RMP
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acoustics energy vibration

Unit 1, 7Hills Business Park
37 Bankhead Crossway South
Edinburgh
EH11 4EP

T: 0345 062 0000
E: rmp@napier.ac.uk
www.rmp.biz

BRIEF FOR CONSULTANCY:

To conduct a rail noise and vibration assessment in relation to the proposed residential development at Temple Road, Glasgow and to offer advice as necessary to facilitate compliance with the relevant standards and guidelines.

Noise & Vibration Impact Assessment 51 Temple Road, Glasgow G13 1EL

Technical Report No. R-9011-EP-DJC
9th April 2021

PREPARED FOR:

Allison Architects
13 Royal Crescent
Glasgow
G3 7SL

For the attention of Stephen Allison

Edinburgh Napier UNIVERSITY

RMP is a consulting division of Edinburgh Napier University.

Contents

1.0 Introduction

1.1 We were instructed by Allison Architects to undertake a noise and vibration impact assessment for a proposed two-dwelling development at 51 Temple Road, Glasgow, G13 1EL and to offer any acoustical advice necessary to facilitate compliance with the acoustic planning guidelines.

1.2 The site is currently occupied by a derelict single storey building; located between Temple Road to the South and the West Highland Freight railway line to the North. A car sales and valet yard is located to the West. A site-layout plan is provided as Figure 1 below.

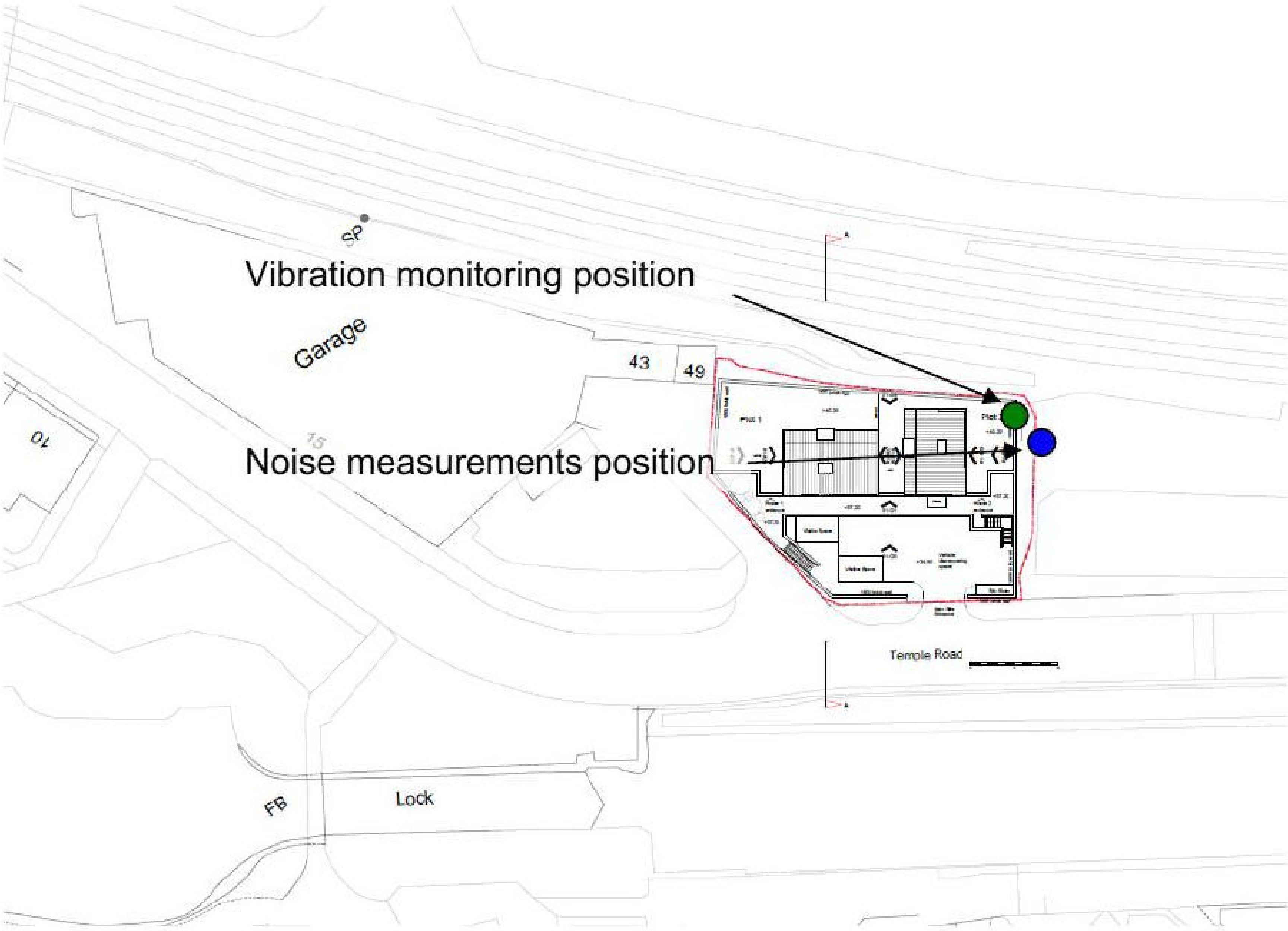

Figure 1. Site layout

1.3 The two dwellings are proposed to be three storey semi-detached townhouses, orientated East-West; parallel to the railway. The significant slope across the width of the site has been incorporated into the design such that the external ground floor on the north elevation is a retaining wall. Windows with a line of sight to the railway are however proposed for the upper levels.

1.4 The railway is located on a 1.5 m embankment approximately 9 m from the closest existing and proposed development façade. There is limited traffic on this section of the line, it is however used daily by diesel powered passenger and freight trains. Details of freight traffic have been obtained from the Freightmaster Online database.

1.5 The assessment has been undertaken by the survey of existing noise and ground vibration generated by passing rail traffic. The results of the survey have been assessed against appropriate residential standards.

2.0 Relevant planning guidance

2.1 Current guidance for local authorities with regard to noise affecting planning matters is given in the Scottish Government's PAN 1/2011 "*Planning and Noise*" document, with further details on the assessment of noise provided in its associated Technical Advice Note (TAN): 'Assessment of Noise'.

2.2 Paragraph 15 of PAN 1/2011 gives the following advice:

2.3 Issues which may be relevant when considering noise in relation to a development proposal include:

- *Type of development and likelihood of significant noise impact,*
- *Sensitivity of location (e.g. existing land uses, NMA, Quiet Area),*
- *Existing noise level and likely change in noise levels,*
- *Character (tonal, impulsivity etc),duration, frequency of any repetition and time of day of noise that is likely to be generated, and*
- *Absolute level and possible dose-response relationships e.g. health effects if robust data available.*

2.4 The Technical Advice Note to PAN 1/2011 provides guidance for the format and approach of Noise Impact Assessments. The approach is summarised as a flow chart and presented in Figure 2, page 7.

2.5 Paragraph 19 recommends that in order to assist in the preparation and consideration of planning applications, Noise Impact Assessments may be requested by the planning authority. Noise Impact Assessments are to "*demonstrate whether any significant adverse noise impacts are likely to occur and if so, identify what effective measures could reduce, control and mitigate the noise impact*."

2.6 Limited advice on the assessment of existing rail and road traffic noise is given in PAN 1/2011.

2.7 Paragraph 23 states "*Road traffic noise impact assessments should take account of level, potential vibration, disturbance and variation in noise levels throughout the day, the pattern of vehicle movements and the configuration of the road system".*

2.8 Paragraph 24 states "*Railway operators should have details of current traffic flows, and in some cases noise levels.*"

2.9 There is no specific guidance in PAN 1/2011 or associated TAN in relation to road and rail traffic vibration affecting a proposed noise-sensitive development.

2.10 PAN 1/2011 (and the accompanying Technical Advice Note) do not provide explicit criteria to employ for the noise assessments; instead, this is recommended to be delegated to the Planning Authority.

2.11 Local authorities typically require that noise impact assessments are based on the guidance from BS 8233:2014 '*Guidance on sound insulation and noise reduction for buildings*' and the World Health Organisation in document "*Guidelines for Community Noise*" (1999).

2.12 The acoustic standards from Table 4 of BS 8233:2014 detail ambient noise levels for dwellings in relation to steady external noise sources. These are reproduced below in Table 1.

Table 1. BS 8233:2014 ambient noise levels for dwellings (dB re 2 x 10^{-5} Pa)

Activity	Location	Time period	
		07:00 to 23:00	23:00 to 07:00
Resting	Gardens (external)	50 dB $L_{Aeq,16hour}$	-
Resting	Living rooms (internal)	35 dB $L_{Aeq,16hour}$	-
Dining	Dining room/area (internal)	40 dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom(internal)	35 dB $L_{Aeq,16hour}$	30 dB $L_{Aeq,8hour}$ 45dB $L_{Amax(5 min)}$

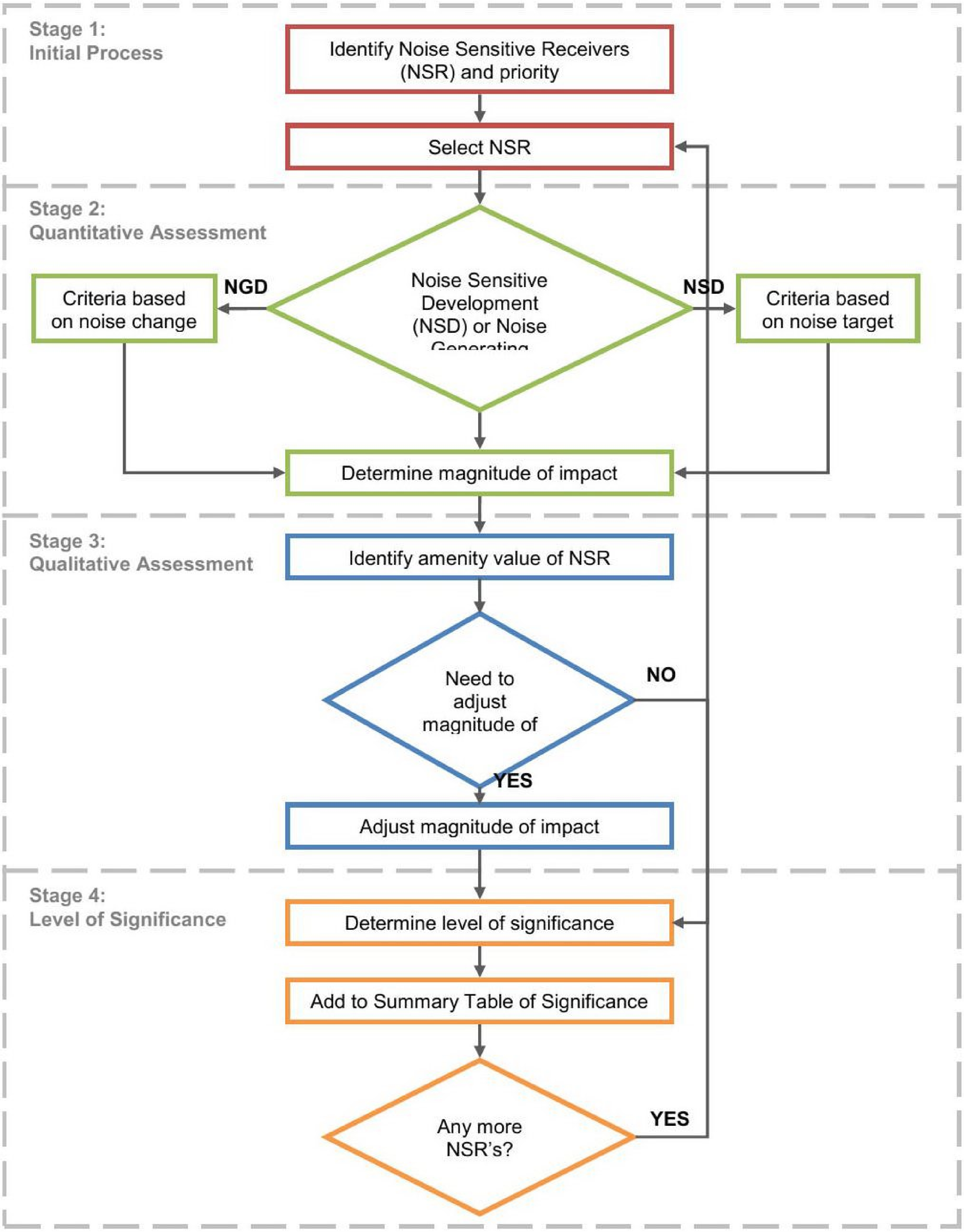

Figure 2: PAN 1/2011 / TAN Assessment Procedure Flow Chart

2.13 The assessment of vibration from railway lines is made with reference to BS 6472:2008 "*Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting*". The standard provides guidance on human exposure to building vibration, the measurement methods to be employed and a scale relating vibration levels to human response.

2.14 For intermittent vibration such as train or road traffic pass-bys, it recommends the use of Vibration Dose Values (VDV), the calculation of which is described in BS 6841:1987 '*Measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock*'.

2.15 Vibration Dose Values (VDV) defines a relationship that yields a consistent assessment of continuous, intermittent, occasional and impulsive vibration and correlates well with subjective response. Use of the vibration dose value to assess the acceptability of building vibration within residential buildings is described in Table 2, reproduced from BS 6472:2008.

Table 2. BS 6472 Vibration dose value criteria ($m/s^{1.75}$) - Likely human response within residential buildings

Location & time period	Low probability of adverse comment[1]	Adverse comment possible	Adverse comment probable[2]
Residential buildings 16 h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

[1] Below these ranges, adverse comment is not expected.

[2] Above these ranges, adverse comment is very likely.

3.0 Measurement procedure

3.1 Noise Measurements

Rail noise measurements were made over four site visits by Scott Lothian, B.Eng (Hons), AMIOA. A summary of the visit times and conditions is provided in Table 3.

Table 3. Details of noise survey periods and conditions

Date	Time Period	Temperature	Wind Speed	Precipitation
24/03/2009	21:00 – 00:15	6ºC	< 3 m/s	Light rain
02/04/2009	22:00 – 23:00	10ºC	< 1 m/s	-
06/04/2009	21:30 – 23:00	8ºC	< 1 m/s	Intermittent rain
09/04/2009	08:00 – 09:15	9ºC	< 1 m/s	Light rain

3.2 The measurement location was coincident with the closest proposed building line to the railway. The microphone was fixed at a height of 2.5 m above local ground height and located approximately 9 m south from the closest westbound rail line. This location, shown in Figure 1, was 4 m East of the existing dwelling and was assumed to provide a free-field acoustic response. The microphone was fitted with a windshield.

3.3 The instrumentation used for the measurements conformed to a Class 1 specification integrating sound level meter in accordance with BS EN 61672-1: 2003. Immediately prior to the survey the sensitivity of the sound level meter was checked using an acoustic calibrator. No significant deviation from the calibration level of 93.9 dB re 2 x 10^{-5} Pa at 1000 Hz was detected. The instrumentation used for the measurements is listed in Appendix 1.

3.4 Noise measurement were taken during individual train pass-bys in accordance with the guidance document *Calculation Of Railway Noise* 1995 (ISBN 0115517545) (CRN).

3.5 Vibration measurements

Ground vibration measurements have been undertaken over two prolonged monitoring periods using in-situ, tri-axial accelerometers. Details of the survey times are presented in Table 4. The measurements were undertaken by Scott Lothian, B.Eng (Hons), AMIOA.

Table 4. Details of vibration survey periods

Monitoring Start	Monitoring End	Duration
17/03/2009 – 17:00	20/03/2009 – 12:00	67 hrs
24/03/2009 – 21:00	26/03/2009 – 10:00	37 hrs

3.6 The equipment used for the ground vibration measurements are listed in Appendix 1. The vibration monitoring position, illustrated on Figure 1, was adjacent to the Northern façade of the existing dwelling, sited on concrete hard standing.

3.7 The vibration survey followed the method published in BS 6472-1:2008: 'Guide to Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)'.

3.8 Tri-axial measurements were made at the measurement location 3, the axes are defined as follows:

x-axis: horizontal, perpendicular to the railway line;
y-axis: horizontal, parallel to the railway line;
z-axis: vertical axis.

3.9 The vibration measurements were made approximately 9 m from the closest rail.

3.10 For both noise and vibration measurements, these were undertaken in 2009. However, RMP do not anticipate any significant noise or vibration differences between 2009 and 2021 from rail passbys.

4.0 Measurement Results

4.1 Railway Traffic Noise

The summary results of the rail traffic noise measurements are presented in Table 5.

Table 5. Rail noise measurement results (dB re 2 x10^{-5} Pa)

Date (dd/mm/yy)	Time (hh:mm)	Train type	No. carriages	Direction	Duration (s)	L_{Aeq} (dB)	L_{AFmax} (dB)
24/03/09	23:51	Passenger	6	W/B	8	76.0	80.6
24/03/09	00:02	Sleeper	5	E/B	16	78.8	82.9
24/03/09	00:06	Passenger	6	E/B	12	73.2	78.3
09/04/09	08:13	Passenger	2	E/B	13	76.9	80.6
09/04/09	08:28	Passenger	4	W/B	13	77.3	83.4
09/04/09	09:13	Freight	12	W/B	22	70.3	76.3

4.2 Ground Vibration

The day and night-time averaged summary results of the ground vibration survey are presented in Table 6 for the three orthogonal measurement directions.

Table 6. Ground vibration measurement results					
Period	Start Time (dd/mm/yyyy hh:mm)	Duration (hrs)	Longtitidinal VDV_d ($m/s^{1.75}$)	Lateral VDV_d ($m/s^{1.75}$)	Vertical VDV_b ($m/s^{1.75}$)
Day	17/03/2009 17:00	7	0.0201	0.0182	0.0261
Night	17/03/2009 23:00	8	0.0219	0.0173	0.0220
Day	18/03/2009 07:00	16	0.0237	0.0186	0.0234
Night	18/03/2009 23:00	8	0.0219	0.0171	0.0221
Day	19/03/2009 07:00	16	0.0229	0.0183	0.0228
Night	19/03/2009 23:00	8	0.0219	0.0168	0.0219
Day	20/03/2009 07:00	6	0.0187	0.0154	0.0180
Day	24/03/2009 21:00	2	0.0137	0.0117	0.0331
Night	24/03/2009 23:00	8	0.0217	0.0168	0.0220
Day	25/03/2009 07:00	16	0.0221	0.0188	0.0259
Night	25/03/2009 23:00	8	0.0196	0.0168	0.0222
Day	26/03/2009 07:00	3	0.0145	0.0132	0.0202

5.0 Train Noise Assessment

5.1 The overall level of rail noise has been estimated in accordance with the CRN methodology. This calculates the total noise contribution for a specific period by logarithmically summing the averaged sound exposure level (SEL), per train type, according to the number of pass-bys within that period. The noise contribution from each train type is then combined to provide the overall rail noise level, $L_{Aeq,T}$.

5.2 The calculation of the overall free-field rail noise level at the closest proposed façade (i.e. measurement position) is based on the data presented in Table 7. Timetable information for the freight and sleeper services is reproduced from the Freightmaster Online database. Noise data has been estimated for the eastbound freight and westbound sleeper service based on the surveyed data.

Table 7. CRN calculation data

Type	Direction	No. pass-bys (Day)	No. pass-bys (Night)	SEL (dB)	$L_{Af,max}$ (dB)
Freight	E/B	1	0	81.7	74.1
Freight	W/B	1	0	83.7	76.3
Sleeper	E/B	0	1	90.8	82.9
Sleeper	W/B	0	1	92.8	83.0
Passenger	E/B	2	1	86.0	80.6
Passenger	W/B	2	1	86.7	83.4

5.3 The results of the rail noise calculations at the closest proposed façade are presented in Table 8.

Table 8. Overall external noise levels predicted at closest proposed residential façade (dB re 2 x10^{-5} Pa)

	Period, T (hh:mm)	$L_{Aeq, T}$ (dB)	$L_{Af, max}$ (dB)
Daytime	07:00 – 23:00	45.7	83
Night time	23:00 – 07:00	51.4	83

5.4 A comparison of the results presented in Table 8 against the residential noise criteria (summarized in Table 1) highlights the maximum, $L_{Af\,max}$, night-time level as being the most demanding. The associated maximum noise spectra is used to estimate the level of acoustic insulation required to the bedrooms based on equation 1 and as shown in Table 9 below.

$$R = L_{ff} + 3 - L_{int} - 10Log_{10}\left(\frac{S}{A}\right) \quad dB \qquad \text{Equation 1}$$

where R is the sound reduction index (dB)
L_{ff} is the free-field external noise level (dB)
L_{int} is the internal noise criteria within the receiving room (dB)
S is the internal surface area of the façade (m^2)
A is the equivalent absorption area of the receiving room (m^2).

5.5 The calculation shown in Table 9 has assumed the bedrooms have standard plasterboard wall and ceiling finishes, a timber floor and internal dimensions of 2.7 x 4.7 x 2.5 m. The surface area of the noise exposed façade is 11.75 m^2 and the internal noise criterion, $L_{Af, max}$ has been approximated from the closest noise rating curve.

Table 9. Acoustic Insulation Requirement for facades Overlooking Railway								
	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	Overall, dB
$L_{ff\ max}$ (dB)	84	85	86	80	77	74	70	$L_{A,max}$ 83
Façade Correction	3	3	3	3	3	3	3	
L_{int} (dB) required	65	54	46	40	36	33	31	$L_{A,max}$ 45
Room absorption A (m^2)	15	15	7	5	4	4	4	
Required reduction R (dB)	24	36	41	40	40	40	38	R_w 40

5.6 The estimate calculation shown in Table 9 indicates the building envelope protecting bedrooms exposed to railway noise will need to provide a high degree of acoustic insulation, particularly within the low to mid frequency range.

5.7 The recommendations for glazing is discussed further in Chapter 7.

6.0 Ground Vibration Assessment

6.1 The rail vibration results presented in Table 10 indicate the vertical axis to have the highest vibration levels; these are therefore used in the assessment.

6.2 The measurement results, having been obtained externally, have been adjusted to an internal floor result using an amplification factor of 2. This transfer function approximates for potential increases in vibration levels from resonance effects associated with the structural elements.

6.3 The adjusted overall day and night-time vibration levels, calculated from the highest measured vertical VDV, are presented in Table 10 against the BS 6472 criteria.

Table 10. Assessment Vibration dose values using BS 6472 at closest proposed building line

Period	VDV ($m/s^{-1.75}$)	Assessment against BS 6472
Daytime	0.07	Adverse comment is not expected
Night-time	0.04	Adverse comment is not expected

6.4 The findings outlined in Table 10 indicate that there is a very low probability of adverse comment due to vibrations from passing trains.

7.0 Recommendations

7.1 The following recommendations are targeted for the bedrooms to ensure the night-time maximum noise levels are adequately controlled.

7.2 The composite sound insulation specification for the noise exposed bedroom façades, determined in Table 9, will require high specification façade components. Table 11 outlines the rooms that should incorporate acoustic glazing.

Table 11. Window areas recommended for acoustic upgrade

Dwelling	Level	Façade	Room
House Type 1	First Floor	North	Drawing room to Bed. 1
House Type 1	Second Floor	East	Bedroom 3
House Type 1	Second Floor	East	Bedroom 4
House Type 2	First Floor	North	Bedroom 1
House Type 2	Second Floor	West	Bedroom 4

7.3 A suitable acoustic glazing product for these facades is a double glazed specification of 10 – 12 – 8.4(laminated) mm or equivalent (R_w 42 dB).

7.4 If bedroom ventilation is to be provided through the rail noise exposed facades, i.e. West, North or East facades, the vent unit is recommended to have a minimum acoustic rating of $D_{ne,w}$ 44 dB (when in the open position). This performance figure is appropriate for single units only; if more than one unit is to be used within the same room the required acoustic performance will increase by a factor +10 $Log_{10}(n)$ (where n is the number of ventilator units).

7.5 The recommended acoustic ventilator specification is generally outwith the capacity of standard trickle vent products. Alternative options are through wall ventilators or over frame acoustic vents. Details on suitable ventilator products are available on request.

7.6 Facades protecting living accommodation will require significantly less acoustic protection compared to bedroom areas. It is recommended that the glazing for these areas be specified with a minimum acoustic rating of R_w 33 dB, such as is typically achieved with 4 / 12 / 6 mm double glazed units.

7.7 Standard slot ventilators will provide adequate acoustic performance for the living room areas to comply with the acoustic criteria.

7.8 Internal rail noise predictions are presented in Table 12; based on the assessment noise levels and the recommended glazing and ventilator performance specifications.

Table 12. Internal Rail Noise Predictions (dB re 2 x 10^{-5} Pa)

Time	Location	Noise Index	Predicted Internal Rail Noise Level (dB)	Acoustic Criteria, BS8233 (dB)
07:00 – 23:00	Living rooms	$L_{Aeq, 16hr}$	20	≤ 35
23:00 – 07:00	Bedrooms	$L_{Aeq, 8hr}$	14	≤ 30
23:00 – 07:00	Bedrooms	$L_{Af\ max\ 8hr}$	44	≤ 45

8.0 Conclusions

8.1 A railway noise and vibration assessment has been undertaken for the proposed residential development at 51 Temple Road, Glasgow, G13 1EL.

8.2 Rail noise has been assessed against the anticipated acoustic criteria required by the Local Authority.

8.3 The maximum noise levels associated with night-time pass-bys of diesel powered passenger trains has been identified as having the most significant noise impact on the development; acoustic predictions indicate that a suitable residential environment can be provided through appropriate façade design.

8.4 Specifications for façade glazing and ventilation have been provided to attenuate rail noise levels to a good residential standard, based on requirements set in BS8233.

8.5 A ground vibration assessment has been undertaken in accordance with BS 6472. The findings of the assessment indicate there is a very low probability of adverse comment from future residents due to ground vibrations.

Prepared by:	Approved by:
Elena Prokofieva BSc, MSc, PhD, MIOA	David Chapman BEng(Hons), MIOA

Appendix 1: Acoustical Instrumentation

Noise survey

Brüel & Kjær Modular Precision Sound Analyser Type 2260 Serial No: 1772256 running Brüel & Kjær Enhanced Sound Analysis Software BZ 7202

Brüel & Kjær Pre-polarised Condenser Microphone Type 4189 Serial No: 2502954

Brüel & Kjær Sound Level Calibrator Type 4231 Serial No: 1807698

Brüel & Kjær Modular Precision Sound Analyser Type 2260 Serial No: 2120171 running Brüel & Kjær Enhanced Sound Analysis Software BZ 7202

Brüel & Kjær Pre-polarised Condenser Microphone Type 4189 Serial No: 2431001

Brüel & Kjær Sound Level Calibrator Type 4231 Serial No: 1780570

TechnoLine Anemometer Type EA – 3010

Vibration survey

Vibrock Seismograph V901 Serial No: 784 connected to a Vibration Dose Value Transducer with VDV weighting filters

Appendix 2: Glossary of Acoustical Terminology

1) Decibel (dB): The range of audible sound pressures is approximately 0.00002 Pa to 200 Pa. Using decibel notation presents this range in a more manageable form, 0 dB to 140 dB.
2) Frequency (Hz): The number of cycles per second, this is subjectively perceived as pitch.
3) Frequency Spectrum: Analysis of the relative contributions of different frequencies that make up a noise.
4) Octave Bandwidth: A range of frequencies defined by an upper limit which is twice the lower limit. Octave bandwidths are identified by their centre frequency.
5) "A" Weighting (dB(A)): The human ear does not respond uniformly to different frequencies. "A" weighting is commonly used to simulate the frequency response of the ear.
6) Noise: Unwanted sound.
7) $L_{Aeq,T}$: The equivalent continuous sound level. It is that steady sound level which would produce the same energy over a given time period T as a specified time varying sound.
8) L_{A90}: The sound level (dB) exceeded for 90% of the measurement period, this may be considered to be the background noise level An 'A' subscript denotes A weighting.
9) R_w: The weighted sound reduction index which has been measured in accordance with the BS EN ISO 140 series of standards and rated in accordance with BS EN ISO 717-1: 1997. It is the sound insulation performance of the tested component, independent of its acoustic environment.
10) R_{TRA}: An indication of the road traffic noise attenuation in dB(A) for a given window.
11) $D_{n,e,w(o)}$: The Weighted element-normalized level difference defined by BS EN 20140-10:1992, which characterises the airborne sound insulation performance of a small building element such as a window ventilator when in the open position.
12) L_{Amax}: The maximum sound pressure level that occurred during a given measurement period specified with a fast (L_{AFmax}) or slow (L_{ASmax}) weighting.

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OFFICES

Head Office Edinburgh
Unit 1, 7Hills Business Park
37 Bankhead Crossway South
Edinburgh
EH11 4EP
0345 062 0000

South West
17 Bishops Close
Torquay
Devon
[redacted]

South East
The Officer's Mess
Royston Road
Duxford
Cambridge
[redacted]

rmp@napier.ac.uk

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