

Ian Sharland LIMITED

Noise & Vibration Control Specialists

Ashfield House
Back Lane
Marlborough
Wiltshire SN8 1JJ
Telephone: (01672) 515761
Facsimile: (01672) 512761
Email: office@iansharland.co.uk



PROPOSED RESIDENTIAL DEVELOPMENT OFF NEW LANE, HAVANT HAMPSHIRE

ASSESSMENT OF ENVIRONMENTAL NOISE & VIBRATION

v.2

Client:

Bloor Homes Southern

River View House
First Avenue
Newbury Business Park
London Road
Newbury
Berkshire RG14 2PS

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R Sharland MA(Cantab), CEng, MSc, MIOA
P Ashford BSc (Eng), MIOA
M Sharland
Ian J Sharland BSc (Eng), CEng, MRAs, FIOA (Consultant)

Registered in England & Wales No. 1293250
Reg'd Office: 25 St Thomas St. Winchester SO23 9DD

CONTENTS

1. SUMMARY	2
2. INTRODUCTION	3
3. SURVEY OF EXISTING NOISE LEVELS	4
4. NOISE AND PLANNING.....	7
4.1. National Planning Policy Framework	7
4.2 National Policy Statement for England.....	8
4.3 BS8233:1999 – Sound Insulation and Noise Reduction for Buildings	9
4.4 WHO ‘Guidelines for Community Noise’ (1999)	9
4.5 BS6472: 2008 "Guide to evaluation of human exposure to vibration in buildings".....	9
5. RECOMMENDATION FOR NOISE ATTENUATION MEASURES.....	11
6. SURVEY OF AMBIENT VIBRATION LEVELS	14
7. ASSESSMENT OF VIBRATION LEVELS	14
8. CONCLUSION.....	16
Table I – Calculation Of Period Noise Levels, Location 1	17
Table II – Calculation Of Period Noise Levels, Location 2	18
Table III – Calculation Of Vibration Levels, Location 1	19
Table IV – Calculation Of Vibration Levels, Location 2	20
 Figure 1 - Site Layout	 21
Figure 2 - Measurement locations	22
Figure 3 - Average Weighted Rms Acceleration Measured At Location 1.....	23
Figure 4 - Average Weighted Rms Acceleration Measured At Location 2.....	24
 Appendix I: Predicted Transmission into North Facing Bedrooms Night Time.....	 25
Appendix II: Predicted Transmission into North Facing Living Rooms, Day Time.....	26
Appendix III: Vibration Survey Results at Location 1.....	27
Appendix IV: Vibration Survey Results at Location 2.....	28

1. SUMMARY

- 1.1 An assessment of ambient noise & vibration has been undertaken at the site of a proposed residential development on the playing fields of Warblington School, adjacent to the junction of Fairfield Road and New Lane, Havant.
- 1.2 It is proposed that a portion of the playing fields and an area of conservation be developed into to a scheme consisting of 78 new dwellings, of which 23 will be for “affordable housing”, whilst the remaining 55 will be for the open market (see Figure 1).
- 1.3 An acoustic survey was commissioned to assess the impact of noise and vibration from the nearby railway, including both passenger and freight trains.
- 1.4 The existing ambient noise climate affecting the site has been established (Section 3), and the survey has confirmed the levels of noise emanating from the nearby roads and railway.
- 1.5 An outline assessment of the site’s suitability for residential development has been provided (Section 5) and means of mitigating the railway noise have been submitted. This is in the form of a specification for suitable façade glazing, and the provision of attenuated ventilation for the critical accommodation. Also, amenity areas on the north boundary of the site will require an acoustic barrier to ensure acceptable noise levels therein
- 1.7 A survey of ground vibration levels (Section 6) has been undertaken and this indicates that there is a ‘low probability of adverse comment’ in the new buildings (Section 7).
- 1.8 It is concluded that, with the recommended measures in place, the occupants of the new dwellings can be provided with an acceptable acoustic environment.

2. INTRODUCTION

- 2.1 An assessment of noise and vibration has been undertaken at the playing fields of Warblington School, Havant, on behalf of Bloor Homes Southern.
- 2.2 The site (Figure 2) lies parallel to the railway line used by Southern Railway and South West Trains, and to the western end of the site is Fairfield Road and New Lane. On the northern side of the railway there are some industrial units, and to the southern end of the site there are residential properties. The school and remaining playing fields are to the east of the proposed site.
- 2.3 It is proposed that the current site is developed, with the construction of 78 properties (see Figure 1). It is proposed that 23 will be made available for "affordable housing" (of which 9 will be flats), the remaining 55 properties will be available to the open market (of which 12 will be flats).
- 2.4 It is recognised that the development could be subject to a level of noise and vibration from the passing trains, as well as vehicular noise from Fairfield Road and New Lane.
- 2.5 The current assessment has therefore been commissioned to determine whether the noise and vibration affecting the site warrants particular acoustic measures. Formally, the objectives of the current exercise may be summarised as follows:
- (i) To determine the existing ambient noise climate affecting the development site;
 - (ii) To specify measures which will attenuate the external noise, to provide a good standard of accommodation for prospective residents;
 - (iii) To measure ground vibration levels on the site;
 - (iv) To compare these levels against recognised criteria of acceptability and, if necessary, to make recommendations for any measures which should be included in the foundation designs.
- 2.6 This report details the investigations carried out in respect of each of these objectives and summarises the conclusions which have been reached.

3. SURVEY OF EXISTING NOISE LEVELS

- 3.1 The first step in the assessment of potential noise impact is to measure and describe the existing noise levels affecting the site. The first aspect of this was to consider the noise emanating from trains passing the site.
- 3.2 There are four variations of passenger services - those used by Southern Railway travelling west and east, from Brighton to Portsmouth and vice versa, and those used by South West trains travelling north and south, from Portsmouth to London and vice versa.
- 3.3 Also, there are a small number of freight services using the line. Enquiries to Network Rail have confirmed a scheduled volume of 2 - 3 trains in each direction, all in the early hours of the morning.
- 3.4 As it was not practicable to leave a long term monitor on the site, it was agreed that an attended survey should be carried out. This survey was undertaken on Wednesday 9th February 2011, between 10.30am and 13.30pm.
- 3.5 It was necessary to measure individual samples of train noise in two locations within the site due to there being a fork in the railway line and the size of the site. For both locations (see Figure 2) a Rion NL31 Sound Level Meter was fixed to a tripod and placed 10m from the northern boundary of the site, this represents the approximate facade location of the dwellings closest to the railway.
- 3.6 The microphone was located at a height of approximately 1.5m above ground level in a free field position, and had a clear line of sight to the railway line.
- 3.7 Measurements of passing trains were recorded, the equipment being configured to measure the following acoustic parameters:
- L_{Aeq} The A-weighted equivalent continuous sound pressure level which, over the sample period, contains the same acoustic energy as the time-varying signal being recorded.
- L_{Amax} The A-weighted maximum sound pressure level recorded during each sample period (as measured on fast time response).
- 3.8 The equipment was calibrated before and after the survey. The weather during the survey was overcast with sunny spells, but still and dry throughout.

- 3.9 The table below confirms typical sample noise levels for each train type at each measurement location.

Location 1				
Train Service	Direction Travelling	Duration Secs	L _{Aeq} dB(A)	L _{Amax, fast} dB(A)
South West	North	14	55.5	59.4
	South	25	58.2	65.2
Southern	Westbound	12	64.3	70.2
	Eastbound	15	61.7	67.9

Location 2				
Train Service	Direction Travelling	Duration Secs	L _{Aeq} dB(A)	L _{Amax, fast} dB(A)
South West	North	15	64.8	75.4
	South	18	69.0	77.6
Southern	Westbound	14	64.7	78.6
	Eastbound	14	67.8	77.2

- 3.10 It is noted that the peak levels were the highest recorded individual L_{Amax, fast} levels across the sample rail movements.
- 3.11 During the course of the attended survey, no freight trains were witnessed (these being scheduled for night time periods).
- 3.12 Reference to the train timetable for this route indicates that there are the following numbers of services during the day time (0700 – 2300) and night time (2300 – 0700) periods:

Train Service	Direction	Day Time	Night Time
South West	Northbound	49	6
	Southbound	52	9
Southern	Westbound	76	9
	Eastbound	75	11
Freight	Both	0	5

- 3.13 Tables I & II sets out a calculation to determine the overall day time and night time noise levels resulting from this level of activity. The calculations include an allowance for freight train noise. These are pessimistically based on reference measurements of 20+ wagon stone trains running at approximately 60 mph on a straight section of the line, measured at a distance of 20m (equivalent to the survey positions here).

Location (1) Day Time L_{Aeq} 07.00 – 23.00 = 49.6 dB(A)
Night Time L_{Aeq} 2300 – 07.00 = 57.0 dB(A)

Location (2) Day Time L_{Aeq} 07.00 – 23.00 = 55.2 dB(A)
Night Time L_{Aeq} 2300 – 07.00 = 57.6 dB(A)

3.14 In addition to taking measurements at the two locations already stated, another Rion NL-31 sound level meter was set up 5m from the western boundary of the playing field to measure capture the ambient noise level (predominantly from road traffic) over the measurement period.

3.15 The equipment was set up to measure 5mins samples of the following acoustic parameters:

L_{Aeq} The A-weighted equivalent continuous sound pressure level which, over the sample period, contains the same acoustic energy as the time-varying signal being recorded.

L_{Amax} The A-weighted maximum sound pressure level recorded during each sample period (as measured on fast time response).

L_{A10} A statistical parameter representing the A-Weighted noise level exceeded for 10% of each sample period. This is commonly used to describe road traffic noise levels.

3.16 The sound level meter was set up on a tripod 1.5m from the ground in a free field position, and was calibrated before and after the survey.

3.17 The table below confirms the measured noise levels during each hour of the survey taken at this location:

Period	L_{Aeq} dB(A)	L_{Amax} dB(A)	L_{A10} dB(A)
10.30 – 11.30	57.0	77.1	56.3
11.30 – 12.30	57.4	77.8	55.0
12.30 – 13.30	57.0	76.3	54.8

3.18 The results equate to the following:

Day Time L_{Aeq} 07.00 – 23.00 = 52.5 dB(A)

Night Time L_{Aeq} 2300 – 07.00 = 45.2 dB(A)

3.19 It can be seen that these results are similar but lower than that calculated from the individual samples of train noise events, therefore it confirms that noise emanating from the railway is the dominant noise source for this site.

4. NOISE AND PLANNING

4.1. National Planning Policy Framework

4.1.1 The newly introduced National Planning Policy Framework (March 2012) defines the Government's planning policies for England and how these are expected to be applied. It sets out the Government's requirements for the planning system only to the extent that it is relevant, proportionate and necessary to do so. It provides a framework within which local people, and their answerable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities.

4.1.2 Section 123 states;

Planning policies and decisions should aim to:

- *avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;*
- *mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;*
- *recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established; and*
- *identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.*

4.1.3 The Framework states that the planning system should contribute to and enhance the natural and local environment by preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of noise pollution. It does not, however, provide any specific formal guidelines.

4.2 National Policy Statement for England

- 4.2.1 The document "Noise Policy Statement for England" sets out the following vision for on-going noise policy:

"Promote good health and quality of life through the effective management of noise within the context of Government policy on sustainable development."

- 4.2.2 This vision should be achieved through the following Noise Policy Aims:

"Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development: avoid significant adverse impacts on health and quality of life; mitigate and minimise adverse impacts on health and quality of life; and where possible, contribute to the improvement of health and quality of life".

- 4.2.3 To achieve these objectives the Noise Policy Statement sets out three noise levels to be defined by the assessor:

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.

SOAEL - Significant Observed Adverse Effect Level

This is the level above which significant adverse effects on health and quality of life occur.

- 4.2.4 The Noise Policy Statement considers that noise levels above the SOAEL would be seen to have, by definition, significant adverse effects and would be considered unacceptable. Where the assessed noise levels fall between the LOAEL and the SOAEL noise levels, the Policy Statement 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... .. This does not mean that such adverse effects cannot occur."

- 4.2.5 Where noise levels are below the LOAEL it is considered there will be no adverse effect. Once noise levels are below the NOEL there will be no observable change. Guidance as to a numerical definition of LOAEL is given by the following Standards.

4.3 BS8233:1999 – Sound Insulation and Noise Reduction for Buildings – Code of Practice

- 4.3.1 There is much guidance on the levels of intrusive noise which would be considered acceptable within a residential dwelling. Typical advice is found in British Standard 8233:1999 "Sound Insulation and Noise Reduction for buildings - Code of Practice" which sets out limits for indoor ambient noise levels within living rooms and bedrooms. This suggests:

Table VII - BS 8233 Guideline Values

	Room Type	Design Range, $L_{Aeq, t}$ dB	
		Good	Reasonable
Reasonable resting / sleeping conditions	Living Room	30	40
	Bedrooms*	30	35

*For a reasonable standard in bedrooms at night, individual noise events (measured with F time-weighting) should not normally exceed 45 dB L_{Amax} .

4.4 WHO 'Guidelines for Community Noise' (1999)

- 4.4.1 The World Health Organisation indicates that, to protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB L_{Aeq} for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB L_{Aeq} .

4.5 BS6472: 2008 "Guide to evaluation of human exposure to vibration in buildings"

- 4.5.1 This defines the Vibration Dose Value of a vibration event, a quantity which may be used to estimate the probability of adverse comment from human beings experiencing vibration in buildings.
- 4.5.2 The Standard advises that
- "In homes, adverse comment about building vibrations is likely when the vibration levels to which occupants are exposed are only slightly above thresholds of perception."
- 4.5.3 As an aside, it is noted that vibration can ultimately affect buildings, causing cracking or more significant damage. However, there is a major difference between the sensitivity of people when feeling vibration, and the onset of levels of vibration which would cause structural damage. It is a consequence therefore that vibration-induced damage is relatively rare, because building occupants will become disturbed by or annoyed with building vibration well before it is sufficiently large to cause damage to the structural elements.
- 4.5.4 The evaluation includes measurements of the frequency-weighted rms acceleration in each orthogonal axis (foot to head, back to front, side to side). The assessment of perceptibility of

vibration is made with respect to the highest weighted value determined in any axis at the point of contact, at any time.

- 4.5.5 BS6472 confirms that human perception does depend on the vibration frequency and direction. It therefore offers a series of frequency weightings which should be applied to vibration, so that the resulting overall levels can be interpreted in terms of perception, comfort or adverse comments. In this instance, the Standard advises that Wb frequency weighting should be applied to the z-axis (foot to head) component of vibration, and that the Wd frequency weighting should be applied to the x and y planes (back-to-chest and side-to-side, respectively). The range of frequencies usually associated with the effects of whole body vibration is between 0.5 Hz and 80 Hz.
- 4.5.6 The Vibration Dose Value may then be calculated as the product of the weighted rms acceleration and the duration of the event over a standard 16 hour day time period (0700 - 2300) or 8 hr night time period (2300 - 0700). Where there are a number of different events, of varying duration and vibration level, the Standard provides a means of combining the individual Dose Values to provide an overall VDV for the period.
- 4.5.7 BS6472 defines values of Vibration Dose Values above which various degrees of adverse comment may be expected in residential buildings. These values are confirmed below:

BS 6472 Guideline Values for VDV Exposure

Location	Low Probability of Adverse Comment	Adverse Comment Possible	Adverse Comment Probable
Residential Buildings, 16 hr day	0.2 - 0.4	0.4 - 0.8	0.8 - 1.6
Residential Buildings, 8 hr night	0.1 - 0.2	0.2 - 0.4	0.4 - 0.8

5. RECOMMENDATION FOR NOISE ATTENUATION MEASURES

- 5.1 From the guidelines in Section 4 of this report, it is recommended that the new buildings be designed to achieve the following levels internally:

Living Rooms:	35 dB(A) L_{Aeq} , 0700 – 2300
Bedrooms	30 dB(A) L_{Aeq} , 2300 – 0800, and also 45 dB(A) L_{Amax} , fast, 2300 – 0700

- 5.2 Considering first the facades of Plots 1 - 32 alongside the railway line, the table below defines the outside to inside sound level difference, dB(A), required through each façade. These figures are based initially on the targets of Para 5.1 and the measured noise levels given in Paras. 3.9 & 3.17
- 5.3 It is noted that the required level differences at night time are determined by the peak noise target, L_{Amax} .

PREDICTED NOISE LEVELS FOR PLOTS 1 - 32

Elevation	External Noise Level	Target Noise Level	Outside to inside level difference
North, East & West			
Living Rooms	58 dB L_{Aeq} , 16 hrs	35 dB(A) L_{Aeq} , 16hrs	23 dB(A)
Bedrooms	60 dB(A) L_{Aeq} , 8 hrs 83 dB(A) L_{Amax} ¹	30 dB(A) L_{Aeq} , 8hrs 45 dB(A) L_{Amax}	38 dB(A)
South			
Living Rooms	48 dB L_{Aeq} , 16 hrs	35 dB(A) L_{Aeq} , 16hrs	13 dB(A)
Bedrooms	50 dB(A) L_{Aeq} , 8 hrs 73 dB(A) L_{Amax}	30 dB(A) L_{Aeq} , 8hrs 45 dB(A) L_{Amax}	28 dB(A)

- 5.4 Appendix I & II provide calculations of external noise passing through the most sensitive facades of the development. It is confirmed that a standard cavity masonry external wall construction will suffice (external leaf in brick or rendered block, inner leaf in block or timber frame), as will a conventional roof construction (tile or slates on a pitched roof, thermal insulation laid over a single plasterboard ceiling).

¹ Peak noise levels from the stone freight trains were measured at 80 dB(A) in free-field conditions

5.5 For the glazing, the following options could therefore be considered:

RECOMMENDED GLAZING PERFORMANCE

Elevation	Acoustic Performance for Glazing	Possible Glazing Configuration ²
North, East & West		
Living Rooms	25 dB $R_w + C_{tr}$	4 / 16 / 4
Bedrooms	38 dB $R_w + C_{tr}$	10 / 12 / 8.8A
South		
Living Rooms	25 dB $R_w + C_{tr}$	4 / 16 / 4
Bedrooms	28 dB $R_w + C_{tr}$	4 / 16 / 6

5.6 For all of the remaining plots, the additional distance to the railway (approximately double the distance compared to Plots 1 - 32) and the screening provided by Plots 1 - 32 themselves, will reduce facade noise levels there at a minimum of 10 dB(A). Consequently, the maximum glazing requirement to any room would be:

28 dB $R_w + C_{tr}$ (4/16/6 configuration) to all bedrooms on north, east or west elevations;
25 dB $R_w + C_{tr}$ (4/16/6 configuration) to all other rooms on north, east or west elevations, and all rooms on the south elevations.

5.7 Whichever level of glazing is provided for the Plots 1 - 32, it is of course the case that when the windows are opened, the acoustic performance of the windows will be irrelevant. Subject to Local Authority requirements, it may therefore be necessary to provide alternative means by which habitable rooms may be ventilated whilst keeping the acoustic integrity of the façade. The options for achieving this include:

- (i) An acoustic trickle vent, such as the Passivent³ Acoustic Grille. This is a external grille which provides a reduction of up to 48 dB, and fits in conjunction with a standard internal trickle vent;
- (ii) A wall ventilation system, such as the Passivent Fresh 90 dB Wall Ventilator. An internal grill and external louvre linked by 150mm diameter duct, providing 300mm² - 6000mm² ventilation;
- (iii) A mechanical ventilation heat recovery (MVHR) unit. This draws fresh air from grills in the external elevation, through a central logistics unit before delivering to rooms across the dwelling. Exhaust air is taken from a set of room grills, back through the unit and then passed out of the building. The acoustic loss through this form of ventilation system will be in excess of 40 dB(A).

² To be confirmed by glazing supplier. Suggestions based on Saint Gobain technical data.

³ Passivent, by Willan Building Services 0161 962 7113

- 5.8 The ventilation requirements, and preferred method of ventilation, should first be determined by the Client (this may involve liaison with the Local Authority to determine any local standards which must be met). The details should then be passed to Acoustic Consultant for confirmation of appropriate means of attenuation.
- 5.9 As a minimum, it is recommended that these requirements be applied to all bedroom windows on the north, east or west elevations of Plots 1 - 32. Ideally, the treatment would be extended to all habitable rooms on those elevations.

External Amenity Space

- 5.10 The World Health Organisation indicates that, to protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB LAeq for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB LAeq.
- 5.11 It is noted that dwellings on the northern side of the site (adjacent to the railway) have gardens between the houses and boundary. The site survey indicates that these areas are likely to experience noise levels of some 55 - 60 dB(A).
- 5.12 In order to attenuate noise from the railway to a reasonable level in the gardens, it is therefore recommended that a 2m high boundary fence, running all along the north boundary of the site, be constructed as an acoustic fence. This should incorporate abutting panels not less than 22 mm thick, with joints sealed by cover strips not less than 22 mm thick, extending not less than 150mm over each adjacent panel.

6. SURVEY OF AMBIENT VIBRATION LEVELS

- 6.1 The second part of the ambient condition survey was to record ground vibration levels due to rail traffic.
- 6.2 Measurements were taken at the same two locations as before (see Figure 2).
- 6.3 An Endevco accelerometer, connected to Norsonic 118 sound level meter, was connected by magnet to a plate welded to a length of rolled steel angle which was driven into the ground to a minimum depth of approximately 600mm. The equipment was set to record the r.m.s. acceleration of each passing train.
- 6.4 Figures 3 & 4 details the typical average ground vibration levels based on individual measured train passages. It can be seen that the vibration is distributed across a range from 6.3 Hz to 40 Hz, with a notable concentration in the 16 Hz $1/3^{\text{rd}}$ octave band.
- 6.5 The assessment of these vibration levels is detailed in Section 7 of this report.

7. ASSESSMENT OF VIBRATION LEVELS

- 7.1 Guidance on the acceptability of vibration levels can be found in a number of sources. For continuous exposure to vibration, BS 6742 "Evaluation of Human Exposure to Vibration in Buildings (1 - 80 Hz)" provides limiting criteria for acceptable levels of vibration in different building types. Residential dwellings form one of the four categories.
- 7.2 In order to assess the measured vibration levels, it is necessary first to apply frequency weighting to the measured levels of acceleration. The weighted $1/3^{\text{rd}}$ octave band levels are then added together and this then allows a calculation of the 'estimated vibration dose value', eVDV, based on the number and duration of events across the standard day time (0700 – 2300) and night time (2300 – 0700) periods.
- 7.3 Appendices III & IV provide a full set of the vibration measurements, and the overall weighted rms accelerations. Taking the average value for each direction, it can be seen that the single event vibration level would typically be:

Train Type	Direction	Typical weighted rms acceleration m/s^2	
		Location 1	Location 2
South West	Northbound	0.0103	0.0175
	Southbound	0.0088	0.0173
Southern	Westbound	0.0103	0.0201
	Eastbound	0.0124	0.0122

- 7.4 The overall day time and night time vibration dose is determined by the magnitude of individual events, coupled with the number of events in each period.

- 7.5 As confirmed earlier, there are the following numbers of services during the day time (0700 – 2300) and night time (2300 – 0700) periods:

Train Service	Direction	Day Time	Night Time
South West	Northbound	49	6
	Southbound	52	9
Southern	Westbound	76	9
	Eastbound	75	11
Freight	Both	0	5

- 7.6 As indicated earlier, no freight trains were witnessed passing the site during the course of the attended survey. Reference is therefore made to measurements of the stone trains surveyed at a similar position. Being heavier and longer than the normal freight traffic which would use the line through Havant, this data will again provide a pessimistic prediction of the likely ground borne vibration.

- 7.6 Taking the measured vibration levels and the daily schedule, the total day time and night time Dose Value may be calculated as follows (refer to Tables III & IV):

Period	Location 1	Location 2
Day Time VDV	0.07 m/s ^{1.75}	0.11 m/s ^{1.75}
Night Time VDV	0.09 m/s ^{1.75}	0.09 m/s ^{1.75}

- 7.7 BS6472 defines values of Vibration Dose Values above which various degrees of adverse comment may be expected in residential buildings. These values are confirmed below:

Location	Low Probability of Adverse Comment	Adverse Comment Possible	Adverse Comment Probable
Residential Buildings 16hr Daytime	0.2 – 0.4	0.4 – 0.8	0.8 – 1.6
Residential Buildings 8hr Night-time	0.1 – 0.2	0.2 – 0.4	0.4 – 0.8

- 7.8 It can be seen from the tables above that the predicted values are at or below the limits of the category of a 'low probability of adverse comment' and the Standard states that comments would not therefore be expected.

- 7.9 It should be understood, however, that this assessment does not preclude the possibility of some perceptible vibration in the building as the train passes.

8. CONCLUSION

- 8.1 This assessment of noise and vibration has looked in detail at the proposed development of land at Warblington School, Havant. It has been shown that the site is subject to noise from the adjacent railway line.
- 8.2 However, it has been concluded that, by specifying appropriate glazing and by providing attenuated forms of ventilation to the most sensitive rooms, it will be quite possible to ensure that the internal environment within the building is well within normal design standards for such residential use.
- 8.3 Amenity areas can be adequately protected by the provision of a 2m high close boarded timber barrier running along the north boundary of the site.
- 8.4 Vibration levels have also been measured and it has been concluded that there is less than a low probability of adverse comment.

Table I – Calculation Of Period Noise Levels, Location 1

Day Time Period - 0700 - 2300

Train Service	Direction	Duration secs	LAeq dB(A)	LAe dB(A)	No. of Events	Combined LAe dB(A)
Southwest Trains	Northbound	14	55.5	67.0	49	83.9
	Southbound	25	58.2	72.2	52	89.3
	Westbound	12	64.3	75.1	76	93.9
Southern Rail	Eastbound	15	61.7	73.5	75	92.2
Freight	Both	40	78.4	94.4	0	0.0

Night Time Period - 2300 - 0700

Train Service	Direction	Duration secs	LAeq dB(A)	LAe dB(A)	No. of Events	Combined LAe dB(A)
Southwest Trains	Northbound	14	55.5	67.0	6	74.7
	Southbound	25	58.2	72.2	9	81.7
	Westbound	12	64.3	75.1	9	84.6
Southern Rail	Eastbound	15	61.7	73.5	11	83.9
Freight	Both	40	78.4	94.4	5	101.4

Table II – Calculation Of Period Noise Levels, Location 2

Day Time Period - 0700 - 2300

Train Service	Direction	Duration secs	L _{Aeq} dB(A)	L _{Ae} dB(A)	No. of Events	Combined L _{Ae} dB(A)
Southwest Trains	Northbound	15	64.8	76.6	49	93.5
	Southbound	18	69	81.6	52	98.7
Southern Rail	Westbound	14	64.7	76.2	76	95.0
	Eastbound	14	67.8	79.3	75	98.0
Freight	Both	40	78.4	94.4	0	0.0

Night Time Period - 2300 - 0700

Train Service	Direction	Duration secs	L _{Aeq} dB(A)	L _{Ae} dB(A)	No. of Events	Combined L _{Ae} dB(A)
Southwest Trains	Northbound	15	64.8	76.6	6	84.3
	Southbound	18	69	81.6	9	91.1
Southern Rail	Westbound	14	64.7	76.2	9	85.7
	Eastbound	14	67.8	79.3	11	89.7
Freight	Both	40	78.4	94.4	5	101.4

Table III – Calculation Of Vibration Levels, Location 1⁴

Train Service	Direction	Measured Acceleration (m/s ²) at 1/3rd Octave Centre Frequency (Hz)								
		6.3	8	10	12.5	16	20	25	31.5	40
South West Trains	Northbound	0.0023	0.0013	0.0018	0.0029	0.0096	0.0031	0.0033	0.0018	0.0006
	Southbound	0.0014	0.0014	0.0017	0.0030	0.0074	0.0045	0.0048	0.0027	0.00
Southern Rail	Westbound	0.0018	0.0014	0.0017	0.0047	0.0071	0.0049	0.0075	0.0039	0.0022
	Eastbound	0.0017	0.0013	0.0018	0.0039	0.0121	0.0058	0.0044	0.0029	0.0016

Train Services	Direction	Average weighted rms acceleration m/s ²	Average duration Secs	Day Time 0700	
				Est. no. of events	
South West Trains	Northbound	0.0062	12	49	
	Southbound	0.0054	12	52	
Southern Rail	Westbound	0.0063	12	76	
	Eastbound	0.0076	9	75	
Freight	Both	0.0170	32	0	
					Period Total

⁴ Ref Association of Noise Consultants publication, "Measurement & Assessment of Ground borne Noise and Vibration"

Table IV – Calculation Of Vibration Levels, Location 2

Train Service	Direction	Measured Acceleration (m/s ²) at 1/3rd Octave Centre Frequency (Hz)								
		6.3	8	10	12.5	16	20	25	31.5	40
South West Trains	Northbound	0.0025	0.0025	0.0031	0.0042	0.0145	0.0080	0.0088	0.0093	0.0032
	Southbound	0.0023	0.0023	0.0027	0.0047	0.0131	0.0090	0.0128	0.0096	0.0043
Southern Rail	Westbound	0.0029	0.0021	0.0037	0.0053	0.0154	0.0104	0.0137	0.0133	0.0052
	Eastbound	0.0027	0.0020	0.0025	0.0040	0.0117	0.0060	0.0081	0.0064	0.0036

Train Services	Direction	Average weighted rms acceleration m/s ²	Average duration Secs	Day Time 0700	
				Est. no. of events	
South West Trains	Northbound	0.0101	14	49	
	Southbound	0.0102	9	52	
Southern Rail	Westbound	0.0119	13	76	
	Eastbound	0.0085	12	75	
Freight	Both	0.0170	32	0	
				Period Total	

Figure 1 - Site Layout

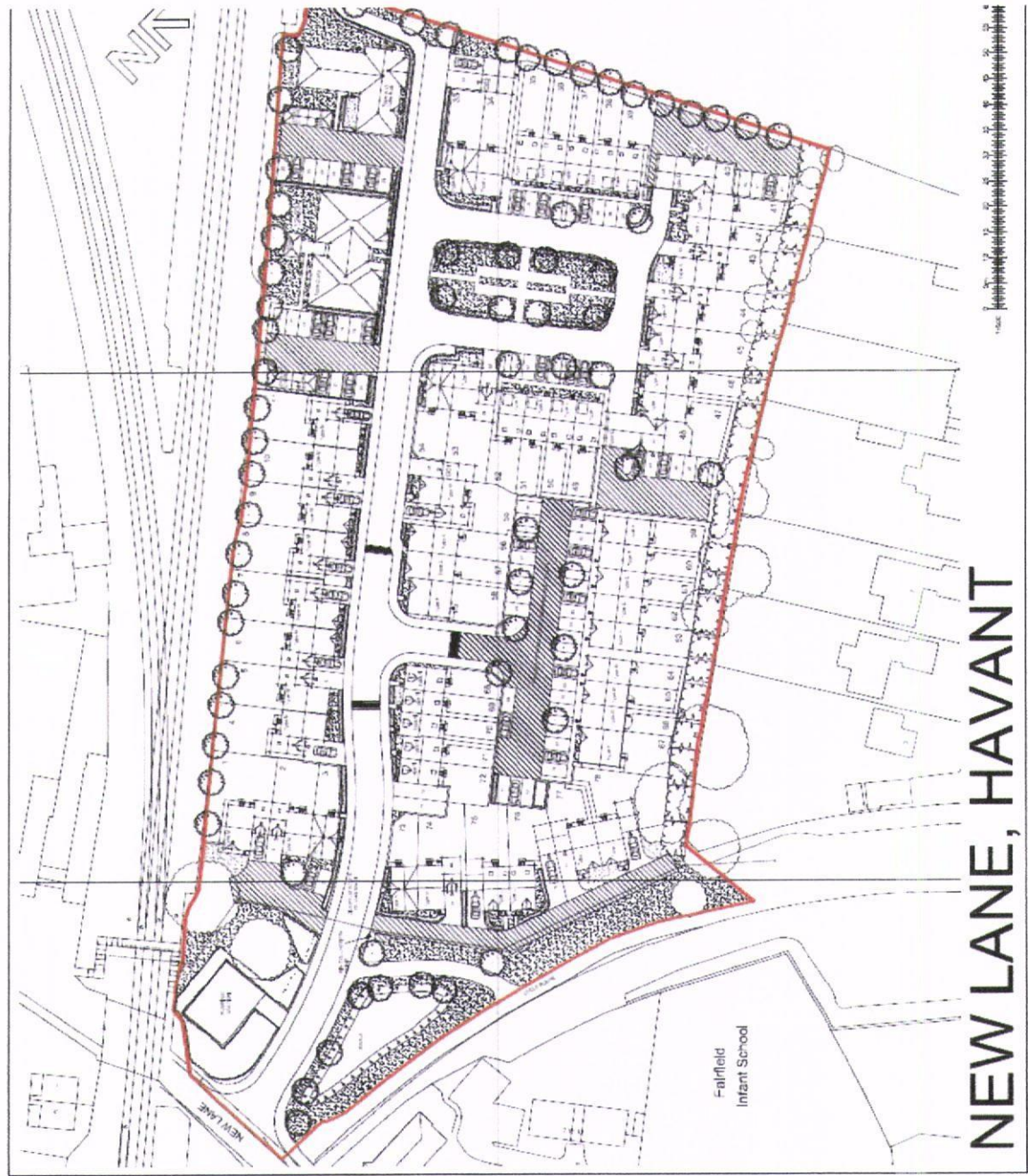


Figure 2 - Measurement locations



Figure 3 - Average Weighted Rms Acceleration For Each Train Type Measured At Location 1

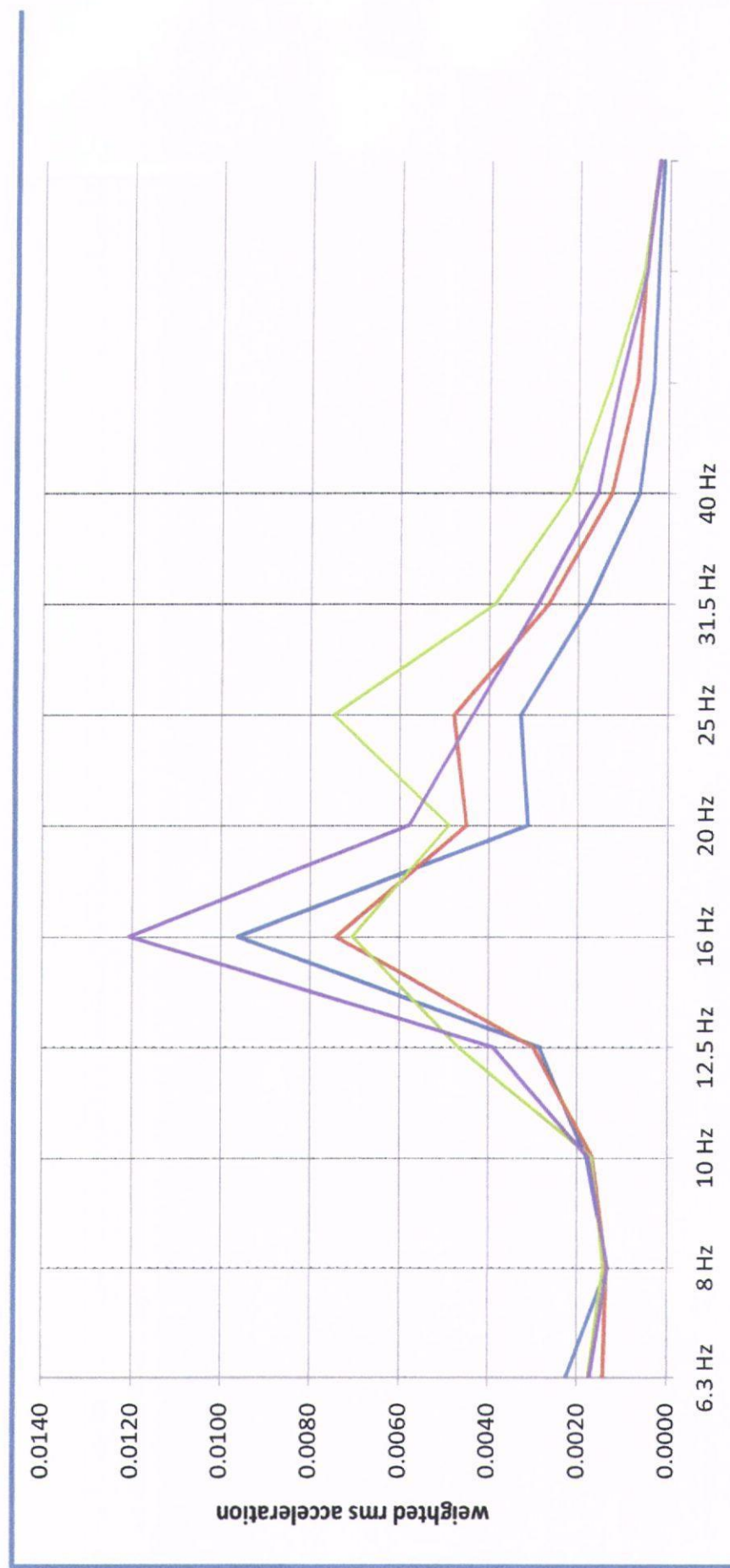
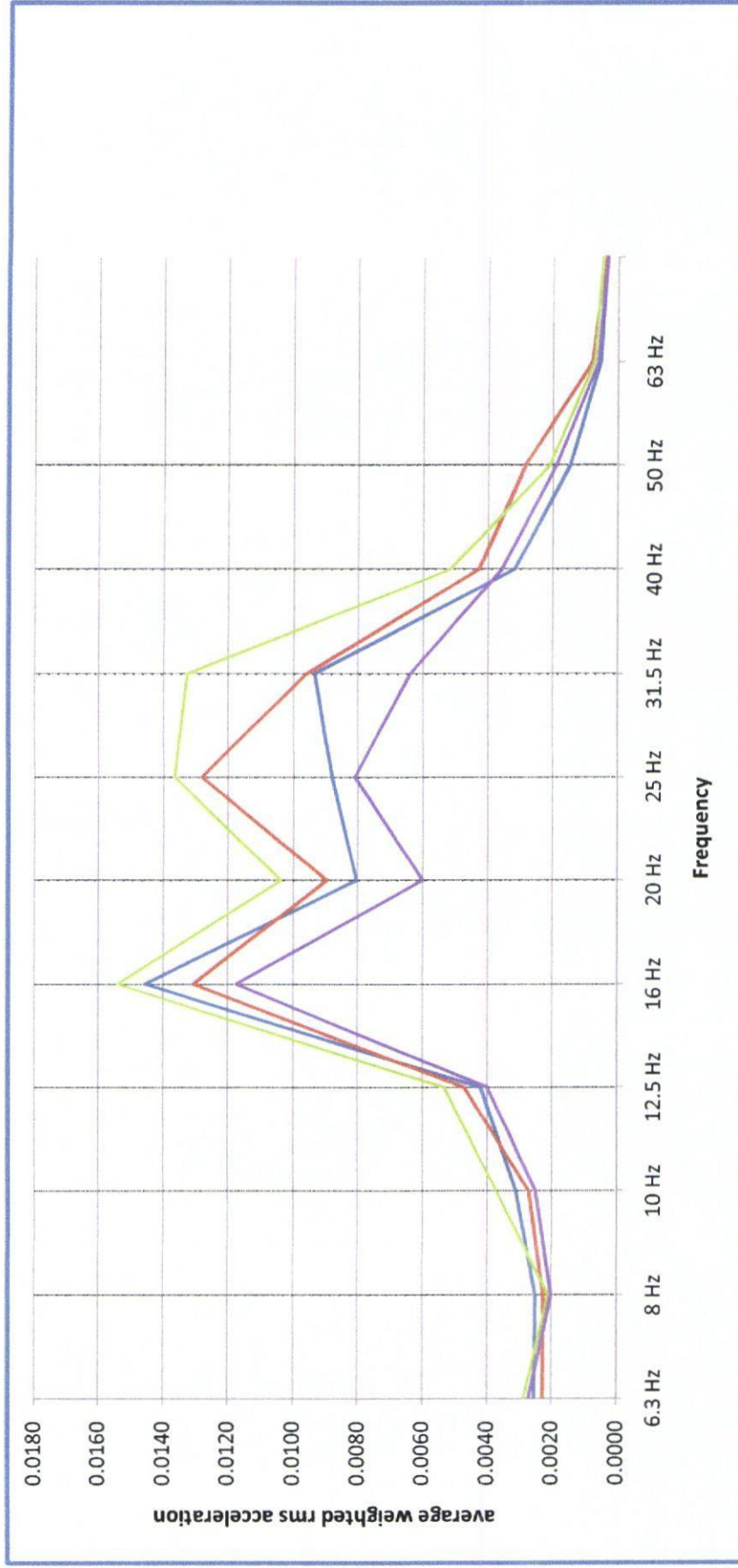


Figure 4 - Average Weighted Rms Acceleration For Each Train Type Measured At Location 2



Appendix I: Predicted Transmission into North Facing Bedrooms, Plots 1 - 32, due to Night Time Stone Trains (Peak Level)

Frequency	Hz	63	125	250	500	1000	2000
External Noise Level Lmax	dB	83	80	75	77	77	75
SRI Glazing Specified (10/12/8.8)	dB	25	31	32	39	45	50
Area of Window	m2	3	3	3	3	3	3
Area Correction	dB	5	5	5	5	5	5
Likely RT in Bedroom	secs	0.8	0.7	0.6	0.5	0.4	0.3
Typical Room Volume	m3	25	25	25	25	25	25
Absorption	m2	5	6	7	8	10	13
Absorption Correction	dB	-7	-8	-8	-9	-10	-11
Net SPL Inside	dB	56	46	40	34	27	18
SRI Brickwork Walls	dB	43	45	44	51	59	67
Area of Wall	m2	15	15	15	15	15	15
Area Correction	dB	12	12	12	12	12	12
Likely RT in Bedroom	secs	0.8	0.7	0.6	0.5	0.4	0.3
Typical Room Volume	m3	25	25	25	25	25	25
Absorption	m2	5	6	7	8	10	13
Absorption Correction	dB	-7	-8	-8	-9	-10	-11
Net SPL Inside	dB	45	39	34	29	20	8
SRI Roof	dB	21	30	36	40	44	42
Area of Ceiling	m2	10	10	10	10	10	10
Area Correction	dB	10	10	10	10	10	10
Likely RT in Bedroom	secs	0.8	0.7	0.6	0.5	0.4	0.3
Typical Room Volume	m3	25	25	25	25	25	25
Absorption	m2	5	6	7	8	10	13
Absorption Correction	dB	-7	-8	-8	-9	-10	-11
Net SPL Inside	dB	65	52	41	38	33	32
TOTAL SPL INSIDE, Lmax	dB	66	53	44	40	34	32

Appendix II: Predicted Transmission into North Facing Living Rooms, Plots 1 - 32, due to Day Time Rail Traffic Noise

Frequency	Hz	63	125	250	500	1000	2000
External Noise Level LAeq	dB	49	46	43	47	55	53
SRI Glazing Specified (4 / 16 / 6)	dB	21	21	18	26	37	42
Area of Window	m2	3	3	3	3	3	3
Area Correction	dB	5	5	5	5	5	5
Likely RT in Bedroom	secs	0.8	0.7	0.6	0.5	0.4	0.3
Typical Room Volume	m3	25	25	25	25	25	25
Absorption	m2	5	6	7	8	10	13
Absorption Correction	dB	-7	-8	-8	-9	-10	-11
Net SPL Inside	dB	26	22	22	17	13	4
SRI Brickwork Walls	dB	43	45	44	51	59	67
Area of Wall	m2	15	15	15	15	15	15
Area Correction	dB	12	12	12	12	12	12
Likely RT in Bedroom	secs	0.8	0.7	0.6	0.5	0.4	0.3
Typical Room Volume	m3	25	25	25	25	25	25
Absorption	m2	5	6	7	8	10	13
Absorption Correction	dB	-7	-8	-8	-9	-10	-11
Net SPL Inside	dB	11	5	2	-1	-2	-14
TOTAL SPL INSIDE	dB	26	22	22	17	13	5

Appendix III: Vibration Survey Results at Location 1

Train Service	Direction	Duratn (secs)	Frequency (Hz)								
			6.3	8.0	10	12.5	16	20	25	31.5	40
Southern	West	11	0.0019	0.0013	0.0021	0.0038	0.0115	0.0091	0.0133	0.0123	0.0107
SouthWest	North	11	0.0023	0.0014	0.0019	0.0040	0.0116	0.0039	0.0047	0.0023	0.00
SouthWest	South	10	0.0014	0.0012	0.0016	0.0031	0.0089	0.0062	0.0083	0.0058	0.0028
Southern	East	9	0.0015	0.0011	0.0015	0.0044	0.0095	0.0072	0.0090	0.0051	0.0036
Southern	West	9	0.0014	0.0013	0.0017	0.0062	0.0086	0.0093	0.0119	0.0077	0.0058
Southern	East	9	0.0015	0.0011	0.0021	0.0050	0.0204	0.0101	0.0099	0.0054	0.0049
SouthWest	North	12	0.0023	0.0011	0.0019	0.0033	0.0257	0.0066	0.0052	0.0034	0.0015
Southern	West	7	0.0023	0.0013	0.0017	0.0046	0.0056	0.0055	0.0102	0.0054	0.0035
Southern	East	9	0.0017	0.0014	0.0013	0.0045	0.0107	0.0098	0.0098	0.0082	0.0042
SouthWest	South	12	0.0011	0.0012	0.0016	0.0033	0.0095	0.0066	0.0072	0.0045	0.0029
Southern	East	15	0.0018	0.0014	0.0021	0.0056	0.0202	0.0078	0.0064	0.0063	0.0027
Southern	West	8	0.0014	0.0014	0.0017	0.0065	0.0072	0.0058	0.0172	0.0132	0.0145
SouthWest	South	13	0.0015	0.0014	0.0020	0.0034	0.0094	0.0065	0.0102	0.0099	0.0045
Southern	East	14	0.0015	0.0014	0.0023	0.0034	0.0135	0.0069	0.0048	0.0053	0.0053
Southern	West	10	0.0013	0.0012	0.0013	0.0042	0.0062	0.0048	0.0100	0.0058	0.0037
SouthWest	North	12	0.0017	0.0012	0.0013	0.0021	0.0035	0.0023	0.0044	0.0027	0.0014
Southern	West	8	0.0014	0.0013	0.0016	0.0047	0.0068	0.0059	0.0101	0.0043	0.0029
SouthWest	North	13	0.0024	0.0015	0.0024	0.0035	0.0186	0.0064	0.0084	0.0085	0.0019
Southern	West	9	0.0021	0.0018	0.0020	0.0072	0.0216	0.0097	0.0172	0.0115	0.0043
Southern	East	13	0.0018	0.0013	0.0018	0.0033	0.0186	0.0078	0.0057	0.0057	0.0039
SouthWest	South	11	0.0014	0.0014	0.0017	0.0034	0.0086	0.0062	0.0068	0.0035	0.0029

Appendix IV: Vibration Survey Results at Location 2

Train Service	Direction	Duratn (secs)	Frequency (Hz)							
			6.3	8.0	10	12.5	16	20	25	31.5
South West	North	15	0.0035	0.0030	0.0038	0.0037	0.0081	0.0079	0.0126	0.0129
Southern	West	11	0.0039	0.0021	0.0039	0.0040	0.0106	0.0061	0.0138	0.0158
Southern	East	12	0.0042	0.0019	0.0029	0.0039	0.0155	0.0062	0.0087	0.0089
South West	South	10	0.0021	0.0027	0.0032	0.0067	0.0232	0.0200	0.0292	0.0331
Southern	West	21	0.0025	0.0027	0.0047	0.0075	0.0214	0.0327	0.0513	0.0473
Southern	East	10	0.0030	0.0025	0.0027	0.0050	0.0160	0.0127	0.0135	0.0127
South West	North	9	0.0021	0.0032	0.0045	0.0068	0.0327	0.0221	0.0176	0.0363
South West	North	12	0.0013	0.0018	0.0023	0.0029	0.0111	0.0068	0.0135	0.0110
Southern	East	9	0.0020	0.0018	0.0023	0.0040	0.0094	0.0079	0.0174	0.0141
Southern	West	11	0.0025	0.0015	0.0036	0.0062	0.0320	0.0170	0.0158	0.0403
South West	South	8	0.0019	0.0019	0.0023	0.0049	0.0122	0.0089	0.0248	0.0209
Southern	East	26	0.0013	0.0017	0.0021	0.0048	0.0191	0.0098	0.0126	0.0126
South West	North	8	0.0030	0.0021	0.0036	0.0067	0.0355	0.0170	0.0191	0.0422
Southern	West	9	0.0015	0.0013	0.0026	0.0037	0.0089	0.0072	0.0136	0.0145
South West	South	10	0.0025	0.0021	0.0030	0.0043	0.0146	0.0114	0.0136	0.0108
South West	North	28	0.0029	0.0024	0.0024	0.0045	0.0174	0.0094	0.0122	0.0116
Southern	East	7	0.0034	0.0020	0.0030	0.0045	0.0140	0.0072	0.0178	0.0186
Southern	West	8	0.0044	0.0035	0.0047	0.0104	0.0376	0.0272	0.0407	0.0331
										0.0178