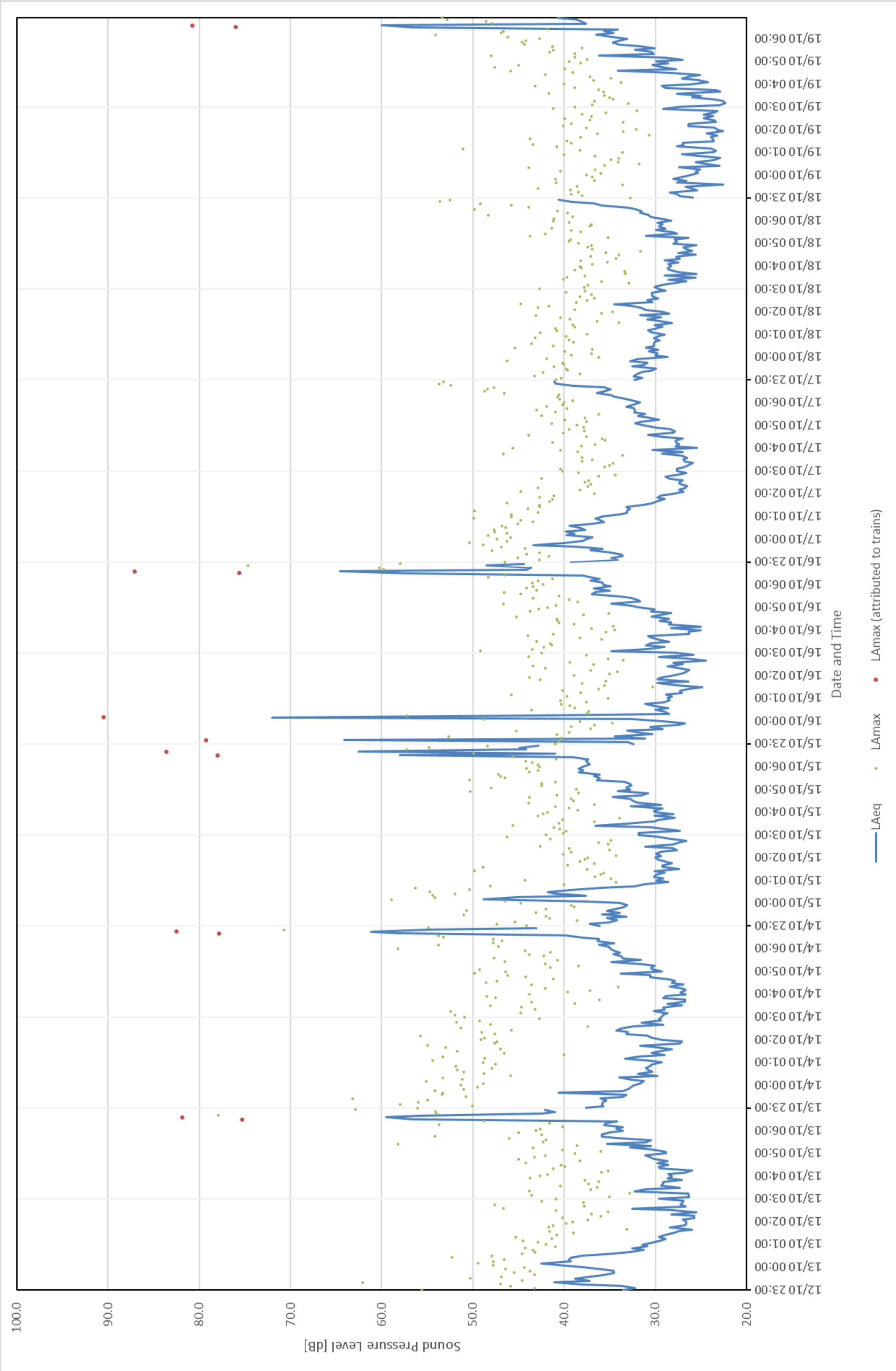


Figure B4: 5-minute data from the 19th-26th of October 2020 – maximum levels from trains highlighted as red dots.

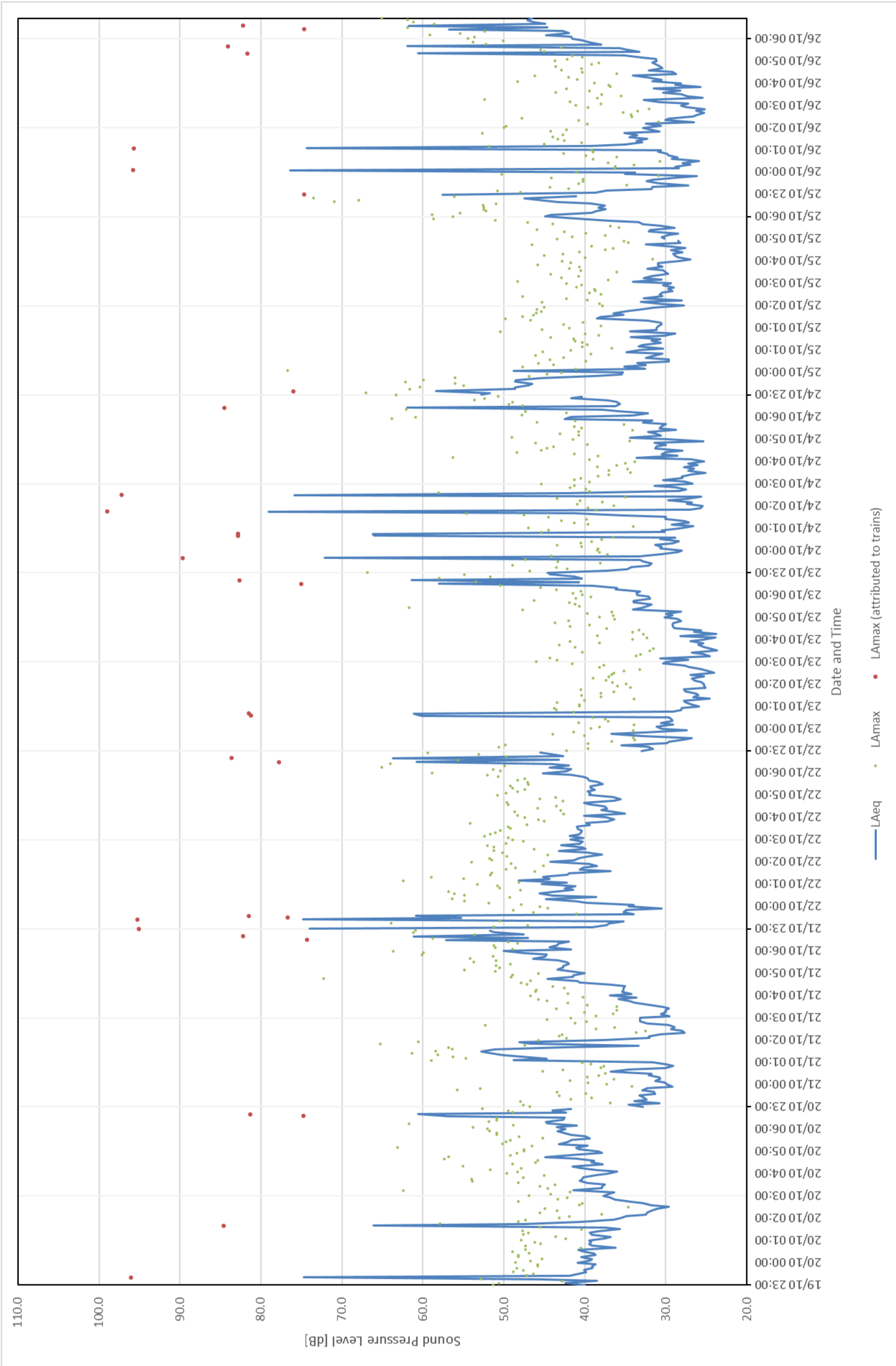
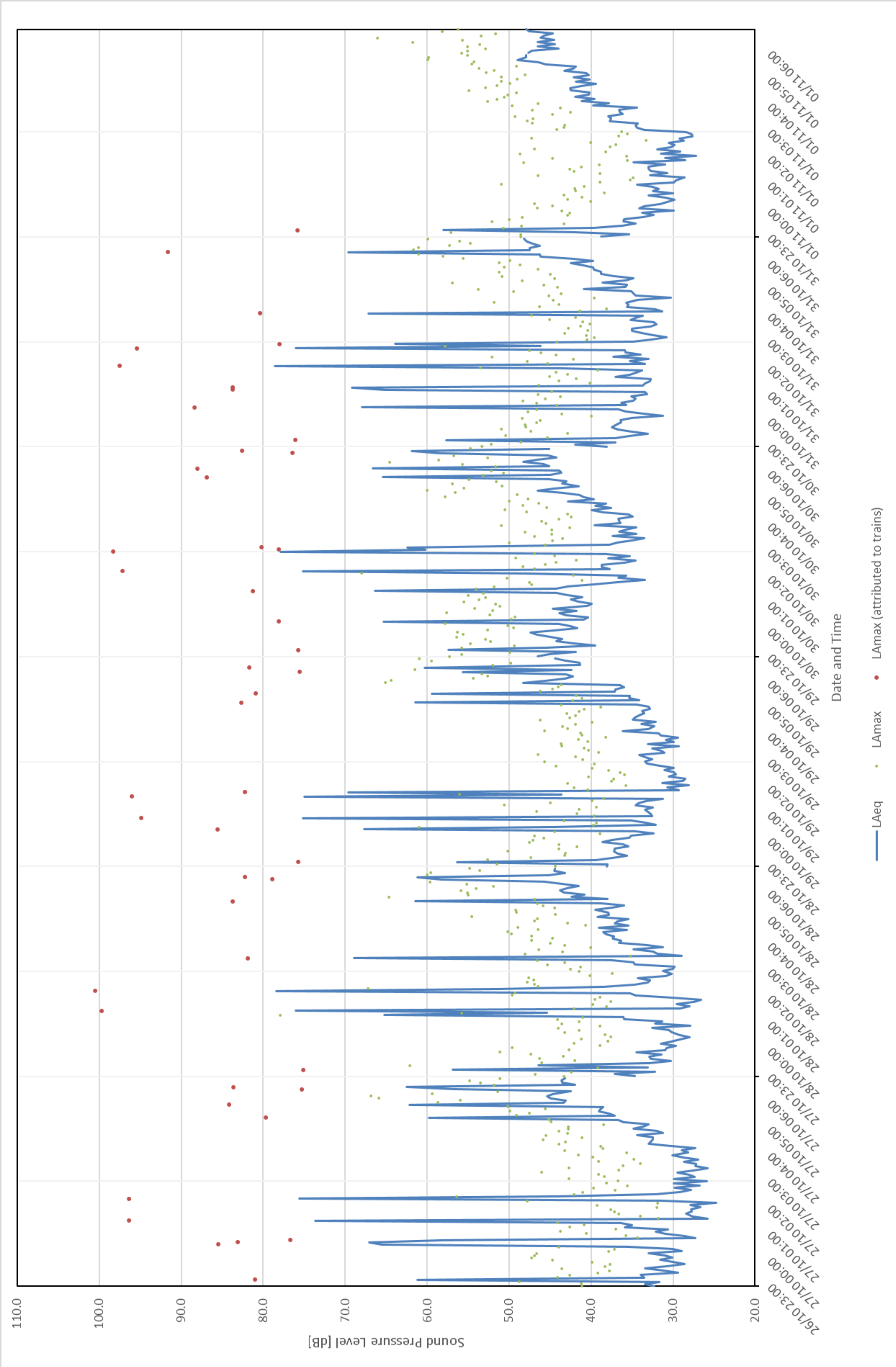


Figure B5: 5-minute data from the 26th October – 1st of November 2020 – maximum levels from trains highlighted as red dots.



Appendix C

Real Time Trains Data – Night Time Trains

Table C1: Woodbridge Station Night Time Train Passes, data provided by www.realtimetrains.co.uk.

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
02-10-2020	06:32:45	06:34:52		LE
02-10-2020	06:35:39	06:37:23		LE
04-10-2020		04:38:00		ZZ
04-10-2020			23:07:11	ZZ
05-10-2020			03:51:34	ZZ
05-10-2020			06:09:31	LE
05-10-2020	06:32:55	06:35:27		LE
05-10-2020	06:35:10	06:36:40		LE
06-10-2020	06:33:19	06:35:08		LE
06-10-2020	06:35:30	06:37:01		LE
07-10-2020	06:32:32	06:34:53		LE
07-10-2020	06:34:48	06:37:11		LE
08-10-2020	06:35:22	06:38:14		LE
08-10-2020	06:37:52	06:38:44		LE
09-10-2020	06:32:24	06:34:43		LE
09-10-2020	06:35:39	06:37:53		LE
11-10-2020			02:35:00	
11-10-2020			03:30:00	
12-10-2020			01:41:01	ZZ
12-10-2020			05:07:20	ZZ
12-10-2020	06:32:30	06:34:39		LE
12-10-2020	06:36:18	06:40:10		LE
13-10-2020	06:36:52	06:37:44		LE
13-10-2020	06:35:15	06:37:54		LE
14-10-2020	06:43:55	06:44:32		LE
14-10-2020	06:35:51	06:44:59		LE
15-10-2020	06:33:10	06:35:20		LE
15-10-2020	06:36:48	06:39:00		LE
15-10-2020			23:10:00	
16-10-2020			00:10:00	
16-10-2020	06:33:11	06:35:15		LE
16-10-2020	06:35:35	06:37:10		LE
19-10-2020	06:32:55	06:34:41		LE
19-10-2020	06:36:16	06:37:01		LE
19-10-2020			23:23:02	ZZ
20-10-2020			01:40:00	
20-10-2020	06:37:53	06:38:39		LE
20-10-2020	06:36:16	06:39:35		LE
21-10-2020	06:35:29	06:36:27		LE
21-10-2020	06:36:24	06:38:18		LE
21-10-2020			22:52:44*	ZZ
21-10-2020			23:30:36	ZZ
22-10-2020	06:34:19	06:35:36		LE

22-10-2020	06:36:52	06:38:52		LE
23-10-2020	06:34:25	06:35:16		LE
23-10-2020	06:35:21	06:38:07		LE
23-10-2020	23:25:08	23:40:32		ZZ
24-10-2020	00:24:08	00:41:29		ZZ
24-10-2020			01:45:00	
24-10-2020	02:34:00			ZZ
24-10-2020			02:34:23	ZZ
24-10-2020	06:24:16	06:25:20		LE
24-10-2020	23:16:47	23:18:36		LE
25-10-2020			23:02:49	LE
26-10-2020			00:01:45	ZZ
26-10-2020			01:08:29	ZZ
26-10-2020	05:17:30	05:18:52		LE
26-10-2020	05:40:46	05:41:54		LE
26-10-2020	06:31:04	06:34:49		LE
26-10-2020	06:33:11	06:34:55		LE
26-10-2020	23:21:02	23:21:29		LE
27-10-2020	00:20:41	00:41:21		ZZ
27-10-2020			01:22:59	ZZ
27-10-2020	02:26:00			ZZ
27-10-2020	05:21:54	05:23:08		LE
27-10-2020	05:52:00	05:53:11		LE
27-10-2020	06:35:04	06:35:35		LE
27-10-2020	06:33:24	06:36:05		LE
27-10-2020	23:18:12	23:18:38		LE
28-10-2020			01:19:10	ZZ
28-10-2020	01:25:38	01:26:21		ZZ
28-10-2020	02:21:46	02:25:49		ZZ
28-10-2020	03:11:29	03:27:39		ZZ
28-10-2020	05:41:07	05:42:24		LE
28-10-2020	06:32:19	06:34:58		LE
28-10-2020	06:34:26	06:37:20		LE
28-10-2020	23:16:52	23:18:14		LE
29-10-2020	00:30:51	00:31:22		ZZ
29-10-2020	01:46:00			ZZ
29-10-2020			01:46:27	ZZ
29-10-2020	01:21:52	01:48:44		ZZ
29-10-2020	05:16:32	05:17:25		LE
29-10-2020	05:33:32	05:35:14		LE
29-10-2020	06:31:44	06:34:40		LE
29-10-2020	06:33:20	06:34:54		LE
29-10-2020	23:18:08	23:19:01		LE
30-10-2020	00:24:02	00:24:52		ZZ
30-10-2020	00:11:16	01:30:53		ZZ
30-10-2020			02:38:00	ZZ
30-10-2020			03:03:30	ZZ

30-10-2020	02:30:18	03:06:22		ZZ
30-10-2020	05:48:46	05:50:18		LE
30-10-2020	05:59:59	06:09:43		LE
30-10-2020	06:51:34	06:52:06		LE
30-10-2020	06:33:06	06:52:23		LE
30-10-2020	23:18:04	23:18:49		LE
31-10-2020	00:32:50	00:33:34		ZZ
31-10-2020	01:12:50	01:13:08		ZZ
31-10-2020	00:31:33	01:15:19		ZZ
31-10-2020			02:27:05	ZZ
31-10-2020			02:51:25	ZZ
31-10-2020	02:16:55	02:53:24		ZZ
31-10-2020	03:49:13	04:04:08		ZZ
31-10-2020	06:22:59	06:24:53		LE
31-10-2020	23:18:00	23:19:16		LE

*Note this time falls outside of the defined night time period of 23:00-07:00, however is the time which the train is recorded to have passed through Woodbridge Railway Station. This train passed the measurement location further down the track shortly after 23:00.

Cells highlighted in blue are train passes which were not recorded by real time trains but have been identified through analysis of noise signals. Rows highlighted orange are train passes which have been identified via a comparison of noise and vibration data.

Appendix C

Monthly Vibration Reports

SHARPS REDMORE
ACOUSTIC CONSULTANTS ▪ Established 1990

Report

Project
EDF – Sizewell C Power Station: Woodbridge Rail Vibration Survey Monthly Report – August 2020

Prepared by
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Contents

Appendices

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of vibration levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing vibration climate at night to assist with understanding the context in which the proposed additional rail movements would need to be considered.

1.2 The survey work began on 4th August 2020. A triaxial ground borne vibration level meter with a connected vibration pickup was installed at the location shown in Figure A1 in Appendix A. The vibration pickup is mounted to a DIN plate and planted in a dug hole approximate 30cm below ground surface level. This is to minimise the influence of surface effects on the measured values. The soil which the DIN plate is inserted into is generally dry and silty. The meter is regularly serviced.

1.3 Due to equipment failure, vibration results were only recorded up to the 15th August. This fault has been raised with the manufacturer and is currently being investigated, such that future measurements are not affected.

1.4 The X axis is aligned parallel to the trainline, and the Y axis is aligned perpendicular to the trainline. These orientations are shown in Figure A1 in Appendix A. The Z axis is aligned vertically.

1.5 The vibration level meter measures and calculates a range of vibration parameters including Root Mean Squared Acceleration (A_{rms}). Acceleration values in each axis are weighted according to the guidance given in BS6472-1:2008. The X and Y axes are weighted using a W_d weighting curve and the Z axis is weighted using a W_b weighting curve. Parameters derived from weighted acceleration values are indicated by a subscript 'W', 'b' or 'd' following them. Vibration does value (VDV), which combines the magnitude of $A_{w,rms}$ as well as its duration to give an indication of the likely human response due to vibration, is also calculated by the meter.

1.6 The key parameter being measured and reported is peak particle velocity (PPV). PPV gives the maximum rate of change in the displacement of ground particles during each measurement interval. It is measured in millimetres per second (mm/s) and is not weighted.

1.7 The meter is set to record data at a resolution of one minute to enable individual events to be analysed in detail. This makes it possible to identify and separate individual events and to determine if they are likely to have been due to a train movement or some other source.

1.8 Vibration parameters have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line. Using a combination of this information and an analysis of the measured vibration parameters, results have been interpreted to provide a summary of data and the likely source which has resulted in those levels, where this is possible to determine.

1.9 Results are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

2.0 Analysis of survey results

2.1 Data was recorded in all 3 axes with a sample rate of 1 minute. PPV values at each interval, have been resampled to produce results in periods of 5 minutes. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing vibration levels over time.

2.2 Raw night time PPV data for all 3 axes has been provided in Appendix B.

2.3 Tables 2.1, 2.2 and 2.3 overleaf show the range of PPV values in each axis measured throughout night time periods in August, as well as the typical PPV in the absence of vibration events. Night is defined to be between 23:00-07:00.

Table 2.1: Night time X PPV ranges and typical values in August*

Date	Day	X PPV (mm/s)		
		Min	Max	Typical
04/08/2020	Tuesday	0.03	0.72	0.04
05/08/2020	Wednesday	0.03	0.83	0.04
06/08/2020	Thursday	0.03	1.33	0.05
07/08/2020	Friday	0.03	0.05	0.04
08/08/2020	Saturday	0.03	0.06	0.04
09/08/2020	Sunday	0.03	1.04	0.05
10/08/2020	Monday	0.03	1.27	0.05
11/08/2020	Tuesday	0.03	1.19	0.05
12/08/2020	Wednesday	0.03	1.01	0.04
13/08/2020	Thursday	0.03	1.45	0.05
14/08/2020	Friday	0.03	0.88	0.05
15/08/2020	Saturday	0.03	0.77	0.05

Table 2.2: Night time Y PPV ranges and typical values in August*

Date	Day	Y PPV (mm/s)		
		Min	Max	Typical
04/08/2020	Tuesday	0.03	1.27	0.05
05/08/2020	Wednesday	0.03	1.98	0.04
06/08/2020	Thursday	0.03	2.72	0.05
07/08/2020	Friday	0.03	0.05	0.04
08/08/2020	Saturday	0.03	0.05	0.04
09/08/2020	Sunday	0.03	2.72	0.04
10/08/2020	Monday	0.03	3.63	0.04
11/08/2020	Tuesday	0.03	4.30	0.04
12/08/2020	Wednesday	0.03	4.00	0.04
13/08/2020	Thursday	0.03	3.86	0.05
14/08/2020	Friday	0.03	2.97	0.04
15/08/2020	Saturday	0.03	2.62	0.04

Table 2.3: Night time Z PPV ranges and typical values in August*

Date	Day	Z PPV (mm/s)		
		Min	Max	Typical
04/08/2020	Tuesday	0.03	0.91	0.04
05/08/2020	Wednesday	0.03	0.74	0.04
06/08/2020	Thursday	0.03	0.98	0.04
07/08/2020	Friday	0.03	0.04	0.04
08/08/2020	Saturday	0.03	0.05	0.04
09/08/2020	Sunday	0.03	0.88	0.04
10/08/2020	Monday	0.03	1.08	0.04
11/08/2020	Tuesday	0.03	1.08	0.04
12/08/2020	Wednesday	0.03	0.71	0.04
13/08/2020	Thursday	0.03	0.63	0.04
14/08/2020	Friday	0.03	1.02	0.04
15/08/2020	Saturday	0.03	0.62	0.04

***Dates signify the date at the start of the night time period (I.e. 04/08/2020 signifies the 8-hour night period which began at 23:00 hours on that date). Due to equipment failures, results were only recorded between the 4th and the 15th of August.**

2.4 The arithmetic average of the typical values for night time periods throughout the month was 0.4mm/s in the Y and Z axes, and 0.5mm/s in the X axis.

2.5 Through comparison of the maximum and minimum PPV values with the typical levels, it can be seen that the general vibration levels in the environment are very low. Typical PPVs are always within 0.02mm/s of the minimum measured PPV.

2.6 For each measured night, the number of times that the PPV exceeded 0.5mm/s, 1mm/s, 2mm/s, 3mm/s and 4mm/s has been determined. Note that each exceedance event only falls into a single category, for example, a PPV of 1.08mm/s only falls into the 1mm/s category, and not the 0.5mm/s category. These bands have been selected based on results measured this month and are subject to change in future reports.

2.7 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Night time train movement data was provided by RTT for the whole month. This data is tabulated and shown in Appendix C.

2.8 Tables 2.4, 2.5 and 2.6 below, show the number of PPV exceedance events for each night. The number of PPV events attributed to train movements is shown in brackets for each category.

Table 2.4: X PPV exceedance events throughout August, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)				
		0.5mm/s	1.0mm/s	2.0mm/s	3.0mm/s	4.0mm/s
04/08/2020	Tuesday	3 (3)	0 (0)	0 (0)	0 (0)	0 (0)
05/08/2020	Wednesday	3 (3)	0 (0)	0 (0)	0 (0)	0 (0)
06/08/2020	Thursday	3 (2)	3 (3)	0 (0)	0 (0)	0 (0)
07/08/2020	Friday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
08/08/2020	Saturday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
09/08/2020	Sunday	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)
10/08/2020	Monday	2 (2)	2 (2)	0 (0)	0 (0)	0 (0)
11/08/2020	Tuesday	3 (3)	2 (2)	0 (0)	0 (0)	0 (0)
12/08/2020	Wednesday	1 (1)	1 (1)	0 (0)	0 (0)	0 (0)
13/08/2020	Thursday	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)
14/08/2020	Friday	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)
15/08/2020	Saturday	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total Exceedance Events		**19**	**11**	**0**	**0**	**0**

Table 2.5: Y PPV exceedance events throughout August, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)				
		0.5mm/s	1.0mm/s	2.0mm/s	3.0mm/s	4.0mm/s
04/08/2020	Tuesday	1 (1)	2 (2)	0 (0)	0 (0)	0 (0)
05/08/2020	Wednesday	0 (0)	3 (3)	0 (0)	0 (0)	0 (0)
06/08/2020	Thursday	0 (0)	2 (2)	4 (3)	0 (0)	0 (0)
07/08/2020	Friday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
08/08/2020	Saturday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
09/08/2020	Sunday	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)
10/08/2020	Monday	0 (0)	0 (0)	1 (1)	3 (3)	0 (0)
11/08/2020	Tuesday	0 (0)	0 (0)	2 (2)	2 (2)	1 (1)
12/08/2020	Wednesday	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)
13/08/2020	Thursday	0 (0)	0 (0)	0 (0)	2 (2)	0 (0)
14/08/2020	Friday	0 (0)	0 (0)	2 (2)	0 (0)	0 (0)
15/08/2020	Saturday	0 (0)	0 (0)	1 (0)	0 (0)	0 (0)
Total Exceedance Events		**1**	**7**	**12**	**9**	**1**

Table 2.6: Z PPV exceedance events throughout August, and number of those attributed to train movements.

Date	Day	Level Exceedences (Attributed to Trains)				
		0.5mm/s	1.0mm/s	2.0mm/s	3.0mm/s	4.0mm/s
04/08/2020	Tuesday	3 (3)	0 (0)	0 (0)	0 (0)	0 (0)
05/08/2020	Wednesday	3 (3)	0 (0)	0 (0)	0 (0)	0 (0)
06/08/2020	Thursday	6 (5)	0 (0)	0 (0)	0 (0)	0 (0)
07/08/2020	Friday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
08/08/2020	Saturday	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
09/08/2020	Sunday	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)
10/08/2020	Monday	3 (3)	1 (1)	0 (0)	0 (0)	0 (0)
11/08/2020	Tuesday	3 (3)	2 (2)	0 (0)	0 (0)	0 (0)
12/08/2020	Wednesday	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)
13/08/2020	Thursday	2 (2)	0 (0)	0 (0)	0 (0)	0 (0)
14/08/2020	Friday	0 (0)	2 (2)	0 (0)	0 (0)	0 (0)
15/08/2020	Saturday	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total Exceedance Events		**25**	**5**	**0**	**0**	**0**

2.9 Tables 2.4, 2.5 and 2.6 show that PPV is axis dependent with the highest levels being measured across the Y axis. Across all axes there was only 1 event exceeded 4mm/s during the month.

2.10 From the above Tables, the percentage of exceedance events attributed to trains can be calculated for each band, per axis. These are shown in Table 2.7.

2.11 Table 2.7 shows that, in the X axis, PPVs generally only exceed 0.5mm/s during train passes. From the typical levels shown in Table 2.1, PPVs are generally far lower than this. The two 0.5mm/s exceedance events not attributed to trains strongly resemble a train pass when examined at 1-minute resolution, however they do not align with any passes on RTT and therefore cannot be attributed to trains.

2.12 In the Y axis, Table 2.7 shows that train passes cause a large range of PPV values, with exceedance events being attributed to trains across all bands. This axis experiences the highest PPV levels due to train passes of all 3 axes. The 2mm/s exceedance events not attributed to trains align with the two measurements mentioned in paragraph 2.11.

2.13 In the Z axis, train passes in August generally caused PPVs between 0.5 and 1mm/s. There were no measured PPVs above 2mm/s. This was also the case in the X axis.

Table 2.7: Percentage of exceedance events attributed to trains between 4-15th August.

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
X			
0.5mm/s	19	17	89%
1.0mm/s	11	11	100%
2.0mm/s	0	0	N/A
3.0mm/s	0	0	N/A
4.0mm/s	0	0	N/A
Y			
0.5mm/s	1	1	100%
1.0mm/s	7	7	100%
2.0mm/s	12	10	83%
3.0mm/s	9	9	100%
4.0mm/s	1	1	100%
Z			
0.5mm/s	25	23	92%
1.0mm/s	5	5	100%
2.0mm/s	0	0	N/A
3.0mm/s	0	0	N/A
4.0mm/s	0	0	N/A

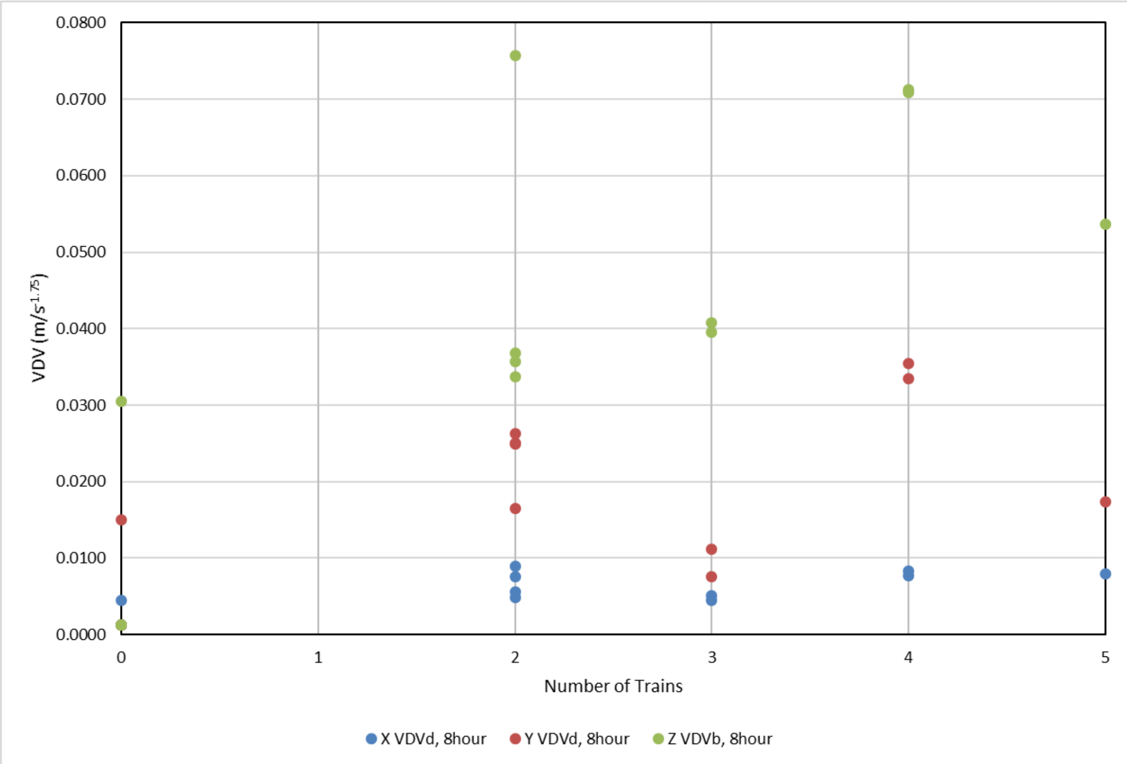
2.14 Vibration dose value (VDV) was derived and calculated by the vibration meter from its measured weighted acceleration values in all 3 axes in 1-minute samples. These measurements have been resampled into 8-hour night time VDV values which can then be compared to the number of train passes from RTT. This is shown in Table 2.8.

Table 2.8: Night Time VDV Values, and the Number of Train Passes

Date	Train Passes (n)	X $VDV_{d,8hour}$	Y $VDV_{d,8hour}$	Z $VDV_{b,8hour}$
04/08/2020	3	0.0044	0.0076	0.0395
05/08/2020	4	0.0051	0.0111	0.0408
06/08/2020	3	0.0080	0.0173	0.0537
07/08/2020	0	0.0012	0.0012	0.0012
08/08/2020	0	0.0012	0.0012	0.0012
09/08/2020	2	0.0056	0.0165	0.0368
10/08/2020	4	0.0083	0.0334	0.0708
11/08/2020	4	0.0077	0.0354	0.0713
12/08/2020	2	0.0049	0.0251	0.0338
13/08/2020	2	0.0089	0.0263	0.0357
14/08/2020	2	0.0076	0.0249	0.0758
15/08/2020	0	0.0045	0.0151	0.0305

2.15 The number of trains per night against the measured VDV values in all three axes are shown graphically in Figure 2.1. This is a lifetime Figure and will therefore be added to each month as new data is taken.

Figure 2.1: Night Time VDV Values, and the Number of Train Passes



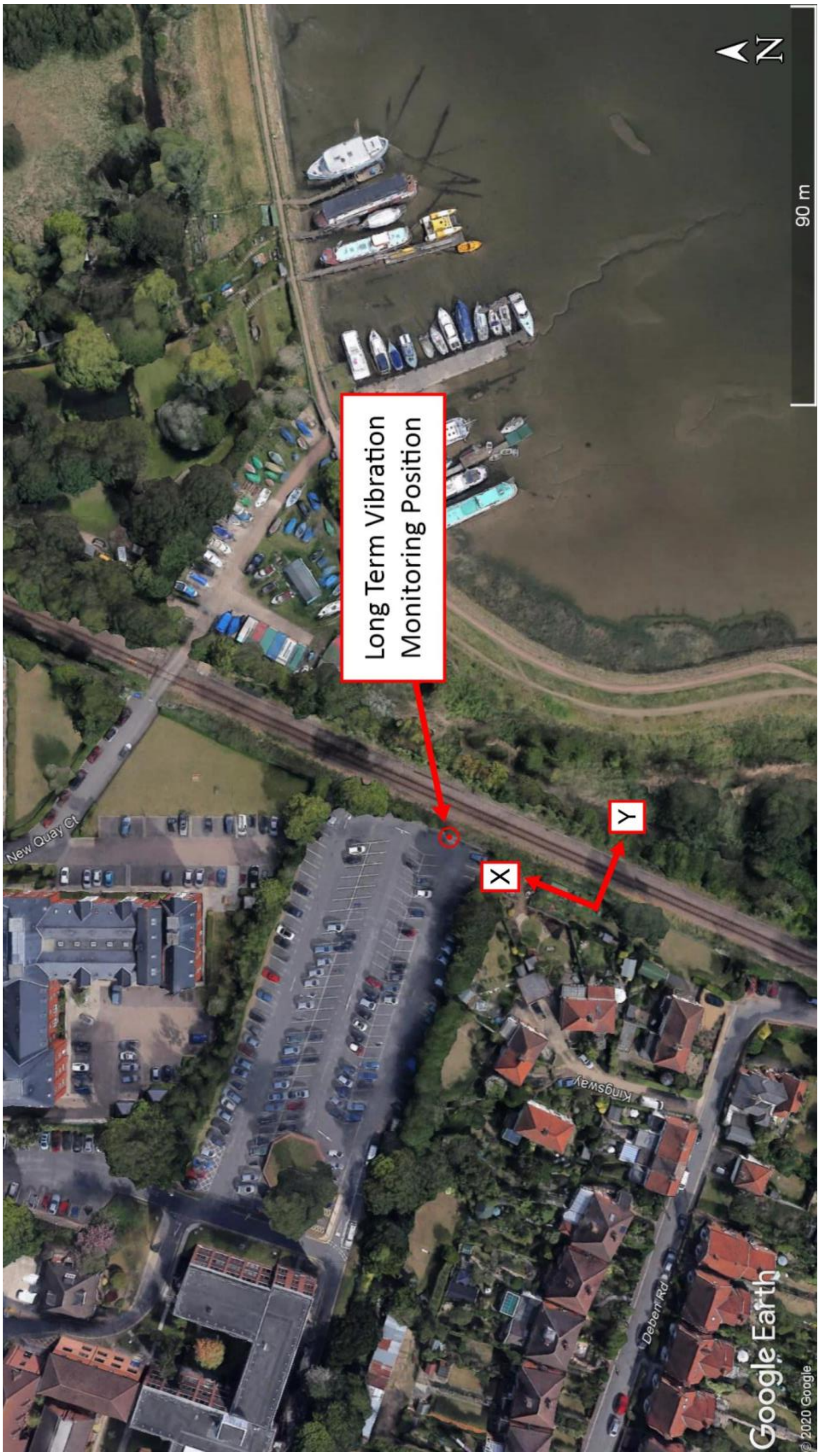
2.16 Due to the relatively small number of measurements at this stage, outliers cannot be identified and correlations cannot yet be drawn upon. As more measurements are taken however, this may change.

2.17 Figure 2.1 shows that VDV values are highest in the Z axis, meaning that cumulative vibrations are highest in this axis. PPVs however, which are instantaneous values, have been found to be highest in the Y axis.

Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing vibration monitoring location



Appendix B

Graphs of Survey Results

Figure B1: 5-minute maximum acceleration data from the 4th-10th of August 2020 – maximum levels attributed to trains are shown as individual dots

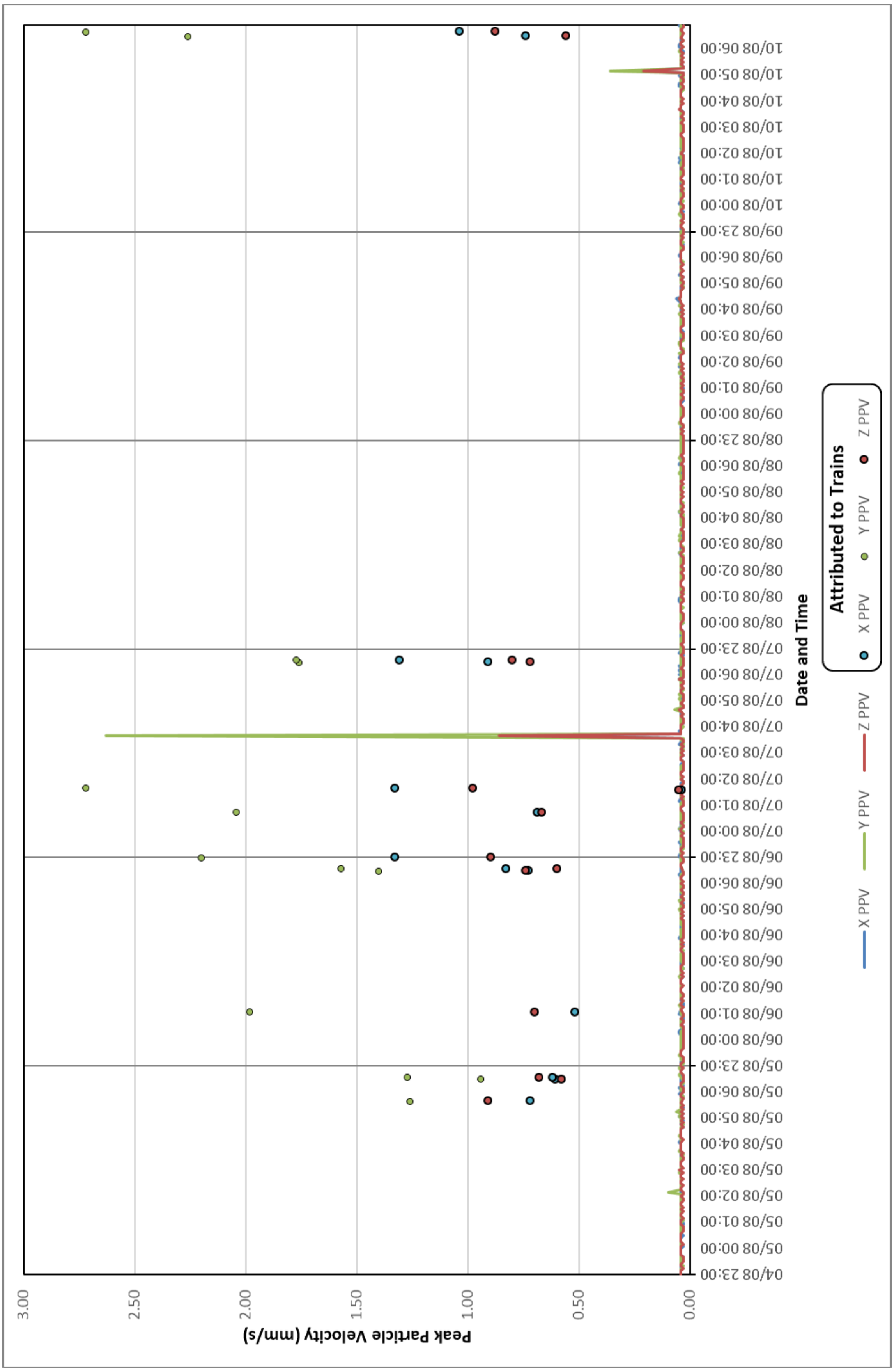
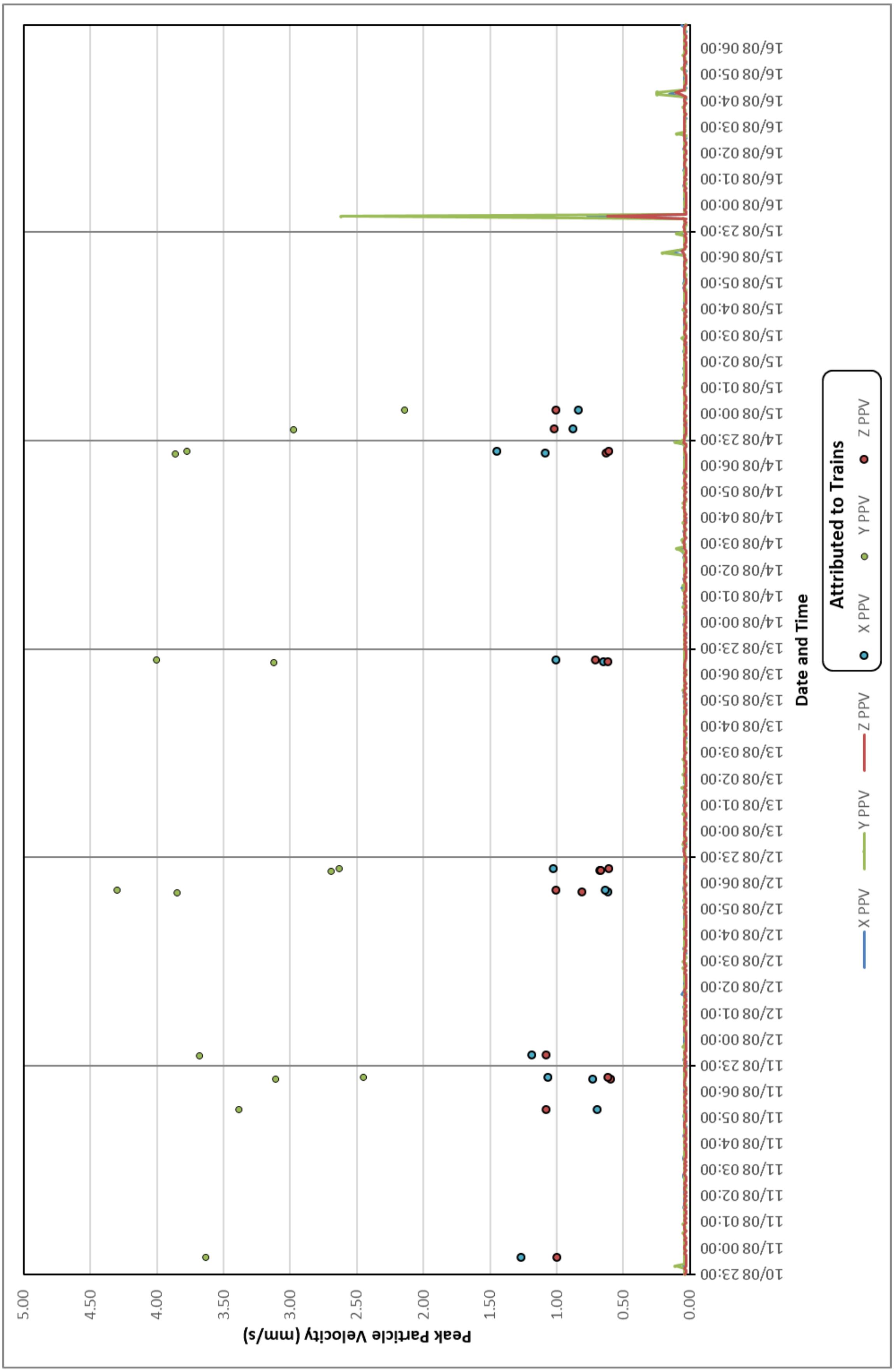


Figure B2: 5-minute maximum acceleration data from the 4th-10th of August 2020 – maximum levels attributed to trains are shown as individual dots



Appendix C

Real Time Train data

Table C1: Woodbridge Station Night Time Train Passes, data provided by www.realtimetrains.co.uk.

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
2020-08-03	06:33:22	06:35:00		LE
2020-08-03	06:35:18	06:37:10		LE
2020-08-04	06:36:36	06:37:25		LE
2020-08-04	06:35:34	06:39:21		LE
2020-08-05	05:37:00	05:39:00		ZZ
2020-08-05	06:32:30	06:34:47		LE
2020-08-05	06:35:47	06:37:01		LE
2020-08-06			01:11:16	ZZ
2020-08-06	06:33:03	06:34:58		LE
2020-08-06	06:34:52	06:36:46		LE
2020-08-06			22:59:00*	ZZ
2020-08-07			00:52:04	ZZ
2020-08-07			01:37:00	ZZ
2020-08-07	06:32:22	06:34:52		LE
2020-08-07	06:34:37	06:36:34		LE
2020-08-10	06:32:28	06:35:06		LE
2020-08-10	06:38:20	06:39:43		LE
2020-08-10	23:29:41	23:40:53		ZZ
2020-08-11	05:25:51	05:25:58		ZZ
2020-08-11	06:32:58	06:34:46		LE
2020-08-11	06:35:58	06:37:24		LE
2020-08-11	23:12:33	23:22:50		ZZ
2020-08-12	05:47:06	05:47:28		ZZ
2020-08-12	06:32:42	06:34:48		LE
2020-08-12	06:35:28	06:37:11		LE
2020-08-13	06:33:22	06:35:24		LE
2020-08-13	06:34:53	06:36:43		LE
2020-08-14	06:33:43	06:34:32		LE
2020-08-14	06:35:48	06:37:10		LE
2020-08-14	23:07:33	23:22:36		ZZ
2020-08-15	23:34:52	00:07:14		ZZ

*Note this time falls outside of the defined night time period of 23:00-07:00, however is the time which the train is recorded to have passed through Woodbridge Railway Station. This train passed the measurement location further down the track shortly after 23:00.

SHARPS REDMORE

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Report

Project

EDF – Sizewell C Power Station: Woodbridge Rail Vibration Survey Monthly Report – September 2020

Prepared by

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and

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Date 20th October 2020

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C. Real Time Train data

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1.4 The X axis is aligned parallel to the trainline, and the Y axis is aligned perpendicular to the trainline. These orientations are shown in Figure A1 in Appendix A. The Z axis is aligned vertically.

1.5 The vibration level meter measures and calculates a range of vibration parameters including Root Mean Squared Acceleration (A_{rms}). Acceleration values in each axis are weighted according to the guidance given in BS6472-1:2008. The X and Y axes are weighted using a W_d weighting curve and the Z axis is weighted using a W_b weighting curve. Parameters derived from weighted acceleration values are indicated by a subscript 'W', 'b' or 'd' following them. Vibration does value (VDV), which combines the magnitude of $A_{w,rms}$ as well as its duration to give an indication of the likely human response due to vibration, is also calculated by the meter.

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Table 2.1: Night time X PPV ranges and typical values in September*

Date	Day	$PPV_{X, 5\ Min}$		
		Min	Max	Typical
01/09/2020	Tuesday	0.03	0.57	0.04
02/09/2020	Wednesday	0.03	0.70	0.04
03/09/2020	Thursday	0.03	0.49	0.05
04/09/2020	Friday	0.03	0.07	0.04
05/09/2020	Saturday	Data not obtained due to meter fault.		
06/09/2020	Sunday			
07/09/2020	Monday	0.01	0.61	0.03
08/09/2020	Tuesday	0.01	0.77	0.03
09/09/2020	Wednesday	0.02	0.59	0.03
10/09/2020	Thursday	0.01	0.67	0.03
11/09/2020	Friday	0.01	0.03	0.03
12/09/2020	Saturday	0.02	0.04	0.03
13/09/2020	Sunday	0.02	0.67	0.03
14/09/2020	Monday	0.02	0.59	0.03
15/09/2020	Tuesday	0.01	0.63	0.03
16/09/2020	Wednesday	0.01	0.70	0.03
17/09/2020	Thursday	0.01	0.61	0.03
18/09/2020	Friday	0.01	0.03	0.02
19/09/2020	Saturday	0.01	0.04	0.03
20/09/2020	Sunday	0.02	0.59	0.03
21/09/2020	Monday	0.02	0.54	0.03
22/09/2020	Tuesday	0.01	0.59	0.03
23/09/2020	Wednesday	0.01	1.65	0.31
24/09/2020	Thursday	0.01	1.19	0.06
25/09/2020	Friday	0.02	0.49	0.04
26/09/2020	Saturday	0.02	0.17	0.04
27/09/2020	Sunday	0.01	0.33	0.03
28/09/2020	Monday	0.01	0.47	0.03
29/09/2020	Tuesday	0.01	0.38	0.03
30/09/2020	Wednesday	0.01	0.42	0.03

Table 2.2: Night time Y PPV ranges and typical values in September*

Date	Day	$PPV_{Y, 5\ Min}$		
		Min	**Max**	**Typical**
01/09/2020	Tuesday	0.03	1.13	0.04
02/09/2020	Wednesday	0.03	1.17	0.04
03/09/2020	Thursday	0.03	1.20	0.04
04/09/2020	Friday	0.03	0.07	0.04
05/09/2020	Saturday	Data not obtained due to meter fault.		
06/09/2020	Sunday			
07/09/2020	Monday	0.01	1.32	0.02
08/09/2020	Tuesday	0.01	1.23	0.02
09/09/2020	Wednesday	0.01	1.50	0.02
10/09/2020	Thursday	0.01	1.28	0.03
11/09/2020	Friday	0.01	0.03	0.02
12/09/2020	Saturday	0.01	0.03	0.02
13/09/2020	Sunday	0.01	1.67	0.02
14/09/2020	Monday	0.01	1.51	0.02
15/09/2020	Tuesday	0.01	1.66	0.02
16/09/2020	Wednesday	0.01	1.50	0.02
17/09/2020	Thursday	0.01	3.14	0.02
18/09/2020	Friday	0.01	0.02	0.02
19/09/2020	Saturday	0.01	0.03	0.02
20/09/2020	Sunday	0.01	1.51	0.02
21/09/2020	Monday	0.01	1.58	0.02
22/09/2020	Tuesday	0.01	1.43	0.02
23/09/2020	Wednesday	0.01	4.39	0.09
24/09/2020	Thursday	0.01	1.66	0.07
25/09/2020	Friday	0.02	0.72	0.03
26/09/2020	Saturday	0.02	0.48	0.03
27/09/2020	Sunday	0.01	0.73	0.02
28/09/2020	Monday	0.01	0.86	0.02
29/09/2020	Tuesday	0.01	0.81	0.02
30/09/2020	Wednesday	0.01	0.78	0.02

Table 2.3: Night time Z PPV ranges and typical values in September*

Date	Day	$PPV_{Z,\ 5\ Min}$		
		Min	Max	Typical
01/09/2020	Tuesday	0.03	0.67	0.04
02/09/2020	Wednesday	0.03	0.66	0.04
03/09/2020	Thursday	0.03	0.57	0.04
04/09/2020	Friday	0.03	0.07	0.04
05/09/2020	Saturday	Data not obtained due to meter fault.		
06/09/2020	Sunday			
07/09/2020	Monday	0.01	0.57	0.02
08/09/2020	Tuesday	0.01	0.71	0.02
09/09/2020	Wednesday	0.01	0.50	0.02
10/09/2020	Thursday	0.01	0.50	0.03
11/09/2020	Friday	0.01	0.03	0.02
12/09/2020	Saturday	0.01	0.07	0.02
13/09/2020	Sunday	0.01	0.57	0.02
14/09/2020	Monday	0.01	0.54	0.02
15/09/2020	Tuesday	0.01	0.65	0.02
16/09/2020	Wednesday	0.01	0.62	0.02
17/09/2020	Thursday	0.01	1.00	0.03
18/09/2020	Friday	0.01	0.03	0.02
19/09/2020	Saturday	0.01	0.03	0.02
20/09/2020	Sunday	0.01	0.57	0.02
21/09/2020	Monday	0.01	0.60	0.02
22/09/2020	Tuesday	0.01	0.56	0.02
23/09/2020	Wednesday	0.01	1.83	0.03
24/09/2020	Thursday	0.01	1.48	0.05
25/09/2020	Friday	0.01	0.64	0.03
26/09/2020	Saturday	0.01	0.31	0.03
27/09/2020	Sunday	0.01	0.39	0.02
28/09/2020	Monday	0.01	0.43	0.02
29/09/2020	Tuesday	0.01	0.41	0.02
30/09/2020	Wednesday	0.01	0.42	0.03

***Dates signify the date at the start of the night time period (I.e. 04/08/2020 signifies the 8-hour night period which began at 23:00 hours on that date). Due to equipment failures, results were only recorded between the 4th and the 15th of August.**

2.4 The arithmetic average of the typical values for night time periods throughout the month was 0.4mm/s in the X axis, and 0.3mm/s in the Y and Z axes.

2.5 Through comparison of the maximum and minimum PPV values with the typical levels, it can be seen that the general vibration levels in the environment are very low. Typical PPVs are always generally within 0.02mm/s of the minimum measured PPV. An unknown event throughout the night of the 23rd September caused raised levels in the X and Y axis. This event was generally constant throughout the night, and is also visible in figure B3 in Appendix B.

2.6 For each measured night, the number of times that the PPV exceeded different levels has been determined for each axis. The bands used have been determined by the levels measured throughout the month and may be subject to change. Note that bands are not inclusive at their upper level, a measurement of 0.5mm/s would fall into the 0.5-1mm/s category.

2.7 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Night time train movement data was provided by RTT for the whole month. This data is tabulated and shown in Appendix C.

2.8 Tables 2.4, 2.5 and 2.6 below, show the number of PPV exceedance events for each night. The number of PPV events attributed to train movements is shown in brackets for each category.

Table 2.4: X PPV exceedance events throughout August, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)									
		0.25 – 0.50 mm/s		0.50 – 1.00 mm/s		1.00 – 1.50 mm/s		1.50 – 2.00 mm/s		2.00+ mm/s	
01/09/2020	Tuesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
02/09/2020	Wednesday	0	(0)	3	(3)	0	(0)	0	(0)	0	(0)
03/09/2020	Thursday	2	(2)	0	(0)	0	(0)	0	(0)	0	(0)
04/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
05/09/2020	Saturday	Data not obtained due to meter fault.									
06/09/2020	Sunday										
07/09/2020	Monday	1	(0)	2	(2)	0	(0)	0	(0)	0	(0)
08/09/2020	Tuesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
09/09/2020	Wednesday	1	(1)	2	(1)	0	(0)	0	(0)	0	(0)
10/09/2020	Thursday	1	(1)	1	(1)	0	(0)	0	(0)	0	(0)
11/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
12/09/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
13/09/2020	Sunday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
14/09/2020	Monday	1	(1)	2	(2)	0	(0)	0	(0)	0	(0)
15/09/2020	Tuesday	1	(0)	3	(3)	0	(0)	0	(0)	0	(0)
16/09/2020	Wednesday	3	(3)	2	(2)	0	(0)	0	(0)	0	(0)
17/09/2020	Thursday	3	(3)	4	(4)	0	(0)	0	(0)	0	(0)
18/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
19/09/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
20/09/2020	Sunday	1	(1)	1	(1)	0	(0)	0	(0)	0	(0)
21/09/2020	Monday	2	(2)	1	(1)	0	(0)	0	(0)	0	(0)
22/09/2020	Tuesday	2	(2)	1	(1)	0	(0)	0	(0)	0	(0)
23/09/2020	Wednesday	18	(0)	2	(2)	0	(0)	1	(1)	0	(0)
24/09/2020	Thursday	0	(0)	2	(2)	2	(2)	0	(0)	0	(0)
25/09/2020	Friday	3	(3)	0	(0)	0	(0)	0	(0)	0	(0)
26/09/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
27/09/2020	Sunday	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)
28/09/2020	Monday	2	(2)	0	(0)	0	(0)	0	(0)	0	(0)
29/09/2020	Tuesday	2	(2)	0	(0)	0	(0)	0	(0)	0	(0)
30/09/2020	Wednesday	2	(2)	0	(0)	0	(0)	0	(0)	0	(0)
Total Exceedance Events		**46**		**32**		**2**		**1**		**0**	

Table 2.5: Y PPV exceedance events throughout August, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)									
		0.25 – 0.50 mm/s		0.50 – 1.00 mm/s		1.00 – 1.50 mm/s		1.50 – 2.00 mm/s		2.00+ mm/s	
01/09/2020	Tuesday	0	(0)	1	(1)	1	(1)	0	(0)	0	(0)
02/09/2020	Wednesday	0	(0)	2	(2)	1	(1)	0	(0)	0	(0)
03/09/2020	Thursday	0	(0)	1	(1)	1	(1)	0	(0)	0	(0)
04/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
05/09/2020	Saturday	Data not obtained due to meter fault.									
06/09/2020	Sunday										
07/09/2020	Monday	0	(0)	2	(1)	1	(1)	0	(0)	0	(0)
08/09/2020	Tuesday	0	(0)	1	(1)	1	(1)	0	(0)	0	(0)
09/09/2020	Wednesday	1	(0)	0	(0)	1	(1)	1	(1)	0	(0)
10/09/2020	Thursday	0	(0)	0	(0)	2	(2)	0	(0)	0	(0)
11/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
12/09/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
13/09/2020	Sunday	0	(0)	0	(0)	1	(1)	1	(1)	0	(0)
14/09/2020	Monday	0	(0)	0	(0)	1	(1)	2	(2)	0	(0)
15/09/2020	Tuesday	0	(0)	0	(0)	3	(2)	1	(1)	0	(0)
16/09/2020	Wednesday	0	(0)	0	(0)	4	(4)	1	(1)	0	(0)
17/09/2020	Thursday	0	(0)	0	(0)	2	(2)	3	(3)	2	(2)
18/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
19/09/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
20/09/2020	Sunday	0	(0)	0	(0)	0	(0)	2	(2)	0	(0)
21/09/2020	Monday	0	(0)	0	(0)	2	(2)	1	(1)	0	(0)
22/09/2020	Tuesday	0	(0)	0	(0)	3	(3)	0	(0)	0	(0)
23/09/2020	Wednesday	0	(0)	0	(0)	0	(0)	2	(2)	1	(1)
24/09/2020	Thursday	0	(0)	1	(1)	2	(2)	1	(1)	0	(0)
25/09/2020	Friday	0	(0)	3	(3)	0	(0)	0	(0)	0	(0)
26/09/2020	Saturday	1	(0)	0	(0)	0	(0)	0	(0)	0	(0)
27/09/2020	Sunday	0	(0)	1	(1)	0	(0)	0	(0)	0	(0)
28/09/2020	Monday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
29/09/2020	Tuesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
30/09/2020	Wednesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
Total Exceedance Events		**2**		**18**		**26**		**15**		**3**	

Table 2.6: Z PPV exceedance events throughout August, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)									
		0.25 – 0.50 mm/s		0.50 – 1.00 mm/s		1.00 – 1.50 mm/s		1.50 – 2.00 mm/s		2.00+ mm/s	
01/09/2020	Tuesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
02/09/2020	Wednesday	1	(1)	2	(2)	0	(0)	0	(0)	0	(0)
03/09/2020	Thursday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
04/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
05/09/2020	Saturday	Data not obtained due to meter fault.									
06/09/2020	Sunday										
07/09/2020	Monday	1	(0)	2	(2)	0	(0)	0	(0)	0	(0)
08/09/2020	Tuesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
09/09/2020	Wednesday	2	(1)	1	(1)	0	(0)	0	(0)	0	(0)
10/09/2020	Thursday	1	(1)	1	(1)	0	(0)	0	(0)	0	(0)
11/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
12/09/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
13/09/2020	Sunday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
14/09/2020	Monday	2	(2)	1	(1)	0	(0)	0	(0)	0	(0)
15/09/2020	Tuesday	0	(0)	4	(3)	0	(0)	0	(0)	0	(0)
16/09/2020	Wednesday	1	(1)	4	(4)	0	(0)	0	(0)	0	(0)
17/09/2020	Thursday	0	(0)	6	(6)	1	(1)	0	(0)	0	(0)
18/09/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
19/09/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
20/09/2020	Sunday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
21/09/2020	Monday	1	(1)	2	(2)	0	(0)	0	(0)	0	(0)
22/09/2020	Tuesday	2	(2)	1	(1)	0	(0)	0	(0)	0	(0)
23/09/2020	Wednesday	0	(0)	2	(2)	0	(0)	1	(1)	0	(0)
24/09/2020	Thursday	0	(0)	3	(3)	1	(1)	0	(0)	0	(0)
25/09/2020	Friday	1	(1)	2	(2)	0	(0)	0	(0)	0	(0)
26/09/2020	Saturday	1	(0)	0	(0)	0	(0)	0	(0)	0	(0)
27/09/2020	Sunday	1	(1)	0	(0)	0	(0)	0	(0)	0	(0)
28/09/2020	Monday	2	(2)	0	(0)	0	(0)	0	(0)	0	(0)
29/09/2020	Tuesday	2	(2)	0	(0)	0	(0)	0	(0)	0	(0)
30/09/2020	Wednesday	2	(2)	0	(0)	0	(0)	0	(0)	0	(0)
Total Exceedance Events		**20**		**41**		**2**		**1**		**0**	

2.9 Tables 2.4, 2.5 and 2.6 show that PPV is axis dependent with the highest levels being measured across the Y axis.

2.10 From the above Tables, the percentage of exceedance events attributed to trains can be calculated for each band, per axis. These are shown in Table 2.7.

Table 2.7: Percentage of exceedance events attributed to trains in September

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
X			
0.25 – 0.50 mm/s	46	26	57%
0.50 – 1.00 mm/s	32	31	97%
1.00 – 1.50 mm/s	2	2	100%
1.50 – 2.00 mm/s	1	1	100%
2.00+ mm/s	0	0	N/A
Y			
0.25 – 0.50 mm/s	2	0	0%
0.50 – 1.00 mm/s	18	17	94%
1.00 – 1.50 mm/s	26	25	96%
1.50 – 2.00 mm/s	15	15	100%
2.00+ mm/s	3	3	100%
Z			
0.25 – 0.50 mm/s	20	17	85%
0.50 – 1.00 mm/s	41	40	98%
1.00 – 1.50 mm/s	2	2	100%
1.50 – 2.00 mm/s	1	1	100%
2.00+ mm/s	0	0	N/A

2.11 Table 2.7 shows that, in the X axis, PPVs only exceed 0.5mm/s during train passes. From the typical levels shown in Table 2.1, PPVs are generally far lower than this. The two 0.5mm/s exceedance events not attributed to trains strongly resemble a train pass when examined at 1-minute resolution, however they do not align with any passes on RTT and therefore cannot be attributed to trains.

2.12 In the Y axis, Table 2.7 shows that train passes cause a large range of PPV values, with exceedance events being attributed to trains across all bands. This axis experiences the highest PPV levels due to train passes of all 3 axes. There are only two events exceeding 0.5mm/s which cannot be attributed to trains, these align with the same exceedances as those mentioned in paragraph 2.11.

2.13 In the Z axis, train passes in August generally caused PPVs between 0.5 and 1mm/s, with only three events being measured with levels exceeding 1mm/s. There were no measured PPVs above 2mm/s. This was also the case in the X axis.

2.14 Table 2.8 shows the lifetime statistics of PPV measurements. Measurements from August which were reported in different bands have been adjusted to reflect these new bands.

Table 2.8: Percentage of All PPV Exceedance Events Attributed to Trains Since Measurements Began in August 2020.

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
X			
0.25 - 0.50 mm/s	47	26	55%
0.50 - 1.00 mm/s	51	39	76%
1.00 - 1.50 mm/s	13	4	31%
1.50 - 2.00 mm/s	1	1	100%
2.00+ mm/s	0	0	N/A
Y			
0.25 - 0.50 mm/s	3	0	0%
0.50 - 1.00 mm/s	37	25	68%
1.00 - 1.50 mm/s	37	27	73%
1.50 - 2.00 mm/s	15	15	100%
2.00+ mm/s	3	3	100%
Z			
0.25 - 0.50 mm/s	27	22	81%
0.50 - 1.00 mm/s	56	55	98%
1.00 - 1.50 mm/s	2	2	100%
1.50 - 2.00 mm/s	1	1	100%
2.00+ mm/s	0	0	N/A

2.15 Vibration dose value (VDV) was derived and calculated by the vibration meter from its measured weighted acceleration values in all 3 axes in 1-minute samples. These measurements have been resampled into 8-hour night time VDV values which can then be compared to the number of train passes from RTT. This is shown in Table 2.8.

Table 2.8: Night Time VDV Values, and the Number of Train Passes

Date	Train Passes (n)	X $VDV_{d, 8hour}$	Y $VDV_{d, 8hour}$	Z $VDV_{b, 8hour}$
01/09/2020	2	0.0040	0.0071	0.0304
02/09/2020	2	0.0043	0.0061	0.0315
03/09/2020	2	0.0034	0.0059	0.0289
04/09/2020	0	0.0012	0.0012	0.0015
05/09/2020	Data not obtained due to meter fault.			
06/09/2020				
07/09/2020	2	0.0039	0.0067	0.0314
08/09/2020	2	0.0040	0.0063	0.0341
09/09/2020	2	0.0035	0.0073	0.0287
10/09/2020	2	0.0037	0.0074	0.0271
11/09/2020	0	0.0005	0.0005	0.0009
12/09/2020	0	0.0005	0.0005	0.0005
13/09/2020	2	0.0038	0.0086	0.0294

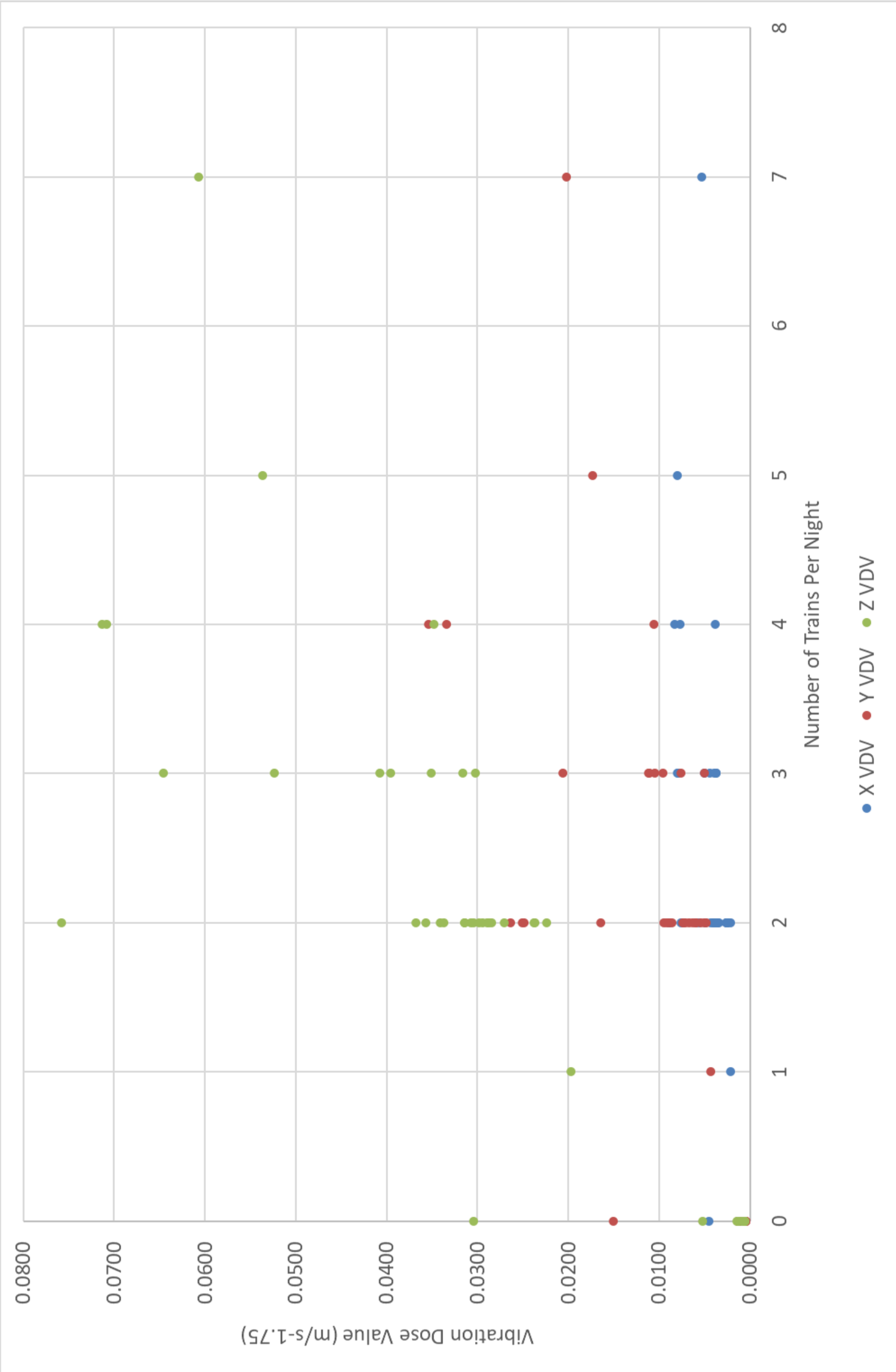
14/09/2020	3	0.0037	0.0096	0.0316
15/09/2020	3	0.0038	0.0105	0.0351
16/09/2020	4	0.0038	0.0106	0.0349
17/09/2020	7	0.0053	0.0202	0.0607
18/09/2020	0	0.0005	0.0005	0.0007
19/09/2020	0	0.0005	0.0005	0.0006
20/09/2020	2	0.0026	0.0092	0.0299
21/09/2020	2	0.0025	0.0095	0.0307
22/09/2020	2	0.0026	0.0089	0.0284
23/09/2020	3	0.0080	0.0206	0.0646
24/09/2020	3	0.0079	0.0112	0.0524
25/09/2020	3	0.0039	0.0051	0.0302
26/09/2020	0	0.0006	0.0014	0.0052
27/09/2020	1	0.0021	0.0043	0.0197
28/09/2020	2	0.0026	0.0050	0.0237
29/09/2020	2	0.0021	0.0048	0.0238
30/09/2020	2	0.0024	0.0054	0.0224

2.16 The number of trains per night against the measured VDV values in all three axes are shown graphically in Figure 2.1 overleaf. This is a lifetime Figure and therefore includes the results shown in table 2.8, as well as those measured in previous months.

2.17 Due to the relatively small number of measurements at this stage, whilst trends do appear to be emerging, outliers cannot be identified and correlations cannot yet be drawn upon. As more measurements are taken however, this may change.

2.18 Figure 2.1 shows that VDV values are highest in the Z axis, meaning that cumulative vibrations are highest in this axis. PPVs however, which are instantaneous values, have been found to be highest in the Y axis.

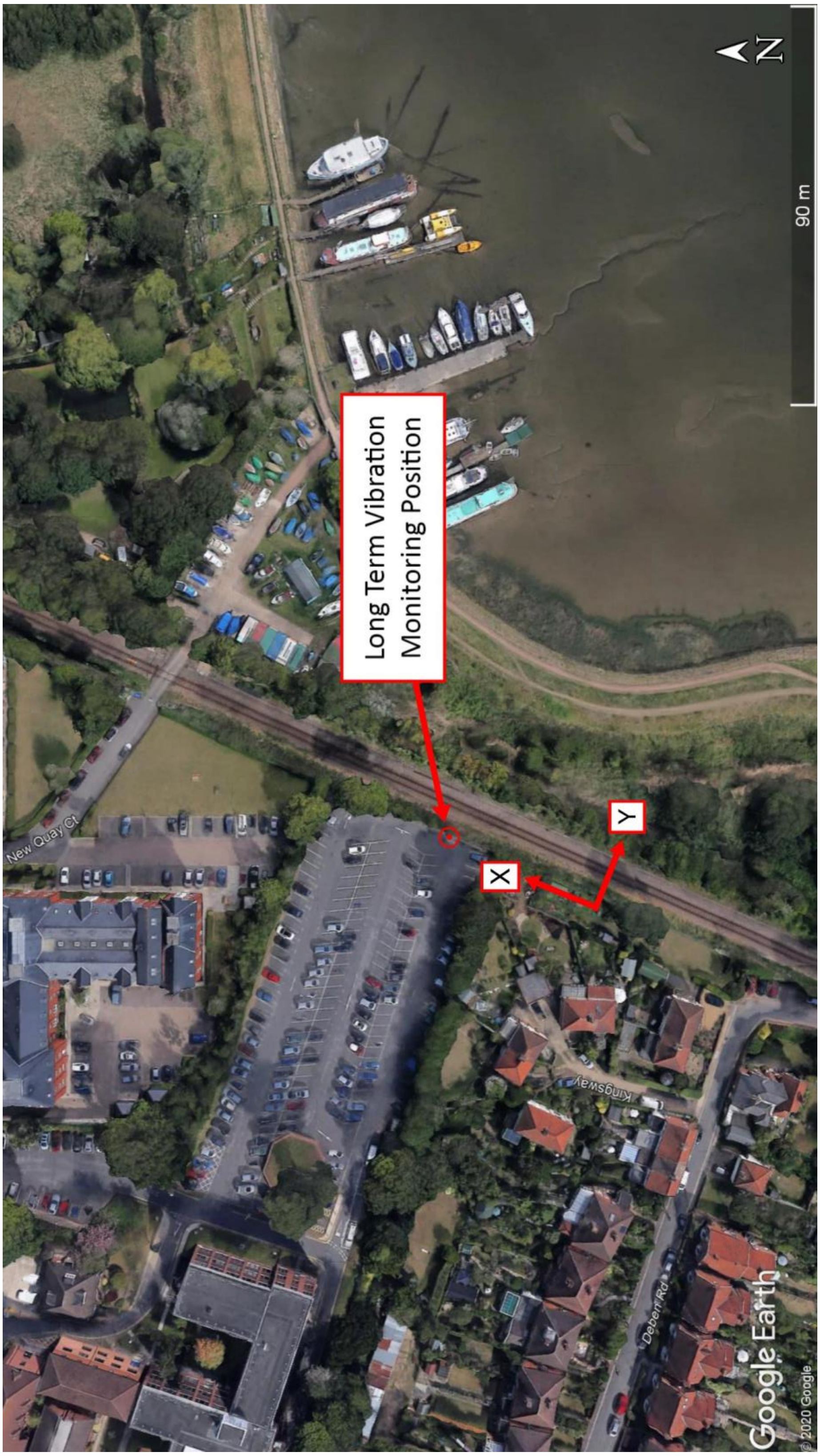
Figure 2.1: Night Time VDV Values, and the Number of Train Passes



Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing vibration monitoring location



Appendix B

Graphs of Survey Results

Figure B1: 5-minute maximum acceleration data from the 1st-5th of September 2020 – maximum PPV attributed to trains are shown as individual dots

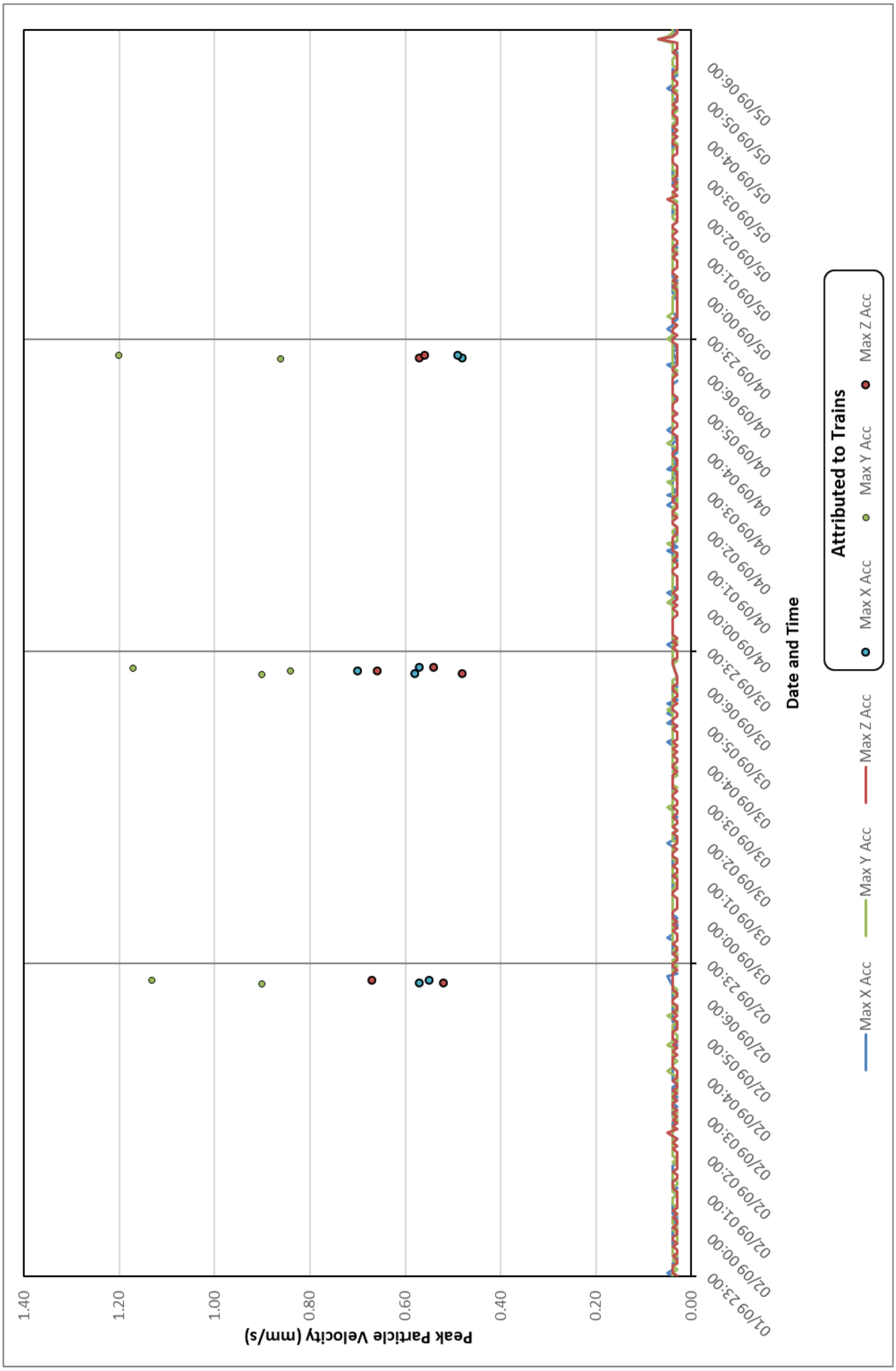


Figure B2: 5-minute maximum acceleration data from the 7th-14th of September 2020 – maximum PPV attributed to trains are shown as individual dots

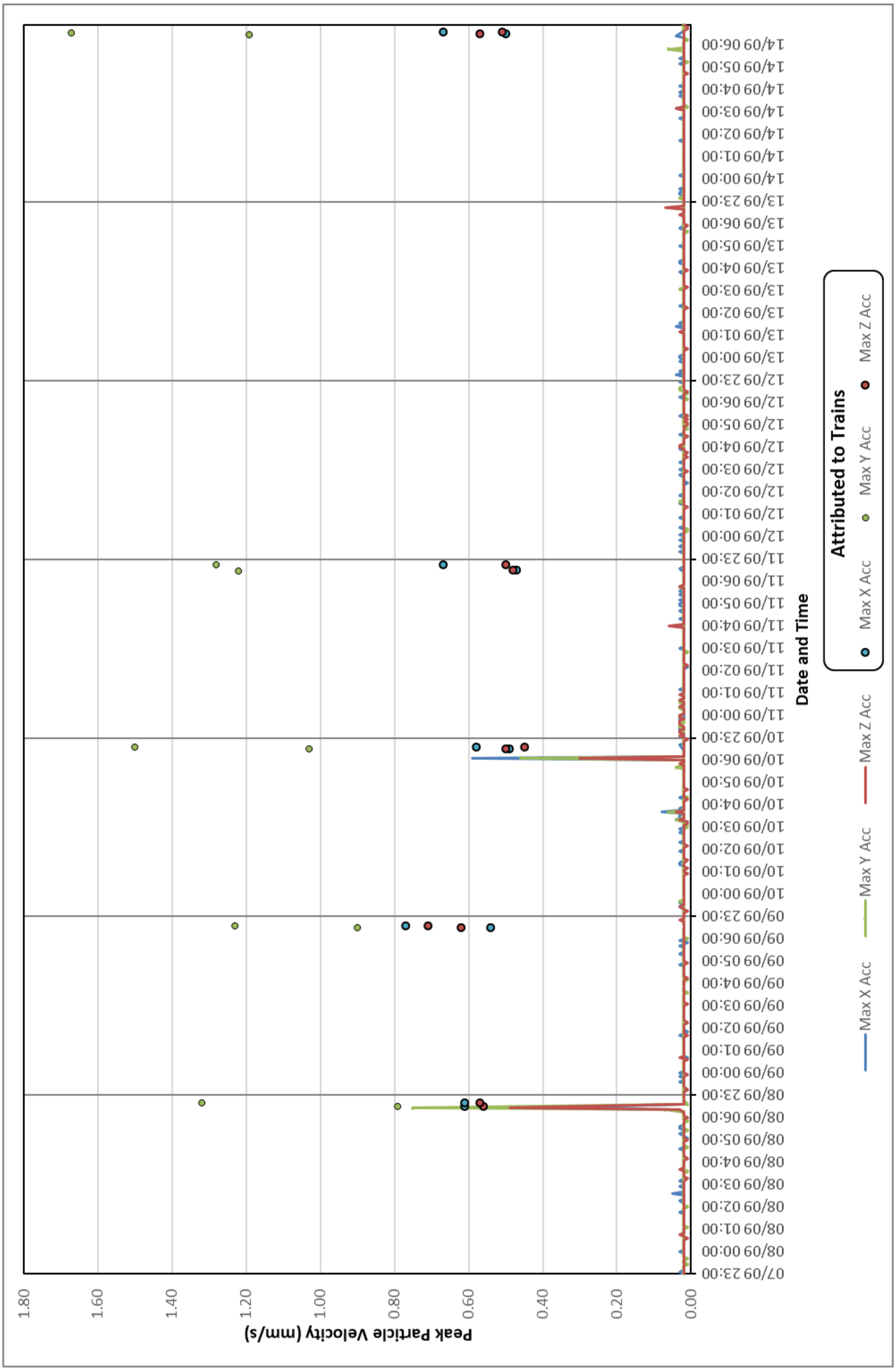


Figure B3: 5-minute maximum acceleration data from the 14th-21st of September 2020 – maximum PPV attributed to trains are shown as individual dots

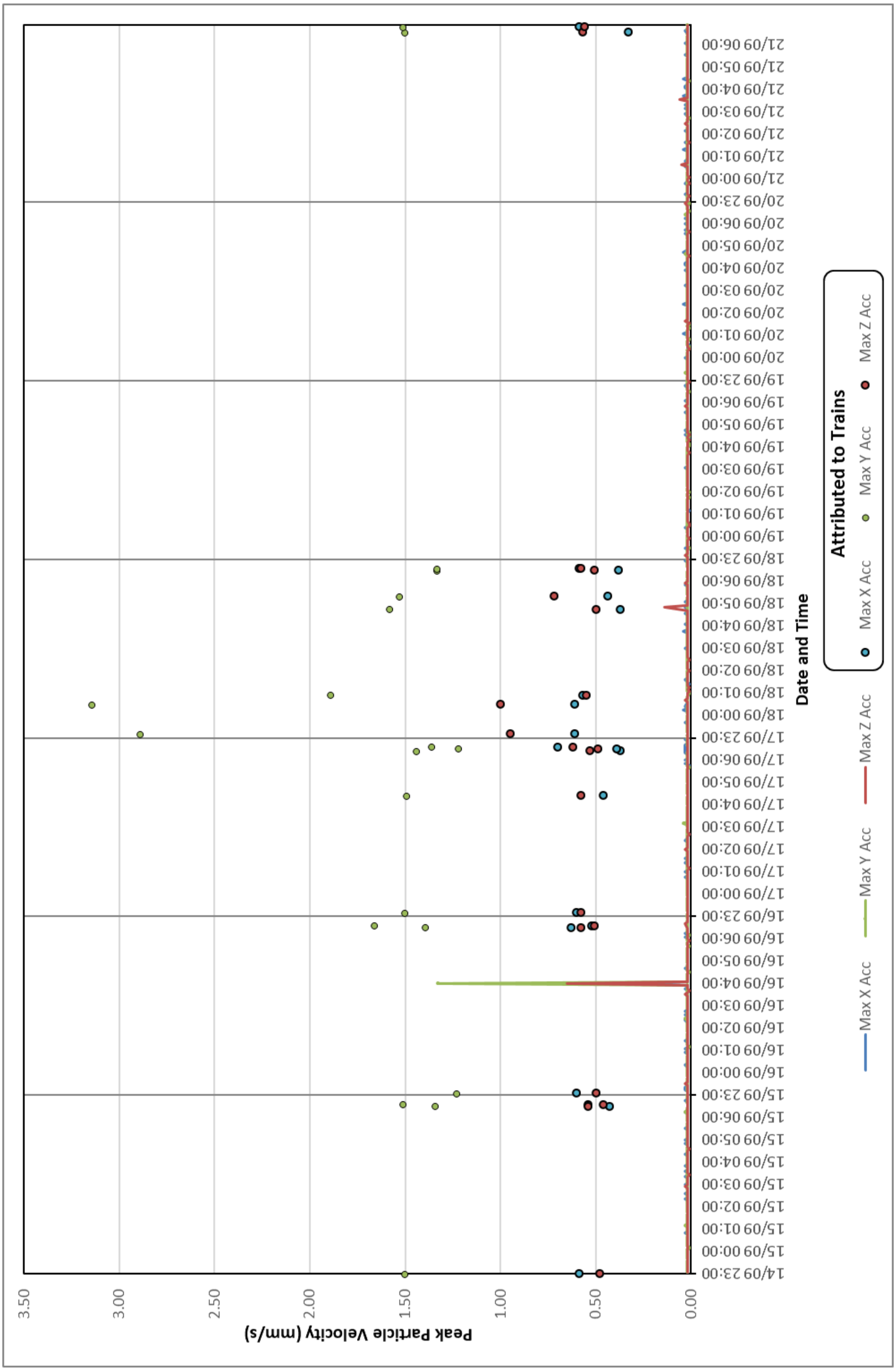


Figure B4: 5-minute maximum acceleration data from the 21st-28th of September 2020 – maximum PPV attributed to trains are shown as individual dots

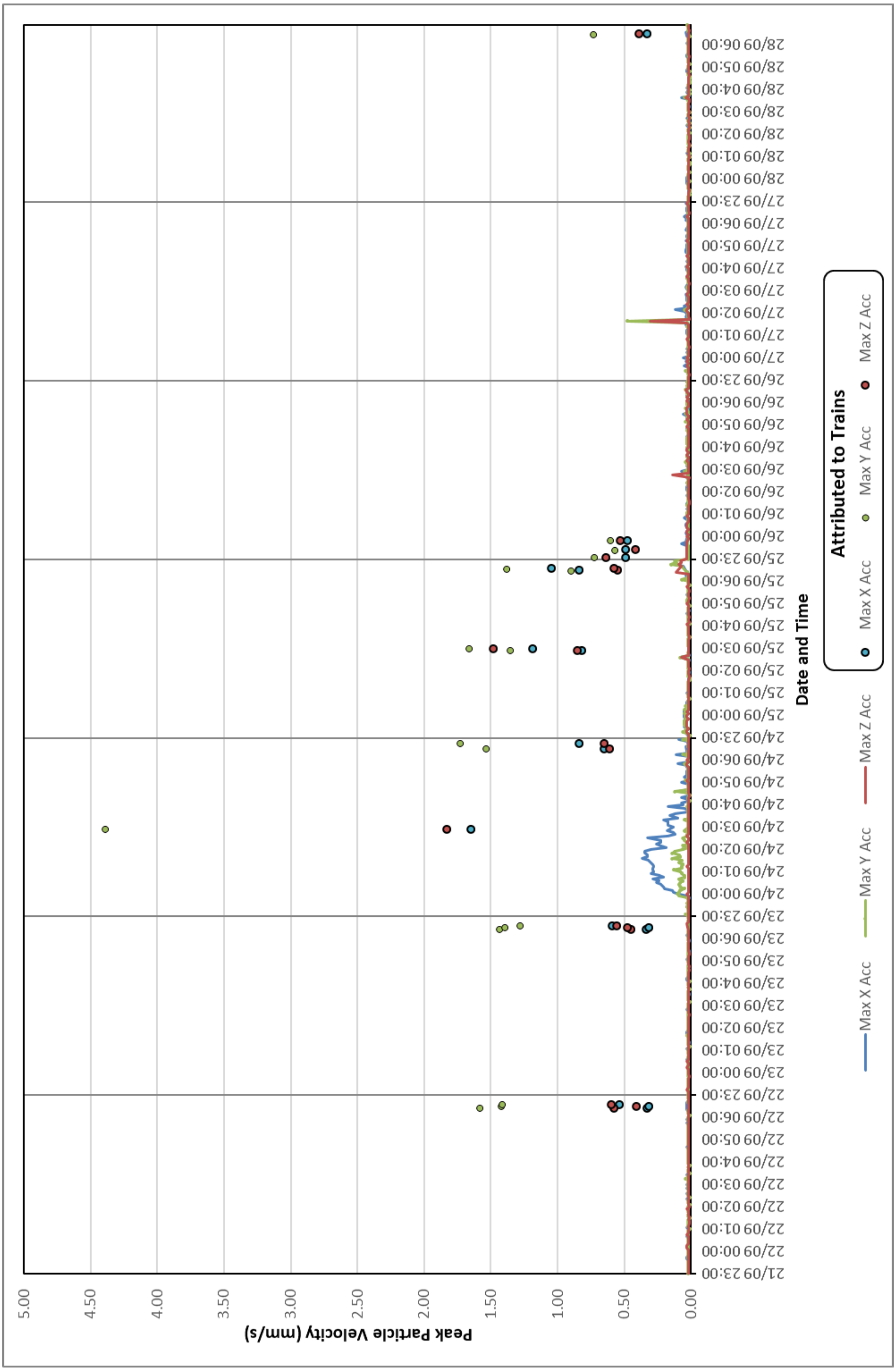
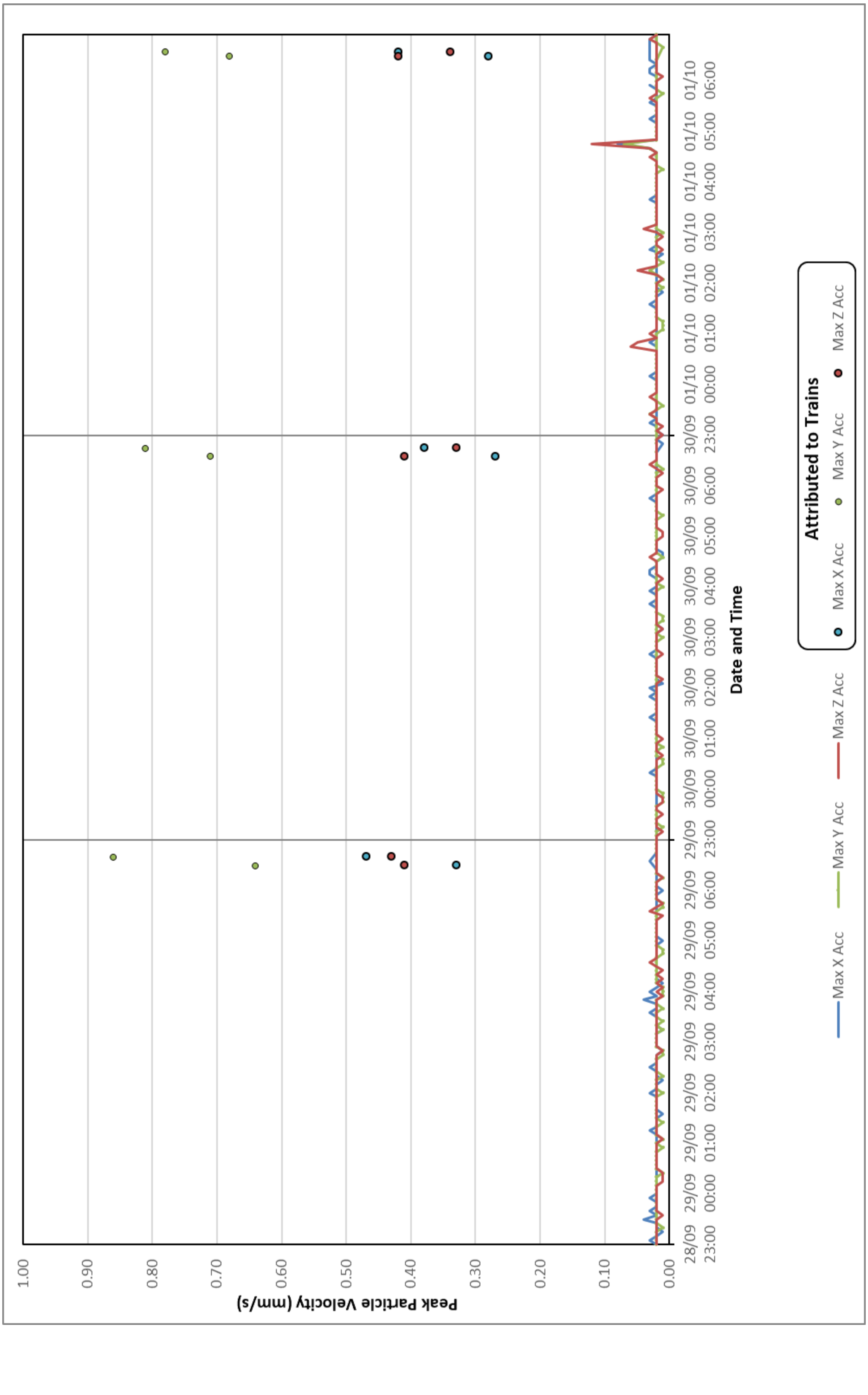


Figure B5: 5-minute maximum acceleration data from the 28th of September – 1st of October – maximum PPV attributed to trains are shown as individual dots



Appendix C

Real Time Train data

Table C1: Woodbridge Station Night Time Train Passes, data provided by www.realtimetrains.co.uk.

Date	Arrival Time	Departure Time	Pass Time	Platform	ATOC Code
2020-09-02	06:32:45	06:35:10		2	LE
2020-09-02	06:35:06	06:36:59		1	LE
2020-09-03	06:32:25	06:34:59		2	LE
2020-09-03	06:35:34	06:37:08		1	LE
2020-09-04	06:33:05	06:35:26		2	LE
2020-09-04	06:35:19	06:37:02		1	LE
2020-09-07	06:32:29	06:34:52		2	LE
2020-09-07	06:36:00	06:36:59		1	LE
2020-09-08	06:32:33	06:34:43		2	LE
2020-09-08	06:38:01	06:39:07		1	LE
2020-09-09	06:32:53	06:34:47		2	LE
2020-09-09	06:35:15	06:37:13		1	LE
2020-09-10	06:32:58	06:34:54		2	LE
2020-09-10	06:35:29	06:37:15		1	LE
2020-09-11	06:32:53	06:35:13		2	LE
2020-09-11	06:43:21	06:44:45		1	LE
2020-09-14	06:33:23	06:34:58		2	LE
2020-09-14	06:34:57	06:36:51		1	LE
2020-09-14			22:57:17*	1	ZZ
2020-09-15	06:33:39	06:34:43		2	LE
2020-09-15	06:35:53	06:37:19		1	LE
2020-09-15			23:01:32	1	ZZ
2020-09-16	06:33:30	06:35:21		2	LE
2020-09-16	06:34:15	06:36:32		1	LE
2020-09-16			23:04:06	1	ZZ
2020-09-17			04:30:12	2	ZZ
2020-09-17	06:32:39	06:35:03		2	LE
2020-09-17	06:34:59	06:37:01		1	LE
2020-09-17			23:13:26	2	ZZ
2020-09-18			00:27:46	1	ZZ
2020-09-18			00:46:00	2	ZZ
2020-09-18			04:48:36	2	ZZ
2020-09-18			05:25:05	2	ZZ
2020-09-18	06:35:32	06:36:08		2	LE
2020-09-18	06:35:42	06:37:21		1	LE
2020-09-21	06:41:58	06:42:41		2	LE
2020-09-21	06:35:10	06:50:20		1	LE
2020-09-22	06:32:39	06:34:46		2	LE
2020-09-22	06:35:12	06:37:12		1	LE
2020-09-23	06:32:46	06:34:56		2	LE
2020-09-23	06:35:21	06:37:29		1	LE
2020-09-24			02:58:42	2	ZZ
2020-09-24	06:36:07	06:36:52		2	LE

2020-09-24	06:43:07	06:44:21		1	LE
2020-09-25	02:46:11	02:57:17		1	ZZ
2020-09-25	06:35:22	06:36:10		2	LE
2020-09-25	06:35:27	06:37:21		1	LE
2020-09-25	23:01:04	23:03:38		1	LE
2020-09-25			23:27:14	1	LE
2020-09-25			23:50:11	1	LE
2020-09-28	06:32:49	06:35:04		2	LE
2020-09-29	06:33:35	06:34:57		2	LE
2020-09-29	06:37:22	06:38:58		1	LE
2020-09-30	06:41:58	06:42:40		2	LE
2020-09-30	06:35:56	06:45:52		1	LE
2020-10-01	06:33:30	06:34:58		2	LE
2020-10-01	06:35:58	06:37:32		1	LE

*Note this time falls outside of the defined night time period of 23:00-07:00, however is the time which the train is recorded to have passed through Woodbridge Railway Station. This train passed the measurement location further down the track shortly after 23:00.

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Report

Project
EDF – Sizewell C Power Station: Woodbridge Rail Vibration Survey Monthly Report – October 2020

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Contents

Appendices

1.0 Introduction

1.1 Sharps Redmore has been instructed by EDF Energy to carry out long term monitoring of vibration levels from trains passing through Woodbridge at night. The purpose of this survey is to provide information about the existing vibration climate at night to assist with understanding the context in which the proposed additional rail movements would need to be considered.

1.2 The survey work began on 4th August 2020. A triaxial ground borne vibration level meter with a connected vibration pickup was installed at the location shown in Figure A1 in Appendix A. The vibration pickup is mounted to a DIN plate and planted in surface soil adjacent to the train line. Due to increasing bad weather as winter approaches, the vibration pickup and din plate are no longer in a dug hole approximate 30cm below ground surface level. This is because the hole was beginning to fill with water which would adversely affect readings, and possibly damage equipment. This change occurred on the 1st October 2020.

1.3 The X axis is aligned parallel to the trainline, and the Y axis is aligned perpendicular to the trainline. These orientations are shown in Figure A1 in Appendix A. The Z axis is aligned vertically.

1.4 The vibration level meter measures and calculates a range of vibration parameters including Root Mean Squared Acceleration (A_{rms}). Acceleration values in each axis are weighted according to the guidance given in BS6472-1:2008. The X and Y axes are weighted using a W_d weighting curve and the Z axis is weighted using a W_b weighting curve. Parameters derived from weighted acceleration values are indicated by a subscript 'W', 'b' or 'd' following them. Vibration does value (VDV), which combines the magnitude of $A_{w,rms}$ as well as its duration to give an indication of the likely human response due to vibration, is also calculated by the meter.

1.5 The key parameter being measured and reported is peak particle velocity (PPV). PPV gives the maximum rate of change in the displacement of ground particles during each measurement interval. It is measured in millimetres per second (mm/s) and is not weighted.

1.6 From October 2020, the vibration meter was set to record data at a resolution of five minutes. This resolution enables individual events to be separated whilst optimising analysis speed as no resampling is required. Comparison to noise measurements, which are sampled at a 1 second resolution, allow for accurate source determination of vibration events.

1.7 Vibration parameters have been considered alongside data from the website Real Time Trains (RTT): www.realtimetrains.co.uk, which logs the majority of train movements along the line. Using a combination of this information and an analysis of the measured vibration parameters, results have been interpreted to provide a summary of data and the likely source which has resulted in those levels, where this is possible to determine.

1.8 Results are shown graphically in Appendix B and an analysis of the results is provided in Section 2.0. Data from RTT is shown in Appendix C.

2.0 Analysis of survey results

2.1 Data was recorded in all 3 axes with a sample rate of 5 minutes. PPV values have then been analysed to produce results. This is considered an optimum period length which is long enough to encompass an entire train pass by whilst being short enough to maintain a high resolution when considering changing vibration levels over time.

2.2 On the 1st October 2020, an audio trigger level of 80 dB L_{Amax} was set for the simultaneous noise measurements being undertaken at the same site. These audio signals were then used to determine the source of noise levels exceeding 80 dB, which were occasionally found to be trains not recorded by RTT. Furthermore, comparison of noise and vibration levels when audio signals were not recorded have allowed vibration events to be attributed to trains in the absence of RTT data. These results are highlighted in Appendix C.

2.3 Raw night time PPV data for all 3 axes has been provided in Appendix B.

2.4 Tables 2.1, 2.2 and 2.3 overleaf show the range of PPV values in each axis measured throughout night time periods in October, as well as the typical PPV in the absence of vibration events. Night is defined to be between 23:00-07:00.

Table 2.1: Night time X PPV ranges and typical values in October*

Date	Day	$PPV_{X,\ 5\ Min}$		
		Min	Max	Typical
01/10/2020	Thursday	0.01	0.99	0.04
02/10/2020	Friday	0.02	0.27	0.15
03/10/2020	Saturday	0.02	0.95	0.18
04/10/2020	Sunday	0.01	2.04	0.09
05/10/2020	Monday	0.01	0.89	0.13
06/10/2020	Tuesday	0.02	0.87	0.04
07/10/2020	Wednesday	0.02	0.82	0.11
08/10/2020	Thursday	0.01	1.10	0.03
09/10/2020	Friday	0.01	1.43	0.03
10/10/2020	Saturday	0.01	1.26	0.04
11/10/2020	Sunday	0.01	1.87	0.03
12/10/2020	Monday	0.01	0.92	0.13
13/10/2020	Tuesday	0.01	0.98	0.03
14/10/2020	Wednesday	0.02	0.91	0.04
15/10/2020	Thursday	0.01	1.65	0.03
16/10/2020	Friday	0.02	0.27	0.20
17/10/2020	Saturday	0.01	0.08	0.03
18/10/2020	Sunday	0.02	0.96	0.03
19/10/2020	Monday	0.02	1.55	0.06
20/10/2020	Tuesday	0.02	0.97	0.12
21/10/2020	Wednesday	0.02	2.52	0.05
22/10/2020	Thursday	0.01	0.91	0.03
23/10/2020	Friday	0.01	2.18	0.04
24/10/2020	Saturday	0.01	0.74	0.05
25/10/2020	Sunday	0.01	1.27	0.06
26/10/2020	Monday	0.01	1.88	0.36
27/10/2020	Tuesday	0.01	1.42	0.15
28/10/2020	Wednesday	0.01	2.07	0.45
29/10/2020	Thursday	0.01	1.84	0.42
30/10/2020	Friday	0.02	3.07	0.12
31/10/2020	Saturday	0.01	0.76	0.04

Table 2.2: Night time Y PPV ranges and typical values in October*

Date	Day	$PPV_{Y, 5\ Min}$		
		Min	Max	Typical
01/10/2020	Thursday	0.01	2.45	0.03
02/10/2020	Friday	0.02	0.17	0.13
03/10/2020	Saturday	0.01	1.46	0.19
04/10/2020	Sunday	0.01	3.51	0.08
05/10/2020	Monday	0.01	1.39	0.12
06/10/2020	Tuesday	0.01	1.69	0.03
07/10/2020	Wednesday	0.01	1.74	0.11
08/10/2020	Thursday	0.01	2.25	0.05
09/10/2020	Friday	0.01	0.63	0.02
10/10/2020	Saturday	0.01	1.76	0.03
11/10/2020	Sunday	0.01	4.12	0.03
12/10/2020	Monday	0.01	2.13	0.19
13/10/2020	Tuesday	0.01	1.89	0.04
14/10/2020	Wednesday	0.01	2.10	0.05
15/10/2020	Thursday	0.01	3.21	0.05
16/10/2020	Friday	0.01	0.14	0.09
17/10/2020	Saturday	0.01	0.09	0.04
18/10/2020	Sunday	0.01	2.03	0.03
19/10/2020	Monday	0.01	3.32	0.04
20/10/2020	Tuesday	0.01	1.92	0.10
21/10/2020	Wednesday	0.01	5.89	0.06
22/10/2020	Thursday	0.01	2.08	0.02
23/10/2020	Friday	0.01	6.09	0.03
24/10/2020	Saturday	0.01	2.00	0.04
25/10/2020	Sunday	0.01	3.36	0.05
26/10/2020	Monday	0.01	3.79	0.85
27/10/2020	Tuesday	0.01	3.51	0.28
28/10/2020	Wednesday	0.01	5.00	1.03
29/10/2020	Thursday	0.01	4.10	0.81
30/10/2020	Friday	0.01	6.32	0.12
31/10/2020	Saturday	0.01	2.02	0.06

Table 2.3: Night time Z PPV ranges and typical values in October*

Date	Day	$PPV_{Z, 5 Min}$		
		Min	Max	Typical
01/10/2020	Thursday	0.01	1.86	0.02
02/10/2020	Friday	0.01	0.13	0.09
03/10/2020	Saturday	0.01	1.26	0.09
04/10/2020	Sunday	0.01	2.81	0.03
05/10/2020	Monday	0.01	1.24	0.06
06/10/2020	Tuesday	0.01	1.57	0.02
07/10/2020	Wednesday	0.01	1.54	0.06
08/10/2020	Thursday	0.01	1.75	0.03
09/10/2020	Friday	0.01	0.45	0.02
10/10/2020	Saturday	0.01	0.87	0.03
11/10/2020	Sunday	0.01	2.06	0.03
12/10/2020	Monday	0.01	2.05	0.06
13/10/2020	Tuesday	0.01	1.59	0.02
14/10/2020	Wednesday	0.01	1.89	0.03
15/10/2020	Thursday	0.01	2.87	0.03
16/10/2020	Friday	0.01	0.10	0.07
17/10/2020	Saturday	0.01	0.07	0.02
18/10/2020	Sunday	0.01	2.12	0.02
19/10/2020	Monday	0.01	2.54	0.03
20/10/2020	Tuesday	0.01	1.89	0.05
21/10/2020	Wednesday	0.01	4.41	0.03
22/10/2020	Thursday	0.01	1.83	0.02
23/10/2020	Friday	0.01	3.59	0.03
24/10/2020	Saturday	0.01	1.74	0.03
25/10/2020	Sunday	0.01	2.45	0.05
26/10/2020	Monday	0.01	2.39	0.78
27/10/2020	Tuesday	0.01	3.65	0.28
28/10/2020	Wednesday	0.01	3.41	0.86
29/10/2020	Thursday	0.01	2.21	0.91
30/10/2020	Friday	0.01	3.56	0.11
31/10/2020	Saturday	0.01	1.87	0.03

***Dates signify the date at the start of the night time period (I.e. 04/10/2020 signifies the 8-hour night period which began at 23:00 hours on that date).**

2.5 The arithmetic average of the typical values for night time periods throughout the month was 0.10mm/s in the X axis, 0.15mm/s in the Y and 0.13mm/s Z axes. These are raised in comparison to previous month's data which is likely due to placing the accelerometer on the ground surface, as described in paragraph 1.2.

2.6 Through comparison of the maximum and minimum PPV values with the typical levels, it can be seen that the general vibration levels in the environment are low.

2.7 For each measured night, the number of times that the PPV exceeded different levels has been determined for each axis. The bands used have been determined by the levels measured throughout the month and may be subject to change. Note that bands are not inclusive at their upper level, a measurement of 0.5mm/s would fall into the 0.5-1mm/s category.

2.8 Using information provided by www.realtimetrains.co.uk (RTT) it is possible to match up exceedance events with passing trains. Night time train movement data was provided by RTT for the whole month. This data is tabulated and shown in Appendix C.

2.9 Tables 2.4, 2.5 and 2.6 below, show the number of PPV exceedance events for each night. The number of PPV events attributed to train movements is shown in brackets for each category.

Table 2.4: X PPV exceedance events throughout October, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)									
		0.25 – 0.50 mm/s		0.50 – 1.00 mm/s		1.00 – 1.50 mm/s		1.50 – 2.00 mm/s		2.00+ mm/s	
01/10/2020	Thursday	0	(0)	3	(3)	0	(0)	0	(0)	0	(0)
02/10/2020	Friday	1	(0)	0	(0)	0	(0)	0	(0)	0	(0)
03/10/2020	Saturday	1	(0)	1	(1)	0	(0)	0	(0)	0	(0)
04/10/2020	Sunday	0	(0)	3	(3)	1	(1)	0	(0)	1	(1)
05/10/2020	Monday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
06/10/2020	Tuesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
07/10/2020	Wednesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
08/10/2020	Thursday	0	(0)	1	(1)	1	(1)	0	(0)	0	(0)
09/10/2020	Friday	0	(0)	0	(0)	1	(0)	0	(0)	0	(0)
10/10/2020	Saturday	0	(0)	1	(1)	1	(1)	0	(0)	0	(0)
11/10/2020	Sunday	0	(0)	2	(2)	1	(1)	1	(1)	0	(0)
12/10/2020	Monday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
13/10/2020	Tuesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
14/10/2020	Wednesday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
15/10/2020	Thursday	0	(0)	2	(2)	0	(0)	2	(2)	0	(0)
16/10/2020	Friday	3	(0)	0	(0)	0	(0)	0	(0)	0	(0)
17/10/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
18/10/2020	Sunday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
19/10/2020	Monday	0	(0)	2	(2)	0	(0)	1	(1)	0	(0)
20/10/2020	Tuesday	1	(0)	2	(2)	0	(0)	0	(0)	0	(0)
21/10/2020	Wednesday	0	(0)	3	(3)	1	(1)	1	(1)	1	(1)
22/10/2020	Thursday	0	(0)	4	(4)	0	(0)	0	(0)	0	(0)
23/10/2020	Friday	0	(0)	1	(1)	2	(2)	2	(2)	1	(1)
24/10/2020	Saturday	0	(0)	1	(1)	0	(0)	0	(0)	0	(0)
25/10/2020	Sunday	0	(0)	5	(5)	2	(2)	0	(0)	0	(0)
26/10/2020	Monday	0	(0)	5	(5)	3	(3)	2	(2)	0	(0)
27/10/2020	Tuesday	1	(1)	4	(4)	5	(5)	0	(0)	0	(0)
28/10/2020	Wednesday	0	(0)	5	(5)	4	(4)	0	(0)	1	(1)
29/10/2020	Thursday	0	(0)	5	(5)	4	(4)	1	(1)	0	(0)
30/10/2020	Friday	0	(0)	1	(1)	3	(3)	3	(3)	2	(2)
31/10/2020	Saturday	0	(0)	1	(1)	0	(0)	0	(0)	0	(0)
Total Exceedance Events		**7**		**66**		**29**		**13**		**6**	

Table 2.5: Y PPV exceedance events throughout October, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)									
		0.25 – 0.50 mm/s		0.50 – 1.00 mm/s		1.00 – 1.50 mm/s		1.50 – 2.00 mm/s		2.00+ mm/s	
01/10/2020	Thursday	0	(0)	0	(0)	1	(1)	1	(1)	1	(1)
02/10/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
03/10/2020	Saturday	1	(0)	0	(0)	1	(1)	0	(0)	0	(0)
04/10/2020	Sunday	0	(0)	0	(0)	1	(1)	2	(2)	2	(2)
05/10/2020	Monday	0	(0)	0	(0)	2	(2)	0	(0)	0	(0)
06/10/2020	Tuesday	0	(0)	0	(0)	1	(1)	1	(1)	0	(0)
07/10/2020	Wednesday	0	(0)	0	(0)	0	(0)	2	(2)	0	(0)
08/10/2020	Thursday	0	(0)	0	(0)	0	(0)	1	(1)	1	(1)
09/10/2020	Friday	0	(0)	1	(0)	0	(0)	0	(0)	0	(0)
10/10/2020	Saturday	0	(0)	1	(1)	0	(0)	1	(1)	0	(0)
11/10/2020	Sunday	0	(0)	0	(0)	0	(0)	2	(2)	2	(2)
12/10/2020	Monday	0	(0)	0	(0)	0	(0)	1	(1)	1	(1)
13/10/2020	Tuesday	0	(0)	0	(0)	0	(0)	2	(2)	0	(0)
14/10/2020	Wednesday	0	(0)	0	(0)	0	(0)	1	(1)	1	(1)
15/10/2020	Thursday	0	(0)	0	(0)	0	(0)	2	(2)	2	(2)
16/10/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
17/10/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
18/10/2020	Sunday	0	(0)	0	(0)	0	(0)	1	(1)	1	(1)
19/10/2020	Monday	0	(0)	0	(0)	0	(0)	2	(2)	1	(1)
20/10/2020	Tuesday	0	(0)	0	(0)	0	(0)	2	(2)	0	(0)
21/10/2020	Wednesday	0	(0)	0	(0)	1	(1)	2	(2)	3	(3)
22/10/2020	Thursday	0	(0)	0	(0)	0	(0)	2	(2)	2	(2)
23/10/2020	Friday	0	(0)	0	(0)	0	(0)	1	(1)	5	(5)
24/10/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	1	(1)
25/10/2020	Sunday	0	(0)	0	(0)	0	(0)	5	(5)	2	(2)
26/10/2020	Monday	0	(0)	0	(0)	0	(0)	3	(3)	7	(7)
27/10/2020	Tuesday	1	(1)	0	(0)	0	(0)	4	(4)	5	(5)
28/10/2020	Wednesday	0	(0)	0	(0)	0	(0)	2	(2)	8	(8)
29/10/2020	Thursday	0	(0)	0	(0)	0	(0)	5	(5)	5	(5)
30/10/2020	Friday	0	(0)	0	(0)	0	(0)	1	(1)	8	(8)
31/10/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	1	(1)
Total Exceedance Events		**2**		**2**		**7**		**46**		**59**	

Table 2.6: Z PPV exceedance events throughout October, and number of those attributed to train movements.

Date	Day	Level Exceedances (Attributed to Trains)									
		0.25 – 0.50 mm/s		0.50 – 1.00 mm/s		1.00 – 1.50 mm/s		1.50 – 2.00 mm/s		2.00+ mm/s	
01/10/2020	Thursday	0	(0)	0	(0)	0	(0)	3	(3)	0	(0)
02/10/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
03/10/2020	Saturday	1	(0)	0	(0)	1	(1)	0	(0)	0	(0)
04/10/2020	Sunday	0	(0)	0	(0)	3	(3)	1	(1)	1	(1)
05/10/2020	Monday	0	(0)	0	(0)	2	(2)	0	(0)	0	(0)
06/10/2020	Tuesday	0	(0)	0	(0)	1	(1)	1	(1)	0	(0)
07/10/2020	Wednesday	0	(0)	0	(0)	1	(1)	1	(1)	0	(0)
08/10/2020	Thursday	0	(0)	0	(0)	0	(0)	2	(2)	0	(0)
09/10/2020	Friday	1	(0)	0	(0)	0	(0)	0	(0)	0	(0)
10/10/2020	Saturday	0	(0)	2	(2)	0	(0)	0	(0)	0	(0)
11/10/2020	Sunday	0	(0)	0	(0)	1	(1)	2	(2)	1	(1)
12/10/2020	Monday	0	(0)	0	(0)	0	(0)	1	(1)	1	(1)
13/10/2020	Tuesday	0	(0)	0	(0)	1	(1)	1	(1)	0	(0)
14/10/2020	Wednesday	0	(0)	0	(0)	0	(0)	2	(2)	0	(0)
15/10/2020	Thursday	0	(0)	0	(0)	1	(1)	1	(1)	2	(2)
16/10/2020	Friday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
17/10/2020	Saturday	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)
18/10/2020	Sunday	0	(0)	0	(0)	0	(0)	1	(1)	1	(1)
19/10/2020	Monday	0	(0)	0	(0)	0	(0)	1	(1)	2	(2)
20/10/2020	Tuesday	0	(0)	0	(0)	0	(0)	2	(2)	0	(0)
21/10/2020	Wednesday	0	(0)	0	(0)	1	(1)	3	(3)	2	(2)
22/10/2020	Thursday	0	(0)	0	(0)	2	(2)	2	(2)	0	(0)
23/10/2020	Friday	0	(0)	0	(0)	1	(1)	2	(2)	3	(3)
24/10/2020	Saturday	0	(0)	0	(0)	0	(0)	1	(1)	0	(0)
25/10/2020	Sunday	0	(0)	0	(0)	0	(0)	4	(4)	3	(3)
26/10/2020	Monday	0	(0)	0	(0)	0	(0)	6	(6)	4	(4)
27/10/2020	Tuesday	0	(0)	1	(1)	0	(0)	7	(7)	2	(2)
28/10/2020	Wednesday	0	(0)	0	(0)	0	(0)	5	(5)	5	(5)
29/10/2020	Thursday	2	(0)	0	(0)	1	(1)	7	(7)	2	(2)
30/10/2020	Friday	0	(0)	0	(0)	0	(0)	3	(3)	6	(6)
31/10/2020	Saturday	0	(0)	0	(0)	0	(0)	1	(1)	0	(0)
Total Exceedance Events		**4**		**3**		**16**		**60**		**35**	

2.10 Tables 2.4, 2.5 and 2.6 show that PPV is axis dependent with the highest levels being measured across the Y axis.

2.11 From the above Tables, the percentage of exceedance events attributed to trains can be calculated for each band, per axis. These are shown in Table 2.7.

Table 2.7: Percentage of exceedance events attributed to trains in October

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
X			
0.25 – 0.50 mm/s	7	1	14%
0.50 – 1.00 mm/s	66	66	100%
1.00 – 1.50 mm/s	29	28	97%
1.50 – 2.00 mm/s	13	13	100%
2.00+ mm/s	6	6	100%
Y			
0.25 – 0.50 mm/s	2	1	50%
0.50 – 1.00 mm/s	2	1	50%
1.00 – 1.50 mm/s	7	7	100%
1.50 – 2.00 mm/s	46	46	100%
2.00+ mm/s	59	59	100%
Z			
0.25 – 0.50 mm/s	4	0	0%
0.50 – 1.00 mm/s	3	3	100%
1.00 – 1.50 mm/s	16	16	100%
1.50 – 2.00 mm/s	60	60	100%
2.00+ mm/s	35	35	100%

2.12 Table 2.7 shows that, in the X axis, PPVs almost always exceed 0.5mm/s due to train passes. From the typical levels shown in Table 2.1, PPVs are generally far lower than this.

2.13 In the Y axis, Table 2.7 shows that train passes cause a large range of PPV values, with exceedance events being attributed to trains across all bands. This axis experiences the highest PPV levels due to train passes of all 3 axes. There are only two events below 1.0mm/s which cannot be attributed to trains.

2.14 In the Z axis, train passes in October caused PPVs greater than 0.5mm/s. It is noted that levels measured in this axis for this month are significantly higher than those previously measured. This is likely a result of mounting the accelerometer on the ground surface as opposed to in a dug hole. The reason for this change is described in paragraph 1.2.

2.15 Table 2.8 shows the lifetime statistics of PPV measurements. Measurements from August which were reported in different bands have been adjusted to reflect these new bands.

Table 2.8: Percentage of All PPV Exceedance Events Attributed to Trains Since Measurements Began in October 2020.

Band	Number of Exceedance Events	Number Attributed to Trains	Percentage
X			
0.25 - 0.50 mm/s	54	27	50%
0.50 - 1.00 mm/s	117	105	90%
1.00 - 1.50 mm/s	42	32	76%
1.50 - 2.00 mm/s	14	14	100%
2.00+ mm/s	6	6	100%
Y			
0.25 - 0.50 mm/s	5	1	20%
0.50 - 1.00 mm/s	39	26	67%
1.00 - 1.50 mm/s	44	34	77%
1.50 - 2.00 mm/s	61	61	100%
2.00+ mm/s	62	62	100%
Z			
0.25 - 0.50 mm/s	31	22	71%
0.50 - 1.00 mm/s	59	58	98%
1.00 - 1.50 mm/s	18	18	100%
1.50 - 2.00 mm/s	61	61	100%
2.00+ mm/s	35	35	100%

2.16 Vibration dose value (VDV) was derived and calculated by the vibration meter from its measured weighted acceleration values in all 3 axes in 1-minute samples. These measurements have been resampled into 8-hour night time VDV values which can then be compared to the number of train passes from RTT. This is shown in Table 2.8.

Table 2.8: Night Time VDV Values, and the Number of Train Passes

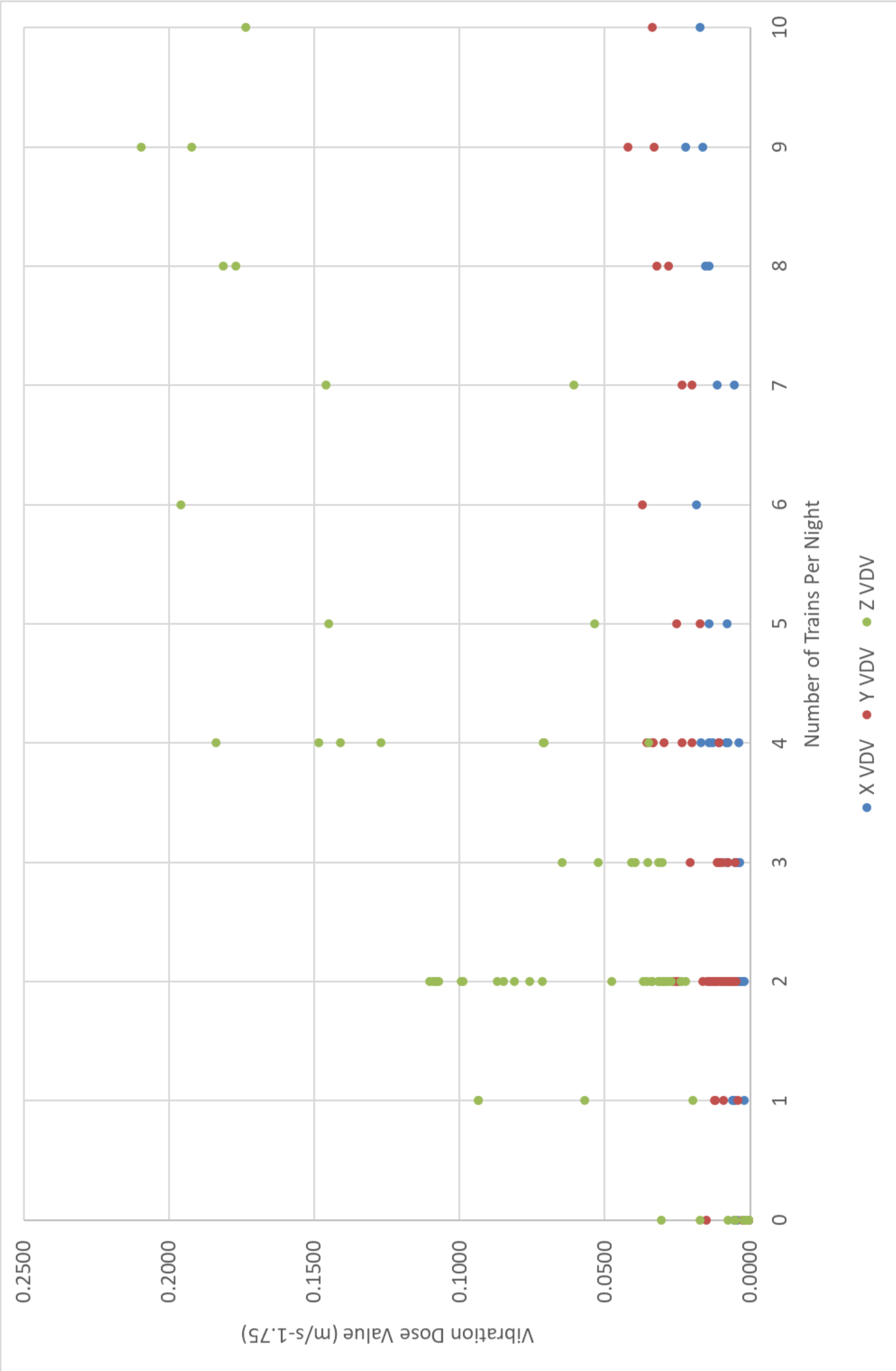
Date	Train Passes (n)	X $VDV_{d,\ 8hour}$	Y $VDV_{d,\ 8hour}$	Z $VDV_{b,\ 8hour}$
01/10/2020	2	0.0070	0.0134	0.1102
02/10/2020	0	0.0017	0.0014	0.0078
03/10/2020	1	0.0061	0.0091	0.0570
04/10/2020	5	0.0143	0.0253	0.1451
05/10/2020	2	0.0065	0.0097	0.0717
06/10/2020	2	0.0068	0.0114	0.0813
07/10/2020	2	0.0063	0.0114	0.0870
08/10/2020	2	0.0070	0.0130	0.0989
09/10/2020	0	0.0056	0.0025	0.0172
10/10/2020	2	0.0065	0.0102	0.0475
11/10/2020	4	0.0141	0.0296	0.1410
12/10/2020	2	0.0071	0.0146	0.1090
13/10/2020	2	0.0064	0.0118	0.0849
14/10/2020	2	0.0071	0.0139	0.0996
15/10/2020	4	0.0130	0.0233	0.1485
16/10/2020	0	0.0019	0.0009	0.0053
17/10/2020	0	0.0006	0.0005	0.0024
18/10/2020	2	0.0071	0.0126	0.1086
19/10/2020	4	0.0109	0.0202	0.1271
20/10/2020	2	0.0065	0.0121	0.1079
21/10/2020	4	0.0170	0.0338	0.1838
22/10/2020	2	0.0071	0.0143	0.1071
23/10/2020	6	0.0186	0.0372	0.1959
24/10/2020	1	0.0054	0.0121	0.0934
25/10/2020	7	0.0115	0.0234	0.1459
26/10/2020	8	0.0153	0.0321	0.1770
27/10/2020	8	0.0142	0.0280	0.1812
28/10/2020	9	0.0163	0.0332	0.1923
29/10/2020	10	0.0172	0.0337	0.1736
30/10/2020	9	0.0222	0.0419	0.2096
31/10/2020	1	0.0054	0.0124	0.0936

2.17 The number of trains per night against the measured VDV values in all three axes are shown graphically in Figure 2.1 overleaf. This is a lifetime Figure and therefore includes the results shown in table 2.8, as well as those measured in previous months.

2.18 Weak trends can be seen between the number of trains and VDV levels. These correlations are positive and are most apparent in the Z axis where VDV values are highest.

2.19 Figure 2.1 shows that VDV values are highest in the Z axis, meaning that cumulative vibrations are highest in this axis. PPVs however, which are instantaneous values, have been found to be highest in the Y axis.

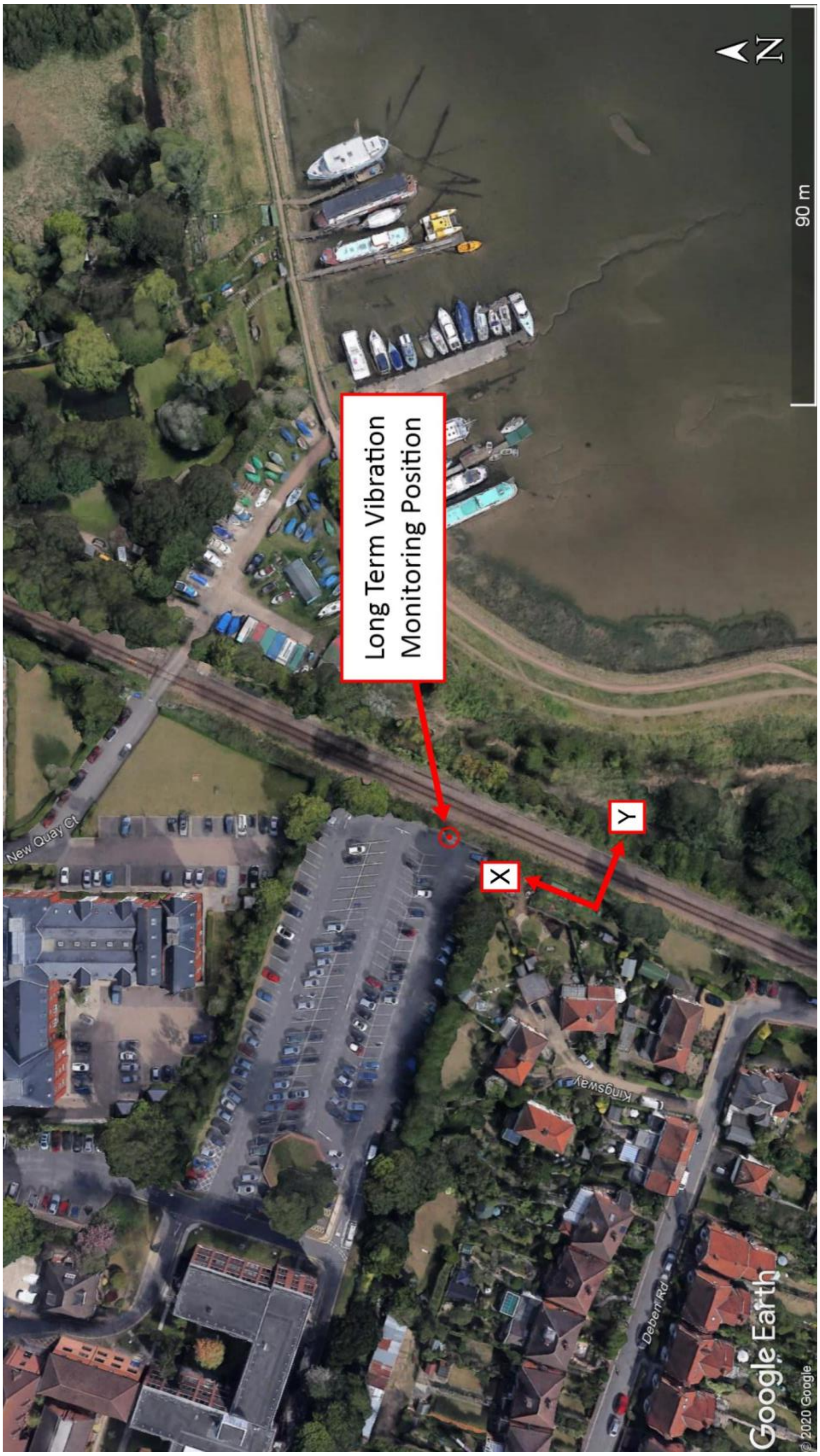
Figure 2.1: Night Time VDV Values, and the Number of Train Passes



Appendix A

Plan showing noise monitoring location

Figure A1: Plan showing vibration monitoring location



Appendix B

Graphs of Survey Results

Figure B1: 5-minute maximum acceleration data from the 1st-5th of October 2020 – maximum PPV attributed to trains are shown as individual dots

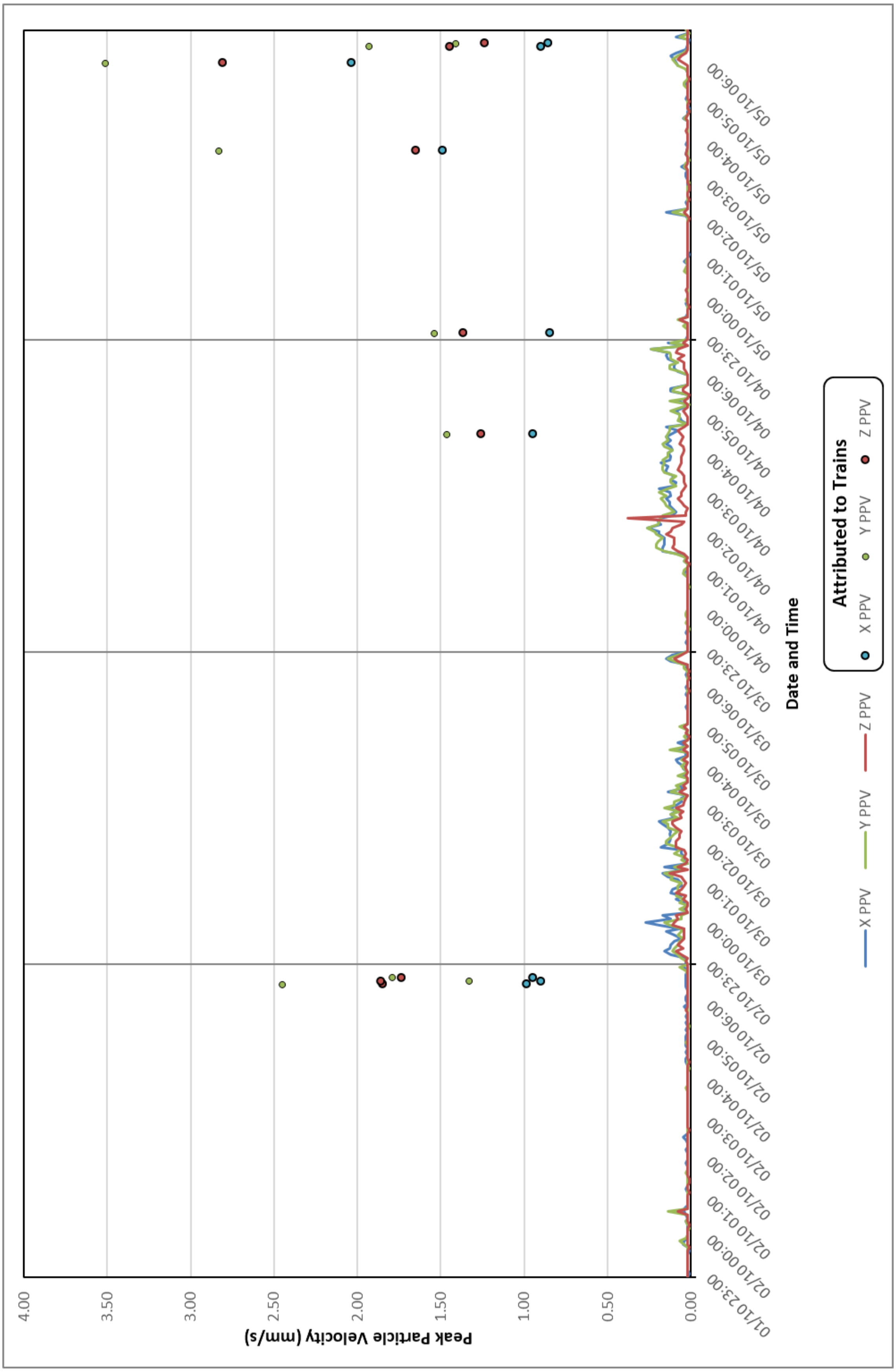


Figure B2: 5-minute maximum acceleration data from the 5th-12th of October 2020 – maximum PPV attributed to trains are shown as individual dots

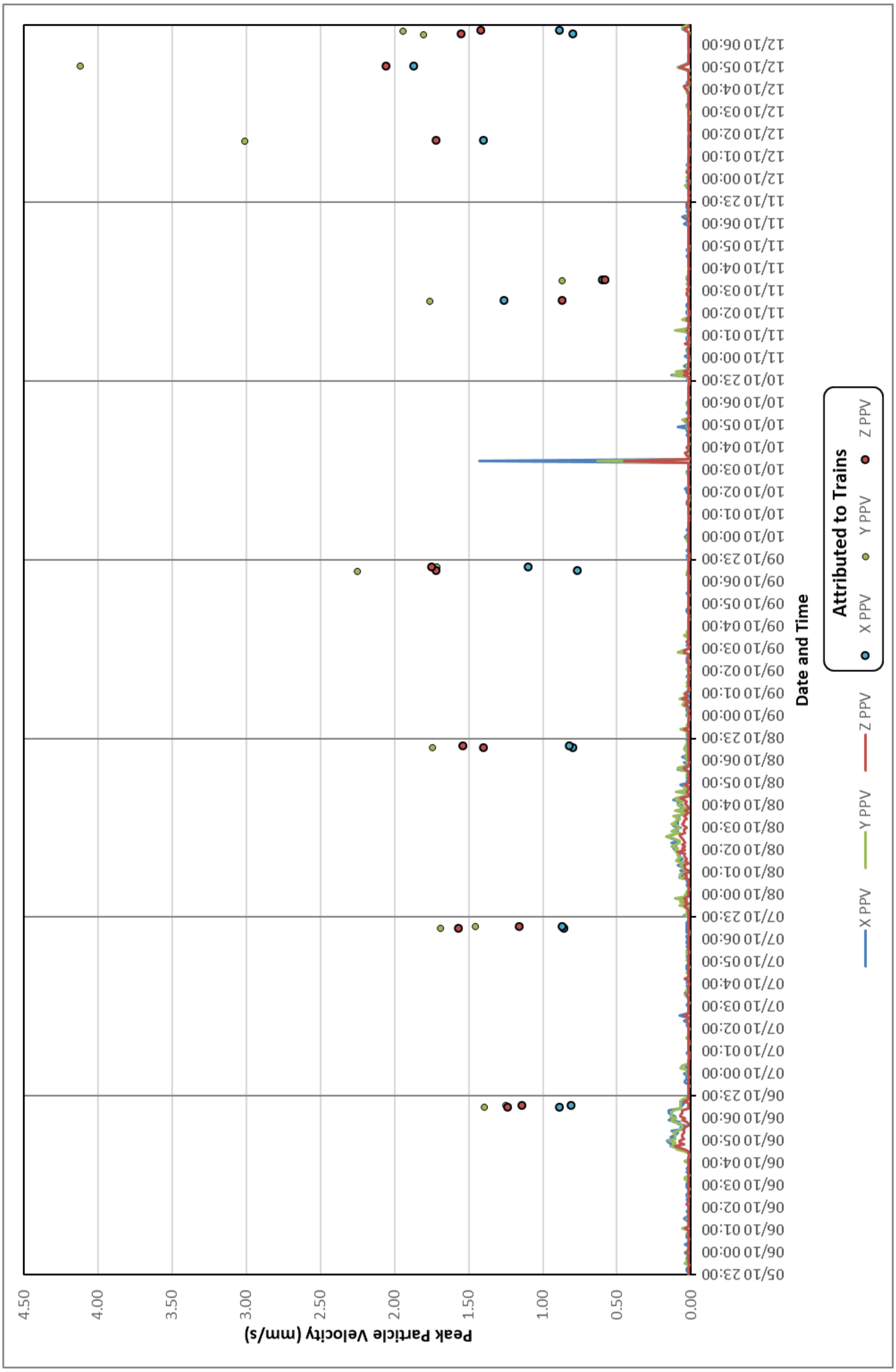


Figure B3: 5-minute maximum acceleration data from the 12th-19th of October 2020 – maximum PPV attributed to trains are shown as individual dots

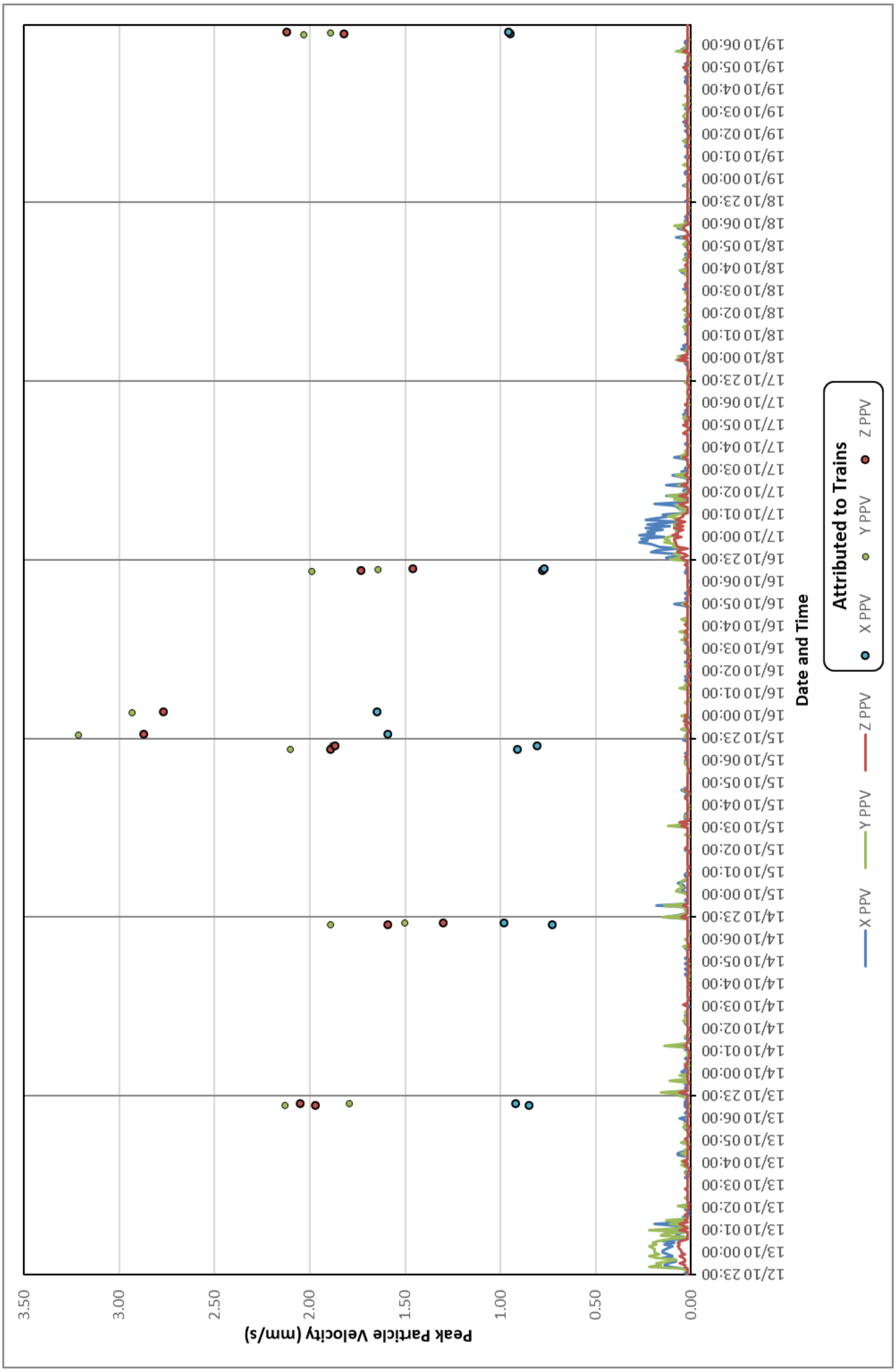


Figure B4: 5-minute maximum acceleration data from the 19th-26th of October 2020 – maximum PPV attributed to trains are shown as individual dots

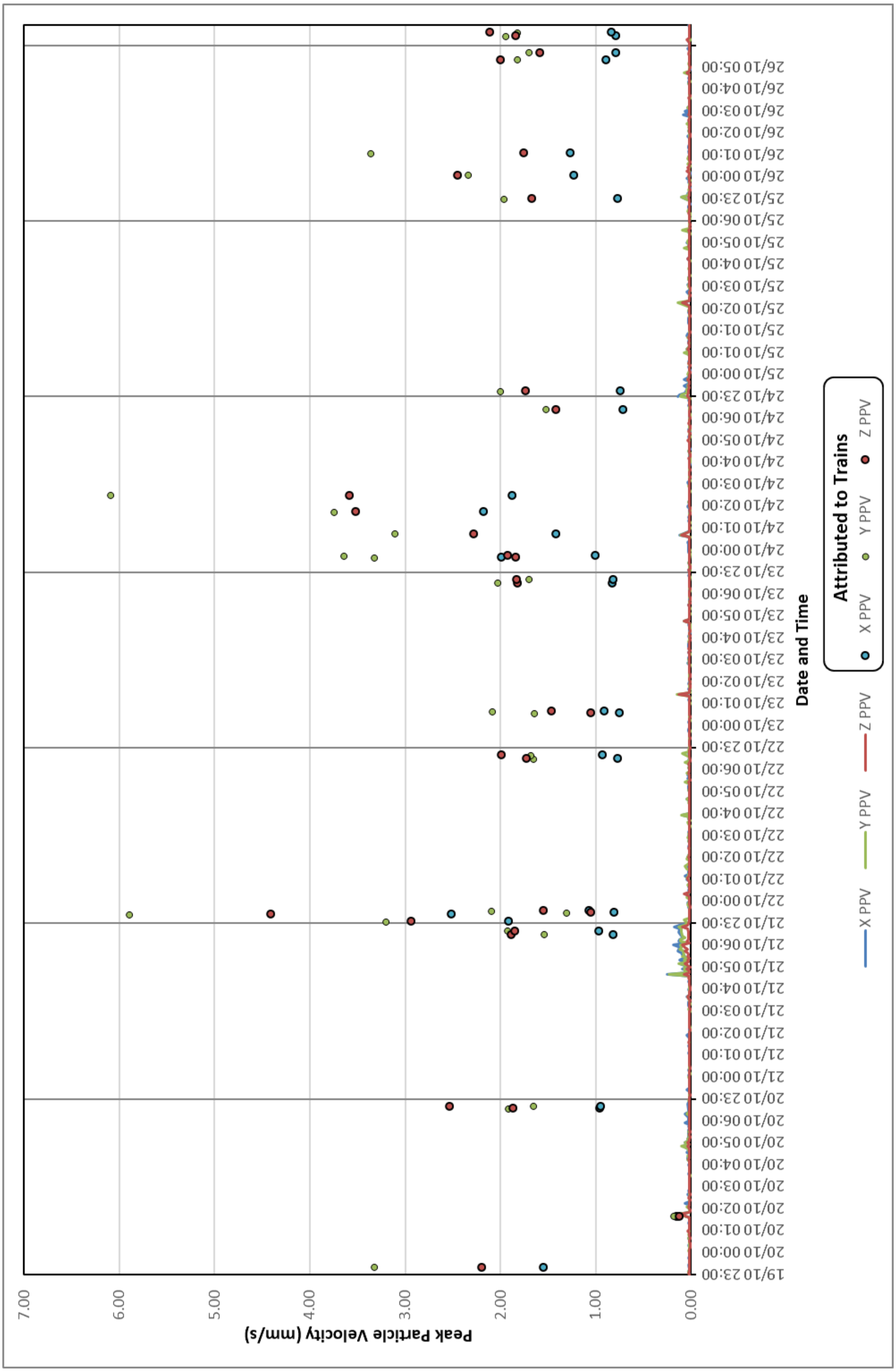
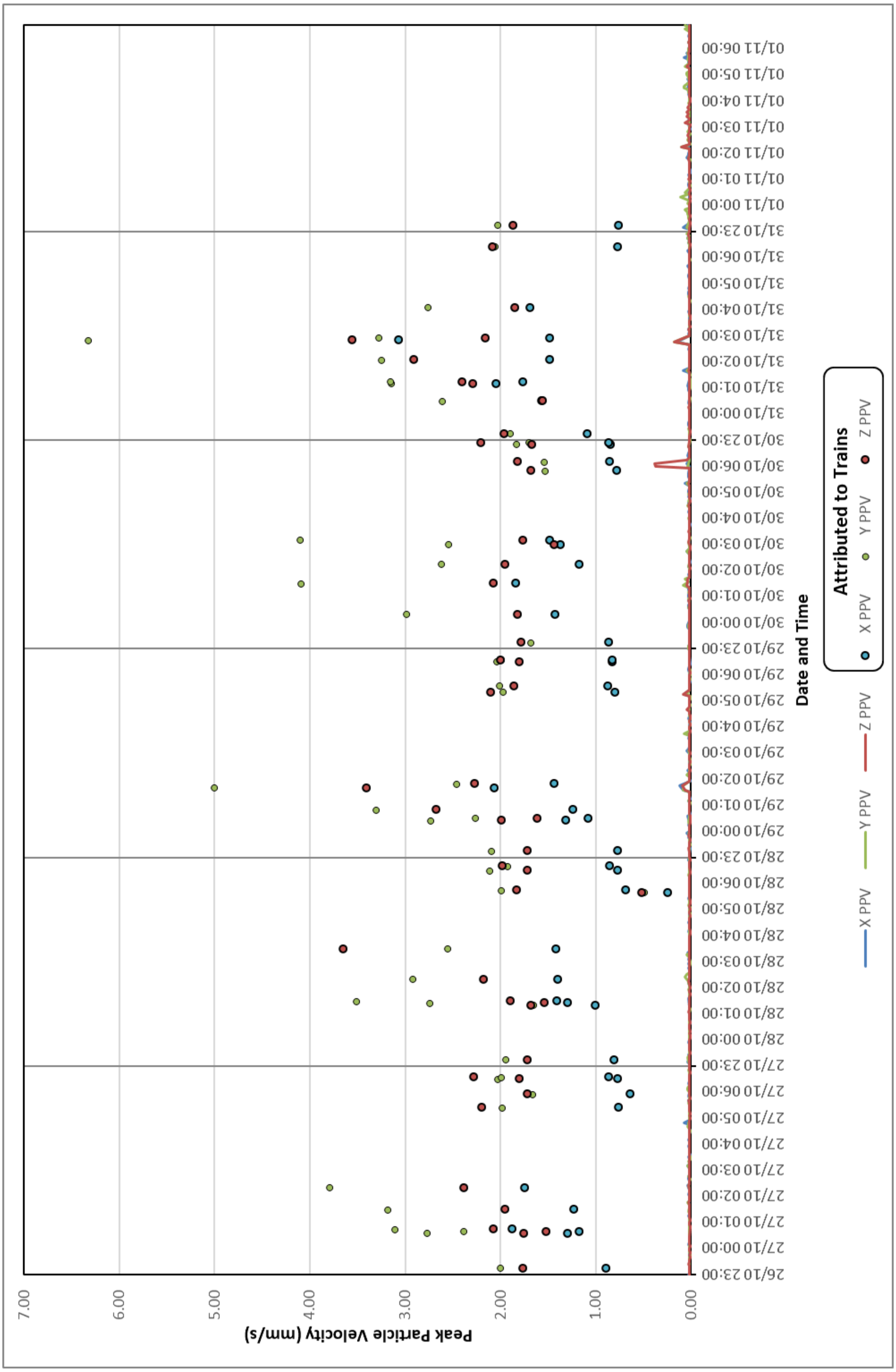


Figure B5: 5-minute maximum acceleration data from the 26th of October– 1st of November – maximum PPV attributed to trains are shown as individual dots



Appendix C

Real Time Train data

Table C1: Woodbridge Station Night Time Train Passes, data provided by www.realtimetrains.co.uk.

Date	Arrival Time	Departure Time	Pass Time	ATOC Code
02-10-2020	06:32:45	06:34:52		LE
02-10-2020	06:35:39	06:37:23		LE
04-10-2020		04:38:00		ZZ
04-10-2020			23:07:11	ZZ
05-10-2020			03:51:34	ZZ
05-10-2020			06:09:31	LE
05-10-2020	06:32:55	06:35:27		LE
05-10-2020	06:35:10	06:36:40		LE
06-10-2020	06:33:19	06:35:08		LE
06-10-2020	06:35:30	06:37:01		LE
07-10-2020	06:32:32	06:34:53		LE
07-10-2020	06:34:48	06:37:11		LE
08-10-2020	06:35:22	06:38:14		LE
08-10-2020	06:37:52	06:38:44		LE
09-10-2020	06:32:24	06:34:43		LE
09-10-2020	06:35:39	06:37:53		LE
11-10-2020			02:35:00	
11-10-2020			03:30:00	
12-10-2020			01:41:01	ZZ
12-10-2020			05:07:20	ZZ
12-10-2020	06:32:30	06:34:39		LE
12-10-2020	06:36:18	06:40:10		LE
13-10-2020	06:36:52	06:37:44		LE
13-10-2020	06:35:15	06:37:54		LE
14-10-2020	06:43:55	06:44:32		LE
14-10-2020	06:35:51	06:44:59		LE
15-10-2020	06:33:10	06:35:20		LE
15-10-2020	06:36:48	06:39:00		LE
15-10-2020			23:10:00	
16-10-2020			00:10:00	
16-10-2020	06:33:11	06:35:15		LE
16-10-2020	06:35:35	06:37:10		LE
19-10-2020	06:32:55	06:34:41		LE
19-10-2020	06:36:16	06:37:01		LE
19-10-2020			23:23:02	ZZ
20-10-2020			01:40:00	
20-10-2020	06:37:53	06:38:39		LE
20-10-2020	06:36:16	06:39:35		LE
21-10-2020	06:35:29	06:36:27		LE
21-10-2020	06:36:24	06:38:18		LE
21-10-2020			22:52:44*	ZZ
21-10-2020			23:30:36	ZZ
22-10-2020	06:34:19	06:35:36		LE

22-10-2020	06:36:52	06:38:52		LE
23-10-2020	06:34:25	06:35:16		LE
23-10-2020	06:35:21	06:38:07		LE
23-10-2020	23:25:08	23:40:32		ZZ
24-10-2020	00:24:08	00:41:29		ZZ
24-10-2020			01:45:00	
24-10-2020	02:34:00			ZZ
24-10-2020			02:34:23	ZZ
24-10-2020	06:24:16	06:25:20		LE
24-10-2020	23:16:47	23:18:36		LE
25-10-2020			23:02:49	LE
26-10-2020			00:01:45	ZZ
26-10-2020			01:08:29	ZZ
26-10-2020	05:17:30	05:18:52		LE
26-10-2020	05:40:46	05:41:54		LE
26-10-2020	06:31:04	06:34:49		LE
26-10-2020	06:33:11	06:34:55		LE
26-10-2020	23:21:02	23:21:29		LE
27-10-2020	00:20:41	00:41:21		ZZ
27-10-2020			01:22:59	ZZ
27-10-2020	02:26:00			ZZ
27-10-2020	05:21:54	05:23:08		LE
27-10-2020	05:52:00	05:53:11		LE
27-10-2020	06:35:04	06:35:35		LE
27-10-2020	06:33:24	06:36:05		LE
27-10-2020	23:18:12	23:18:38		LE
28-10-2020			01:19:10	ZZ
28-10-2020	01:25:38	01:26:21		ZZ
28-10-2020	02:21:46	02:25:49		ZZ
28-10-2020	03:11:29	03:27:39		ZZ
28-10-2020	05:41:07	05:42:24		LE
28-10-2020	06:32:19	06:34:58		LE
28-10-2020	06:34:26	06:37:20		LE
28-10-2020	23:16:52	23:18:14		LE
29-10-2020	00:30:51	00:31:22		ZZ
29-10-2020	01:46:00			ZZ
29-10-2020			01:46:27	ZZ
29-10-2020	01:21:52	01:48:44		ZZ
29-10-2020	05:16:32	05:17:25		LE
29-10-2020	05:33:32	05:35:14		LE
29-10-2020	06:31:44	06:34:40		LE
29-10-2020	06:33:20	06:34:54		LE
29-10-2020	23:18:08	23:19:01		LE
30-10-2020	00:24:02	00:24:52		ZZ
30-10-2020	00:11:16	01:30:53		ZZ
30-10-2020			02:38:00	ZZ
30-10-2020			03:03:30	ZZ

30-10-2020	02:30:18	03:06:22		ZZ
30-10-2020	05:48:46	05:50:18		LE
30-10-2020	05:59:59	06:09:43		LE
30-10-2020	06:51:34	06:52:06		LE
30-10-2020	06:33:06	06:52:23		LE
30-10-2020	23:18:04	23:18:49		LE
31-10-2020	00:32:50	00:33:34		ZZ
31-10-2020	01:12:50	01:13:08		ZZ
31-10-2020	00:31:33	01:15:19		ZZ
31-10-2020			02:27:05	ZZ
31-10-2020			02:51:25	ZZ
31-10-2020	02:16:55	02:53:24		ZZ
31-10-2020	03:49:13	04:04:08		ZZ
31-10-2020	06:22:59	06:24:53		LE
31-10-2020	23:18:00	23:19:16		LE

*Note this time falls outside of the defined night time period of 23:00-07:00, however is the time which the train is recorded to have passed through Woodbridge Railway Station. This train passed the measurement location further down the track shortly after 23:00.

Cells highlighted in blue are train passes which were not recorded by real time trains but have been identified through analysis of noise signals. Rows highlighted orange are train passes which have been identified via a comparison of noise and vibration data.

APPENDIX 9.3.C UPDATE OF VOLUME 9 APPENDIX 4B

CONTENTS

TABLES

PLATES

None provided.

FIGURES

APPENDICES

None provided.

1 INTRODUCTION

1.1.1 This appendix contains details of changes to the airborne noise assessment reported in **Volume 9, Chapter 4** of the **ES** and its associated figures and appendices (Doc Ref 6.10) [APP-545 to APP-547] resulting from corrections, update to the 'Freight Management Strategy' (Doc Ref 8.18) and from changes to speed limits.

2 CORRECTIONS

2.1.1 The L_{Aeq} values have been revised to correct an error in the noise model that was used to predict night time L_{Aeq} levels on the Saxmundham to Leiston branch line. **Table 9.3.C.1** shows the values submitted in **Table 1.7** of **Volume 9, Appendix 4B** of the **ES** (Doc Ref 6.10) [APP-546] and the corrected values for the early years.

Table 9.3.C.1: Corrections to predicted airborne $L_{Aeq,8h}$ noise levels for receptors between Saxmundham junction and LEEIE during early years operation, all values are free field

Receptor / receptor group	Night time predicted levels, $L_{Aeq, 8h}$, dB	
	As submitted in Table 1.7 of Volume 9, Appendix 4B of the ES (Doc Ref 6.10) [APP-546]	Corrected values
Clayhills Road	32	33
Cottage Farm	39	40
Crossing Cottages	32	14
Crossing East	34	9
Kelsale Covert	46	46
Westhouse Crossing Cottage	41	40

2.1.2 The night-time L_{Aeq} values for the later years have also been revised to correct an error in the noise model for the Saxmundham to Leiston branch line. **Table 9.3.C.2** shows the values submitted in **Table 1.8** of **Volume 9, Appendix 4B** of the **ES** (Doc Ref 6.10) [APP-546] and the corrected values for the later years. All of the $L_{Aeq,8h}$ values other than those in **Table 9.3.C.2** remain unchanged.

Table 9.3.C.2: Corrections to predicted airborne $L_{Aeq,8h}$ noise levels for receptors between Saxmundham junction and LEEIE during later years operation, all values are free field

Receptor / receptor group	Night time predicted levels, $L_{Aeq, 8h}$, dB	
	As submitted in Table 1.8 of Volume 9, Appendix 4B of the ES (Doc Ref 6.10) [APP-546]	Corrected values
Clayhills Road	31	33

Receptor / receptor group	Night time predicted levels, $L_{Aeq,\,8h}$, dB	
	As submitted in Table 1.8 of Volume 9, Appendix 4B of the ES (Doc Ref 6.10) [APP-546]	Corrected values
Cottage Farm	37	40
Crossing Cottages	39	43
Crossing East	45	50
Kelsale Covert	45	49
Westhouse Crossing Cottage	45	50

2.1.3 The L_{Amax} values have also been revised to correct an error in the model used to predict night-time noise levels in the later years for the western end of the Saxmundham to Leiston branch line. **Table 9.3.C.3** shows the values submitted in **Table 1.8** of **Volume 9, Appendix 4B** of the **ES** (Doc Ref 6.10) [APP-546] and the corrected values. All values other than those in **Table 9.3.C.3** remain unchanged.

Table 9.3.C.3: Corrections to predicted airborne L_{Amax} noise levels for receptors between Saxmundham junction and LEEIE during later years operation, all values are free field

Receptor / receptor group	Night time predicted levels, L_{Amax}, dB	
	As submitted in Table 1.8 of Volume 9, Appendix 4B of the ES (Doc Ref 6.10) [APP-546]	Corrected values
Clayhills Road	51	55
Cottage Farm	65	69

3 REVISIONS RESULTING FROM DCO CHANGES

3.1.1 Changes that have been considered as a result of the update to the 'Freight Management Strategy' are:

- Instead of the five train movements per night and one during the day which were considered in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545], seven movements per night and one during the day have been modelled; and

- Instead of the five train movements per night and one during the day which were considered in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545], eight movements per night and none during the day have been modelled.

3.1.2 Other changes that have been taken into account are the night-time speed limit on the Saxmundham to Leiston branch line and rail extension route, which was assumed to be 20mph in **Volume 9, Chapter 4** of the **ES** (Doc Ref 6.10) [APP-545], are now assumed to be 10mph.

3.1.3 The following tables and figures set out the revised noise levels and noise contours:

- Table 9.3.C.4: Predicted airborne noise levels for receptors between Saxmundham junction and LEEIE during early years operation, all values are free field;

- Table 9.3.C.5: Predicted airborne noise levels for receptors between Saxmundham junction and LEEIE during later years operation, all values are free field;

- Figure 9.3.C.1: Saxmundham to Leiston – Early Years – Night – Branch Line Section, $L_{Aeq,\,6h}$;

- Figure 9.3.C.2: Saxmundham to Leiston – Later Years – Night – 7 train passes – Branch Line Section, $L_{Aeq,\,6h}$;

- Figure 9.3.C.3: Saxmundham to Leiston – Later Years – Night 8 train passes – Branch Line Section, $L_{Aeq,\,6h}$;

- Figure 9.3.C.4: Saxmundham to Leiston – Later Years – Night – Branch Line Section, L_{Amax};

- Figure 9.3.C.5: Rail Extension Route – Later Years – Night – 7 train passes – Branch Line Section, $L_{Aeq,\,6h}$;

- Figure 9.3.C.6: Rail Extension Route – Later Years – Night – 8 train passes – Branch Line Section, $L_{Aeq, 6h}$;
- Figure 9.3.C.7: Rail Extension Route – Later Years – Night – Branch Line Section, L_{Amax};
- Figure 9.3.C.8: East Suffolk Line, Section 1A – Night time contours, 7 train passes – $L_{Aeq, 6h}$;
- Figure 9.3.C.9: East Suffolk Line, Section 1A – Night time contours, 8 train passes – $L_{Aeq, 6h}$;
- Figure 9.3.C.10: East Suffolk Line, Section 1B – Night time contours, 7 train passes – $L_{Aeq, 6h}$;
- Figure 9.3.C.11: East Suffolk Line, Section 1B – Night time contours, 8 train passes – $L_{Aeq, 6h}$;
- Figure 9.3.C.12: East Suffolk Line, Section 1C – Night time contours, 7 train passes – $L_{Aeq, 6h}$;
- Figure 9.3.C.13: East Suffolk Line, Section 1C – Night time contours, 8 train passes – $L_{Aeq, 6h}$;
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- Figure 9.3.C.19: East Suffolk Line, Section 3 – Night time contours, 8 train passes – $L_{Aeq, 6h}$;
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- Figure 9.3.C.29: East Suffolk Line, Section 6 – Night time contours, 8 train passes – $L_{Aeq, 6h}$;
- Figure 9.3.C.30: East Suffolk Line, Section 7A – Night time contours, 7 train passes – $L_{Aeq, 6h}$;
- Figure 9.3.C.31: East Suffolk Line, Section 7A – Night time contours, 8 train passes – $L_{Aeq, 6h}$;
- Figure 9.3.C.32: East Suffolk Line, Section 7B – Night time contours, 7 train passes – $L_{Aeq, 6h}$;
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- Figure 9.3.C.34: East Suffolk Line, Section 7A – Night time contours, 7 train passes – $L_{Aeq, 6h}$ with secondary mitigation: avoiding the need for trains to stop;
- Figure 9.3.C.35: East Suffolk Line, Section 7A – Night time contours, 8 train passes – $L_{Aeq, 6h}$ with secondary mitigation: avoiding the need for trains to stop;

- Figure 9.3.C.36: East Suffolk Line, Section 7B – Night time contours, 7 train passes – $L_{Aeq, 6h}$ with secondary mitigation: avoiding the need for trains to stop;
- Figure 9.3.C.37: East Suffolk Line, Section 7B – Night time contours, 8 train passes – $L_{Aeq, 6h}$ with secondary mitigation: avoiding the need for trains to stop.

3.1.4 All noise contour figures for the East Suffolk line show predicted levels with the existing plus the proposed additional train passes.

Table 9.3.C.4: Predicted airborne noise levels for receptors between Saxmundham junction and LEEIE during early years operation, all values are free field

Receptor / receptor group	As submitted in Tables 1.7 and 1.8 of Volume 9, Appendix 4B (Doc Ref 6.10) [APP-546] – corrected as shown in Tables 9.3.C.1 and 9.3.C.3 above		Predicted levels, with 10mph speed limit on branch line	
	Night time predicted levels, $L_{Aeq,\,8h}$, dB	Predicted L_{Amax}, dB	Night time predicted levels, $L_{Aeq,\,8h}$, dB	Predicted L_{Amax}, dB
Clayhills Road	33	55	35	55
Cottage Farm	40	69	42	69
Crossing Cottages	14	66	15	66
Crossing East	9	51	11	51
Kelsale Covert	46	97	47	97
Westhouse Crossing Cottage	40	95	35	95
1 Westward Ho	-	-	-	-
28 Harling Way	-	-	-	-
Carr Avenue	-	-	-	-
Leiston House Farm	-	-	-	-
Valley Terrace	-	-	-	-

Table 9.3.C.5: Predicted airborne noise levels for receptors between Saxmundham junction and LEEIE during later years operation, all values are free field

Receptor / receptor group	As submitted in Tables 1.7 and 1.8 of Volume 9, Appendix 4B (Doc Ref 6.10) [APP-546] – corrected as shown in Tables 9.3.C.2 and 9.3.C.3 above		Predicted levels with 10mph speed limit on branch line			
			7 train passes per night		8 train passes per night	
	Night time predicted levels, $L_{Aeq, 8h}$, dB	Predicted L_{Amax}, dB	Night time predicted levels, $L_{Aeq, 8h}$, dB	Predicted L_{Amax}, dB	Night time predicted levels, $L_{Aeq, 8h}$, dB	Predicted L_{Amax}, dB
Clayhills Road	33	55	35	55	35	55
Cottage Farm	40	69	42	69	42	69
Crossing Cottages	43	75	39	67	40	67
Crossing East	50	81	45	73	46	73
Kelsale Covert	49	93	45	85	45	85
Westhouse Crossing Cottage	50	91	45	83	46	83
28 Harling Way	23	53	17	45	18	45
Aldhurst Farm Cottage	28	59	22	51	23	51
Ash Wood Cottage	25	50	28	52	29	52
Buckleswood House	21	50	16	41	17	41
Fisher's Farm	25	54	20	46	20	46

Receptor / receptor group	As submitted in Tables 1.7 and 1.8 of Volume 9, Appendix 4B (Doc Ref 6.10) [APP-546] – corrected as shown in Tables 9.3.C.2 and 9.3.C.3 above		Predicted levels with 10mph speed limit on branch line			
			7 train passes per night		8 train passes per night	
	Night time predicted levels, $L_{Aeq, 8h}$, dB	Predicted L_{Amax}, dB	Night time predicted levels, $L_{Aeq, 8h}$, dB	Predicted L_{Amax}, dB	Night time predicted levels, $L_{Aeq, 8h}$, dB	Predicted L_{Amax}, dB
Leiston Abbey House	24	51	19	44	19	44
Leiston House Farm	30	56	24	48	25	48
No. 99 Abbey Road	27	57	22	49	23	49
No. 105 Abbey Road	31	61	26	53	27	53
Old Abbey Farm / Old Abbey Care Home	23	53	18	45	19	45
Upper Abbey	29	49	31	53	32	53

Figure 9.3.C.1: Saxmundham to Leiston – Early Years – Night – Branch Line Section, $L_{Aeq,\ 6\ h}$

Figure 9.3.C.2: Saxmundham to Leiston – Later Years – Night – 7 train passes – Branch Line Section, $L_{Aeq, 6\,h}$

Figure 9.3.C.3: Saxmundham to Leiston – Later Years – Night 8 train passes – Branch Line Section, $L_{Aeq,\ 6\ h}$

Figure 9.3.C.4: Saxmundham to Leiston – Later Years – Night – Branch Line Section, L_{Amax}

Figure 9.3.C.5: Rail Extension Route – Later Years – Night – 7 train passes – Branch Line Section, $L_{Aeq,\ 6\ h}$

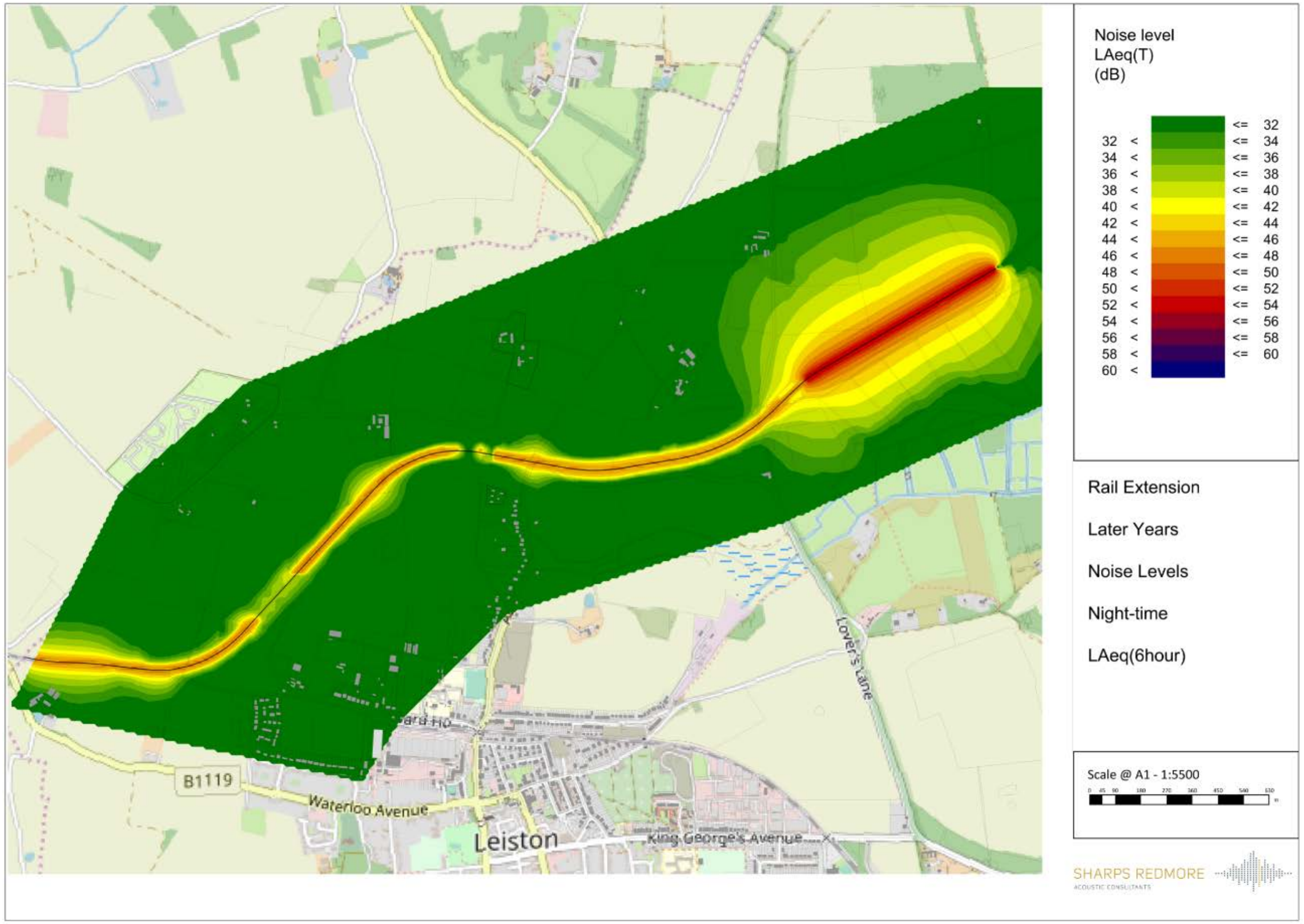


Figure 9.3.C.6: Rail Extension Route – Later Years – Night – 8 train passes – Branch Line Section, $L_{Aeq,\,6\,h}$

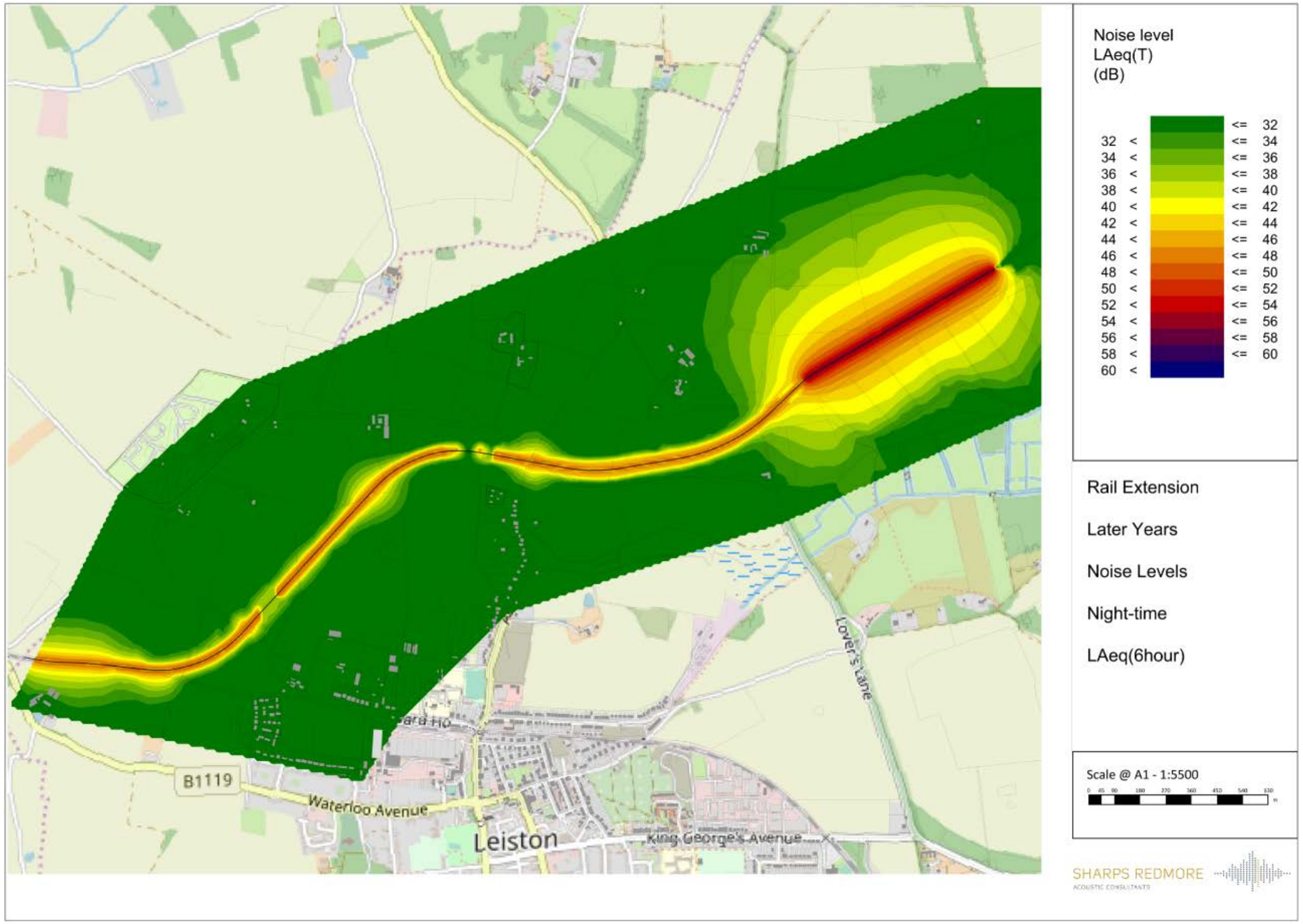


Figure 9.3.C.7: Rail Extension Route – Later Years – Night – Branch Line Section, L_{Amax}

Figure 9.3.C.8: East Suffolk Line, Section 1A – Night time contours, 7 train passes – $L_{Aeq,\ 6h}$

Figure 9.3.C.9: East Suffolk Line, Section 1A – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

Figure 9.3.C.10: East Suffolk Line, Section 1B – Night time contours, 7 train passes – $L_{Aeq,\,6h}$

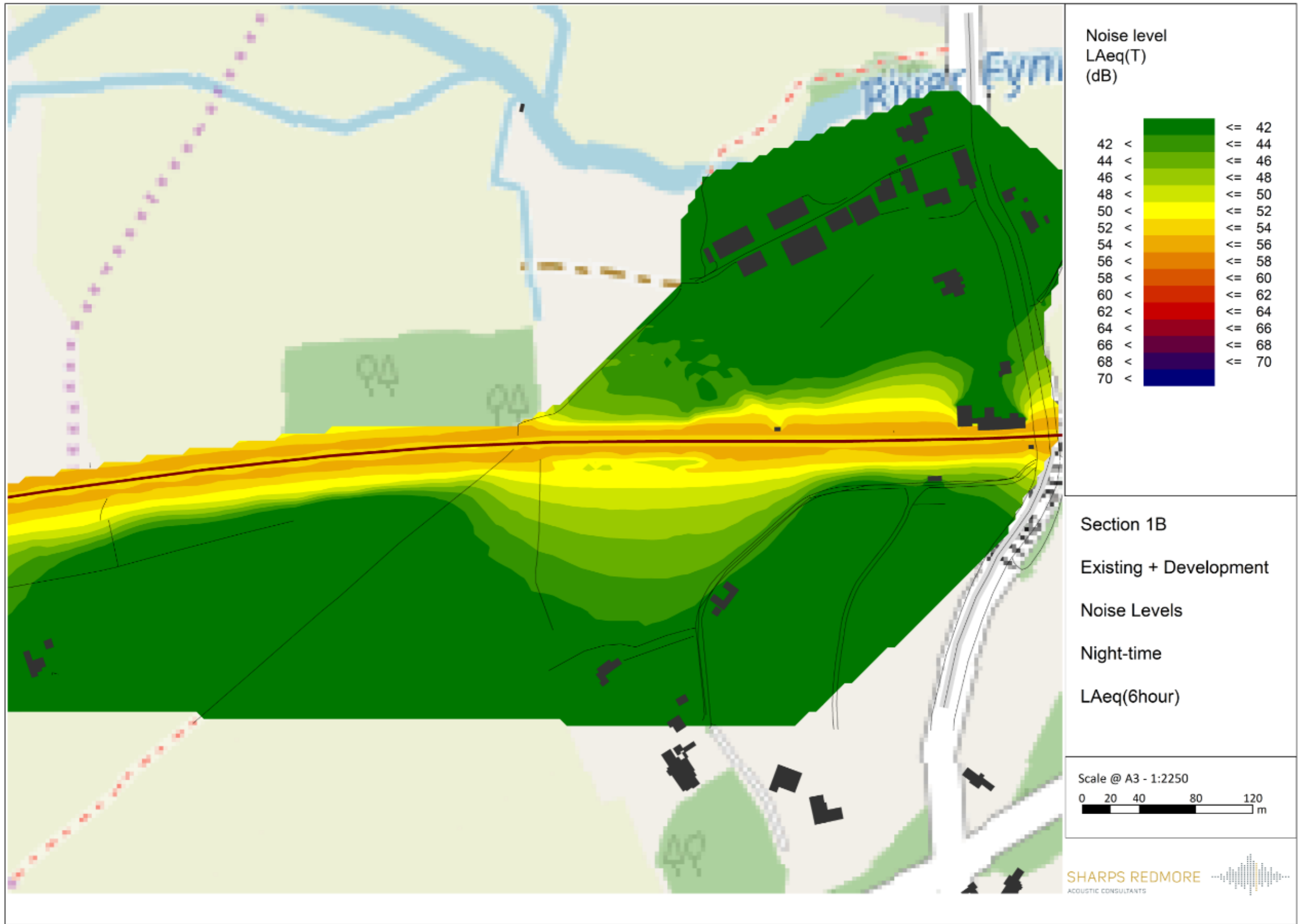


Figure 9.3.C.11: East Suffolk Line, Section 1B – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

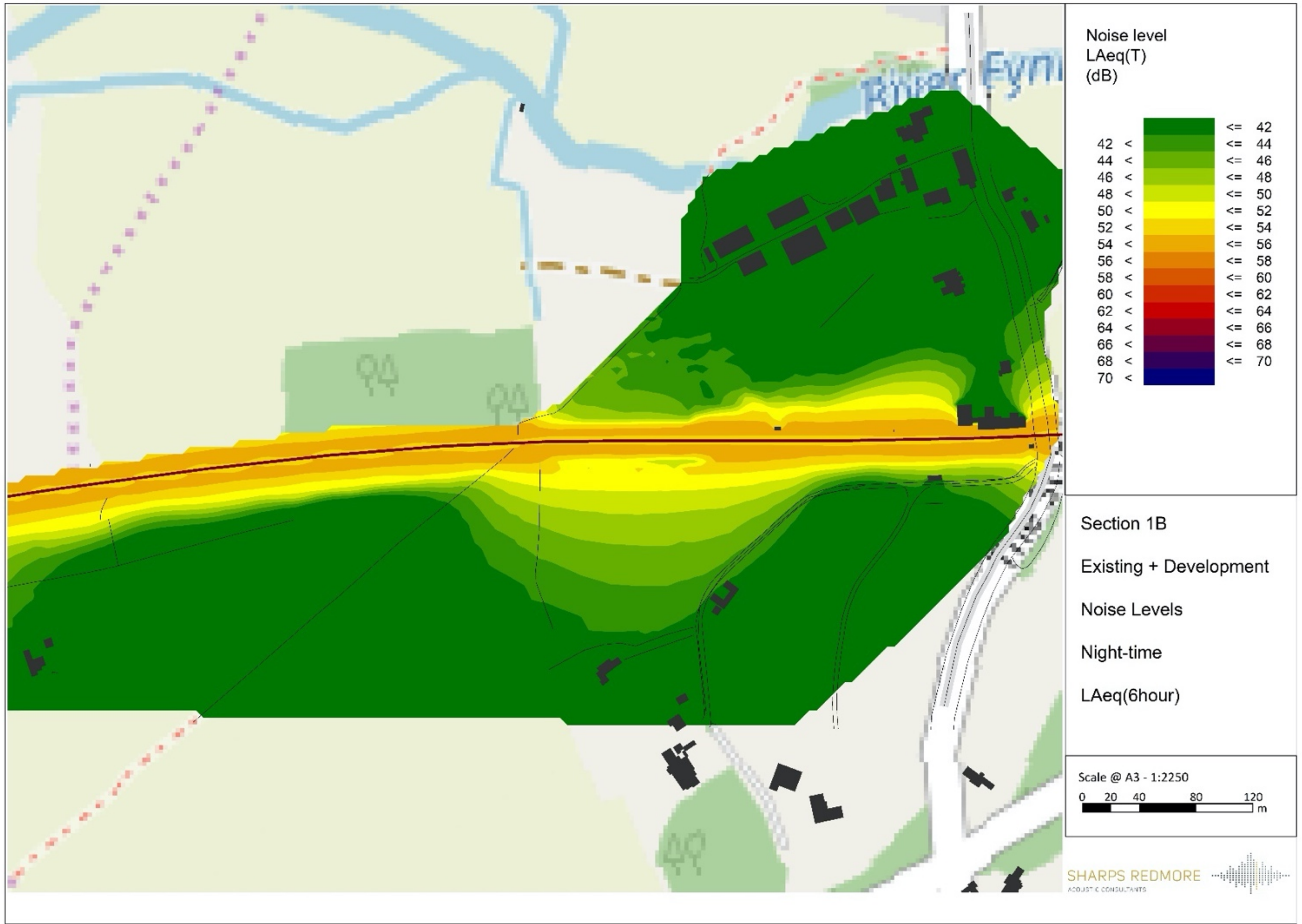


Figure 9.3.C.12: East Suffolk Line, Section 1C – Night time contours, 7 train passes – $L_{Aeq, 6h}$

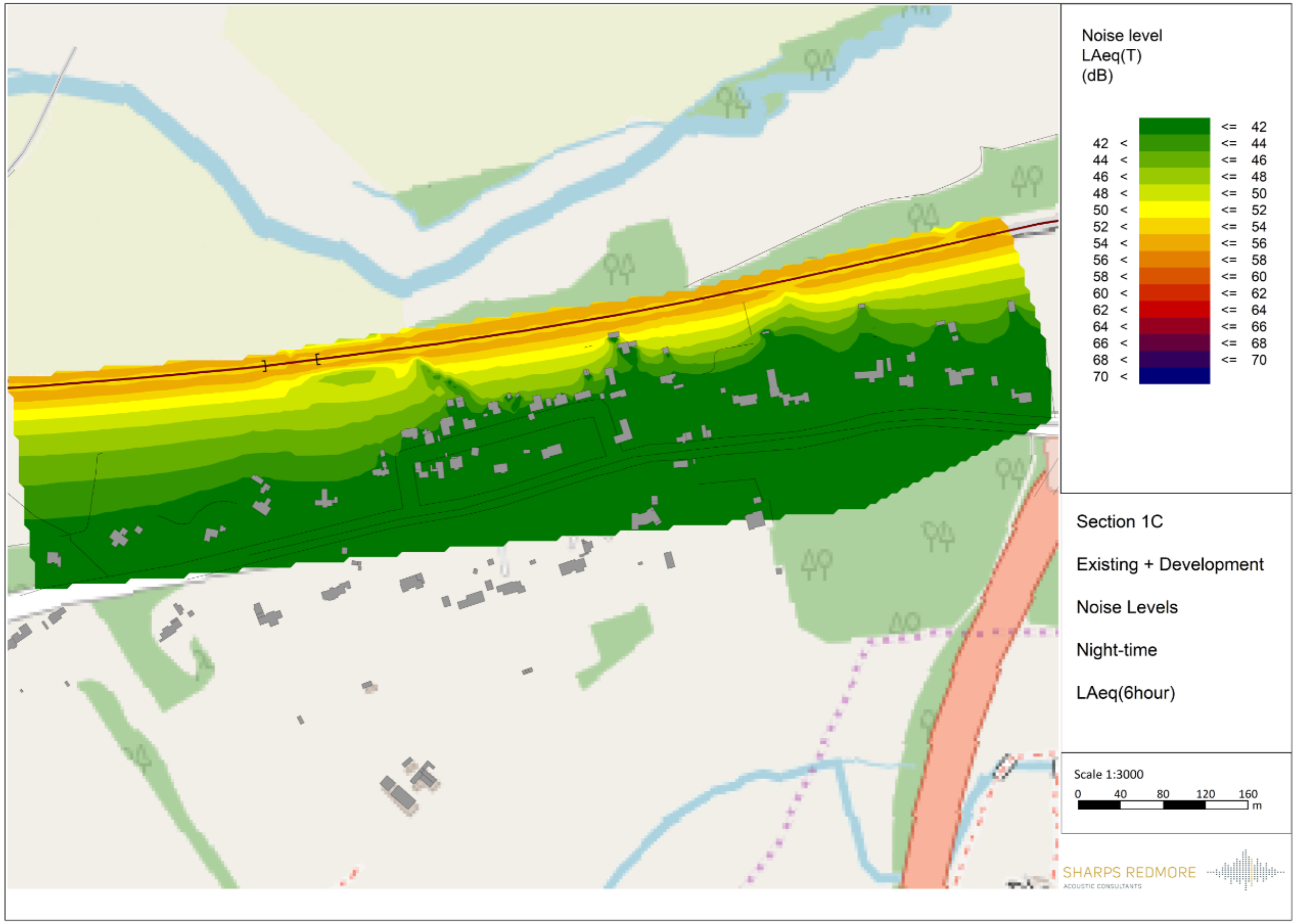


Figure 9.3.C.13: East Suffolk Line, Section 1C – Night time contours, 8 train passes – $L_{Aeq,\,6h}$

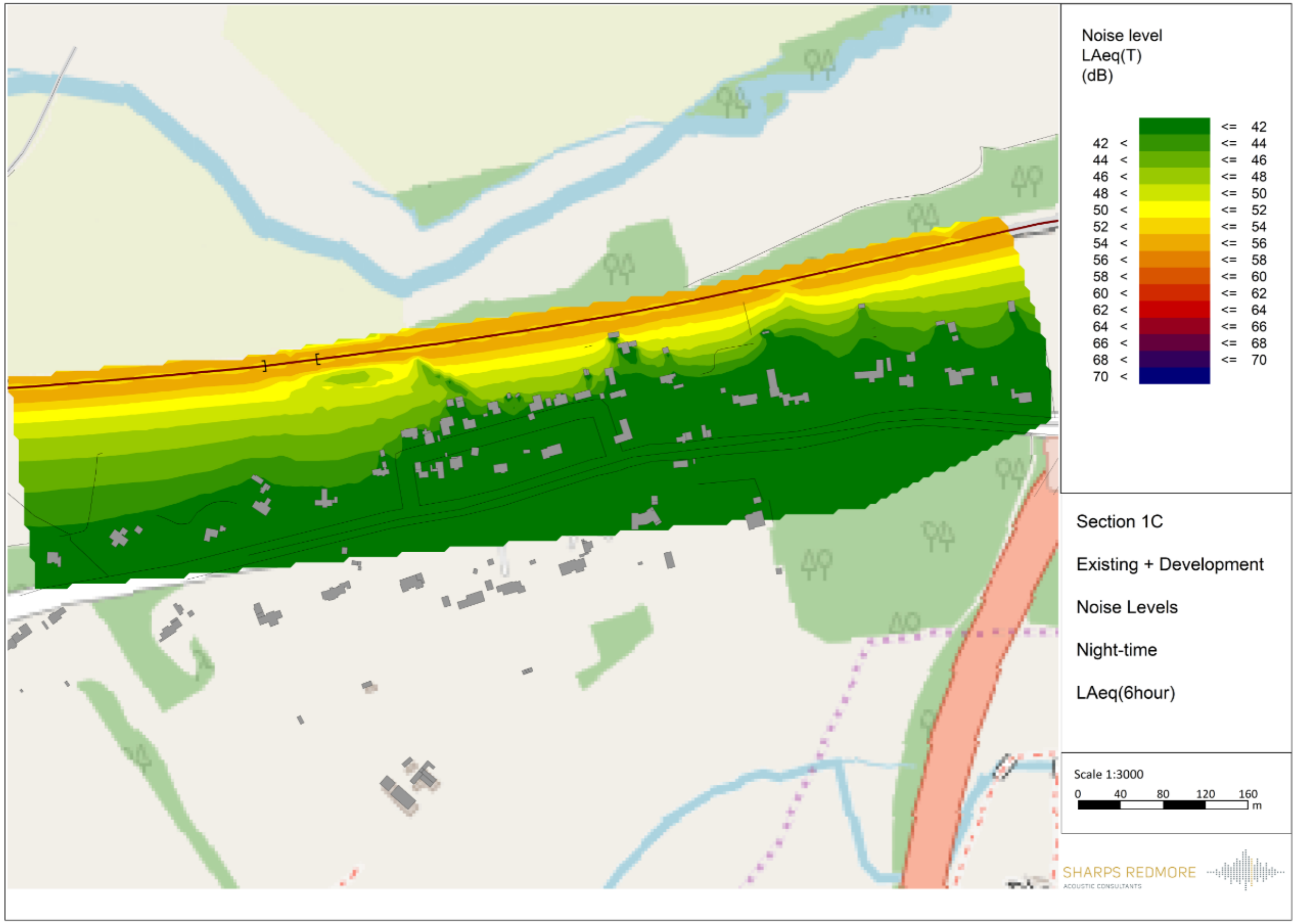


Figure 9.3.C.14: East Suffolk Line, Section 1D – Night time contours, 7 train passes – $L_{Aeq,\ 6h}$

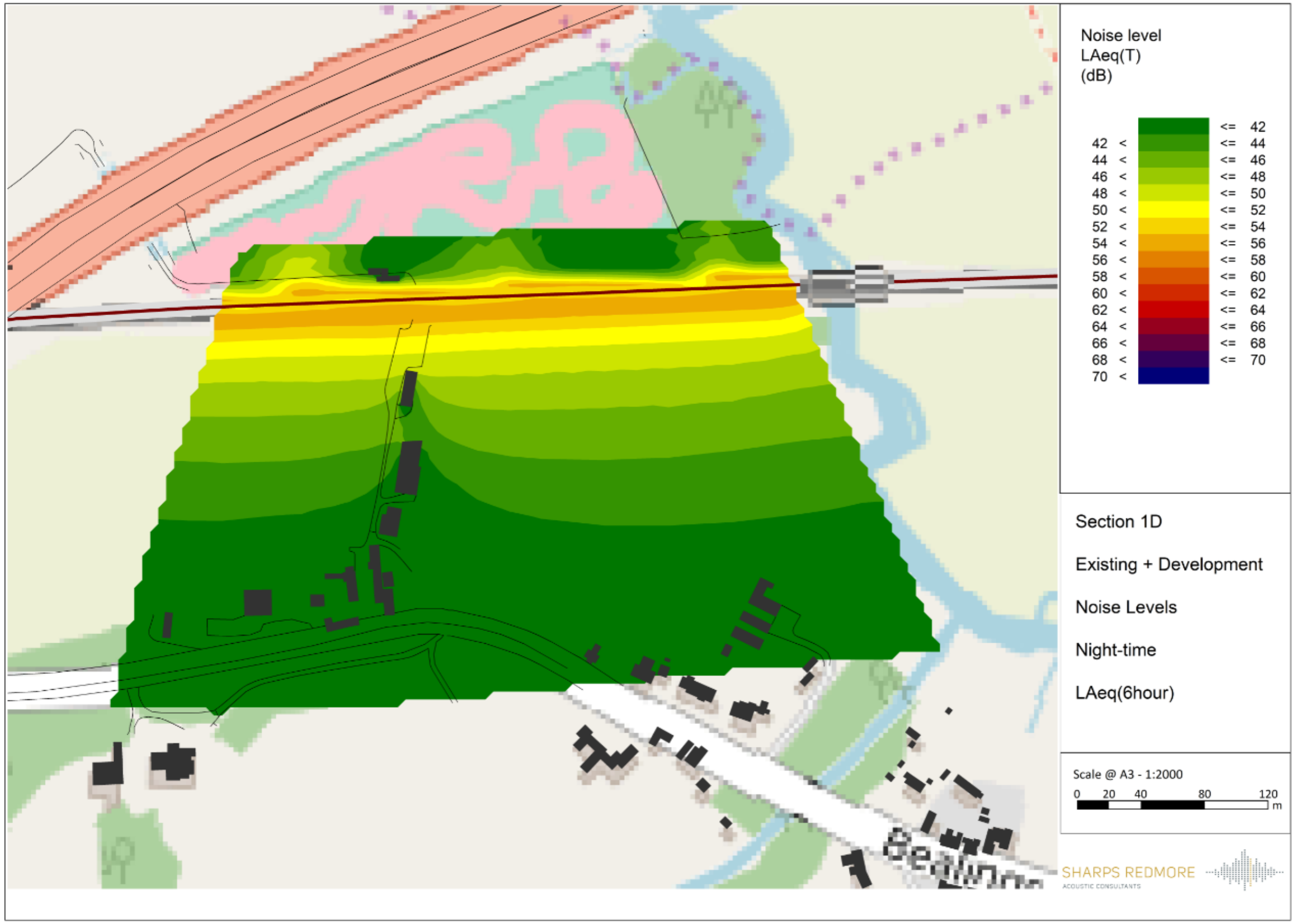


Figure 9.3.C.15: East Suffolk Line, Section 1D – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

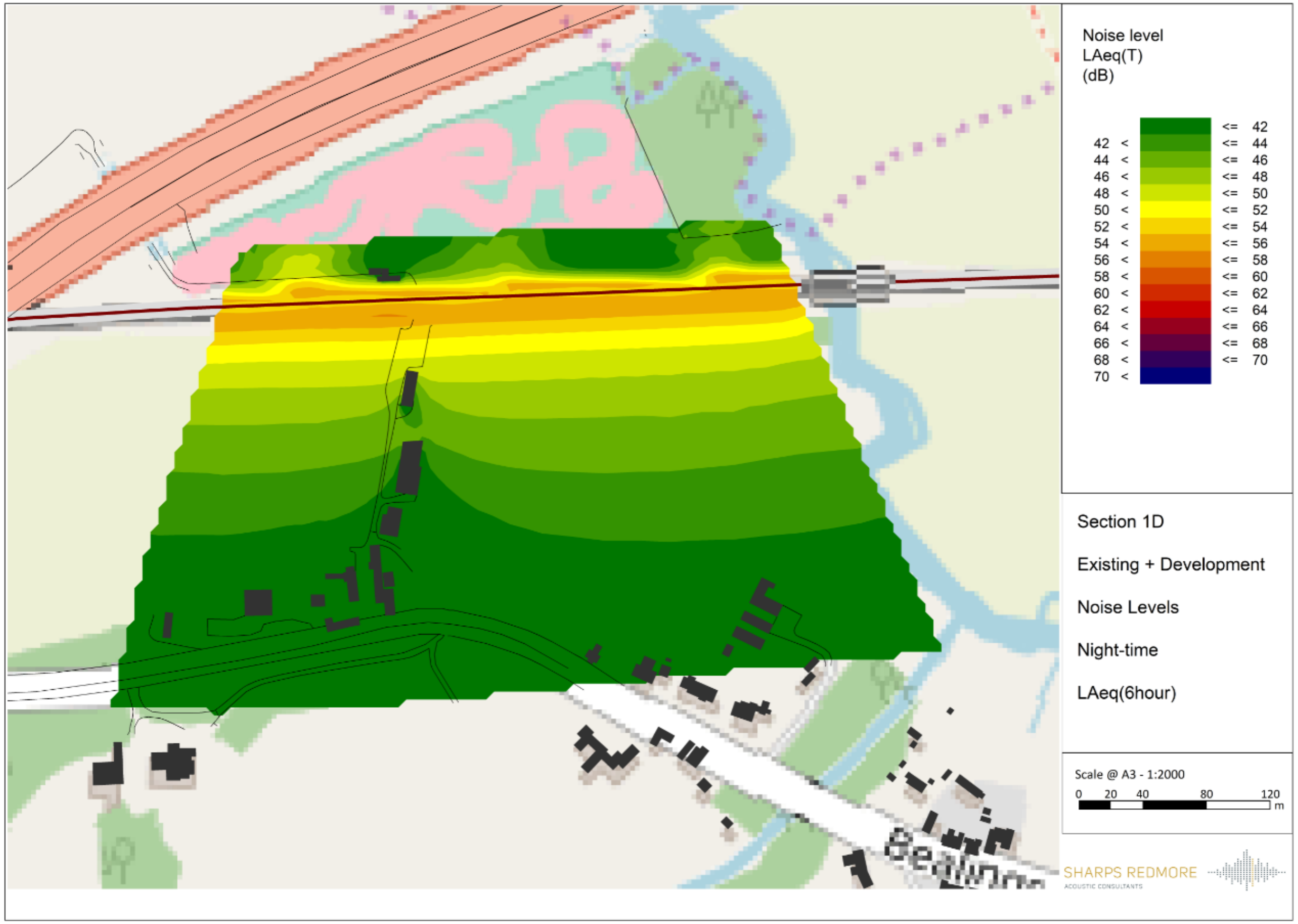


Figure 9.3.C.16: East Suffolk Line, Section 2 – Night time contours, 7 train passes – $L_{Aeq,\ 6h}$

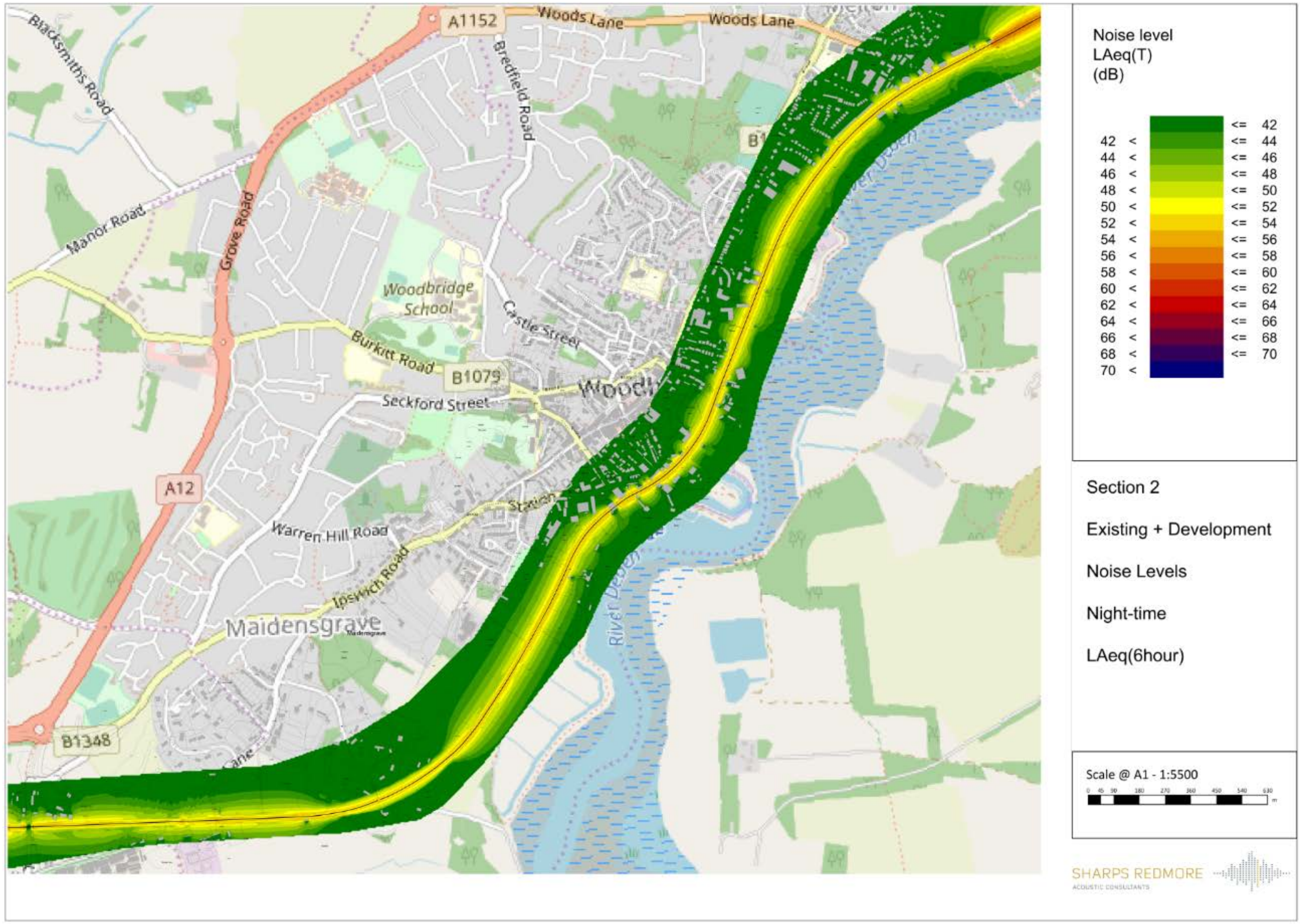


Figure 9.3.C.17: East Suffolk Line, Section 2 – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

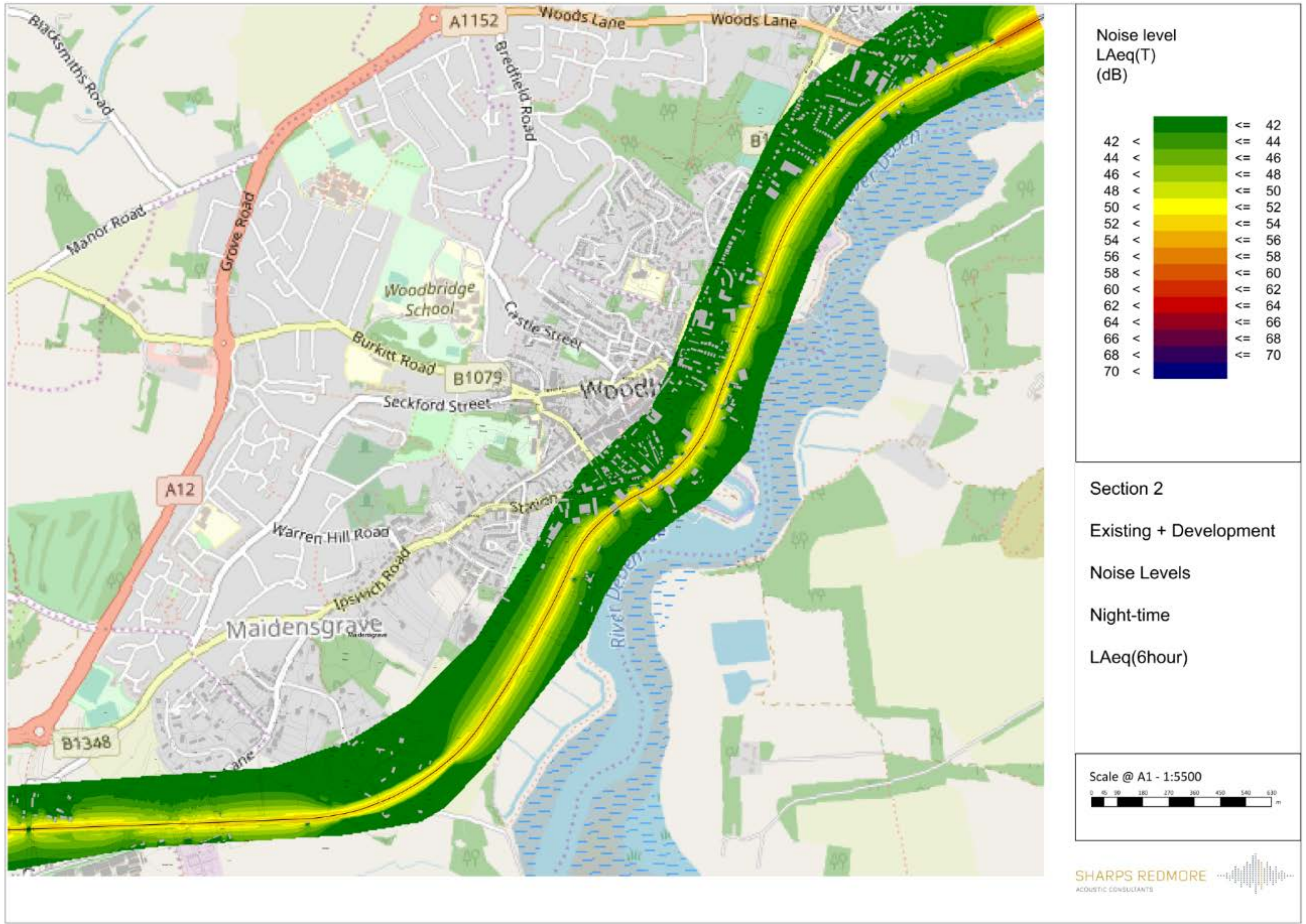


Figure 9.3.C.18: East Suffolk Line, Section 3 – Night time contours, 7 train passes – $L_{Aeq, 6h}$

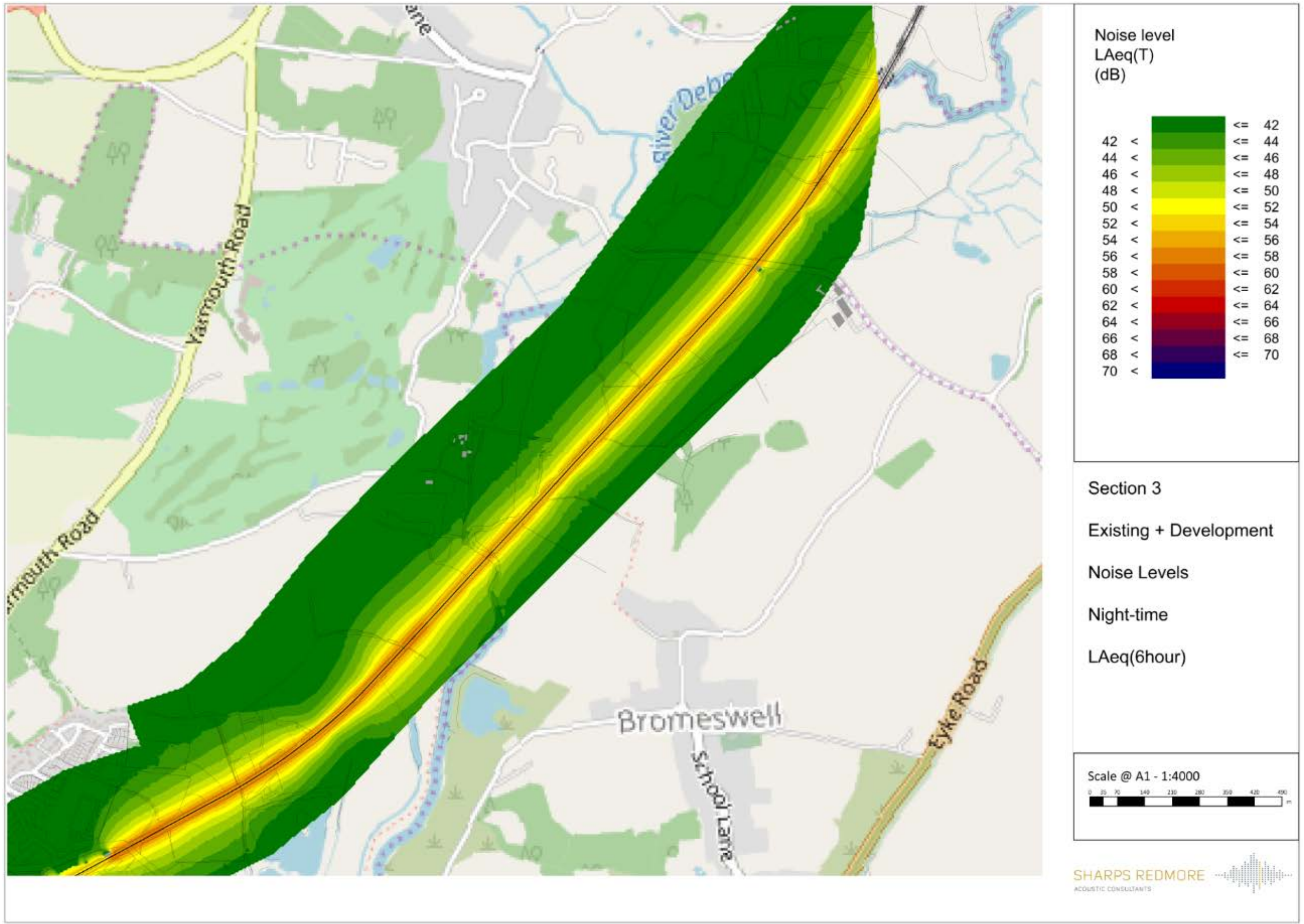


Figure 9.3.C.19: East Suffolk Line, Section 3 – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

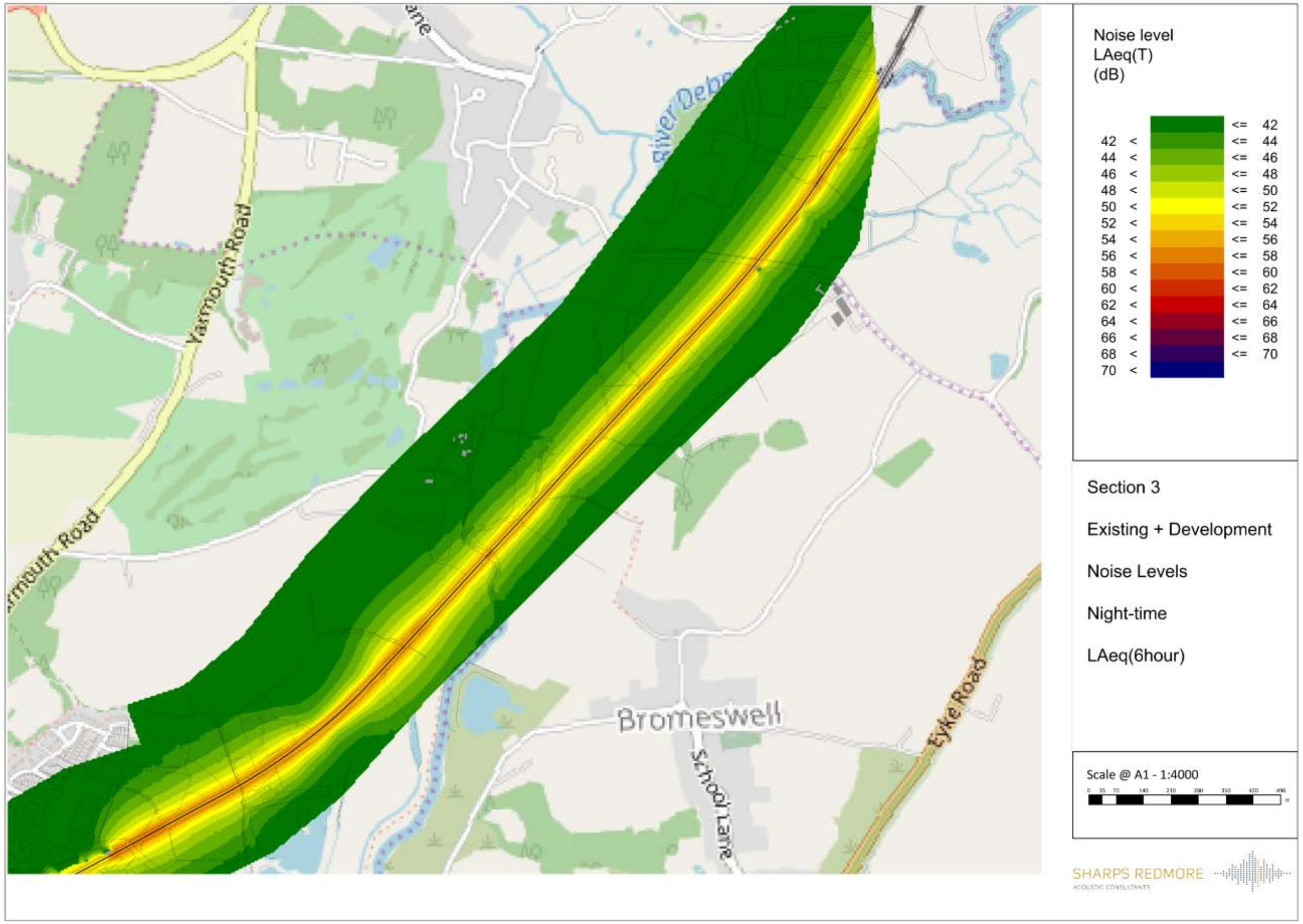


Figure 9.3.C.20: East Suffolk Line, Section 4 – Night time contours, 7 train passes – $L_{Aeq, 6h}$

Figure 9.3.C.21: East Suffolk Line, Section 4 – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

Figure 9.3.C.22: East Suffolk Line, Section 5A – Night time contours, 7 train passes – $L_{Aeq, 6h}$

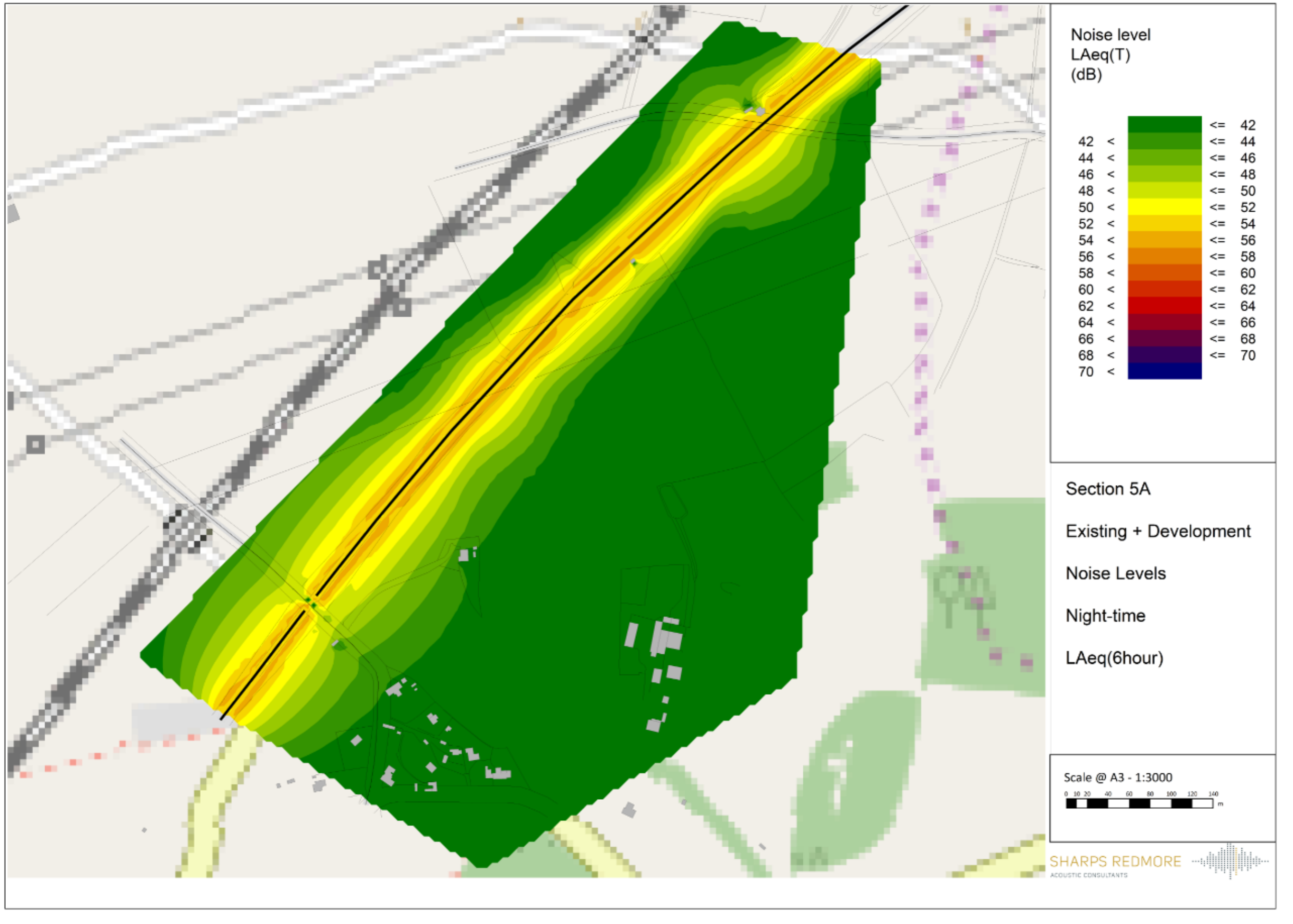


Figure 9.3.C.23: East Suffolk Line, Section 5A – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

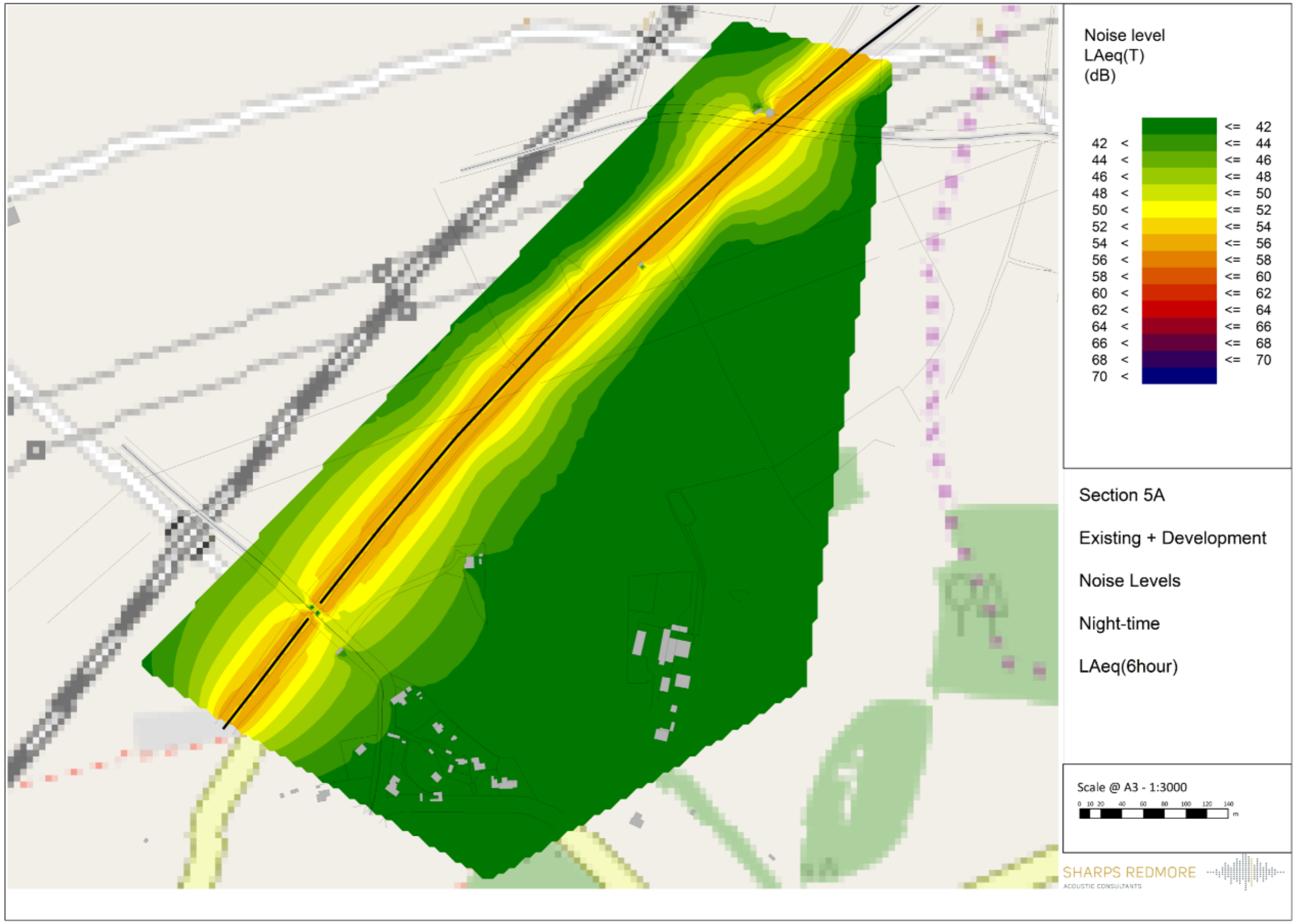


Figure 9.3.C.24: East Suffolk Line, Section 5B – Night time contours, 7 train passes – $L_{Aeq,\ 6h}$

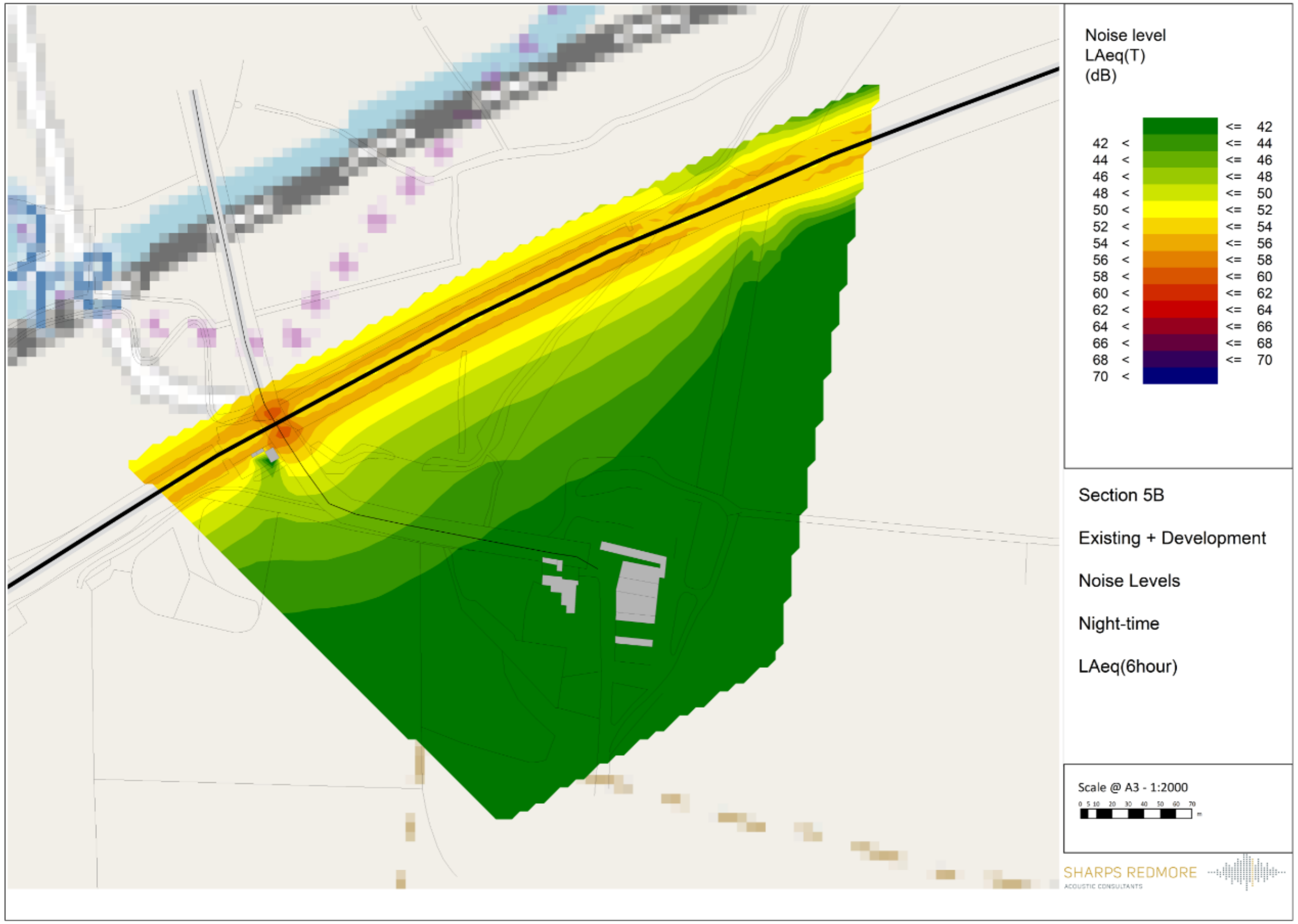


Figure 9.3.C.25: East Suffolk Line, Section 5B – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

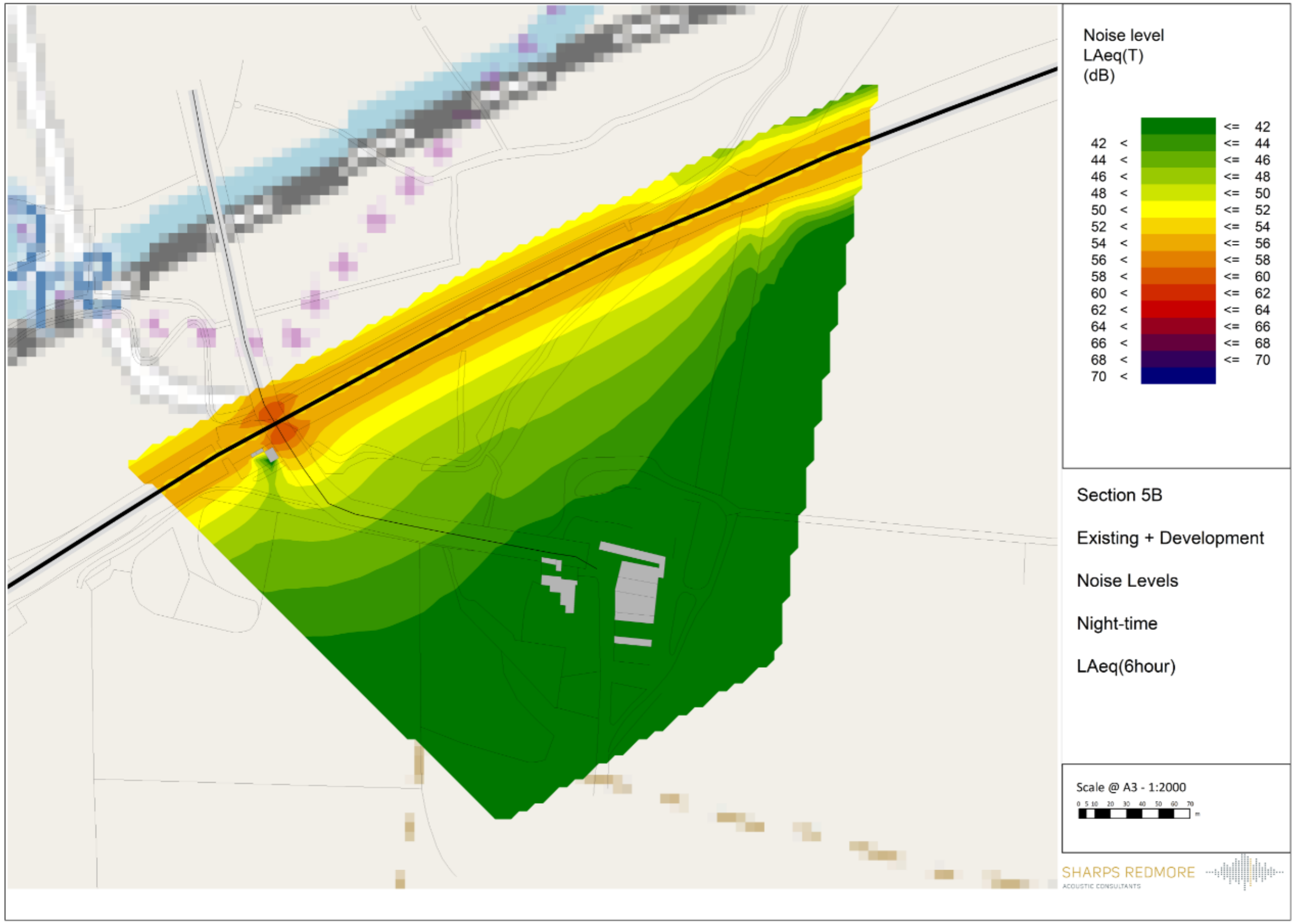


Figure 9.3.C.26: East Suffolk Line, Section 5C – Night time contours, 7 train passes – $L_{Aeq,\ 6h}$

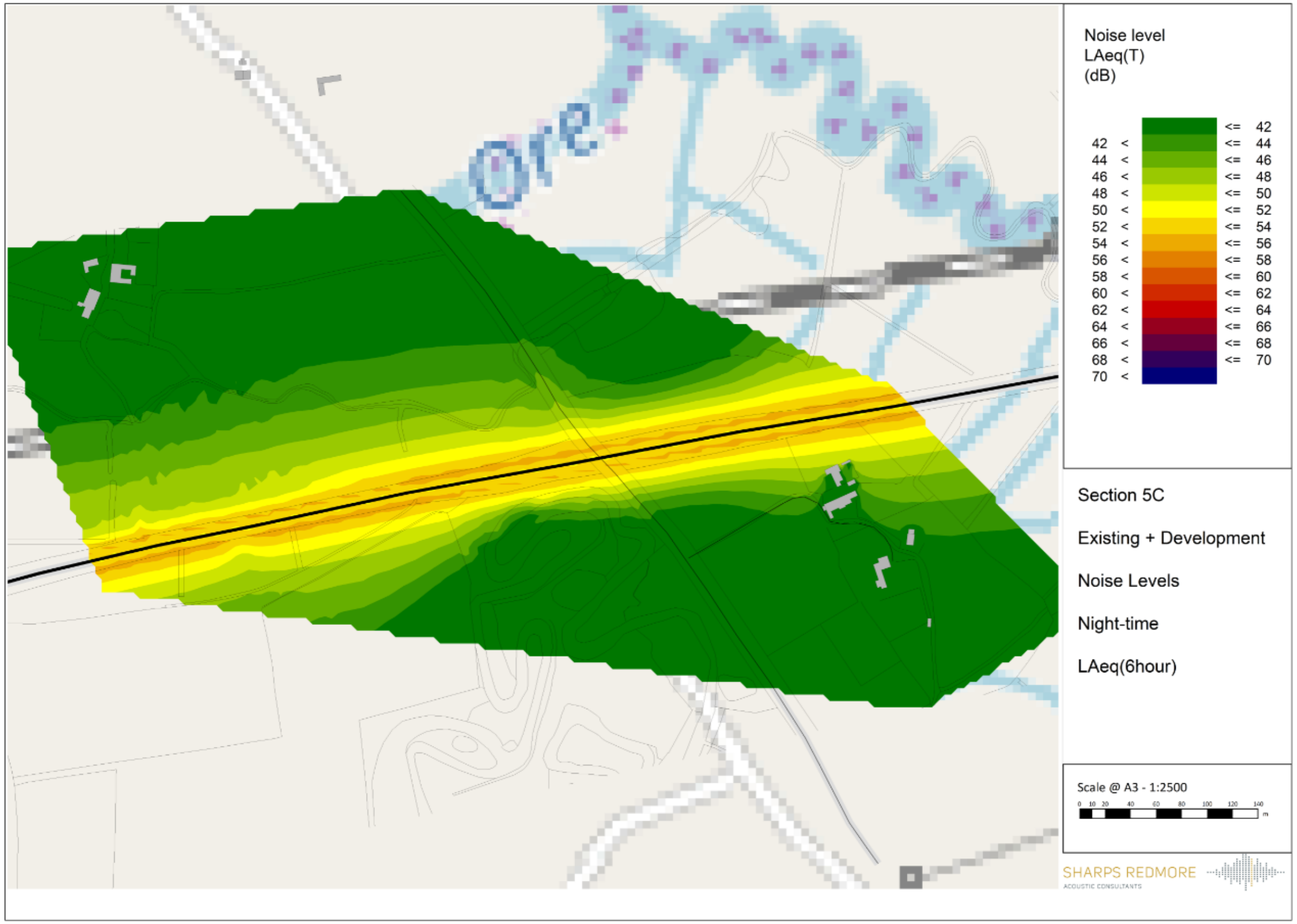


Figure 9.3.C.27: East Suffolk Line, Section 5C – Night time contours, 8 train passes – $L_{Aeq, 6h}$

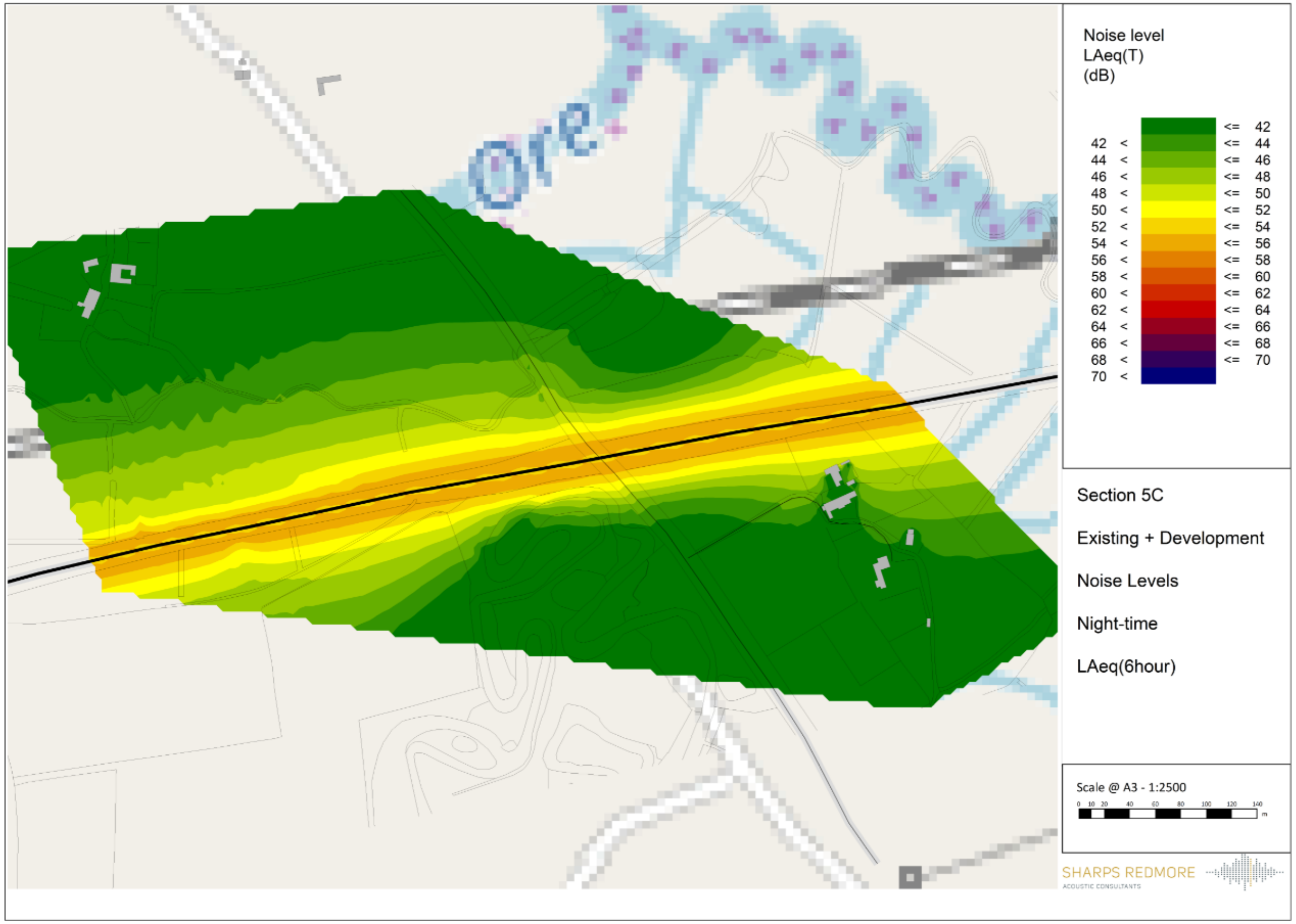


Figure 9.3.C.28: East Suffolk Line, Section 6 – Night time contours, 7 train passes – $L_{Aeq,\ 6h}$

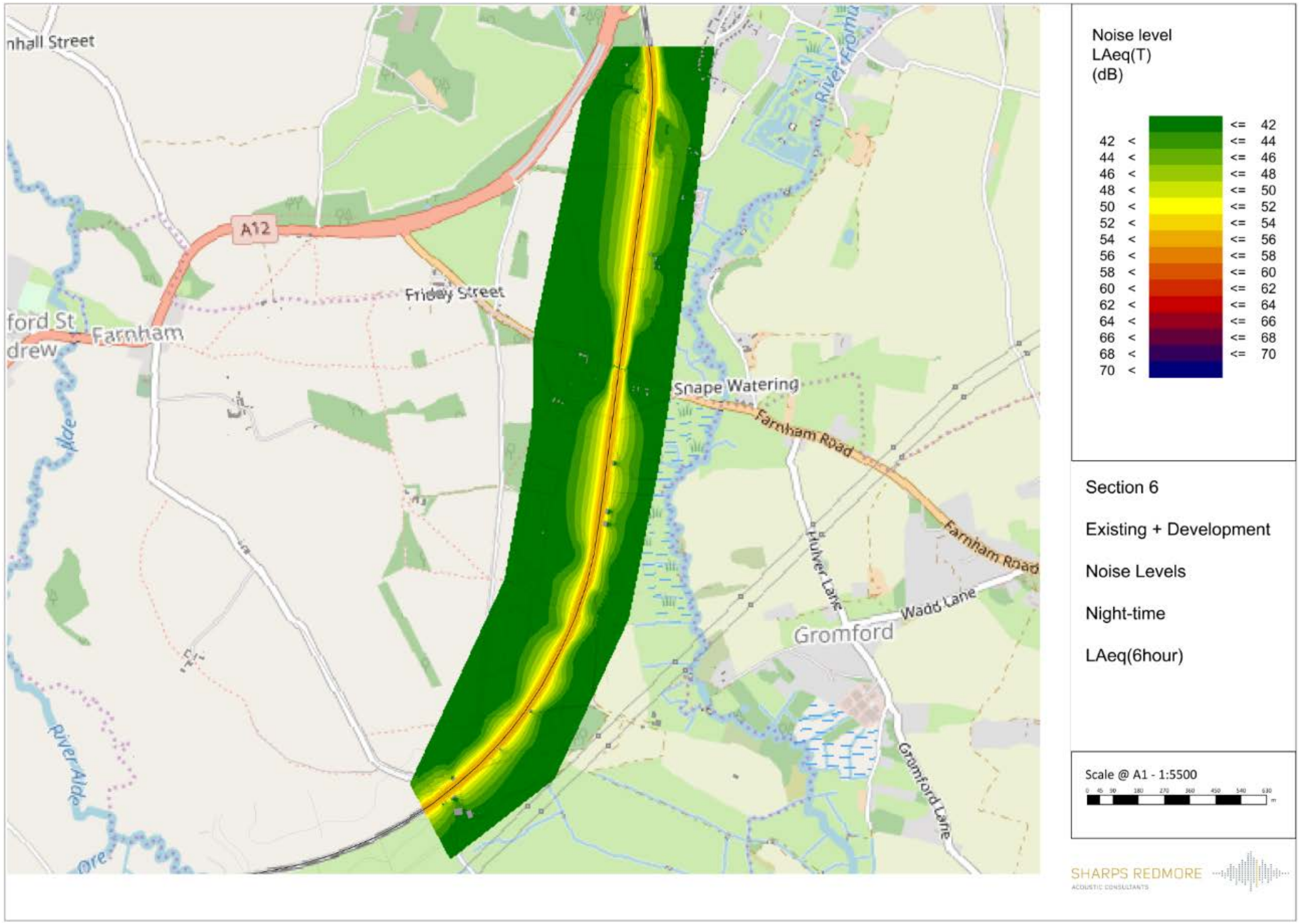


Figure 9.3.C.29: East Suffolk Line, Section 6 – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

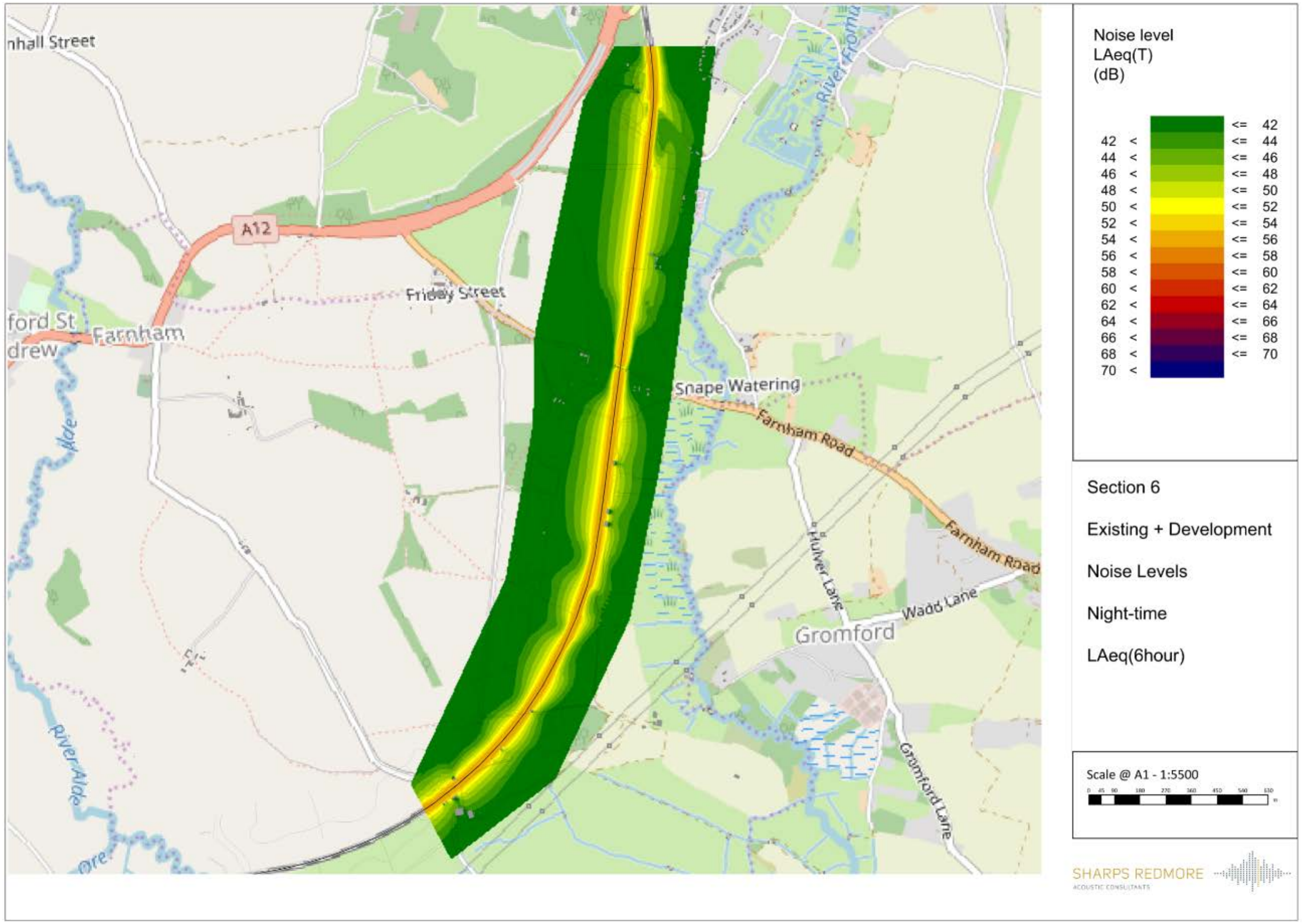


Figure 9.3.C.30: East Suffolk Line, Section 7A – Night time contours, 7 train passes – $L_{Aeq,\ 6h}$

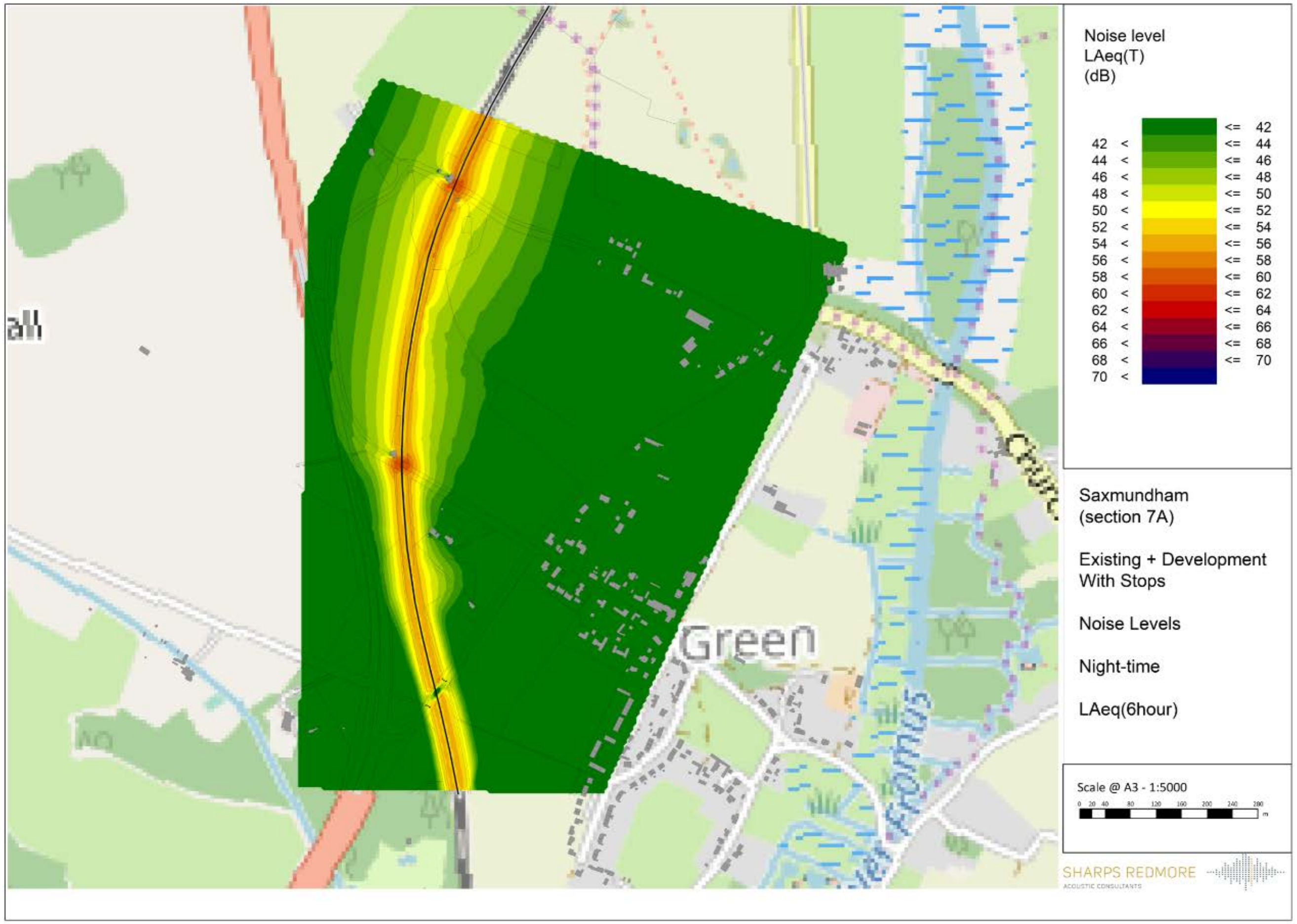


Figure 9.3.C.31: East Suffolk Line, Section 7A – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

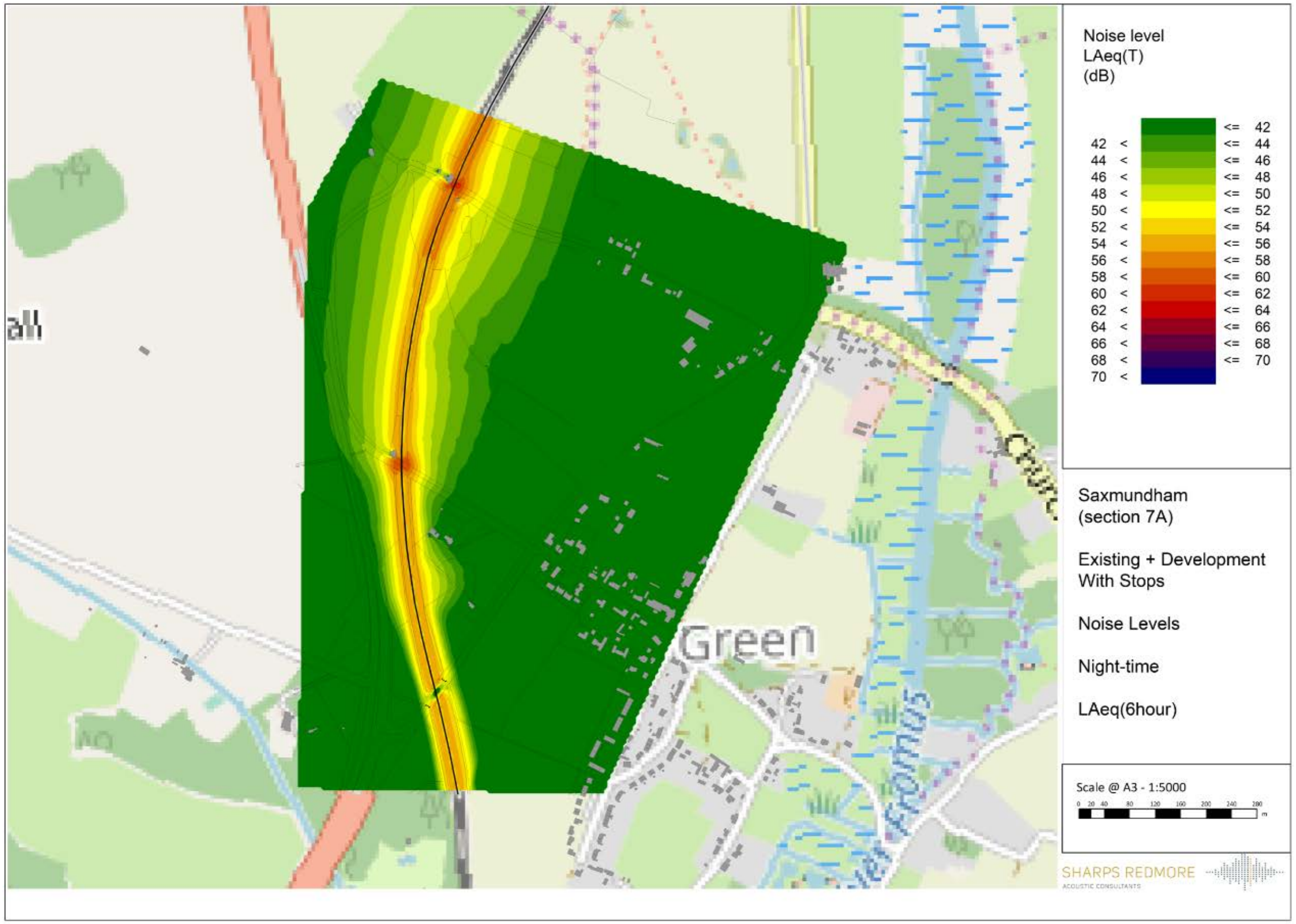


Figure 9.3.C.32: East Suffolk Line, Section 7B – Night time contours, 7 train passes – $L_{Aeq, 6h}$

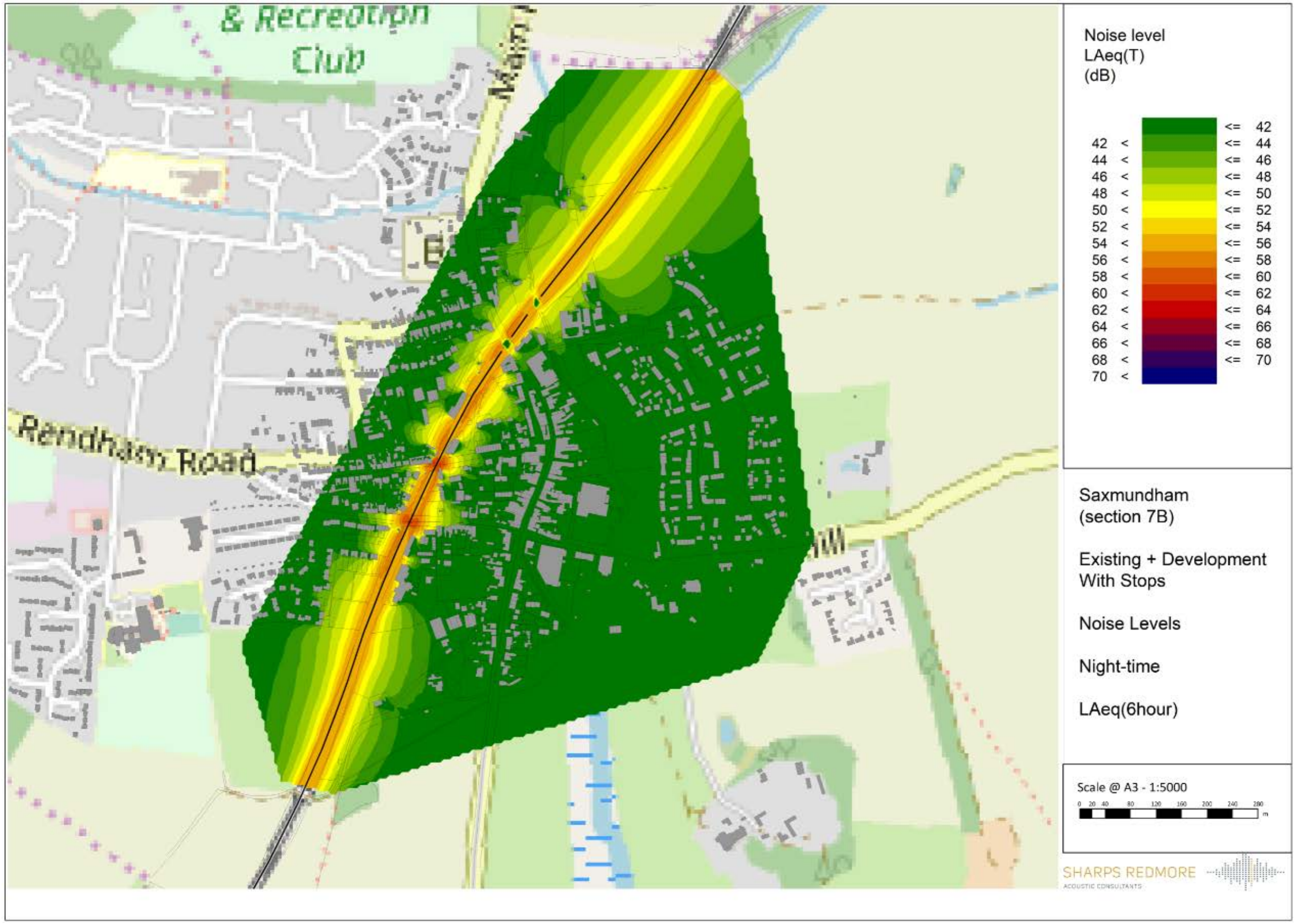


Figure 9.3.C.33: East Suffolk Line, Section 7B – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$

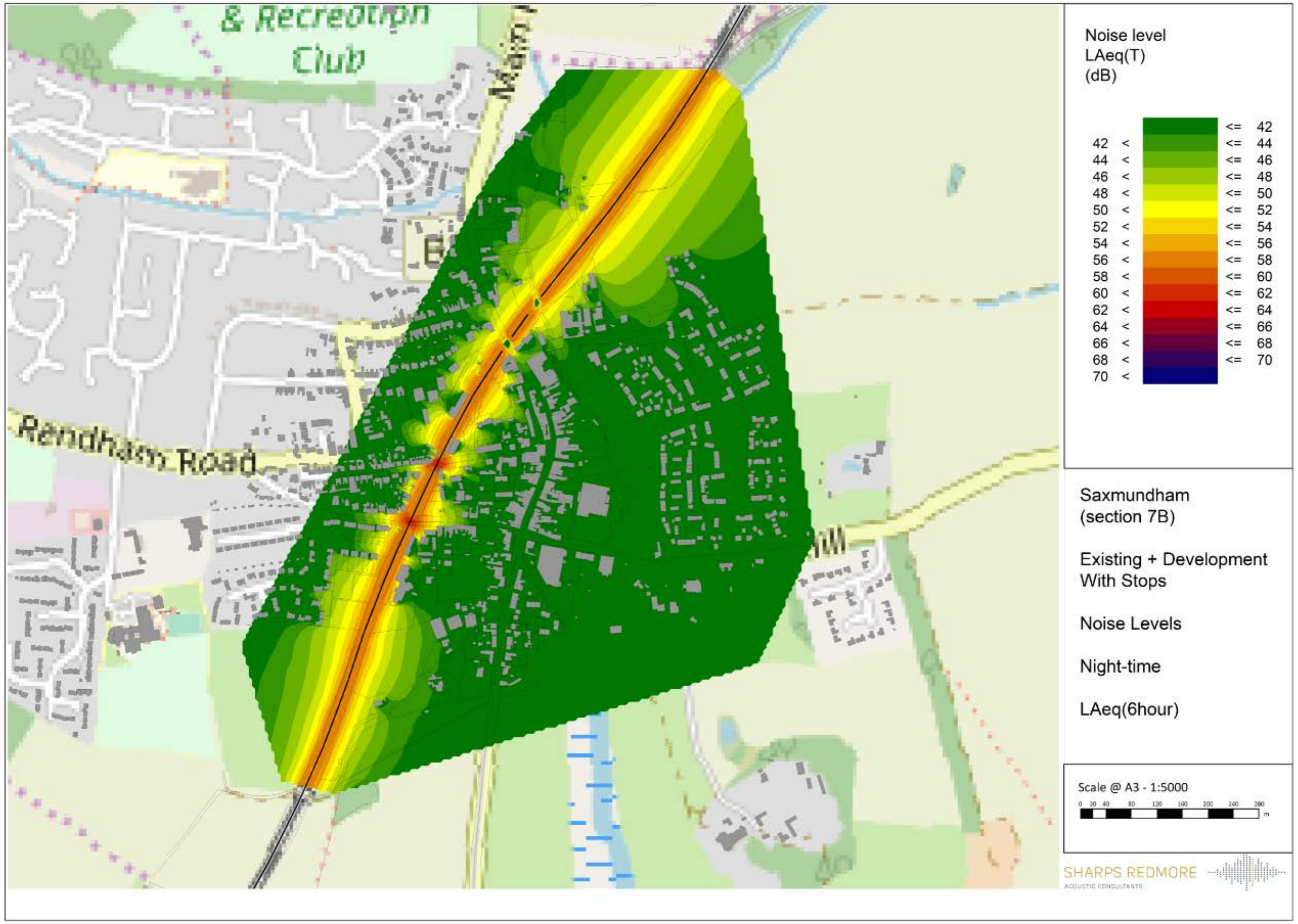


Figure 9.3.C.34: East Suffolk Line, Section 7A – Night time contours, 7 train passes – $L_{Aeq,\,6h}$ + proposed with secondary mitigation: avoiding the need for trains to stop

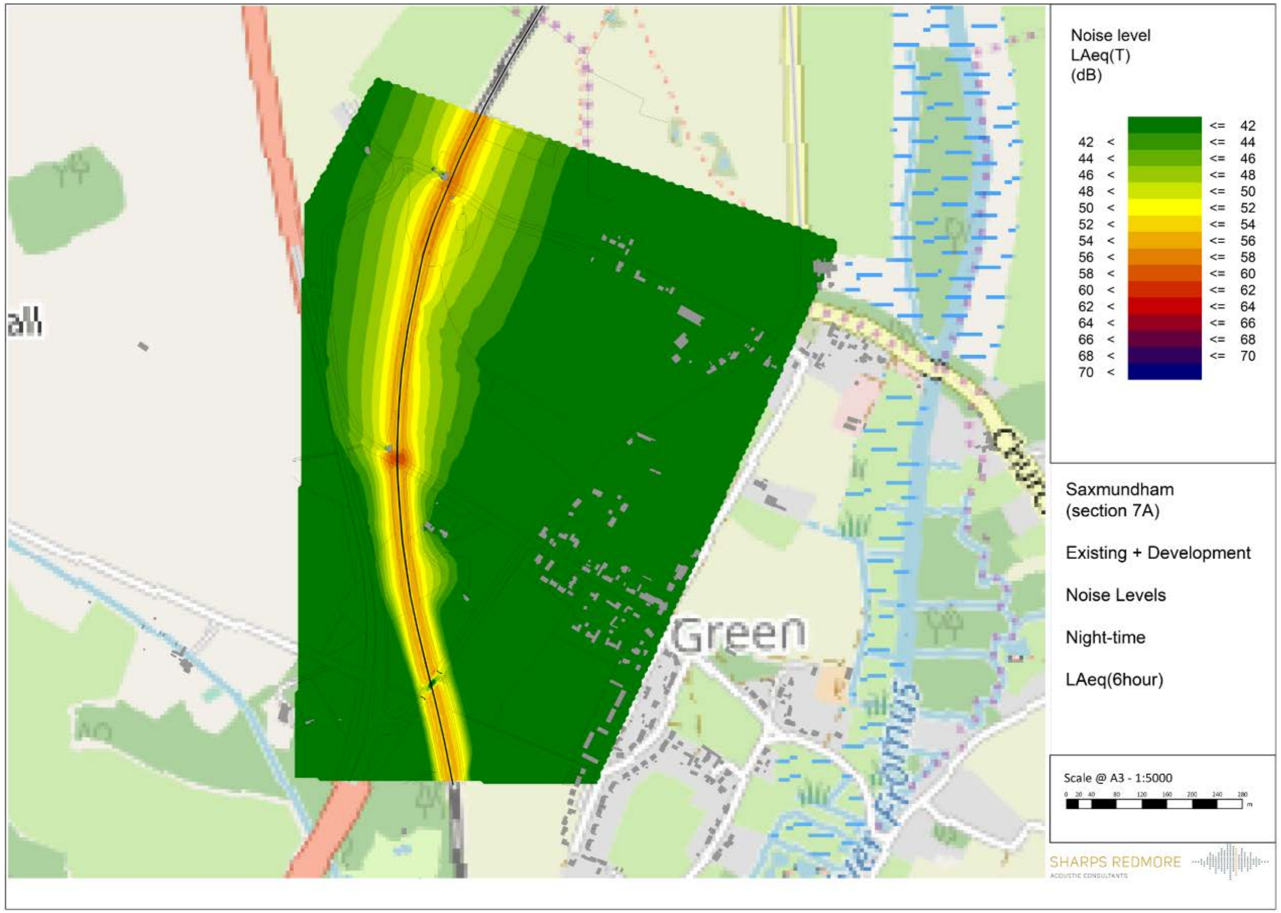


Figure 9.3.C.35: East Suffolk Line, Section 7A – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$ + proposed with secondary mitigation: avoiding the need for trains to stop

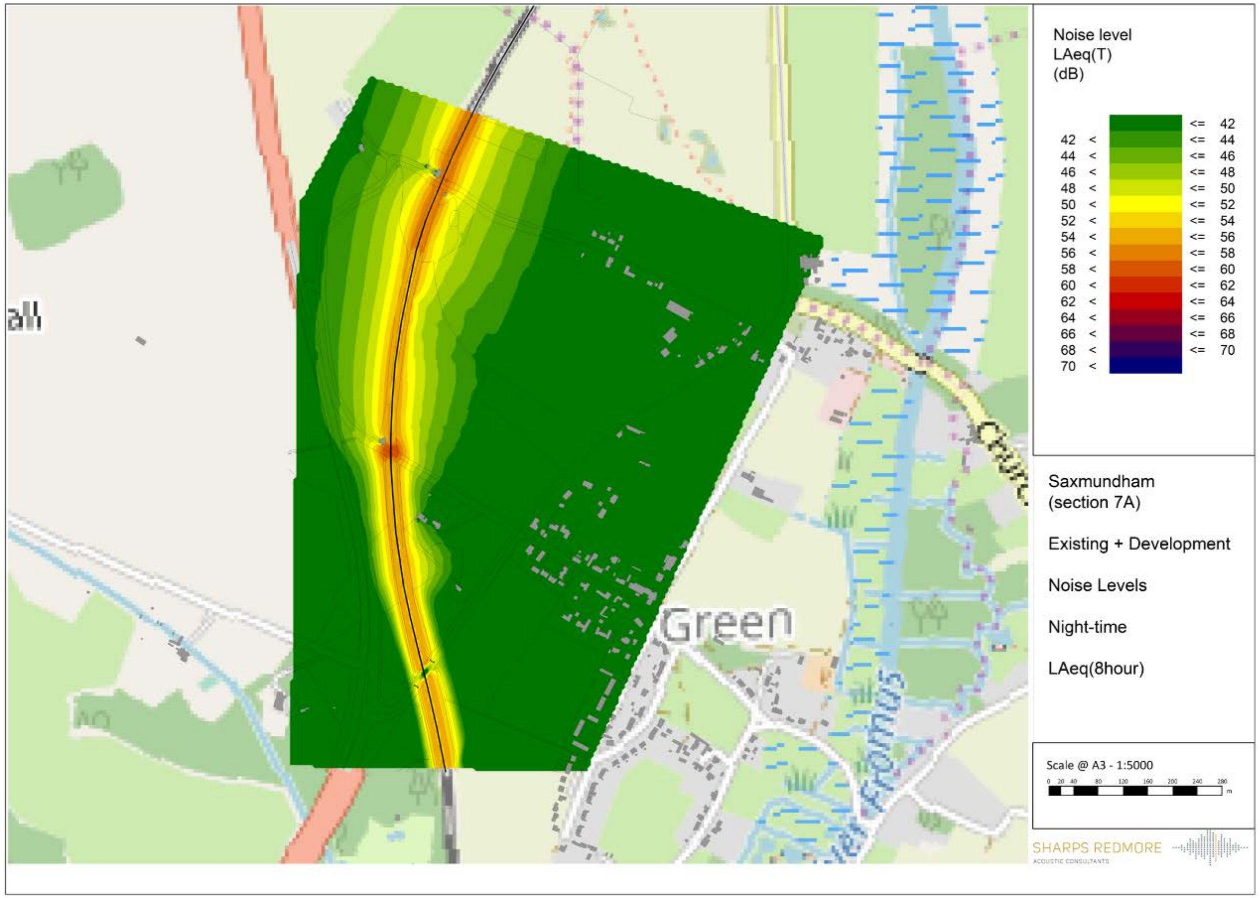


Figure 9.3.C.36: East Suffolk Line, Section 7B – Night time contours, 7 train passes – $L_{Aeq, 6h}$ + proposed with secondary mitigation: avoiding the need for trains to stop

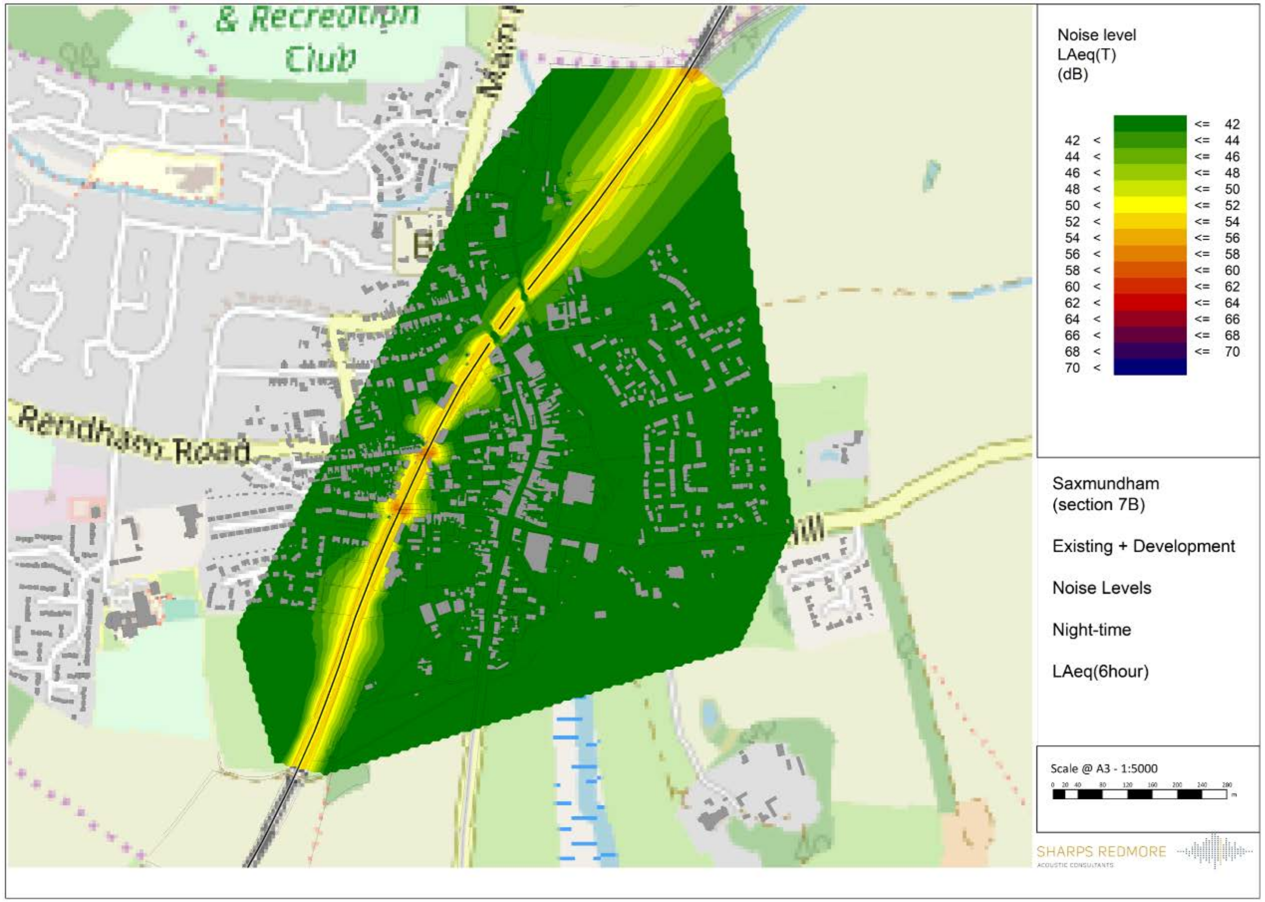
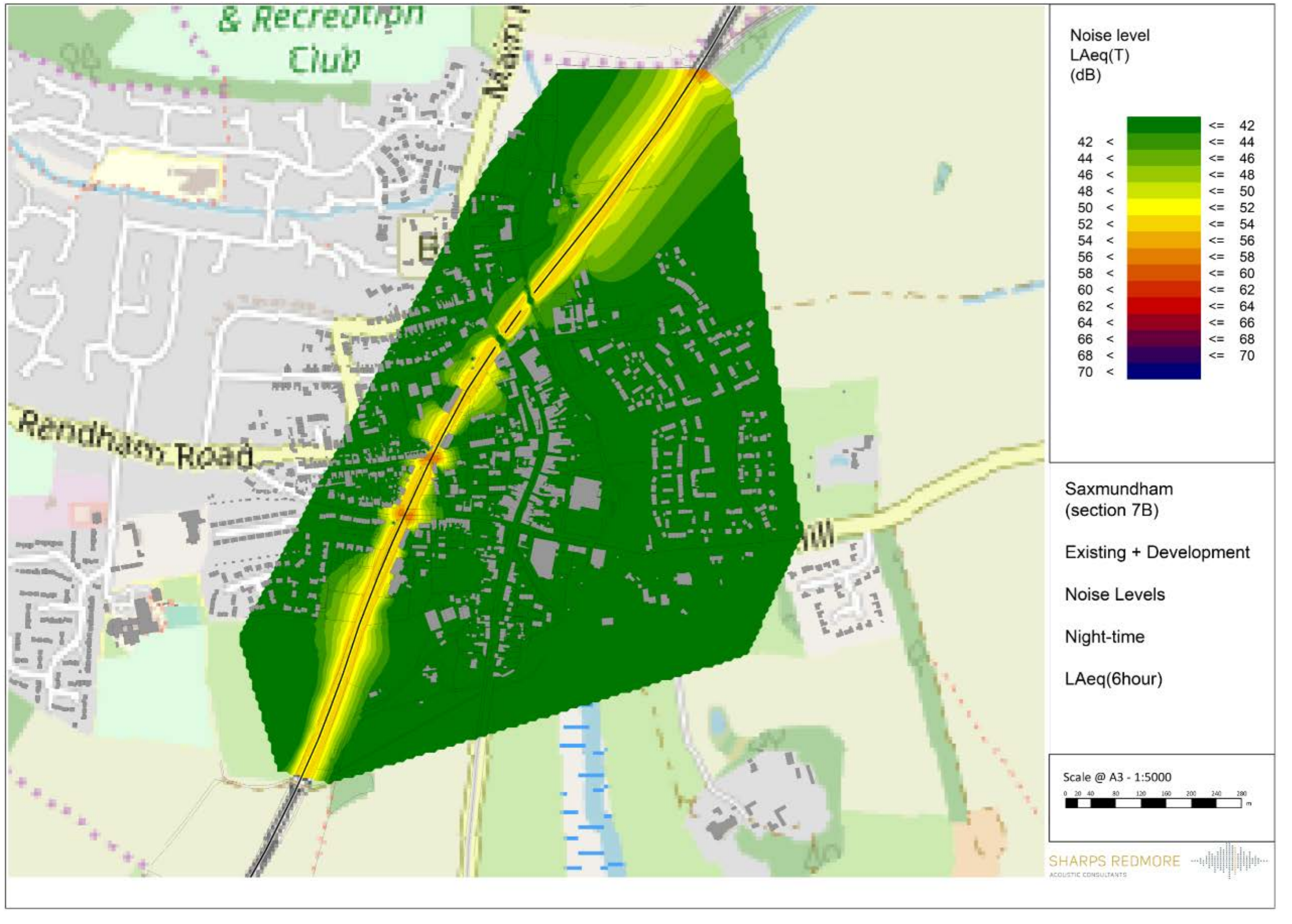


Figure 9.3.C.37: East Suffolk Line, Section 7B – Night time contours, 8 train passes – $L_{Aeq,\ 6h}$ + proposed with secondary mitigation: avoiding the need for trains to stop



APPENDIX 9.3.D SLEEP DISTURBANCE ASSESSMENT

CONTENTS

TABLES

None provided.

PLATES

None provided.

FIGURES

None provided.

APPENDICES

1 INTRODUCTION

1.1.1 This document discusses the approach adopted by SZC Co. to the assessment of potential sleep disturbance from trains, with reference to relevant guidance / research. The document is submitted to assist the discussions with the local planning authorities.

1.1.2 This document is based on the information set out in **Volume 1, Appendix 6G** of the **Environmental Statement (ES)** (Doc Ref 6.1) [APP-171], but reframes the information following discussions with the local planning authorities. It is considered that reframing the information from **Volume 1, Appendix 6G** of the **ES** (Doc Ref 6.1) [APP-171] in this way may assist the local planning authorities in understanding the approach to assessing the potential for sleep disturbance.

1.1.3 No new assessment information is presented in this document; it deals with guidance, criteria and the derivation of the thresholds set out in the ES submitted with the application for development consent.

2 PLANNING POLICY AND LEGISLATION

2.1.1 This document does not contain a full consideration of planning policy, as that is discussed in **Volume 1, Appendix 6G** of the **ES** (Doc Ref 6.1) [APP-171]. However, it is useful to restate the key planning policy requirements, insofar as they relate to sleep disturbance.

2.2 National Planning Policy

2.2.1 The most relevant planning policy for the Development Consent Order (DCO) is contained in the National Policy Statements NPS EN-1 'Overarching National Policy Statement for Energy' [Ref 1] and NPS EN-6 'National Policy Statement for Nuclear Power Generation' [Ref 2].

2.2.2 Paragraph 5.11.9 of NPS EN-1 sets out the policy tests for noise:

> *'5.11.9 The IPC should not grant development consent unless it is satisfied that the proposals will meet the following aims:*
>
> - *avoid significant adverse impacts on health and quality of life from noise;*
> - *mitigate and minimise other adverse impacts on health and quality of life from noise; and*
> - *where possible, contribute to improvements to health and quality of life through the effective management and control of noise.'*

2.2.3 NPS EN-6 does not contain any additional policy tests or requirements beyond those set out in NPS EN-1.

2.2.4 Paragraph 5.11.1 of NPS EN-1 cross-references the Noise Policy Statement for England (NPSE):

> *'5.11.1 The Government's policy on noise is set out in the Noise Policy Statement for England.'*

2.3 Noise Policy Statement for England

2.3.1 The NPSE [Ref 3] was published by the Department for Environment, Food and Rural Affairs in March 2010; paragraph 2.20 of the explanatory note of the NPSE provides an explanation of the terms used in NPS EN-1:

> *'2.20 There are two established concepts from toxicology that are currently being applied to noise*

impacts, for example, by the World Health Organisation. They are:

NOEL – No Observed Effect Level

This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.

LOAEL – Lowest Observed Adverse Effect Level

This is the level above which adverse effects on health and quality of life can be detected.

2.21 Extending these concepts for the purpose of this NPSE leads to the concept of a significant observed adverse effect level.

SOAEL – Significant Observed Adverse Effect Level

This is the level above which significant adverse effects on health and quality of life occur.'

2.3.2 Importantly, the NPSE does not define the SOAEL or the LOAEL, with paragraph 2.22 stating the following in relation to the SOAEL:

'2.22 It is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times. It is acknowledged that further research is required to increase our understanding of what may constitute a significant adverse impact on health and quality of life from noise. However, not having specific SOAEL values in the NPSE provides the necessary policy flexibility until further evidence and suitable guidance is available.'

2.3.3 There are three aims in the NPSE, which are consistent with those set out in paragraph 5.11.9 of NPS EN-1 (the bold text is in the NPSE, with the additional text set out in the NPSE Explanatory Note):

'The first aim of the Noise Policy Statement for England

Avoid significant adverse impacts on health and quality of life from environmental, neighbour and

neighbourhood noise within the context of Government policy on sustainable development.

2.23 The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development (paragraph 1.8).

The second aim of the Noise Policy Statement for England

Mitigate and minimise adverse impacts on health and quality of life from environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

2.24 The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL and SOAEL. It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development (paragraph 1.8). This does not mean that such adverse effects cannot occur.

The third aim of the Noise Policy Statement for England

Where possible, contribute to the improvement of health and quality of life through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development.

2.25 This aim seeks, where possible, positively to improve health and quality of life through the pro-active management of noise while also taking into account the guiding principles of sustainable development (paragraph 1.8), recognising that there will be opportunities for such measures to be taken and that they will deliver potential benefits to society. The protection of quiet places and quiet times as well as the *enhancement of the acoustic environment will assist with delivering this aim.'* [1]

2.4 Planning Practice Guidance

2.4.1 In March 2014, the Government issued Planning Practice Guidance (PPG) on noise, titled 'Noise' [Ref 4]. This document sets out a number of principles in the form of questions and answers, and reinforces the guidance set out in the NPS and the NPSE. The most recent version of this document was published in July 2019.

2.4.2 The PPG was issued by the Government to advise:

> *'…on how planning can manage potential noise impacts in new development.'*

2.4.3 It does not constitute planning policy, however it provides guidance on how planning policy should be implemented.

2.4.4 The noise PPG broadly repeats the NPSE definitions of the NOEL, LOAEL and SOAEL and it provides a summary table to explain how the terms relate to each other and to typical human reactions to sound.

2.4.5 Although presented in tabular form in the PPG, it is more useful to explore each threshold and description of typical reactions separately.

2.4.6 The No Observed Effect Level (NOEL) is the lowest level identified in the PPG, where noise does not cause any observable effect at all.

2.4.7 The LOAEL, which is the lowest level at which an observable adverse effect occurs, provides a useful delineation between noise that causes an observable adverse effect, and noise that does not. Below the LOAEL, the PPG description is:

> *'Noise can be heard, but does not cause any change in behaviour, attitude or other physiological response. Can slightly affect the acoustic character of the area but not such that there is a change in the quality of life.'*

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[1] The Explanatory Note to the NPSE explains the importance of government policy for sustainable development. Guiding principles for sustainable development are explained at paragraph 1.8 of the NPS to include factors such as ensuring a strong healthy and just society and achieving a sustainable economy. Paragraph 2.18 of the Explanatory Note explains that:

"*There is a need to integrate consideration of the economic and social benefit of the activity or policy under examination with proper consideration of the adverse environmental effects, including the impact on noise and quality of life. This should avoid noise being treated in isolation in any particular situation, ie not focusing solely on the noise impact without taking into account other related factors*."

2.4.8 No specific measures are required at this level, since there is no adverse effect to address.

2.4.9 Once noise is above the LOAEL, i.e. there is an observable adverse effect, the PPG suggests that it should mitigated and reduced to a minimum. The characteristics of this effect are described as below, with the effects relevant to sleep disturbance in bold:

> *'Noise can be heard and causes small changes in behaviour, attitude or other physiological response, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise.* ***Potential for some reported sleep disturbance.*** *Affects the acoustic character of the area such that there is a small actual or perceived change in the quality of life.'*

2.4.10 Once the LOAEL is exceeded, the expectation is that some sleep disturbance will occur. It is important to note that the NPSE is clear that even allowing for all reasonable mitigation, such adverse effects can still occur. There is no policy requirement for it to be "avoided".

2.4.11 As the noise increases further, the SOAEL is exceeded; this is the point at which a significant adverse effect on health and quality of life can be observed. Planning policy requires this to be avoided.

2.4.12 The characteristics of this effect are described below, with the effects relevant to sleep disturbance in bold:

> *'The noise causes a material change in behaviour, attitude or other physiological response, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep the windows closed most of the time because of the noise.* ***Potential for sleep disturbance resulting in difficulty in getting back to sleep, premature awakening and difficulty in getting back to sleep.*** *Quality of life diminished due to change in acoustic character of the area.'*

2.4.13 The key difference in terms of sleep disturbance between an effect that is above the SOAEL and one that is above the LOAEL, but below the SOAEL, can be seen from the difference in the descriptions in the PPG:

- Above LOAEL: Potential for some reported sleep disturbance.

- Above SOAEL: Potential for sleep disturbance resulting in difficulty in getting back to sleep, premature awakening and difficulty in getting back to sleep.

2.4.14 The SOAEL is a much higher and prolonged level of effect.

2.4.15 Since none of the thresholds that flow from policy are defined numerically, direction must be taken from relevant guidance and research on the particular element of noise being considered.

2.4.16 A summary of relevant guidance and research is contained in **Volume 1, Appendix 6G** of the **ES** (Doc Ref 6.1) [APP-171], and summarised in Appendix A of this document.

2.5 EIA Regulations

2.5.1 In addition to the policy tests, the EIA Regulations [Ref 5] set out requirements for the assessment and presentation of environmental impact assessments.

2.5.2 The requirements for the Environmental Statement in terms of noise effects are set out in Schedule 4 of The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017, which broadly require:

> *'5. A description of the likely significant effects of the development on the environment…'*
>
> *'7. A description of the measures envisaged to avoid, prevent, reduce or, if possible, offset any identified significant adverse effects on the environment and, where appropriate, of any proposed monitoring arrangements (for example the preparation of a post-project analysis). That description should explain the extent, to which significant adverse effects on the environment are avoided, prevented, reduced or offset, and should cover both the construction and operational phases.'*

2.5.3 The threshold of EIA significance, i.e. the point at which the noise is considered to have a significant adverse effect in EIA terms, and must be reported as such, can sit between the LOAEL and SOAEL, or depending on the guidance, can be equal to one or the other.

3 ADOPTED THRESHOLD VALUES

3.1.1 The requirements of planning policy are:

- to avoid significant adverse effects on health and quality of life. These are the effects above the SOAEL;
- to mitigate and minimise adverse effects on health and quality of life. These are the effects that are above the LOAEL, but below the SOAEL.

3.1.2 To confirm that these requirements are met, it is necessary to define where the thresholds of LOAEL and SOAEL lie, and the guidance included in **Appendix A** of this document, which mirrors the information set out in the **Volume 1, Appendix 6G** of the **ES** (Doc Ref 6.1) [APP-171], provides the tools to do this.

3.1.3 Where it is helpful to expand upon or clarify a particular threshold value, reference to relevant guidance is included in this section of the document.

3.1.4 A useful summary of the research into the link between sleep disturbance and maximum sound levels is provided in the 'Planning & Noise Professional Practice Guidance on Planning & Noise', known as the ProPG and published in May 2017 [Ref 6] by the Institute of Acoustics (IoA), the Association of Noise Consultants (ANC) and the Chartered Institute of Environmental Health (CIEH).

3.1.5 Appendix A of the ProPG provides a helpful summary of the main research on sleep disturbance, much of which is relevant to this document. It is considered more useful to refer to the summary of sleep disturbance research as published in the ProPG, rather than set out a new set of almost identical conclusions from SZC Co.'s own review. The presence of this summary in a document published by the IoA, ANC and CIEH is considered to give it weight.

3.1.6 The research on sleep disturbance and maximum sound levels is summarised in paragraph A.18 of the ProPG :

> *'A.18 The main body of sleep research is consistent with a careful interpretation of the viewpoint set out in the World Health Organisation Guidelines which for the ordinary population is that:*
>
> - *Impacts on sleep can be detected from relatively low level maximum noise events, however the degree of resulting harm may not be significant.*

- *‘Effects’ on sleep (such as EEG awakenings and sleep stage changes) occur spontaneously in the general population many times per night regardless of any impacts due to noise.*

- *The smaller the number of noise events, the louder the maximum noise level that can be tolerated without adverse effects upon sleep; subject to an upper limit.*

- *At relatively low levels e.g. around 45 dB $L_{Amax,F}$ when sufficient number of such events take place during the night the adverse effects of individual noise events are likely to be limited to sleep disturbance in the form of changes in sleep state or perhaps some EEG awakenings.*

- *It normally requires noise levels higher than 45 dB $L_{Amax,F}$ before significant adverse effects such as behavioural awakenings, difficulty getting to sleep, premature awakening or difficulty getting back to sleep generally occur (and the latest field research on rail and aircraft noise suggest that it requires internal L_{Amax} noise levels of around 65 dB before noise induced awakenings become distinguishable from spontaneous awakenings).’*

3.1.7 To reiterate the key points:

- Sleep disturbance effects can occur, irrespective of whether noise is present; it is a natural component of normal sleep patterns;

- Adverse effects begin to occur at internal noise levels of around 45dB L_{AFmax}, although the effects are limited;

- Higher levels are required to lead to noise-induced awakenings and behavioural awakenings, that would be classed as significant adverse effects, with the latest research suggesting that internal levels of 65dB L_{AFmax} are required.

3.1.8 These key points inform the approach adopted to LOAEL and SOAEL for maximum railway sound levels.

3.2 LOAEL

3.2.1 The LOAEL is the lowest point at which an observable adverse effect on health and quality of life occurs. It is therefore useful to consider guidance or research that point to the onset of an adverse effect.

3.2.2 There is evidence for some awakening events at internal noise levels as low as 32dB L_{AFmax}, such as an increase in motility described in the WHO Night Noise Guidelines [Ref 7]. However, these are not always distinguishable from awakening events unlinked to noise and they are not widely adopted.

3.2.3 It is also important to note that, on average, most people will have awakening events, even if no noise is present. Paragraph A.6 of the ProPG summarises this:

> *'A.6 It is important to recognise that typically many awakening events are unrelated to noise and that normally the average person is subject to several spontaneous awakenings per night independent of any effects of noise. For example the WHO Community Noise Guidelines at section 3.4 advises that "It is estimated that 80-90% of the reported cases of sleep disturbance in noisy environments are for reasons other than noise originating outdoors. For example, sanitary needs; indoor noises from other occupants; worries; illness; and climate (e.g. Reyner & Horne 1995)".'*

3.2.4 The 1999 WHO guidelines [Ref 8] suggest that an internal level of 45dB L_{AFmax} marks the noise level when sleep disturbance begins to occur, stating on page 46:

> *'For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{Amax} more than 10–15 times per night'*

3.2.5 It can be inferred from this that, below this threshold, good sleep is likely. This suggests that an internal 45dB L_{AFmax} noise level sits on the boundary between an adverse effect, and no adverse effect, i.e. the LOAEL.

3.2.6 Since potential sleep disturbance may occur at noise levels above the 45dB L_{AFmax} internal threshold, this is also consistent with the PPG definition of the LOAEL, where some reported sleep disturbance is identified as a characteristic response.

3.2.7 For Sizewell C, the 45dB L_{AFmax} internal threshold was adopted as the level at which potential sleep disturbance begins to occur.

3.2.8 External thresholds are used in the assessment, as they can be measured without disturbing occupants, which will be useful in the future if consent is granted, and they can be assessed as a starting point without considering the precise reduction due to the windows on each property.

3.2.9 To provide an external equivalent level that can be considered equal to the lowest level at which the observable adverse effect of sleep disturbance occurs, it is assumed that the occupants of buildings have their windows at least partially open. The correction that the WHO suggests is appropriate to obtain an external level that is equivalent to an internal level, is 15dB[2].

3.2.10 The external level that is therefore considered to represent the lowest level at which an observable adverse effect will occur, is 60dB L_{AFmax}. This is the LOAEL in the Sizewell C railway noise assessment.

3.2.11 It is noted that the external 60dB L_{AFmax} LOAEL, based on the WHO internal 45dB L_{AFmax} guideline value, has been adopted without reference to the number of events. The guidance is clear that the internal 45dB L_{AFmax} value should not be exceeded more than 10 to 15 times per night to maintain good sleep.

3.2.12 A precautionary approach has therefore been adopted by SZC Co. by omitting the number of events the WHO state are required to lead to sleep disturbance.

3.2.13 It is considered that the minimum action that an affected occupant will take to reduce internal noise levels is to close their window, and by doing so, the occupant will reduce internal sound levels by more than the 15dB that represents a partially open window. Closing windows is recognised in the PPG as a characteristic action where noise is above the LOAEL.

3.2.14 **Paragraphs 4.73 to 4.84** of **Volume 1, Appendix 6G, Annex 6G.1** of the **ES** (Doc Ref 6.1) [APP-171] describe how the typical sound reduction performance of a ‘basic’ double-glazed window can be calculated. A sound reduction performance value of 25dB was adopted, based on that calculation process.

3.2.15 By closing their window, the occupant gains a reduction of 25dB instead of the 15dB when the window was open, i.e. internal levels are likely to reduce further by 10dB. An external sound level of 70dB L_{AFmax} is therefore considered to be the external sound level that is equivalent to an internal sound level of 45dB L_{AFmax}, but where the windows are closed.

3.2.16 The external 70dB L_{AFmax} threshold has been adopted in the Sizewell C railway noise assessment as the point at which a significant effect might

[2] Page 46 World Health Organisation *Guidelines for Community Noise* (1999)

occur, in EIA terms. The rationale for this is that above 70dB L_{AFmax}, an occupant cannot close their window and keep internal noise levels to no more than 45dB L_{AFmax}.

3.3 SOAEL

3.3.1 The SOAEL is the point at which a significant adverse effect on health and quality of life occurs, and planning policy requires this to be avoided; from the NPSE, this must be determined in the context of sustainable development. The PPG describes exceeding the SOAEL as having the '*potential for sleep disturbance resulting in difficulty in getting back to sleep, premature awakening and difficulty in getting back to sleep*' and '*where there is no alternative ventilation, having to close windows for some of the time because of the noise'*.

3.3.2 It is a much higher level of adverse effect than the point at which the adverse effect starts to occur, i.e. the LOAEL. The 1999 WHO 45dB L_{AFmax} internal noise level, described above, marks the noise level when sleep disturbance begins to occur; the threshold between an observable adverse effect ,and no observable adverse effect.

3.3.3 It is not appropriate to also seek to correlate the 45dB L_{AFmax} internal noise level with the nature and experience of sleep disturbance envisaged by the SOAEL. The anticipated effect that must be avoided is more intrusive than just sleep disturbance; the PPG suggests that there should a repeated effect, that causes difficulties beyond the initial disturbance to sleep and causes difficulties in getting back to sleep.

3.3.4 Exceeding the SOAEL is defined as a high level of disturbance and other guidance and research must therefore be considered from which a noise level indicator of a significant adverse effect on health and quality of life can be identified.

3.3.5 For Sizewell C, the derivation of the SOAEL is based on the research by Basner et al [Ref 9, Ref 10], as adopted by High Speed Two (HS2) Limited. This research suggests that at internal noise levels above 65dB L_{AFmax}, the incidence of recalled awakenings increases.

3.3.6 There is an important distinction between this level and the 45dB L_{AFmax} WHO guideline level, as the two relate to different effects. The 45dB L_{AFmax} value is regarded as the onset or start of sleep disturbance, and therefore synonymous with the LOAEL, whilst the internal 65dB L_{AFmax} value relates to a significant level of disturbance, as envisaged by planning policy.

3.3.7 This is also recognised in paragraph A.18 of the ProPG, as noted at the start of **Chapter 3** of this document:

'It normally requires noise levels higher than 45 dB $L_{Amax,F}$ before significant adverse effects such as behavioural awakenings, difficulty getting to sleep, premature awakening or difficulty getting back to sleep generally occur (and the latest field research on rail and aircraft noise suggest that it requires internal LAmax noise levels of around 65 dB before noise induced awakenings become distinguishable from spontaneous awakenings).'

3.3.8 The internal 65dB L_{AFmax} threshold translates to an external level of 80dB when the effect of a partially open window is taken into account, i.e. by applying the same 15dB internal to external correction as was applied in the derivation of the LOAEL.

3.3.9 As with the LOAEL, the number of events cited in the research as significant when considering the potential for sleep disturbance, has not been taken into account, with the SOAEL equated to a single railway event.

3.3.10 The research states that a higher external threshold of 85dB L_{AFmax} is appropriate where there are 20 events or fewer per night, which will be the case for Sizewell C. The research states the external 80dB L_{AFmax} threshold is appropriate where there are more than 20 events per night.

3.3.11 HS2 adopted the full research findings as the SOAEL, i.e. 80dB L_{AFmax} for more than 20 events per night and 85d L_{AFmax} for 20 events or fewer per night.

3.3.12 Paragraph A.17 of the ProPG reinforces the adoption of these criteria as the indicator of SOAEL:

'Based on these studies it can be concluded that at night (2300 - 0700 hrs) a significant effect on sleep disturbance e.g. behavioural awakening, is likely to occur where the maximum sound level at the façade of a building with partially open windows is above:

- *85 dB $L_{Amax,F}$ (where the number of events exceeding this value is ≤ 20); or*
- *80 dB $L_{Amax,F}$ (where the number of events exceeding this value is > 20).'*

3.3.13 SZC Co. has adopted the precautionary approach of equating the lower 80dB external L_{AFmax} threshold with the SOAEL, irrespective of the number of events.

4 MITIGATION

4.1.1 A range of mitigation measures is being developed to mitigate and reduce noise from rail movements on the Saxmundham to Leiston branch line, the rail extension route and the East Suffolk line. The measures are a mix of operational and physical controls, and will be documented in the 'Rail Noise Mitigation Strategy'.

4.1.2 At external noise levels above the 60dB L_{AFmax} LOAEL, maximum sound levels from trains have the potential to lead to sleep disturbance where householders have their windows open; the same outcome has the potential to occur where external train noise levels exceed 70dB L_{AFmax} and householders have their windows closed.

4.1.3 Planning policy, and good practice requires all reasonable mitigation to reduce these effects, although an irreducible minimum is not required by planning policy. The principal measures adopted are:

- Balancing freight movements across three modes of transport, road, rail and sea;
- Speed limits in built-up areas;
- Selection of the quietest locomotives;
- Use of long-welded track;
- Measures to control groundborne vibration, to minimise any cumulative effects.

4.1.4 At external noise levels above the 80dB L_{AFmax} SOAEL, maximum sound levels from trains have the potential to lead to significant adverse effects where householders have their windows open. Planning policy requires this to be avoided.

4.1.5 A 'Noise Mitigation Scheme' (**Volume 2, Appendix 11H** of the **ES** (Doc Ref 6.3) [APP-210]) has been developed that will enable householders to improve their glazing and, if appropriate, their ventilation provision too, so that a greater reduction of external sound levels can be achieved.

4.1.6 The 'Noise Mitigation Scheme' applies to noise from all aspects of the Sizewell C Project, including construction. The criteria adopted for railway noise are aligned to the thresholds in the Noise Insulation Regulations [Ref 11], with an additional maximum sound level threshold aligned to the SOAEL.

4.1.7 The relevant criteria for railway noise are:

- the Future (Rail) Noise Levels exceed façade noise levels of 69dB $L_{Aeq,16hrs}$ during the hours of 07:00 to 23:00 or 58dB $L_{Aeq,8hrs}$ during the hours of 23:00 to 07:00; and
- the Future (Rail) Noise Levels are at least 1dB higher than the Existing (Rail) Noise Levels as a result of the use of the new or amended railway line associated with the Development; and
- the contribution from the new or amended railway line associated with the Development to the Future (Rail) Noise Levels at the façade is at least 1dB; or
- maximum sound level L_{AFmax} 80dB between 23:00 and 07:00 hours.

4.1.8 The 'Noise Mitigation Scheme' applies to new or amended railway lines and to the impact of construction rail traffic on existing railway lines.

4.1.9 The process to be applied under the 'Noise Mitigation Scheme' involves an updated noise assessment to identify eligible properties, which will be subject to the agreement of East Suffolk Council, an offer will be made to the householder and their property surveyed, followed by an offer of payment for insulation works.

4.1.10 East Suffolk Council has requested that the 'Noise Mitigation Scheme' be amended to include a post-commencement review process, so that properties that are found to be more adversely affected than had been anticipated prior to the start of the works can still be deemed eligible for insulation. This modification is currently being drafted and will be issued in a later revision of the 'Noise Mitigation Scheme'.

4.1.11 By enabling improvements in the sound reduction performance of glazing, it will be possible to keep internal sound levels to below the 65dB L_{AFmax} internal SOAEL, even where external noise levels are much higher than the 80dB L_{AFmax} equivalent value.

4.1.12 NPS EN-1 and the PPG both state that insulation is valid mitigation measure. NPS EN-1 states:

> *'5.11.13 In certain situations, and only when all other forms of noise mitigation have been exhausted, it may be appropriate for the IPC to consider requiring noise mitigation through improved sound insulation to dwellings.'*

4.1.13 Paragraph 005 of the PPG states:

> *'005 Increasing noise exposure will at some point cause the 'significant observed adverse effect' level boundary to be crossed. Above this level the noise causes a material change in behaviour such as keeping windows closed for most of the time or avoiding certain activities during periods when the noise is present.* ***If the exposure is predicted to be above this level the planning process should be used to avoid this effect occurring, for example through the choice of sites at the plan-making stage, or by use of appropriate mitigation such as by altering the design and layout.*** *While such decisions must be made taking account of the economic and social benefit of the activity causing or affected by the noise, it is undesirable for such exposure to be caused.'*

4.1.14 Four types of mitigation described in paragraph 010 of the PPG:

> *'In general, for developments that are likely to generate noise, there are 4 broad types of mitigation:*
>
> - *engineering: reducing the noise generated at source and/or containing the noise generated;*
> - *layout: where possible, optimising the distance between the source and noise-sensitive receptors and/or incorporating good design to minimise noise transmission through the use of screening by natural or purpose built barriers, or other buildings;*
> - *using planning conditions/obligations to restrict activities allowed on the site at certain times and/or specifying permissible noise levels differentiating as appropriate between different times of day, such as evenings and late at night, and;*
> - *mitigating the impact on areas likely to be affected by noise including through noise insulation when the impact is on a building.'*

4.1.15 By taking a comprehensive approach to mitigation so that noise levels are reduced as far as practical, and then adopting a threshold for noise insulation based on authoritative guidance, the approach taken in the

DCO application is policy compliant and satisfies the terms of the planning practice guidance.

4.1.16 Furthermore, by adopting the numerical thresholds that relate to different levels of sleep disturbance as LOAEL and SOAEL, without requiring the associated number of events to also be met, the thresholds adopted in the DCO ae considered to be robust and reasonable.

5 OUTCOMES

5.1.1 The outcomes set out in the DCO are set out in this chapter of the document, with additional explanatory text putting them into the context described in the preceding sections.

5.1.2 Once the operational and physical mitigation measures are implemented, it is expected that between 320 and 350 properties will be subject to railway noise levels of between 60dB and 70dB L_{AFmax}, which is above the LOAEL, but would not constitute a significant adverse effect in terms of the EIA Regulations.

5.1.3 The sound levels within these properties could be above the 45dB L_{AFmax} WHO threshold that marks the potential onset of sleep disturbance, where their windows are open. By closing their windows, internal noise levels should be below the 45dB L_{AFmax} and sleep disturbance should not occur.

5.1.4 It is considered that the range of operational and physical mitigation implemented as part of the DCO, the policy requirement to use all reasonable steps to mitigate and reduce adverse effects on health and quality of life is met.

5.1.5 The next level of adverse effect includes those properties expected to have external noise levels above 70dB L_{AFmax} but below 77dB L_{AFmax} and there are expected to be between 100 and 110 properties in this category. These properties are considered to have significant adverse effects, in terms of the EIA Regulations. The 77dB L_{AFmax} threshold is the free-field equivalent of the 80dB L_{AFmax} external SOAEL that is to be determined 1 metre from the façade of the property.

5.1.6 For these properties, however, their internal sound levels will be below the 65dB L_{AFmax} threshold that is considered to represent a significant adverse effect, even if their windows are partially open. The policy required to avoid significant adverse effects on health and the quality of life is not triggered.

5.1.7 The highest level of adverse effect incudes those properties expected to have external free-field noise levels above 77dB L_{AFmax}, equivalent to 80dB L_{Amax} at 1 metre from the property façade; these properties are considered to be above the SOAEL and between 5 and 10 properties fall into this category.

5.1.8 The ‘Noise Mitigation Scheme’ will apply at this threshold and properties that exceed the external threshold will be eligible for insulation to improve their existing glazing to obtain a better reduction of external sound.

5.1.9 While the external sound levels are expected to be above the SOAEL, internally the sound levels will be below the 65dB L_{AFmax} threshold that represents a significant adverse effect and therefore the SOAEL is avoided at the location where it is relevant, i.e. within properties. Where required, the 'Noise Mitigation Scheme' will enable the installation of glazing with a higher sound reduction performance than existing glazing to achieve this outcome.

5.1.10 In all but a few cases, internal sound levels would be reduced to 45dB L_{AFmax} or below, even when the external 80dB L_{AFmax} SOAEL is exceeded, given that improved glazing provided under the 'Noise Mitigation Scheme', e.g. a secondary glazing system, would reduce noise levels by around 40 to 45dB. Further, in all instances, the internal sound levels will be reduced to well below the 65dB L_{AFmax} threshold that is considered to represent a significant adverse effect on health and quality of life. The policy requirement to avoid levels above the SOAEL will therefore be achieved.

6 CONCLUSION

6.1.1 This document considers guidance on sleep disturbance and how it relates to planning policy, to explain the criteria adopted in the DCO in relation to railway noise. This document is submitted to assist the discussions with the local planning authorities.

6.1.2 The 1999 WHO internal guideline value of 45dB L_{AFmax} informs both the LOAEL and the threshold deemed significant in EIA terms, but with different assumptions about the internal to external transfer of sound. The LOAEL is based on the assumption that people have their windows partially open and the EIA significance value is based on people having their windows closed.

6.1.3 The SOAEL is based on the same research on recalled awakenings adopted by HS2, albeit the value adopted for Sizewell C is the lower threshold in the research whereas HS2 adopted two values, linked to the number of events.

6.1.4 In all instances, the thresholds have been applied as if the guidance and reference studies relate to a single train movement. In practice, those studies establish the acceptability of the adopted thresholds for multiple movements (10 to 15 or even up to 20), which makes the application of the guideline values more stringent than might otherwise be the case. The research suggests that the number of occurrences of a sound is material in terms of the likelihood of disturbing the sleep of people nearby, but by ignoring the number of occurrences and applying the criteria to each event, a more robust position is achieved.

6.1.5 The combination of mitigation embedded into the freight management strategy and the 'Noise Mitigation Scheme' (**Volume 2, Appendix 11H** of the **ES** (Doc Ref 6.3) [APP-210]) satisfy planning policy requirements to avoid significant adverse effects on health and quality of life and to mitigate and reduce to a minimum adverse effects on health and quality of life.

REFERENCES

1. DECC (2011) Overarching National Policy Statement (NPS) for Energy (NPS EN-1)
2. DECC (2011) National Policy Statement for Nuclear Power Generation (NPS EN-6)
3. DEFRA (2010) Noise Policy Statement for England
4. MHCLG (2019) Planning Practice Guidance
5. The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (SI 2017 No 572)
6. Institute of Acoustics, Association of Noise Consultants, Chartered Institute of Environmental Health (2017) Professional Practice Guidance on Planning and Noise
7. World Health Organisation (2009) Night noise guidelines for Europe
8. World Health Organisation (1999) Guidelines for community noise
9. Basner et al, Aircraft noise effects on sleep: Application of the results of a large polysomnographic field study, Journal of the Acoustical Society of America **119**, 2772 (2006)
10. Basner et al, Single and combined effect of air, road and rail traffic noise on sleep and recuperation, SLEEP 2011; 34(1):11-23 (2011)
11. The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996 (SI 1996 No 428)
12. British Standard 8233: 2014 Guidance on sound insulation and noise reduction for buildings
13. World Health Organisation Regional Office for Europe (2018) Environmental Noise Guidelines for the European Region
14. C.G. Rice and P.A. Morgan (1982) ISVR Technical Memorandum No 623 A Synthesis of Studies on Noise-Induced Sleep Disturbance

APPENDIX A: GUIDANCE

A.1. Introduction

A.1.1. There are a number of sources of guidance on sleep disturbance, which are described in **Volume 1, Appendix 6G** of the **ES** (Doc Ref 6.1) [APP-171]. The documents are summarised here.

A.2. British Standard 8233: 2014

A.2.1. The scope of British Standard (BS) 8233: 2014 'Guidance on sound insulation and noise reduction for buildings' (BS 8233) [Ref 12] is the provision of recommendations for the control of noise in and around buildings. It suggests appropriate criteria and limits for different situations, which are primarily intended to guide the design of new or refurbished buildings undergoing a change of use rather than to assess the effect of changes in the external noise climate. However, there is justification for using BS 8233 to consider how changes in the noise environment affect existing sensitive properties, as it notes:

> *'NOTE The standard is intended to be used routinely where noise sources are brought to existing noise-sensitive buildings.'*

A.2.2. BS 8233 sets out internal criteria for residential properties, as shown in Table A2.1.

Table A2.1: BS 8233 recommended internal noise levels, dB

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	35dB $L_{Aeq,16h}$	
Dining	Dining room/area	40dB $L_{Aeq,16h}$	
Sleeping (daytime resting)	Bedroom	35dB $L_{Aeq,16h}$	30dB $L_{Aeq,8h}$

A.2.3. BS 8233 contains the following relevant guidance in footnotes to the above information:

> *'Note 4: Regular individual noise events (for example, scheduled aircraft or passing trains) can cause sleep disturbance. A guideline value may be set in terms of SEL or $L_{Amax,F}$, depending on the character and number of events per night. Sporadic noise events could require separate values.*

Note 5: If relying on closed windows to meet the guide values, there needs to be an appropriate alternative ventilation that does not compromise the façade insulation or the resulting noise level.

Note 7: Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5dB and reasonable internal conditions still achieved.'

A.2.4. Although Note 4 above refers to setting a guideline value for maximum noise levels, BS 8233: 2014 does not provide any guidance on a suitable criterion. Other sources of appropriate guidance must be sought.

A.3. World Health Organisation Guidance

A.3.1. The World Health Organisation (WHO) has published three guidance documents in the last 20 years or so, which provide guidance relevant to the assessment of sleep disturbance. The three documents are:

- The 2018 'Environmental Noise Guidelines for the European Region' [Ref 13];
- The 2009 'Night Noise Guidelines for Europe' [Ref 7]; and
- The 1999 'Guidelines for Community Noise' [Ref 8]

A.3.2. The 2018 Guidance supersedes earlier guidance although the 2018 guidance specifies that earlier guidance remains valid for values not covered in the 2018 document.

A.3.3. In comparison to the 1999 guidelines, which defined environment-specific exposure levels, the 2018 guidance is source-specific. It recommends values for outdoor exposure to road traffic, railway, aircraft and wind turbine noise, and indoor as well as outdoor exposure levels for leisure noise and describes health effects using L_{den} and L_{night} parameters. Despite this, the 2018 guidance recognises that other parameters may be needed in certain circumstances, stating:

'In many situations, average noise levels like the L_{den} or L_{night} indicators may not be the best to explain a particular noise effect. Single-event noise indicators – such as the maximum sound pressure level ($L_{A,max}$) and its frequency distribution – are warranted in specific situations, such as in the context of night-time railway or aircraft noise events that can clearly elicit awakenings and other physiological reactions that are mostly determined by $L_{A,max}$. Nevertheless, the assessment of

the relationship between different types of single-event noise indicators and long-term health outcomes at the population level remains tentative. The guidelines therefore make no recommendations for single- event noise indicators.'

A.3.4. The 2018 guidance has not been incorporated within any standards and nor is it referred to in policy, so although it provides an information review of evidence and thresholds for likely health effects, it is not suitable for use for predicting noise effects.

A.3.5. Internal noise levels are not recommended within the 2018 WHO guidance; however, it does recommend that where internal levels are required, earlier advice from the 1999 WHO 'Guidelines for Community Noise' may be used, stating:

'all CNG indoor guideline values and any values not covered by the current guidelines (such as industrial noise and shopping areas) should remain valid.'

(CNG here refers to the 1999 'Guidelines for Community Noise', or Community Noise Guidelines)

A.3.6. WHO 'Night Noise Guidelines for Europe' (2009) (NNG) recommends:

'$L_{night,outside}$ of 40dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise.'

A.3.7. The 2009 NNG set out a range of internal noise levels that correlate with the onset of a number of sleep disturbance-related effects, such as motility, changes in sleep state, or waking up. These values are useful when considering an appropriate value for the LOAEL, i.e. the level at which an adverse effect on health and quality of life begins to occur. However, a number of the effects are physiological without necessarily having an adverse effect, and therefore do sit easily with the aims of planning policy in terms of the LOAEL.

A.3.8. They also recommend an Interim Target at 55dB $L_{Aeq,8hr}$ outside dwellings at night, stating that:

'Above this level, the situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.'

A.3.9. The World Health Organisation's (WHO) 'Guidelines for Community Noise' (1999) sets out guidance on suitable internal and external noise levels in and around residential properties. The guidance on internal and external noise levels is the same as set out in BS8233: 2014 in terms of L_{Aeq} values, but the WHO guidelines also provide guidance on night-time maximum noise levels, stating:

> *'For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{AFmax} more than 10-15 times per night.'*

A.3.10. The 1999 guidelines indicate that the internal 45dB L_{AFmax} threshold is equivalent to an external façade level of 60dB L_{AFmax}, which allows for the reduction through a partially open window.

A.4. Other Research/Guidance

A.4.1. In seeking to define a SOAEL for the relation to the L_{Amax} parameter, reference was made in the DCO to the 1982 paper 'A Synthesis of Studies on Noise-Induced Sleep Disturbance' by Rice and Morgan [Ref 14], which considered the evidence available at that time on sound levels that might lead to sleep disturbance from specific sound sources. The paper concluded that instantaneous train sound levels of more than 85dB, measured at the façade of a dwelling, could result in significant disturbance to sleep, where there are 20 or fewer events per night. Where there are more than 20 events per night, significant disturbance to sleep could occur at a lower threshold of 80dB L_{Amax}.

A.4.2. The papers by Basner et al 'Aircraft noise effects on sleep: Application of the results of a large polysomnographic field study' (2006) [Ref 9] and 'Single and combined effects of air, road and rail traffic noise on sleep and recuperation' (2011) [Ref 10] suggested that maximum sound levels in bedrooms should not exceed 65dB L_{Amax} to avoid recalled awakenings, which is equivalent to an external sound level of 80dB L_{Amax}, where there is a reduction of 15dB through an open window. This is similar to the findings of Rice and Morgan and was also relied upon by HS2 Limited in their assessments of the HS2 high speed railway line.

A.4.3. Adopting a precautionary approach, in part, in recognition of the proposed new night-time freight trains along the East Suffolk Line where the current service only contains irregular night-time freight movements, the lower 80dB L_{Amax} value was adopted as the SOAEL; the research suggests that where there are 20 or fewer trains per night, a higher 85dB L_{Amax} value is appropriate.

A.5. Professional Practice Guidance

A.5.1. A useful summary of the research into the link between sleep disturbance and maximum sound levels is provided in the 'Planning & Noise Professional Practice Guidance on Planning & Noise', known as the ProPG and published in May 2017 [Ref 6] by the Institute of Acoustics

(IoA), the Association of Noise Consultants (ANC) and the Chartered Institute of Environmental Health (CIEH).

A.5.2. The purpose of the ProPG is set out in the Foreword:

> *"This Professional Practice Guidance on Planning and Noise (ProPG) has been produced to provide practitioners with guidance on a recommended approach to the management of noise within the planning system in England."*

A.5.3. Appendix A of the ProPG provides a helpful summary of the main research on sleep disturbance, much of which is relevant to this document. It is considered more useful to set out the summary of sleep disturbance research as published in the ProPG, rather than set out a new set of almost identical conclusions from SZC Co.'s own review. The presence of this summary in a document published by the IoA, ANC and CIEH is considered to give it weight.

A.5.4. It is important to recognise that sleep disturbance takes many forms, and not all of them are regarded as significant, as paragraphs A2 to A4:

> *'A.2 Phrases like "sleep disturbance", "sleep interference" or 'sleep interruption' imply that the noise from individual noise events would fully awaken people who are asleep i.e. they would become completely conscious. However, the 'effects' of noise on sleep referred to in the WHO Guidelines and the vast majority of research and wider literature etc. cover many impacts during sleep, not solely being woken up. In order to understand the effects of these impacts it is important to recognise that sleep consists of a cycle of alternating stages which during a typical night repeats roughly every 90 minutes. This cycle consists of stages 1 and 2 of light non- rapid eye movement (NREM) sleep, a stage 3 of heavy sleep followed by a stage of rapid eye movement (REM) heavy sleep.*
>
> *A.3 The noise level threshold for awakening is highest in the stage 3 and REM stages of heavy sleep, and is lower in the light sleep stages 1 and 2. The awakening noise threshold also depends on the characteristics of the noise e.g. intermittent noises or rapid on-set noise events have greater impact than continuous noise or slower onset noise events; as well as the connotation of the noise. For example, whispering the sleeper's name can awake the person more easily than a much louder but anonymous noise. Similarly the noise of an alarm or*

warning will awaken a sleeper more easily than a noise of similar level without any particular meaning.

A.4 Noise effects on sleep increase arousal levels leading to a redistribution of time spent in the different stages of sleep, with typically an increase in the duration of the awake and light sleep stages 1 and 2 as these are more easily disturbed by noise; and a reduction of time in the heavy sleep stage 3 and REM parts of the cycle. Such sleep fragmentation has been shown to affect, among other effects, waking psychomotor function, next day performance, memory, creativity, risk- taking behaviour, mood, signal detection performance, daytime fatigue and tiredness and to increase accident risks. The degree to which these effects occur varies at any particular sound level and the association with noise in some cases is not particularly strong.'

A.5.5. There are different types of awakening, which differ in terms of their short-term effects on the following day:

'In order to understand the results of the research of the effects of noise on sleep it is therefore important to be able to distinguish between various kinds of awakening, for example:

- *Behavioural awakening - equivalent to the everyday understanding of conscious 'awakening', when the subject is usually aware of being conscious at the time and can often recall being 'awake' the next day;*
- *Physiological awakening - defined by changes in sleep stages measured by a polysomnograph or an EEG, which the subject may not be aware of at the time or recall the next day; and*
- *The onset and degree of 'motility' i.e. body movements which the subject may not be aware of at the time or recall the next day – typically measured using wrist watch like actimeters.'*

A.5.6. It is also important to note that, on average, most people will have awakening events, even if no noise is present:

'A.6 It is important to recognise that typically many awakening events are unrelated to noise and that normally the average person is subject to several

spontaneous awakenings per night independent of any effects of noise. For example the WHO Community Noise Guidelines at section 3.4 advises that "It is estimated that 80-90% of the reported cases of sleep disturbance in noisy environments are for reasons other than noise originating outdoors. For example, sanitary needs; indoor noises from other occupants; worries; illness; and climate (e.g. Reyner & Horne 1995)".'

A.5.7. Paragraphs A.8 and A.9 of the ProPG reiterate the point that normal sleep patterns will include awakenings and that these should not be assumed to lead to detrimental effects:

> *'…it should be recognised that physiological awakenings are part of the normal architecture of sleep with on average 24 EEG awakenings occurring at night independent of any noise effects.*
>
> *A.9 The above shows that at a physiological level sleep disturbance due to noise can occur, although behavioural awakening may not result. In other words, there are noise impacts on sleep that can be measured by examining changes in EEG patterns or a person's motility, but the person would not necessarily be aware of these impacts and they may not have adverse or significant adverse pathological effects. Therefore care should be taken to not ascribe significance to impacts on sleep detectable at a physiological level, that may occur or appear to occur as a result of noise impacts, as they may not reflect significant pathological effects or even the impact of noise (because they are part of normal sleep).'*

A.5.8. It is also clear that not all awakening effects are equivalent in terms of effect, and not all provide a clear indication of noise-induced sleep disturbance, as envisaged by planning policy and practice guidance. Motility is one such example. The 2009 NNG indicate that the motility can occur at an internal sound level of 32dB L_{AFmax}; however, motility occurs naturally, and the 32dB L_{AFmax} threshold appeared to be the very lowest level at which the effect appeared to be linked to noise. This is summarised in paragraph A.15 of the ProPG:

> *'A.15 However, there is research that indicates impacts of individual noise events on sleep at relatively low maximum noise levels. For example studies have found that "the threshold of aircraft noise-induced motility during events is L_{max} indoor of 32dBA". At these levels*

> *the probability of increased motility associated with a noise event was found to increase just above the equivalent probability with no noise event taking place i.e. there appeared to be no observed effect below this level. This should be considered in the light of the finding in the same study that the probability of awakening at a L_{Amax} noise level at the ear of around 27 dB was 7.2% and rose to only 18.4% at around L_{Amax} 73 dB.'*

A.5.9. The ProPG confirms how the different effects of sleep disturbance align with planning policy:

> *'A.10 The distinction between detectable impacts and adverse and significant adverse effects of noise on sleep is highlighted in the Government's Planning Practice Guidance in the table summarising the noise exposure hierarchy where it states that:*
>
> - *Noise with the "potential for some reported sleep disturbance" is an "Observed Adverse Effect" that should be mitigated and reduced to a minimum; and*
> - *Noise with the "potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep" is a "Significant Observed Adverse Effect" that should be avoided; and*
> - *Noise that causes "regular sleep deprivation/awakening" is a "Significant Observed Adverse Effect" that should be prevented.'*

A.5.10. It is clear from both the ProPG and the PPG that the distinction in effect between the onset of the potential for sleep disturbance through to the point where the noise that causes sleep disturbance also leads to difficulty in getting back to sleep, align with the range anticipated in the NPSE between the LOAEL and SOAEL.

A.5.11. In line with the 1999 WHO guidance, which indicates that the onset of sleep disturbance is a result of a combination of noise level and the number of occurrences, the ProPG highlights that it is this combination that is important:

> *'A.11 The relationship between the maximum noise level of a noise event and the number of intermittent noise events and the effects upon sleep has been debated for many years. It is generally accepted, however, that the*

smaller the number of noise events, the higher the maximum levels that can be withstood without adverse effects on sleep (up to an upper limit, and providing the overarching noise level during the overall sleep period e.g. $L_{Aeq,T}$ does not exceed a suitable threshold).

A.12 Consequently, the L_{Amax} of noise events plus the number of events can be used as the basis of assessing impact; although this is subject to an upper limit. For example work which informs the WHO community noise guidelines recommendation that peak noise in bedrooms should not exceed 45 dB L_{Amax} more than 10 to 15 times per night concluded that "It will be noted in particular that the tolerance to noise in regard to sleep passes through a maximum value for an optimum number of 10 to 15 flights per night and that beyond 20 to 25 occurrences of noise per night the aircraft need to be very quiet or the dwellings provided with excellent sound proofing".'

'A.17 Various studies have linked the L_{Amax} from individual noise events to behavioural awakenings. For example one study found that the "Probability of sleep stage changes to wake/S1 from railway noise increased significantly from 6.5% at 35 dB(A) to 20.5% at 80 dB(A) $L_{Amax,F}$"; whilst another study concluded that "noise disturbance of sleep may be expected to become significant once the outdoor L_{Aeq} exceeds 55 dB provided peak noise levels do not exceed 75 to 80 dB. Higher L_{Aeq} values up to 60 dB may be allowed providing the peak levels do not exceed 85 dB, and the number of such events is less than about 20 per night". Based on these studies it can be concluded that at night (2300 - 0700 hrs) a significant effect on sleep disturbance e.g. behavioural awakening, is likely to occur where the maximum sound level at the façade of a building with partially open windows is above:

- *85 dB $L_{Amax,F}$ (where the number of events exceeding this value is ≤ 20); or*
- *80 dB $L_{Amax,F}$ (where the number of events exceeding this value is > 20).'*

A.5.12. The research on sleep disturbance and maximum sound levels is summarised in paragraph A.18 of the ProPG :

‘A.18 The main body of sleep research is consistent with a careful interpretation of the viewpoint set out in the World Health Organisation Guidelines which for the ordinary population is that:

- *Impacts on sleep can be detected from relatively low level maximum noise events, however the degree of resulting harm may not be significant.*
- *‘Effects’ on sleep (such as EEG awakenings and sleep stage changes) occur spontaneously in the general population many times per night regardless of any impacts due to noise.*
- *The smaller the number of noise events, the louder the maximum noise level that can be tolerated without adverse effects upon sleep; subject to an upper limit.*
- *At relatively low levels e.g. around 45 dB $L_{Amax,F}$ when sufficient number of such events take place during the night the adverse effects of individual noise events are likely to be limited to sleep disturbance in the form of changes in sleep state or perhaps some EEG awakenings.*
- *It normally requires noise levels higher than 45 dB $L_{Amax,F}$ before significant adverse effects such as behavioural awakenings, difficulty getting to sleep, premature awakening or difficulty getting back to sleep generally occur (and the latest field research on rail and aircraft noise suggest that it requires internal L_{Amax} noise levels of around 65 dB before noise induced awakenings become distinguishable from spontaneous awakenings).’*