Proposed Residential Development
Langwathby, Cumbria

Noise Assessment Report

Story Homes

September 2013

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Ref: 053/2013

Authorised for and on behalf RS Acoustic Engineering Ltd
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Director

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Executive Summary

A baseline noise survey over a 24-hour period has been undertaken to determine the noise levels from passing trains and local road traffic.

On the basis of the noise survey and assessment results, the proposed site is considered to be suitable for residential development, subject to the incorporation of the mitigation measures outlined in this report.

With regard to the building envelope performance requirements, using traditional masonry wall constructions, standard double glazing configurations and traditional tiled roof constructions should ensure that the BS8233 ‘good’ noise targets are achieved with windows closed.

With windows partially open, the ‘reasonable’ noise targets will be achieved within first floor bedrooms at a separation distance of approximately 15 metres from the eastern boundary line.

If windows to bedrooms are within 15 metres of the eastern boundary line and directly face the railway tracks, acoustic mitigation is required to ensure that the appropriate internal noise targets are achieved. This may be in the form of PIV units or acoustically rated ventilator units

The noise targets will be satisfied within habitable rooms where open windows face in the opposite direction (facing west) to the railway tracks.

The recommended external noise target will be satisfied within garden areas to new dwellings at a distance of greater than 5 metres from the eastern boundary line.

The predicted vibration dose values that are likely to occur at first floor level (bedrooms) suggest that there is a low probability of adverse comment.

1. Introduction

1.1 RS Acoustic Engineering Ltd has been appointed by Story Homes to undertake a noise and vibration assessment in relation to a proposed residential development off Salkeld Road, Langwathby.

1.2 A noise assessment has been undertaken with reference to BS8233:1999 '*Sound insulation and noise reduction for buildings – code of practice*' and the World Health Organisation document '*Guidelines for community noise*'.

1.3 This assessment is based on the results of an environmental noise survey undertaken at the site by RS Acoustic Engineering Ltd. The noise survey was undertaken over 24-hours to establish the prevailing ambient noise climate during daytime and night-time periods.

1.4 A vibration assessment has also been undertaken with reference to BS6472-1: 2008: Guide to e*valuation of human exposure to vibration in buildings (0.5 Hz to 80 Hz)*.

1.5 The measured noise data has been used to determine the acoustic performance required from building envelope constructions and to determine whether it is suitable to naturally ventilate new dwellings via opening windows.

1.6 This report presents the results of the noise survey, assessment criteria and a discussion of the results with respect to the appropriate targets. Recommendations regarding sound insulation, property ventilation and mitigation are also provided.

2. Assessment Criteria & Guidance

National Planning Policy Framework (March 2012)

2.1 The National Planning Policy Framework (NPPF) was published on the 27th March 2012 with immediate effect. The NPPF revokes and replaces a number of Planning Policy Statements and Planning Policy Guidance documents, including the following regarding noise:

- Planning Policy Guidance Note 24: *Planning and Noise* (published 1994)

2.2 The following text contained within the NPPF refers specifically to noise:

Conserving and enhancing the natural environment

2.3 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.

2.4 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
- 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.

British Standard 8233:1999: Sound Insulation and Noise Reduction for Buildings – Code of Practice

2.5 The scope of BS8233 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 buildings or refurbished buildings undergoing a change of use, rather than to assess the effect of changes in the external noise climate.

2.6 The standard suggests appropriate internal noise levels within different types of buildings including dwellings, and for reference these are repeated in Table 2.1:

Table 2.1 – Recommended Internal Noise Levels for Dwellings

Room Type	Design Range $L_{Aeq,T}$ dB	
	Good	Reasonable
Living Rooms	30	40
Bedrooms	30	35

2.7 It is also stated that for a reasonable standard in bedrooms at night, individual noise events should not normally exceed 45 dB $L_{Amax,fast}$.

2.8 The main factors affecting whether these internal target noise levels can be achieved are the levels of noise outside the building and the sound insulation of the building envelope (windows, roof, walls and ventilation systems).

2.9 With regards to outdoor living areas, BS8233 recommends that:

"In gardens and balconies etc, it is desirable that the steady state noise level does not exceed 50 dB $L_{Aeq,T}$ and 55 dB $L_{Aeq,T}$ should be regarded as the upper limit".

World Health Organisation (WHO) 1999: Guidelines for Community Noise

2.10 This document provides guideline values for avoidance of particular negative health effects e.g. annoyance and sleep disturbance.

2.11 To avoid serious annoyance during the daytime and evening period, the guidelines recommend that the noise level within outdoor living areas (gardens) does not exceed 55 dB L_{Aeq} when measured over a 16-hour period.

2.12 The internal noise targets recommended by BS8233 are also closely corroborated by the document entitled *Guidelines for Community Noise* that was published by the World Health Organisation (WHO) in 1999. However, where BS8233 states that the L_{AFmax} should not normally be exceeded, the WHO guidelines state the following:

"For 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".

British Standard 6472-1:2008: Guidelines to Evaluation of Human Exposure to Vibration in Buildings (Part 1)

2.13 BS6472 contains guidance relating to human response to vibration, and uses the 'vibration dose value' that an occupant would receive over the course of a 16 hour day or 8 hour night-time period. The vibration dose value provides a means of specifying the time-varying, frequency-dependent vibration level of a given duration as a single number.

2.14 In terms of the vibration dose value over a 16 hour daytime period or 8 hour night-time period, the guidance in BS6472 is set out in Table 2.2.

Table 2.2 – Vibration dose value ranges ($ms^{-1.75}$) which might result in various probabilities of adverse comment within residential buildings

Place and Time	Low probability of adverse comment(1)	Adverse comment possible	Adverse comment probable(2)
Residential buildings 16h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Note: (1) Below these ranges adverse comments is not expected. (2) Above these ranges adverse comment is very likely.

2.15 Below a VDV of 0.2 $ms^{-1.75}$ for a 16 hour day and a VDV of 0.1 $ms^{-1.75}$ for an 8 hour night-time, adverse comment is considered unlikely.

2.16 The above guidance relates to vibration measured at the point of entry into the human body, which is usually taken to mean the ground surface or at a point mid-span of an upper storey floor, rather than the point of entry into the building (a foundation element).

British Standard 4142:1997: Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas

2.17 BS4142 may be used to assess whether noise from factories, industrial premises or fixed installations and sources of an industrial nature in commercial premises, when measured outside of a building, is likely to give rise to complaints from people residing within neighbouring dwellings. However, no consideration is given to the sound insulation performance of the building façade or the resulting internal noise levels within the dwellings affected.

2.18 The prevailing noise climate at the site is due to road and rail traffic which is the dominant noise source during the daytime and night-time period. During the survey, no industrial or commercial noise sources (e.g. fixed building services plant and/or machinery) were noted to impact on the site and therefore no further consideration will be given to this standard or its application.

3. Environmental Noise Survey

Survey Methodology

3.1 An environmental noise survey has been undertaken by RS Acoustic Engineering Ltd to establish the prevailing ambient noise climate at the site during both daytime and night-time periods.

3.2 Continuous noise monitoring was conducted over a 24-hour period at the sites eastern boundary line in close proximity to the Settle to Carlisle railway tracks. Measurements were performed from 14:05 hours on Tuesday 3rd through to 14:05 hours on Wednesday 4th September 2013.

3.3 At the measurement position, the microphone was fixed at a height of approximately 1.5 metres from the ground and approximately 10 metres from the nearside railway track.

3.4 The noise monitoring position was deemed the most secure location at the site and was considered to be representative of the highest (worst-case) noise levels impacting on the site. Since the sound level meter was installed at an elevated position, the microphone had both a direct line of sight to the railway tracks and also the local road network.

3.5 A measurement interval of 15 minutes was used and measurements were considered to be subject to free-field conditions. 1/3rd octave band and A-weighted broadband sound pressure levels were recorded throughout the survey.

3.6 The measurement position used during the survey is shown in Appendix A.

Survey Equipment

3.7 The noise survey was carried out using the following type 1 specification noise measurement equipment:

- Brüel & Kjaer 2250-Light data logging sound level meter, with microphone type 4189 and pre-amplifier type ZC0032.
- Cirrus CR:515 Class 1 Sound Calibrator.

3.8 Calibration of the sound level meter and microphone used for the measurements are traceable to UKAS accredited laboratories (certificate number 00798/1). The calibration of both sound level meter and microphone was checked using a 1 kHz tone at 94 dB prior to and following the measurements performed. No drift in calibration was observed.

Weather Conditions

3.9 The weather conditions during the survey were dry, warm and sunny, with an occasional light breeze. Wind speeds were considered to be negligible during the survey and typically ranged between 0 – 2 m/s. The overall weather conditions were suitable to obtain representative measurements.

Measured Noise Indices / Parameters

3.10 Although a wide range of statistical noise data was recorded, the L_{Aeq} and L_{Amax} indices are of most interest here:

- $L_{Aeq,T}$ - The A-weighted equivalent continuous sound pressure level over a period of time, T. Representative of the 'average' sound pressure level over a given period.
- $L_{Amax,T}$ - The A-weighted 'maximum' sound pressure level that occurred during a given period, T and is sometimes used for the assessment of occasional loud noises. Measurements are normally made with a 'fast' time-weighting although a 'slow' time weighting may be used where appropriate.
- $L_{A90,T}$ - The noise level that is exceeded for 90% of the measurement time interval, T. L_{A90} is often used to describe the 'background' noise level.

3.11 Sound pressure level measurements are normally taken with an A-weighting (denoted by a subscript 'A', e.g. L_{Aeq}) to approximate the frequency response of the human ear.

Survey Observations

3.12 The dominant noise source contributing to the existing ambient noise climate at the site was noted to be distant traffic flow on the A686 (Eden Straits) and passing trains. Distant traffic noise is more consistent and sets the general background noise level, whereas passing trains create the peak in ambient noise levels typically prevailing at the site.

3.13 Intermittent traffic flow on the wider local road network (i.e. Salkeld Road and Back Lane) also contributes to the existing noise climate, but to a much lesser degree than the above.

3.14 During the survey, no disruptions in traffic flow (due to road works etc) along the local road network were observed and therefore traffic flow was considered typical.

3.15 There are currently 12 Northern Rail passenger trains passing the site during the daytime period (6 trains in each direction). Passenger trains were noted to be typically two to four carriages in length and passed the site at a relatively slow-moderate speed. A review of the survey data and current train-timetables show that the first passenger train typically passes the site at just after 06:00 hours and the last passenger train passes the site at just after 20:20 hours.

3.16 A number of freight trains also pass the site at slow-moderate speed throughout the course of a 24-hour period. During the survey, approximately 9 freight trains passed the site with the majority occurring during the daytime period.

3.17 Noise from passing trains is notably reduced with increased distance towards the western boundary line (towards Salkeld Road) since the tracks are located down an embankment (within a cutting) and therefore the direct line of sight is obscured (acoustic screening occurs at the receptor location).

3.18 Intermittent tractor noise from distant fields was just audible at the site boundary during the daytime site visits.

3.19 During the daytime and night-time site visits, there was no audible noise of an industrial nature impacting on the site (e.g. fixed building services plant, fixed machinery and equipment).

3.20 Other noted sources include intermittent high altitude aircraft and domestic activity from neighbouring dwellings. The noise levels from these sources were considered to contribute little to the overall measured noise climate at the site.

Results Summary

3.21 Table 3.1 presents a summary of the measured noise levels at the continuous monitoring position.

3.22 Additional measurement data is presented in Appendix B and a full comprehensive dataset (e.g. 1/3rd octave band frequency spectra) can be made available on request.

Table 3.1 – Summary of Measured Noise Levels

Position	Period	Duration, T	$L_{Aeq,T}$ dB	$L_{A90,T}$ dB	Typical $L_{AFmax,T}$[1] dB
Boundary line, adjacent to railway tracks	Daytime (07:00-23:00)	16 hours	56.5	38.5	---
	Night-time (23:00-07:00)	8 hours	55.8	29.6	50.4

[1] L_{AFmax} noise levels taken as the 10th loudest maximum level during the night-time period, in accordance with WHO guidelines.

4. Assessment & Mitigation

Internal Noise Level Targets & Sound Insulation Requirements

4.1 In order to assess the noise mitigation measures required to ensure an adequate level of protection against rail and road traffic noise, it is considered appropriate to explore in the first instance the acoustic attenuation that can be provided by the building envelope constructions and associated elements. This has been undertaken taking into account the guidance within BS8233.

4.2 It is assumed that the proposed dwellings will be of a traditional masonry construction and it is therefore anticipated that the glazed units (windows) will be the acoustically weak element with regard to the sound reduction performance of the façade.

4.3 With regard to windows to habitable rooms being closed, it is considered appropriate to determine the sound insulation performance requirements on the basis of meeting the 'good' design targets given within BS8233 (which are more onerous to achieve than the 'reasonable' design targets).

4.4 Table 4.1 presents the measured noise levels, the 'good' internal noise targets given within BS8233 and the sound insulation performance required to achieve the relevant targets.

Table 4.1 – Internal Noise Level Targets and Sound Insulation Requirements for New Dwellings

Façade Location	Period	External Noise Level (dB)	BS8233 'Good' Internal Noise Target L_{Aeq} (dB)	Required Sound Insulation Performance (dB R_w+C_{tr})
At the boundary line, approximately 10 metres from the railway track	Daytime $L_{Aeq,16h}$	57	30 (Living Rooms)	27
	Night-time $L_{Aeq,8h}$	56	30 (Bedrooms)	26
	Typical $L_{AFmax,T}$	50	45 (Bedrooms)	5

4.5 The results in Table 4.1 indicate that a sound insulation performance of at least **27 dB $R_{w+}C_{tr}$** is required from the building envelope construction and associated elements to achieve the appropriate noise targets.

4.6 This assessment assumes that the façade line/elevation is located at the site boundary and there is a clear direct line of sight between the noise source (i.e. passing train) and the receptor location (e.g. 1st floor bedroom windows). This is therefore considered to be a worst-case scenario.

4.7 Façade noise levels and therefore sound insulation requirements will be reduced with increased distance from the noise source and also where acoustic screening is provided (e.g. by other dwellings or where a façade is orientated away from the noise source).

4.8 A sound insulation performance of 27 dB $R_{w+}C_{tr}$ can be easily achieved by traditional masonry wall constructions (brickwork/blockwork), standard double glazing and traditional pitched slate/tile roof constructions with an internal plasterboard ceiling.

4.9 Traditional masonry wall constructions typically provide a sound insulation performance in the region 40 – 55 dB $R_{w+}C_{tr}$ whereas pitched tiled roof constructions with an internal plasterboard ceiling and mineral wool insulation will provide a sound insulation performance in the region 37 - 45 dB $R_{w+}C_{tr}$.

4.10 Double glazing with a configuration comprising 4 – 6 mm glass/ 12 – 20 mm cavity / 4 – 6 mm glass typically provides a sound insulation performance in the region **27 – 28 dB $R_{w+}C_{tr}$**.

4.11 There are alternative constructions and configurations that will achieve the required minimum acoustic rating and therefore the acoustic performance of the unit should always be verified with the manufacturer/supplier prior to procurement.

4.12 To achieve the optimum performance, external windows should be well sealed around the frame when installed. Large gaps between the frame and the adjacent masonry/brickwork and poorly sealed frames will lead to high frequency acoustic weaknesses (from external noise), which will in turn reduce the overall acoustic performance of the façade.

Internal Noise Levels with Open Windows

4.13 Table 4.2 provides an early indication of the likely internal noise levels within habitable rooms when windows are partially open to provide rapid ventilation and summer cooling. For this assessment, it is considered reasonable to assume an acoustic performance of up to 15 dBA for a partially open window (as given in Table 10 of BS8233).

4.14 The internal noise levels given within Table 4.2 assume that windows to habitable rooms are located at the site boundary line (as per the monitoring position) and are directly facing the railway tracks. This is considered to be a worst-case scenario.

Table 4.2 – Internal Noise Levels with Windows Partially Open - New Dwellings adjacent to Railway

Façade Location	Period	External Noise Level (dB)	Sound Attenuation, Window Open (dB)	Indicative Internal Noise Level (dB)
At the boundary line, approximately 10 metres from the railway track (direct line of sight)	Daytime $L_{Aeq,16h}$	57	15	42
	Night-time $L_{Aeq,8h}$	56	15	41
	Typical $L_{AFmax,T}$	50	15	35

4.15 The results in Table 4.2 show that for façades/elevations positioned directly along the eastern boundary line, the recommended 'reasonable' ambient (L_{Aeq}) noise targets given within BS8233 would be exceeded within habitable rooms with windows open.

4.16 The night-time L_{AFmax} target (45 dB) will be satisfied for the majority of the night-time period.

Noise Mitigation Options for External Elevations

4.17 No further acoustic mitigation is deemed necessary with regard to the building envelope sound insulation performance with windows closed to habitable rooms (so long as a glazing performance of at least 27 dB $R_{w+}C_{tr}$ is achieved).

4.18 For façades/elevations located directly along the eastern boundary line, the 'reasonable' internal noise level targets will be exceeded within habitable rooms when windows are open to provide rapid ventilation and summer cooling. Therefore appropriate mitigation is required to reduce noise ingress to appropriate levels.

Increasing the Separation / Stand-off Distance of New Dwellings

4.19 Calculations have been undertaken to determine the level of noise attenuation achievable due to increased distance separation and also due to acoustic screening where the line of sight is reduced/obscured between the source and receiver. The level of acoustic screening will gradually increase with greater separation distances, since the rail tracks are located down an embankment (within a cutting).

4.20 The barrier calculations take into the account the frequency spectrum of the noise source, separation distance (to the middle of the railway tracks), estimated embankment height and also receptor height. A receptor height of 5 metres has been assumed in order to represent first floor bedroom windows.

4.21 For a separation distance of around **10 metres** from the eastern boundary line (approximately 20 metres from the railway track), noise attenuation in the region **4 dB** is achievable. Approximately 3 dB of attenuation is achieved through distance separation and approximately 1 dB through acoustic screening.

- 10 log (10m/20m) = - 3dB

4.22 Little screening attenuation is achieved at this distance since the line of sight is still significant between the source and receiver (bedroom window). In this instance, the 'reasonable' BS8233 noise targets would still be exceeded within first floor bedrooms.

4.23 For a separation distance of around **15 metres** from the eastern boundary line, noise attenuation in the region **10 dB** is achievable. Approximately 4 dB of attenuation is achieved through distance separation and approximately 6 dB through acoustic screening (see Table 4.3).

- 10 log (10m/25m) = - 4dB

4.24 Table 4.3 provides a summary of the barrier calculation results for a receptor height of 5 metres (i.e. first floor bedroom window) and a separation distance of 15 metres from the existing boundary line. Further calculation details are provided in Appendix C.

Table 4.3 – Attenuation due to Screening for a Receptor Height of 5 metres (Bedroom Window)

Frequency (Hz)	Sum	63	125	250	500	1000	2000	4000	8000
Source level (dB)	60.0	55.4	48.4	46.2	53.5	54.5	44.9	39.2	31.5
A-weighting (dB)		-26.2	-16.2	-8.7	-3.2	0.0	1.2	1.0	-1.1
A-weighted source level (dB)	56.5	29.2	32.2	37.6	50.3	54.5	46.1	40.2	30.4
Barrier attenuation (dB)		**5.4**	**5.6**	**5.8**	**6.1**	**6.5**	**7.1**	**7.9**	**9.0**
Attenuated level (dB)	50.0	23.8	26.6	31.8	44.2	48.0	39.0	32.3	21.4
Attenuation (dBA)	**6.5**								

4.25 The results of the calculations indicate that the 'reasonable' BS8233 noise targets will be achieved within first floor bedrooms at a separation distance of approximately **15 metres** from the eastern boundary line (with windows partially open).

Windows to Habitable Rooms Orientated Away from the Noise Source

4.26 For façades facing away from the railway tracks (facing west), noise attenuation in the order 10 – 15 dBA will be achieved at windows to habitable rooms since they will be acoustically screened from the noise source by the dwellings themselves once constructed. In these instances, the 'reasonable' noise targets will be satisfied within habitable rooms.

4.27 Side elevations to properties may only have windows to circulation spaces (hall, stairs and landing) and non-habitable rooms and in these instances do not require any further noise mitigation.

Positive Input Ventilation Unit or Acoustically Rated Ventilator Units

4.28 If windows to bedrooms are within 15 metres of the existing eastern boundary line and are directly facing the rail tracks, acoustic mitigation is required to ensure that the appropriate internal noise targets are achieved.

4.29 A potential suitable option with regard to providing appropriate property ventilation whilst maintaining a high level of sound insulation would be to use a Positive Input Ventilation (PIV) system. An appropriate system would allow occupants to leave windows closed on the worst-case façades whilst achieving satisfactory ventilation rates.

4.30 Example suppliers of PIV systems include:

- http://www.envirovent-specifier.com/whole-house-ventilation.php
- http://www.brookvent.co.uk/index.asp

4.31 As an alternative mitigation option to PIV units, acoustically rated ventilator units (wall vents and window trickle vents) could be installed to worst-case habitable rooms to allow background ventilation whilst maintaining a high level of sound insulation.

4.32 Example suppliers of acoustically rated ventilator units include:

- Passivent (http://www.passivent.com)
- Velfac (http://www.velfac.co.uk)
- Greenwood (http://www.greenwood.co.uk)

External/Garden Ambient Noise Levels & Appropriate Mitigation

4.33 Regarding outdoor living and amenity areas, BS8233 states the following:

"In gardens and balconies etc, it is desirable that the steady state noise level does not exceed 50 dB $L_{Aeq,T}$ and 55 dB $L_{Aeq,T}$ should be regarded as the upper limit".

4.34 Furthermore, to avoid serious annoyance during the daytime and evening period, the WHO guidelines recommend that the noise level within outdoor living areas (gardens) does not exceed 55 dB L_{Aeq} when measured over a 16-hour period.

4.35 The survey results indicate that daytime noise levels are in the region 57 dB ($L_{Aeq,16hour}$) at the site boundary line. However, the monitoring location was at the edge of the site with a clear direct line of sight to the railway tracks and was therefore a worst-case location.

4.36 Increasing the separation/stand-off distance from the railway tracks will provide additional noise attenuation of train noise levels. Furthermore, for a receptor height of 1.5 metres above ground level (e.g. somebody sitting within a garden space), additional noise attenuation will be provided by way of acoustic screening where the direct line of sight is obscured. The level of acoustic screening will gradually increase with greater separation distances, since the rail tracks are located down an embankment.

4.37 Table 4.4 provides a summary of the barrier calculation results for a receptor height of 1.5 metres and a separation distance of 5 metres from the existing boundary line (running parallel with the railway). Further calculation details are provided in Appendix C.

Table 4.4 – Attenuation due to Screening for a Receptor Height of 1.5 metres (Sitting in Garden)

Frequency (Hz)	Sum	63	125	250	500	1000	2000	4000	8000
Source level (dB)	60.0	55.4	48.4	46.2	53.5	54.5	44.9	39.2	31.5
A-weighting (dB)		-26.2	-16.2	-8.7	-3.2	0.0	1.2	1.0	-1.1
A-weighted source level (dB)	56.5	29.2	32.2	37.6	50.3	54.5	46.1	40.2	30.4
Barrier attenuation (dB)		**5.6**	**5.8**	**6.1**	**6.5**	**7.0**	**7.8**	**8.9**	**10.3**
Attenuated level (dB)	49.5	23.6	26.4	31.5	43.8	47.5	38.3	31.3	20.1
Attenuation (dBA)	**7.0**								

4.38 For a receptor height of 1.5 metres, the results of the barrier calculations indicate that approximately 7 dB of attenuation will be achieved at a distance of 5 metres from the eastern boundary line. This is therefore expected to reduce garden ambient noise levels to around 50 dB ($L_{Aeq,16hour}$) which will satisfy BS8233 and WHO recommended guidelines.

4.39 A maximum of 12 dB of noise attenuation due to acoustic screening is achievable for separation distances of 20 – 100 metres from the eastern boundary line.

4.40 External noise levels are therefore expected to be in the region 45 – 50 dB ($L_{Aeq,16hour}$) within gardens once the proposed residential development is in place.

Vibration due to Train Pass-bys

4.41 Ground vibration was subjectively assessed for both passenger and freight trains along the site boundary adjacent to the railway track.

4.42 There was found to be no perceptible vibration in the ground at the site boundary for passenger and freight trains during the site visits. A notable degree of damping/attenuation is being currently provided by the soft ground conditions and also by the separation distance generated by the steep embankment.

4.43 It should be noted that alterations to the ground conditions (e.g. pouring concrete) near to the site boundary would have the potential to increase vibration levels.

Predicted Train Vibration Levels

4.44 Vibration Dose Value (VDV) predictions have been made based on previous detailed vibration measurements undertaken at similar sites by RS Acoustic Engineering Ltd. Vibration measurements were made at a distance of 10 metres from the rail track (in Carlisle) for both a Northern Rail passenger train and also a large EWR freight train.

4.45 The maximum measured VDV (on a given axis) for a Northern Rail passenger train was 0.04 ms $^{1.75}$ and for a freight train 0.087 ms$^{-1.75}$.

4.46 VDV's are used to analyse the cumulative effects of bursts of intermittent vibration and can be estimated by combining the VDV's of individual events according to the fourth power law.

4.47 In accordance with BS 6472, an allowance should be made for the transfer function between the measurement position and the point of entry to the body (i.e. within the building).

4.48 It is necessary to use a transfer function that would represent the likely effect that the foundation would have on the vibration magnitude as it propagates into the building structure. In assessing the effect that different foundations may have, guidance has been sought from the *Handbook of Urban Rail Noise and Vibration Control* (HURNVC).

4.49 The multiplication factor given for vibration levels measured directly on the ground to those transmitting through a strip foundation is approximately 0.5 based on the 31.5 Hz frequency band.

4.50 A multiplication factor of approximately 2.8 can be applied to represent the amplification of vibration as it propagates up the building structure and across a suspended floor, such as those installed within dwellings. This value is based on guidance presented in the Journal of Low Frequency Noise and Vibration, Vol. 8 No. 3, 1989: *Transmission of Ground-borne Vibration in Buildings*.

4.51 The VDV's can therefore be amplified/multiplied by a transfer function of 1.4 (i.e. 2.8 × 0.5).

4.52 In terms of total train movements, it is considered appropriate to assume that 12 passenger trains and 9 freight trains may pass the site on a given weekday (21 trains in total).

4.53 Table 4.5 presents the predicted daytime and night-time VDV's taking into consideration the maximum measured VDV on any given axis for both a passenger and a freight train, the appropriate multiplication factors and the train pass-by frequency for the site (17 daytime trains and 4 night-time freight trains).

Table 4.5 – Predicted Vibration Dose Values ($ms^{-1.75}$)

Calculated VDV $ms^{-1.75}$	
Daytime Period (07:00 – 23:00hrs)	**Night-Time Period (23:00 – 07:00hrs)**
0.187	0.172

4.54 The predicted VDV's suggest that there is less than a low probability of adverse comment during the daytime period and a low probability of adverse comment during the night-time period within bedrooms at first floor level. This assessment assumes that dwellings are 10 metres from the nearest rail track.

4.55 An increased separation distance (>10 metres) from the rail track will provide additional attenuation (damping) of ground-borne vibration and will therefore reduce the probability of adverse comment even further.

4.56 On the basis of this assessment, it is considered that on-site vibration levels should not cause a constraint to the development and further mitigation with regard to vibration is considered unnecessary at this stage.

5. Conclusion

5.1 This assessment is based on the results of an environmental noise survey undertaken at the site over a 24-hour period.

5.2 A sound insulation performance of at least **27 dB $R_{w+}C_{tr}$** is required from the building envelope construction and associated elements to achieve the appropriate internal noise targets.

5.3 This performance requirement can be easily achieved by using traditional masonry wall constructions, standard double glazing configurations and traditional tiled roof constructions with an internal plasterboard ceiling.

5.4 Standard double glazing typically provides a sound insulation performance in the region 27 – 28 dB $R_{w+}C_{tr}$, however the performance of the unit should be verified with the manufacturer/supplier.

5.5 For façades/elevations located directly along the eastern boundary line, the 'reasonable' BS8233 internal noise level targets will be exceeded within habitable rooms when windows are open to provide rapid ventilation and summer cooling. Therefore appropriate mitigation is required to reduce noise ingress to appropriate levels.

5.6 The results of our calculations indicate that the 'reasonable' noise targets will be achieved within first floor bedrooms at a separation distance of approximately **15 metres** from the eastern boundary line (with windows partially open).

5.7 If windows to bedrooms are within 15 metres of the eastern boundary line and directly face the railway tracks, acoustic mitigation is required to ensure that the appropriate internal noise targets are achieved. This may be in the form of PIV units or acoustically rated ventilator units.

5.8 The noise targets will be satisfied within habitable rooms where open windows face in the opposite direction (facing west) to the railway tracks.

5.9 The recommended external noise target of 50 – 55 dB ($L_{Aeq,16hour}$) will be generally satisfied within garden areas at a separation distance of greater than **5 metres** from the eastern boundary line.

5.10 The predicted vibration dose values that are likely to occur at first floor level (bedrooms), suggest that there is a low probability of adverse comment when assessed against BS6472 guidance.

5.11 On the basis of the measured existing noise climate and predicted vibration levels, the site location is considered to be suitable for the proposed development, subject to the recommended mitigation measures outlined in this report.

Appendix A

Site Location and Survey Measurement Position

Figure A.1 – Site Location & Survey Measurement Position

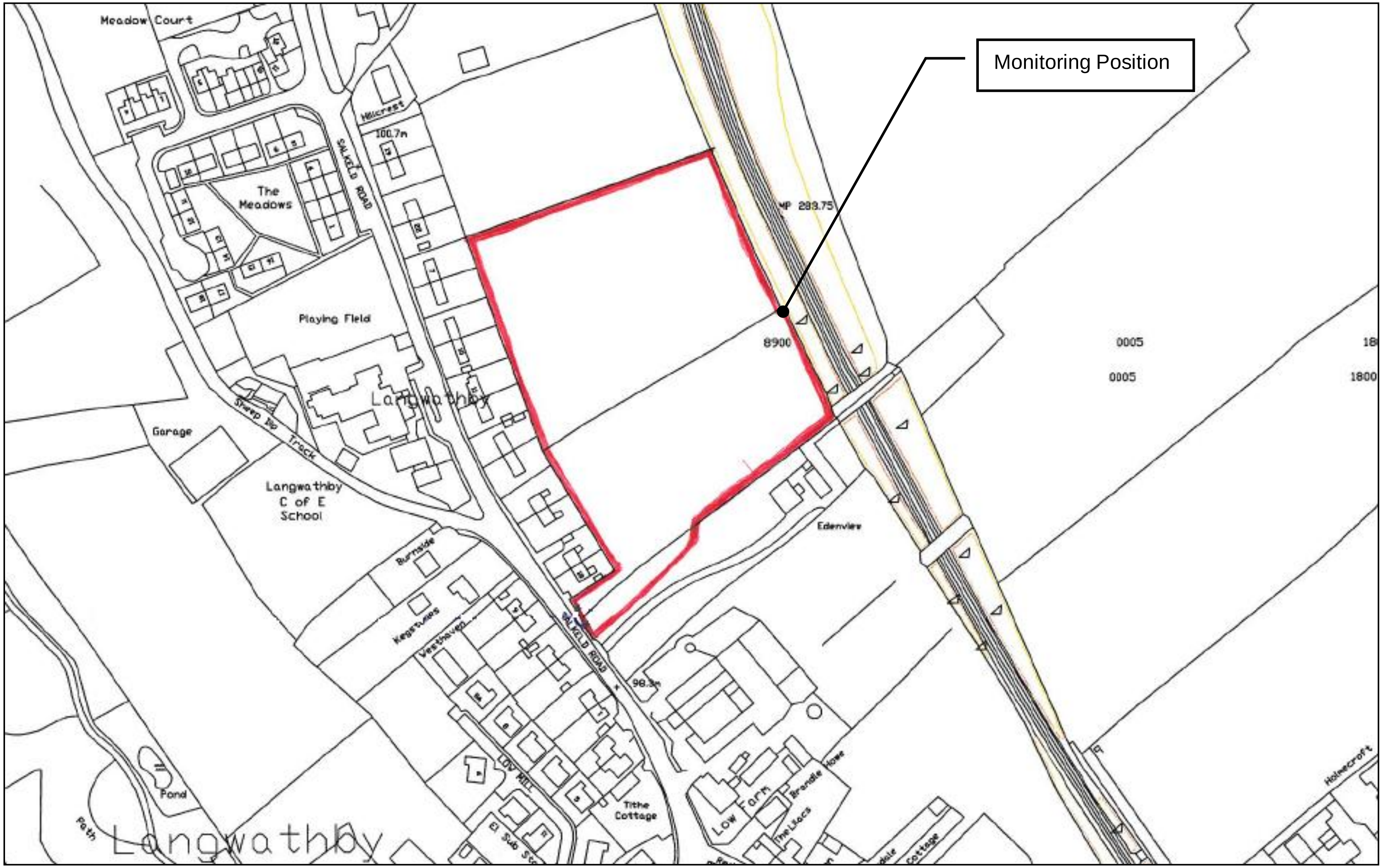


Figure A.2 – Photograph Showing Survey Measurement Position

Figure A.3 – Photograph Showing Survey Measurement Position

Appendix B
Tabulated & Graphical Survey Results

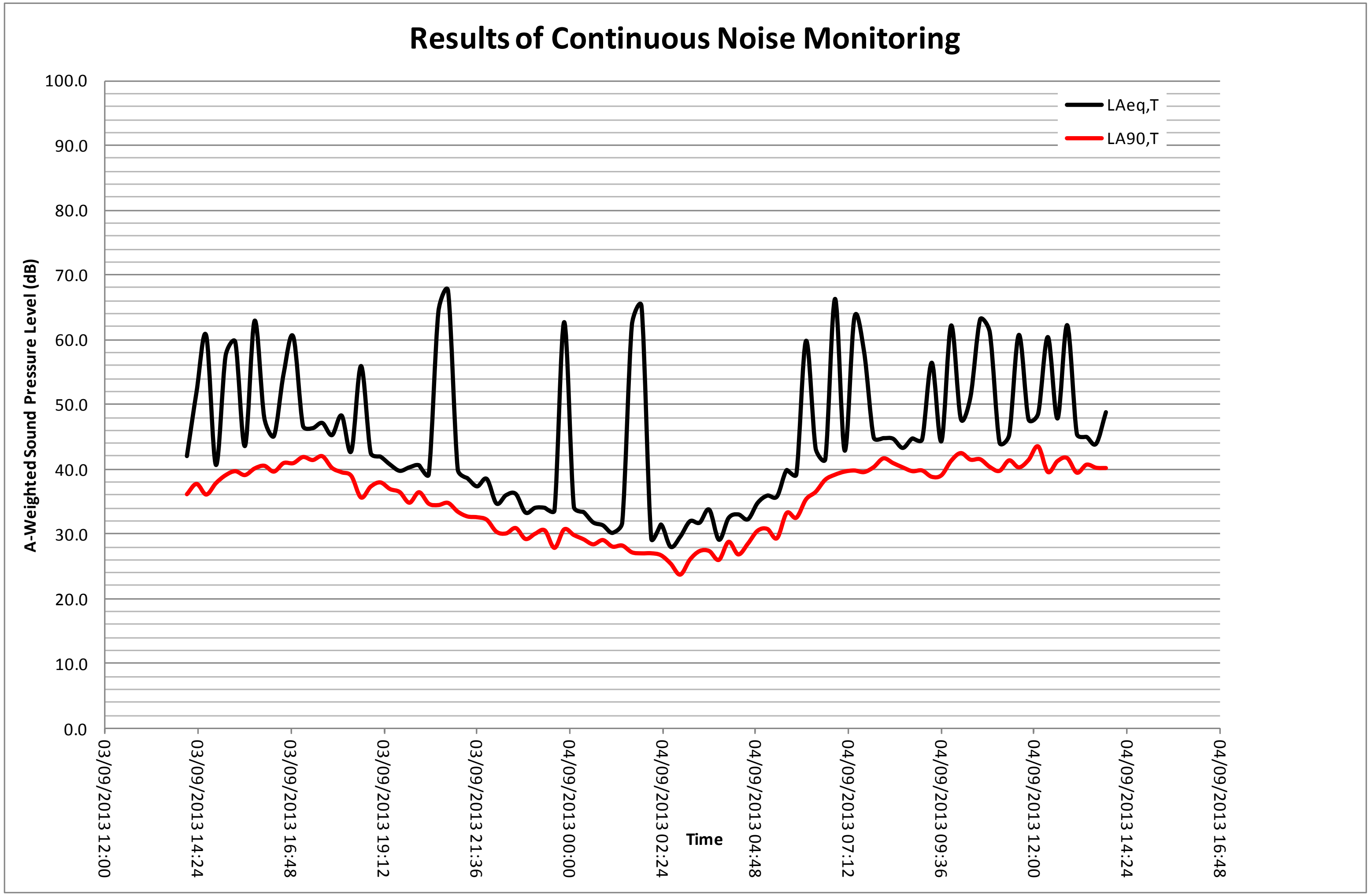
Table B.1 – Results of Continuous Noise Monitoring

Start Time	$L_{Aeq,15min}$	$L_{A90,15min}$	$L_{AFmax,15min}$	$L_{ASmax,15min}$
03/09/2013 14:05	42.0	36.2	57.0	51.7
03/09/2013 14:20	52.0	37.8	73.5	70.7
03/09/2013 14:35	60.6	36.1	85.3	83.6
03/09/2013 14:50	40.6	37.9	52.5	48.2
03/09/2013 15:05	57.5	39.1	82.8	81.1
03/09/2013 15:20	59.6	39.8	85.3	83.6
03/09/2013 15:35	43.6	39.2	58.7	54.2
03/09/2013 15:50	62.9	40.2	87.7	85.8
03/09/2013 16:05	47.9	40.6	63.3	58.9
03/09/2013 16:20	45.1	39.7	58.8	58.0
03/09/2013 16:35	54.8	41.0	80.0	78.2
03/09/2013 16:50	60.5	41.0	85.2	84.0
03/09/2013 17:05	46.7	42.0	59.0	56.2
03/09/2013 17:20	46.3	41.5	59.9	55.3
03/09/2013 17:35	47.1	42.1	64.0	57.1
03/09/2013 17:50	45.2	40.3	59.0	53.4
03/09/2013 18:05	48.3	39.6	65.2	60.2
03/09/2013 18:20	42.8	39.0	65.1	60.9
03/09/2013 18:35	55.9	35.7	79.7	78.1
03/09/2013 18:50	42.5	37.4	59.8	55.7
03/09/2013 19:05	41.9	38.0	59.4	52.0
03/09/2013 19:20	40.7	37.0	57.5	50.5
03/09/2013 19:35	39.7	36.5	49.8	46.3
03/09/2013 19:50	40.3	34.9	55.7	53.6
03/09/2013 20:05	40.6	36.5	56.0	51.3
03/09/2013 20:20	39.2	34.7	64.5	56.8
03/09/2013 20:35	64.4	34.5	87.1	85.8
03/09/2013 20:50	67.5	34.8	93.0	89.0
03/09/2013 21:05	39.9	33.5	56.5	53.7
03/09/2013 21:20	38.6	32.7	49.6	47.5
03/09/2013 21:35	37.3	32.6	49.2	47.4
03/09/2013 21:50	38.5	32.2	51.8	49.0
03/09/2013 22:05	34.7	30.4	49.0	46.2
03/09/2013 22:20	36.0	30.1	51.9	48.6
03/09/2013 22:35	36.1	30.9	47.1	45.5
03/09/2013 22:50	33.3	29.3	49.5	45.0
03/09/2013 23:05	34.0	30.1	44.5	42.9
03/09/2013 23:20	34.0	30.6	43.2	41.5
03/09/2013 23:35	33.6	27.9	47.5	46.0
03/09/2013 23:50	62.7	30.7	84.1	82.3
04/09/2013 00:05	34.2	29.9	47.3	44.9
04/09/2013 00:20	33.4	29.2	43.6	42.1

Start Time	$L_{Aeq,15min}$	$L_{A90,15min}$	$L_{AFmax,15min}$	$L_{ASmax,15min}$
04/09/2013 00:35	31.7	28.4	42.8	41.5
04/09/2013 00:50	31.3	29.1	51.7	45.6
04/09/2013 01:05	30.1	28.1	46.0	40.3
04/09/2013 01:20	31.7	28.2	43.8	41.8
04/09/2013 01:35	62.3	27.2	85.1	82.7
04/09/2013 01:50	65.1	27.0	86.7	84.2
04/09/2013 02:05	29.3	27.0	46.6	40.8
04/09/2013 02:20	31.4	26.7	44.7	41.6
04/09/2013 02:35	28.0	25.4	47.0	43.3
04/09/2013 02:50	29.5	23.7	49.5	44.9
04/09/2013 03:05	31.9	26.1	50.4	48.1
04/09/2013 03:20	31.7	27.4	44.4	40.3
04/09/2013 03:35	33.7	27.4	48.5	47.3
04/09/2013 03:50	29.1	26.0	44.4	43.3
04/09/2013 04:05	32.4	28.8	45.0	44.0
04/09/2013 04:20	33.0	26.9	49.5	45.5
04/09/2013 04:35	32.2	28.5	45.5	43.8
04/09/2013 04:50	34.8	30.5	47.8	44.0
04/09/2013 05:05	35.9	30.8	47.5	45.9
04/09/2013 05:20	35.8	29.4	47.3	45.5
04/09/2013 05:35	39.8	33.3	56.0	50.3
04/09/2013 05:50	39.2	32.6	55.4	50.5
04/09/2013 06:05	59.8	35.4	86.2	84.4
04/09/2013 06:20	43.2	36.6	65.8	62.9
04/09/2013 06:35	41.6	38.5	49.0	47.3
04/09/2013 06:50	66.3	39.2	85.2	83.2
04/09/2013 07:05	42.8	39.7	59.6	53.9
04/09/2013 07:20	63.4	39.9	88.3	84.0
04/09/2013 07:35	58.2	39.6	84.5	82.6
04/09/2013 07:50	44.9	40.4	64.6	57.5
04/09/2013 08:05	44.8	41.8	56.0	53.8
04/09/2013 08:20	44.7	41.0	63.0	57.4
04/09/2013 08:35	43.3	40.4	56.5	52.3
04/09/2013 08:50	44.7	39.8	62.3	58.6
04/09/2013 09:05	44.6	39.9	59.6	56.0
04/09/2013 09:20	56.4	38.9	81.6	79.2
04/09/2013 09:35	44.3	39.1	59.0	55.0
04/09/2013 09:50	62.2	41.4	83.7	82.5
04/09/2013 10:05	47.8	42.6	65.2	62.5
04/09/2013 10:20	51.1	41.6	75.9	71.1
04/09/2013 10:35	63.1	41.6	87.2	85.2
04/09/2013 10:50	61.1	40.4	87.2	85.2
04/09/2013 11:05	44.1	39.8	57.1	55.0

Start Time	$L_{Aeq,15min}$	$L_{A90,15min}$	$L_{AFmax,15min}$	$L_{ASmax,15min}$
04/09/2013 11:20	45.3	41.4	59.7	55.1
04/09/2013 11:35	60.7	40.4	86.2	84.6
04/09/2013 11:50	47.7	41.5	60.3	58.0
04/09/2013 12:05	48.6	43.6	59.6	58.4
04/09/2013 12:20	60.4	39.6	86.0	84.3
04/09/2013 12:35	47.8	41.3	63.6	60.2
04/09/2013 12:50	62.3	41.8	83.5	82.6
04/09/2013 13:05	45.4	39.5	62.2	58.0
04/09/2013 13:20	45.0	40.8	63.7	60.7
04/09/2013 13:35	43.9	40.3	56.7	55.4
04/09/2013 13:50	48.8	40.3	71.3	66.9

Figure B.1 – Graph Showing Results of Continuous Noise Monitoring



Appendix C
Barrier Calculation Details

Figure C.1 – Attenuation due to Screening for a Receptor Height of 5 metres (Bedroom Window)

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
h1	0	0	0	0	0	0	0	0
h2	10	10	10	10	10	10	10	10
Δh	10	10	10	10	10	10	10	10
H	5	5	5	5	5	5	5	5
d1	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
d2	15	15	15	15	15	15	15	15
d1+d2	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5
r0	14.40	14.40	14.40	14.40	14.40	14.40	14.40	14.40
rr	15.81	15.81	15.81	15.81	15.81	15.81	15.81	15.81
R	30.20	30.20	30.20	30.20	30.20	30.20	30.20	30.20
δ	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
C	343	343	343	343	343	343	343	343
λ	5.44	2.74	1.37	0.69	0.34	0.17	0.09	0.04
N	0.00	0.00	0.01	0.01	0.02	0.05	0.10	0.19
Shadow Height	10.555556	10.55556	10.55556	10.55556	10.55556	10.55556	10.55556	10.55556
	11.1	11.1	11.1	11.1	11.1	11.2	11.2	11.2
Y&T formulas	5.4	5.6	5.8	6.1	6.5	7.1	7.9	9.0
Attenuation	**5.4**	**5.6**	**5.8**	**6.1**	**6.5**	**7.1**	**7.9**	**9.0**

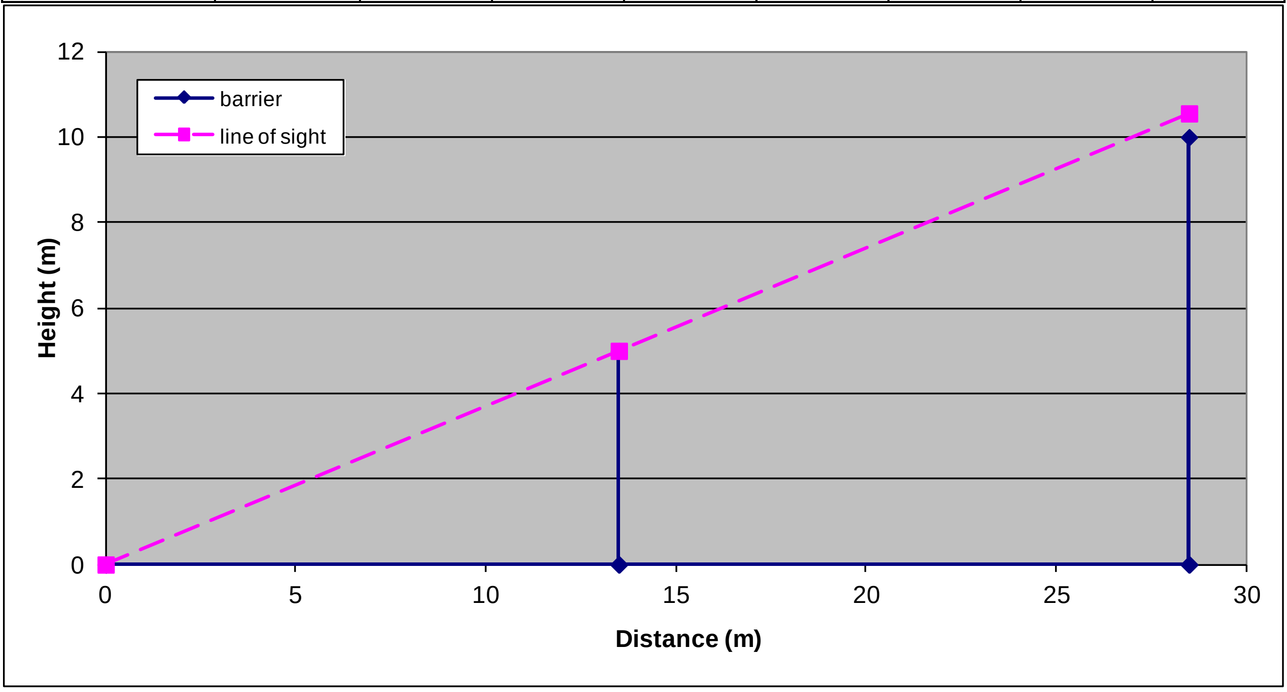
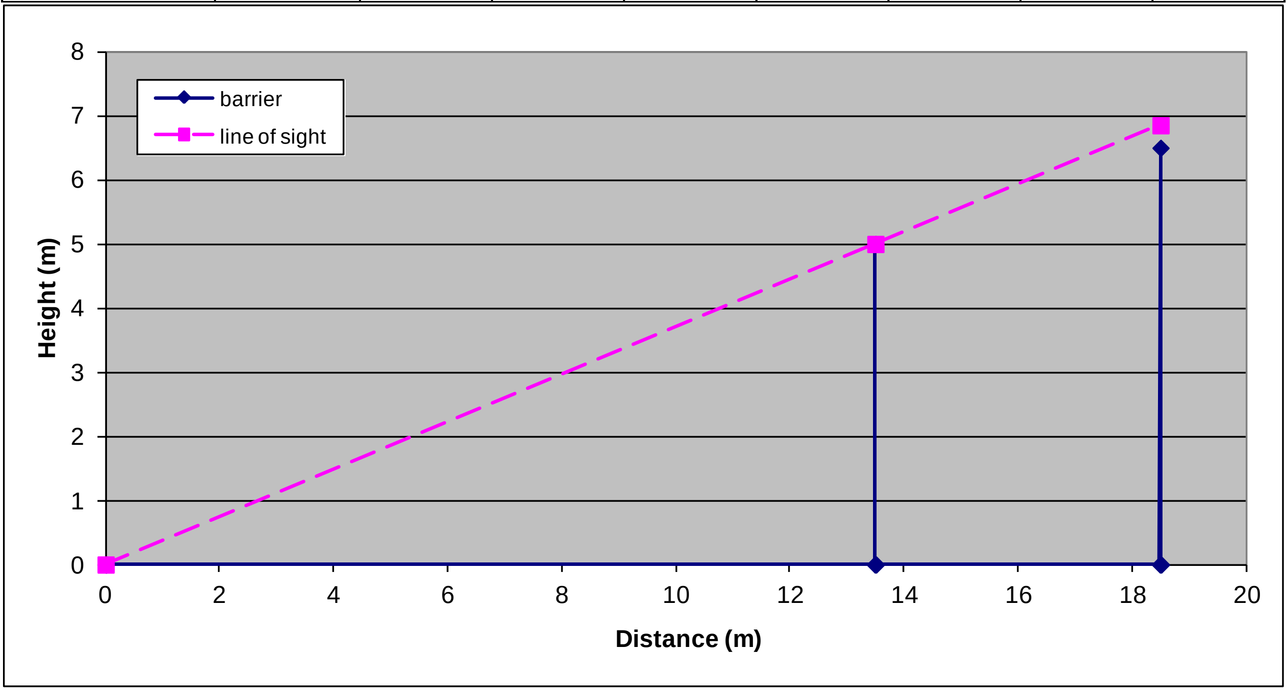


Figure C.2 – Attenuation due to Screening for a Receptor Height of 1.5 metres (Sitting in Garden)

Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
h1	0	0	0	0	0	0	0	0
h2	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Δh	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
H	5	5	5	5	5	5	5	5
d1	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5
d2	5	5	5	5	5	5	5	5
d1+d2	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.5
r0	14.40	14.40	14.40	14.40	14.40	14.40	14.40	14.40
rr	5.22	5.22	5.22	5.22	5.22	5.22	5.22	5.22
R	19.61	19.61	19.61	19.61	19.61	19.61	19.61	19.61
δ	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
C	343	343	343	343	343	343	343	343
λ	5.44	2.74	1.37	0.69	0.34	0.17	0.09	0.04
N	0.00	0.01	0.01	0.02	0.04	0.09	0.18	0.36
Shadow Height	6.8518519	6.851852	6.851852	6.851852	6.851852	6.851852	6.851852	6.851852
	11.1	11.1	11.1	11.1	11.2	11.2	11.2	11.3
Y&T formulas	5.6	5.8	6.1	6.5	7.0	7.8	8.9	10.3
Attenuation	**5.6**	**5.8**	**6.1**	**6.5**	**7.0**	**7.8**	**8.9**	**10.3**



Appendix D
Glossary of Acoustic Terminology

Acoustic Terminology

Term	Description
dB (decibel)	The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure ($2x10^{-5}$Pa).
dB(A)	The most widely used weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement, and the levels are denoted as dB(A) or L_{Aeq}, L_{A90} etc, according to the parameter being measured.
$L_{Aeq,T}$	The A-weighted equivalent continuous sound pressure level over a period of time, T. Representative of the 'average' sound pressure level over a given period.
L_{Amax}	L_{Amax} is the maximum A - weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response (L_{AFmax}).
$L_{A90,T}$	The A-weighted sound pressure level exceeded for 90% of the measurement period. Indicative of the general minimum or 'background' noise level.
$L_{A10,T}$	The noise level exceeded for 10% of the measurement period and is the noise parameter commonly used in the assessment of traffic noise (e.g. for a new road scheme).
Free-field Level	A sound field determined at a point away from reflective surfaces other than the ground with no significant contributions due to sound from other significant reflective surfaces. Generally as measured outside and away from buildings.
Fast	A time weighting used in the root mean square section of a sound level meter, with a 125 millisecond time constant.
Slow	A time weighting used in the root mean square section of a sound level meter, with a 1000 millisecond time constant.
Ambient Noise Level	The totally encompassing noise in a given situation at a given time; it is usually composed of noise from many sources, near and far.
Background Noise Level	The noise level in the absence of a specific noise source under consideration (e.g. plant/machinery), measured in $L_{A90,T}$.