The Seam, Barnsley
Plots 1 & 2

Environmental Noise & Vibration Assessment Report

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ARCHITECTURE ▪ DESIGN ▪ ENGINEERING ▪ URBANISM ▪ SUSTAINABILITY ▪ LIGHTING ▪ ACOUSTICS

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1. Introduction

BDP Acoustics has been commissioned by Barnsley Metropolitan Borough Council (BMBC) to undertake an environmental noise and vibration assessment to support an outline planning application for the proposed residential development of Plots 1 and 2 of Phase 1 of The Seam Digital Campus, Barnsley (the 'Site').

Plot 1 is proposed to incorporate a 4 storey block comprising 80 apartments and Plot 2 is proposed to incorporate a 4 storey block comprising 36 apartments and 20 townhouses.

The Site is currently used as surface car parking operated by BMBC, with primary access off Old Mill Lane and County Way. The site is bounded by Old Mill Lane to the north and car parking to the west. The Network Rail Wakefield-Sheffield railway line runs immediately adjacent to the eastern edge of the Site and Barnsley Transport Interchange is located to the south.

Figure 1 presents the proposed location of Plots 1 and 2 (shaded in red) and the site red-line boundary.

This report details the outline acoustic assessment undertaken and consists of the following:

- Review of current planning guidance and relevant acoustic standards;
- Anticipated acoustic design criteria for residential development based on the relevant standards;
- Details of the environmental noise and vibration surveys undertaken;
- High level assessment of design implications for residential development at the site;

A glossary of acoustic terms is presented in Appendix I – Glossary of Acoustic Terms.

Figure 1: Proposed location of Plots 1 and 2 (shaded in red) and site red-line boundary

2. Relevant Standards and Guidance

1.1 Noise Policy Statement for England (NPSE)

The NPSE provides guidance on the management of noise from sustainable development. The statement sets out three key aims in paragraph 1.7:

"*Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:*

- *Avoid significant adverse impact 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.*"

1.2 Planning Practice Guidance – Noise (PPGN)

PPGN offers clarity on NPSE and states the following, under the heading "*How to determine the noise impact*":

"*Local planning authorities' plan-making and decision taking should take account of the acoustic environment and in doing so consider:*

- *Whether or not a significant adverse effect is occurring or likely to occur;*
- *Whether or not an adverse effect is occurring or likely to occur; and*
- *Whether or not a good standard of amenity can be achieved.*"

1.3 National Planning Policy Framework (NPPF)

The NPPF sets out the Government's planning policies for England and how these are expected to be applied. It replaces a number of previous planning policy documents, including Planning Policy Guidance 24: Planning and Noise (PPG 24). Unlike PPG24 which it replaced, NPPF does not contain any methodology for objective assessment. The relevant Local Planning Authority must therefore consider the suitability of any proposed scheme themselves, based on evidence such as this environmental noise assessment report.

1.4 BS 8233: 2014 '*Guidance on Sound Insulation and Noise Reduction for Buildings*'

This code of practice recommends suitable acoustic rating criteria for various indoor environments and uses. BS 8233 recommends levels for overall noise design of a building based on existing guidelines issued by the World Health Organisation (WHO) in 1999, for areas where a controlled acoustic environment is necessary. The following criteria for unoccupied bedrooms, living rooms and dining rooms are stated as desirable.

Table 1: BS 8233:2014, 'Recommended internal ambient noise levels for dwellings'

Activity	*Location*	*07:00 to 23:00*	*23:00 to 07:00*
Resting	Living room	35 dB $L_{Aeq,16hour}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16hour}$	30 dB $L_{Aeq,8hour}$

In relation to criteria for external noise for residential balconies in city centres or urban areas adjoining the strategic transport network, the document states the following:

"In higher noise areas, such as city centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited.

Other locations, such as balconies, roof gardens and terraces, are also important in residential buildings where normal external amenity space might be limited or not available, *i.e. in flats, apartment blocks, etc. In these locations, specification of noise limits is not necessarily appropriate. Small balconies may be included for uses such as drying washing or growing pot plants, and noise limits should not be necessary for these uses. However, the general guidance on noise in amenity space is still appropriate for larger balconies, roof gardens and terraces, which might be intended to be used for relaxation. In high-noise areas, consideration should be given to protecting these areas by screening or building design to achieve the lowest practicable levels. Achieving levels of 55 dB $L_{Aeq,T}$ or less might not be possible at the outer edge of these areas, but should be achievable in some areas of the space."*

1.5 '*Planning & Noise Professional Practice Guidance on Planning & Noise New Residential Development*', May 2017. (ProPG)

ProPG has been produced to provide practitioners with guidance on a recommended approach to the management of noise within the planning system in England.

The NPPF encourages improved standards of design. The CIEH, IOA and the ANC have worked together to produce this guidance which encourages better acoustic design for new residential development and aims to protect people from the harmful effects of noise.

The document presents internal noise level guidelines which are largely based on BS8233:2014; this table is presented in Figure 2.

The use of openable windows to control overheating and the potential noise impact during periods of overheating is discussed within ProPG, however this design consideration is addressed by Approved Document O: Overheating (ADO) which came into effect on 15 June 2022, which requires new residential buildings to include sufficient measures to limit overheating whilst controlling internal noise levels.

Figure 2: 'ProPG Internal Noise Level Guidelines (additions to BS8233:2014 shown in blue)'

ACTIVITY	LOCATION	07:00 – 23:00 HRS	23:00 – 07:00 HRS
Resting	Living room	35 dB $L_{Aeq,16 hr}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16 hr}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16 hr}$	30 dB $L_{Aeq,8 hr}$ 45 dB $L_{Amax,F}$ (Note 4)

NOTE 1 The Table provides recommended internal L_{Aeq} target levels for overall noise in the design of a building. These are the sum total of structure-borne and airborne noise sources. Ground-borne noise is assessed separately and is not included as part of these targets, as human response to ground-borne noise varies with many factors such as level, character, timing, occupant expectation and sensitivity.

NOTE 2 The internal L_{Aeq} target levels shown in the Table are based on the existing guidelines issued by the WHO and assume normal diurnal fluctuations in external noise. In cases where local conditions do not follow a typical diurnal pattern, for example on a road serving a port with high levels of traffic at certain times of the night, an appropriate alternative period, e.g. 1 hour, may be used, but the level should be selected to ensure consistency with the internal L_{Aeq} target levels recommended in the Table.

NOTE 3 These internal L_{Aeq} target levels are based on annual average data and do not have to be achieved in all circumstances. For example, it is normal to exclude occasional events, such as fireworks night or New Year's Eve.

NOTE 4 Regular individual noise events (for example, scheduled aircraft or passing trains) can cause sleep disturbance. A guideline value may be set in terms of SEL or $L_{Amax,F}$, depending on the character and number of events per night. Sporadic noise events could require separate values. In most circumstances in noise-sensitive rooms at night (e.g. bedrooms) good acoustic design can be used so that individual noise events do not normally exceed 45dB $L_{Amax,F}$ more than 10 times a night. However, where it is not reasonably practicable to achieve this guideline then the judgement of acceptability will depend not only on the maximum noise levels but also on factors such as the source, number, distribution, predictability and regularity of noise events (see Appendix A).

NOTE 5 Designing the site layout and the dwellings so that the internal target levels can be achieved with open windows in as many properties as possible demonstrates good acoustic design. Where it is not possible to meet internal target levels with windows open, internal noise levels can be assessed with windows closed, however any façade openings used to provide whole dwelling ventilation (e.g. trickle ventilators) should be assessed in the "open" position and, in this scenario, the internal L_{Aeq} target levels should not normally be exceeded, subject to the further advice in Note 7.

NOTE 6 Attention is drawn to the requirements of the Building Regulations.

NOTE 7 Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal L_{Aeq} target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved. The more often internal L_{Aeq} levels start to exceed the internal L_{Aeq} target levels by more than 5 dB, the more that most people are likely to regard them as "unreasonable". Where such exceedances are predicted, applicants should be required to show how the relevant number of rooms affected has been kept to a minimum. Once internal L_{Aeq} levels exceed the target levels by more than 10 dB, they are highly likely to be regarded as "unacceptable" by most people, particularly if such levels occur more than occasionally. Every effort should be made to avoid relevant rooms experiencing "unacceptable" noise levels at all and where such levels are likely to occur frequently, the development should be prevented in its proposed form **(see Section 3.D)**.

1.6 Approved Document F Ventilation

Guidance on ventilation requirements for dwellings under The Building Regulations is described in Approved Document F, 2021 Edition ('ADF').

The document provides the following guidance on noise from ventilation systems in dwellings:

"1.5 Mechanical ventilation systems, including both continuous and intermittent mechanical ventilation, should be designed and installed to minimise noise. This includes doing all of the following.

a. Correctly sizing and jointing ducts.
b. Ensuring that equipment is appropriately and securely fixed, such as using resilient mountings where noise carried by the structure of the building could be a problem.
c. Selecting appropriate equipment, including following paragraph 1.6.

1.6 For mechanical ventilation systems, fan units should be appropriately sized so that fans operating in normal background ventilation mode are not overly noisy. This might require fans to be sized so that they do not operate near maximum capacity when in normal background ventilation mode.

1.7 Account should be taken of outside noise when considering whether openable windows are appropriate for purge ventilation.

NOTE: Although there is no requirement to undertake noise testing, achieving the levels in the following guidance would ensure good acoustic conditions. The average A-weighted sound pressure level for a ventilator operating under normal conditions and not at boost rates should not exceed both of the following.

a. 30dB LAeq,T for noise-sensitive rooms (e.g. bedrooms and living rooms) when a continuous mechanical ventilation system is running on its minimum low rate.*

b. 45dB LAeq,T in less noise-sensitive rooms (e.g. kitchens and bathrooms) when a continuous operation system is running at the minimum high rate or an intermittent operation system is running..."*

2.1 Calculation of Railway Noise (CRN)

Calculation of Railway Noise 1995 is the standard method for calculating rail noise in the UK. Sound event levels are derived for rail pass-bys based upon multiple controlling factors for typical rolling stock types (e.g. speed, number of vehicles, track type etc.); continuous equivalent day and night time noise levels are predicted accounting for propagation effects between source and receiver (e.g. distance, ground cover, screening).

2.2 '*Guidelines Measurement & Assessment of Groundborne Noise & Vibration*' 3rd Edition, Association of Noise Consultants, 2020 (the "ANC Guidelines")

This document provides practical guidelines on the measurement and assessment of groundborne noise and vibration. It has been prepared on behalf of the Association of Noise Consultants by specialists in this field. A wide range of vibration issues and sources is covered with particular attention to railway vibration and groundborne noise. This third edition includes a full review of current standards and guidance as well as recent research. It provides guidance on techniques for measurement, prediction, assessment and mitigation of groundborne noise and vibration in a wide range of circumstances.

2.3 BS 6472-1:2008 'Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting'

This part of BS 6472 provides guidance on predicting human response to vibration in buildings over the frequency range 0.5 Hz to 80 Hz. Frequency weighting curves for human beings exposed to whole-body vibration are included, together with advice on measurement methods to be employed. Methods of assessing continuous, intermittent and impulsive vibration are presented.

This part of BS 6472 describes how to determine the vibration dose value, VDV, from frequency-weighted vibration measurements. The vibration dose value is used to estimate the probability of adverse comment which might be expected from human beings experiencing vibration in buildings. Consideration is given to the time of day and use made of occupied space in buildings, whether residential, office or workshop.

The standard states in section 6 "*When the appropriately-weighted vibration measurements or predictions have been used to derive the VDV for either 16 h (daytime) or 8 h (night-time) at the relevant places of interest, their significance in terms of human response for people in those places can be derived from Table 1. The judgement made is of the probability that the determined vibration dose might result in adverse comment by those who experience it.*

Table 2 BS 6472:1, Table 1: Vibration dose value ranges which might result in various probabilities of adverse comment within residential buildings

Place and time	***Low probability of adverse comment*** $ms^{-1.75}$ [1]	***Adverse comment possible*** $ms^{-1.75}$	***Adverse comment probable*** $ms^{-1.75}$ [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."

2.4 Local Planning Authority Consultation

BMBC Environmental Health Officer Adam Cattell has confirmed the following internal noise limits would be applicable for the proposed residential development:

- Bedrooms: L_{Aeq} (8 hours) - 30dB (2300 to 0700 hours);
- Living Rooms & Bedrooms: L_{Aeq} (16 hour) - 35dB (0700 to 2300 hours);
- Bedrooms: L_{AFmax} - 45dB not to be exceeded more than 10 times per night (2300 to 0700 hours)

3. Proposed assessment design criteria

The section below highlights appropriate design criteria for new residential development. Based on comments received from BMBC it is expected that these typical criteria would form the basis of any noise impact assessment to be submitted to the local authority in support of a planning application for residential development at the Site.

3.1 Internal ambient noise levels

In line with the guidance detailed in the previous section, we would anticipate the following internal noise criteria for a new residential development:

- Daytime internal ambient noise levels not to exceed $L_{Aeq,\ 16\ hour}$ = 35 dB
- Night-time internal ambient noise levels not to exceed $L_{Aeq,\ 8\ hour}$ = 30 dB
- Regular individual noise events should not normally exceed of 45dB L_{Amax} more than 10 times a night in bedrooms between 23.00 and 07.00 hours

Designing to these levels will result in a good internal acoustic environment within a residential dwelling, and these levels are in line with current guidance and codes of practice.

The noise criteria should be achieved whilst providing Part F of the Building Regulations minimum background ventilation requirements.

3.2 External amenity areas

In line with the guidance detailed in the previous section, we would anticipate the following external noise criteria for a new residential development:

Where possible external noise levels within residential outdoor amenity areas should aim to achieve the desirable criterion of 50 dB $L_{Aeq,T}$; and should not exceed the upper guideline limit of 55 dB $L_{Aeq,T}$.

3.3 Vibration

The assessment criteria for both groundborne noise and VDV is proposed to be defined in terms of Lowest Observable Adverse Effect Level (LOAEL) and Significant Observable Adverse Effect Level (SOAEL).

LOAEL and SOAEL are noise exposure hierarchy terms used in PPGN. Where groundborne noise levels are below the LOAEL value, PPGN guidance advises that no specific measures are required to manage the acoustic environment. For the purposes of this assessment, specific measures would relate to building vibration isolation measures to attenuate existing external vibratory sources, such as isolating the building foundations of the new buildings from the ground via acoustic bearings.

3.3.1 Groundborne noise

The ANC Guidelines states that, in respect of health and quality of life criteria, the following groundborne noise values have been typically applied in residential environments:

Lowest Observable Adverse Effect Level (LOAEL) 35 dB $L_{AMax,S}$
Significant Observable Adverse Effect Level (SOAEL) 45 dB $L_{AMax,S}$

1.6.1 VDV criteria

The ANC Guidelines states that the criteria presented in

Table 3 have been applied to some recent infrastructure schemes, where the approach taken has been to use established criteria for perceptions and annoyance and assume that these equate to the thresholds for health and quality of life effects.

Table 3: Table 6.1 from the ANC Guidelines: Suggested vibration dose values for the assessment of potential health effects inside residential dwellings

Threshold (residential)	***VDV day ($ms^{-1.75}$)***	***VDV night ($ms^{-1.75}$)***
LOAEL	0.2	0.1
SOAEL	0.8	0.4

The LOAEL values for vibration have been taken at the lower end of the range of VDVs for which BS 6472-1 indicates a "*low probability of adverse comment*". The SOAEL values are the lower values for "*adverse comment probable*" defined in BS6472-1.

4. Environmental Noise Survey

4.1 Introduction

An environmental noise survey has been undertaken on Friday 17th June 2022 to establish the baseline noise climate across the Site. The data obtained has been used to inform a high level feasibility assessment of the potential implications associated with future residential development at the site.

4.2 Methodology

A series of short-term measurements were undertaken by BDP Acoustics at a number of locations on the site.

A long term measurement was undertaken at position 4 consisting of continuously logged 5 minute measurements, elsewhere manned short term 5 minute measurements were taken in rotation at three satellite measurement positions.

The approximate measurement positions are presented in Figure 3 and were selected to provide data representative of the typical worst case on-site noise climate, considering noise sources including adjacent rail lines, local roads, and nearby bus interchange activity.

Measurements were undertaken at positions 1 to 3 between 05:47 and 07:00 hours to encompass likely worst-case (noisiest) night time levels; between 07:00 and 09:39 hours to encompass likely worst-case (noisiest) day time levels.

Weather conditions during the survey were fine and dry, with wind speeds varying between 2-5 m/s, temperature varying between 19–27ºC, and cloud cover varying between 30%-70%).

All measurements were taken using Rion NA-28 sound level meters, which were field calibrated with no significant drift in sensitivity observed. The sound level meters and calibrator used on site are also calibrated to traceable standards and calibration certificates can be provided upon request.

At each measurement position the octave band and A-weighted fast-response levels were recorded for a comprehensive suite of noise level metrics. All measurements were taken at a height of 1.5m above local ground level in free-field conditions. Measurements were carried out by Alex Taylor - BDP Senior Acoustic Consultant, MIOA BSc(Hons).

4.3 Observations

Descriptions of the ambient noise climates observed at survey positions 1 – 4 are presented in Table 4

Table 4: Descriptions of noise climates observed during noise survey

Position	***Description of measurement position and noise climate***
EN1	Located on the car park at the approximate location of the eastern elevation line between Plots 1 and 2. Noise contributions from train pass-by events with additional noise contributions from bird song, distant road traffic noise to the east, bus activity at Barnsley Transport Interchange, occasional car park activity and distant construction activity noise.
EN2	Located on the car park at the approximate location of the southern corner of Plot 2 closest to the railway line. Noise contributions from bus activity at Barnsley Transport Interchange, screened traffic noise from Eldon St, and train pass-by events. Additional noise contributions from bird song, distant traffic noise to the east, occasional car park activity and distant construction activity noise.
EN3	Located on the car park at the approximate location of the northern corner of Plot 2 closest to the railway line.

Position	***Description of measurement position and noise climate***
	Noise contributions from train pass-by events with additional noise contributions from bird song, screened traffic noise from Old Mill Lane to the north, occasional car park activities and distant construction activity noise.
EN4	Located on the site boundary close to position EN2. This unattended measurement position had line of sight to the traffic on Eldon St below and was selected to inform source noise levels for indicative noise modelling of the site rather than representing noise levels that would be experienced at the facades of the proposed development. Noise contributions from unscreened traffic noise from Eldon St, bus activity at Barnsley Transport Interchange, and train pass-by events. Additional noise contributions from bird song, distant traffic noise to the east and occasional car park activity and distant construction activity noise.

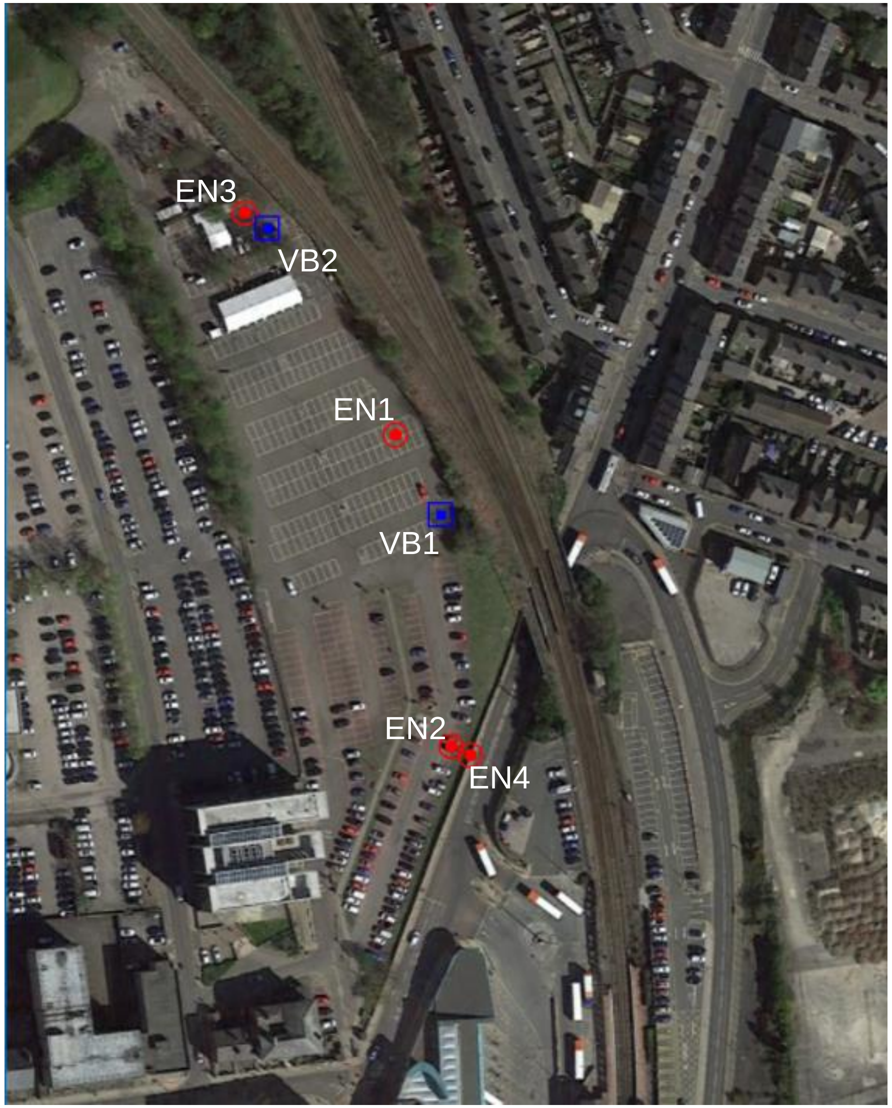
4.4 Results

A summary of the measured results for the purposes of determining the on-site noise climate are presented in Table 5. Full measured results in tabular form can be provided upon request.

Table 5: Summary of measured results 17th June 2022

Measurement Position	***Start Time (hh:mm)***	***End Time (hh:mm)***	$L_{Aeq,5min}$ ***Range (dB)***	$L_{AFmax,5min}$ ***Range (dB)***	$L_{AF90,5min}$ ***Range (dB)***
EN1	05:47	05:58	47 - 48	64 - 68	44 - 44
EN1	06:21	06:35	55 - 62	66 - 84	47 - 51
EN1	07:01	07:11	59 - 61	80 - 81	49 - 50
EN1	07:40	07:57	52 - 59	67 - 78	50 - 51
EN1	08:36	08:52	49 - 56	65 - 67	48 - 50
EN2	05:59	06:09	53 - 56	65 - 70	47 - 47
EN2	06:37	06:47	55 - 56	70 - 78	49 - 51
EN2	07:14	07:26	55 - 56	64 - 72	50 - 52
EN2	08:00	08:16	54 - 54	64 - 66	51 - 52
EN2	08:56	09:13	55 - 56	66 - 68	51 - 52
EN3	06:10	06:21	47 - 48	61 - 62	43 - 44
EN3	06:49	06:59	51 - 54	64 - 73	46 - 48
EN3	07:29	07:39	55 - 55	72 - 72	49 - 49
EN3	08:19	08:35	53 - 54	69 - 70	46 - 48
EN3	09:24	09:39	51 - 55	67 - 71	47 - 48
EN4	07:16	09:16	59 - 63	68 - 85	51 - 56

Figure 3: Noise monitoring locations



5. Vibration survey

5.1 Introduction

Sample train pass-by vibration measurements have been undertaken to determine indicative vibration levels at the closest proposed building locations to the railway line.

5.2 Methodology

A manned vibration survey was undertaken on 17 June 2022 by Alex Taylor - BDP Senior Acoustic Consultant, MIOA BSc(Hons). The vibration measurements were undertaken with reference to the guidance offered in the ANC Guidelines using a 01dB Harmonie vibration analysis system utilising 3 no. mono-axial accelerometers. The mono-axial accelerometers were mounted on a tri-axial mounting block sensor which was then magnetically mounted to a 50 x 50 mm metal plate which was bonded with adhesive to the tarmacadam car parking surface.

Sample vibration measurements were undertaken at 2 locations on the existing car park at the approximate locations of the closest proposed buildings to the railway line. The approximate vibration measurement positions are presented in Figure 3.

The measurement position chosen for Plot 1 (VB1) is expected to represent a worst case scenario with regards to groundborne noise and vibration levels from train pass-bys given the close proximity to the track junction.

Table 6: Descriptions of vibration measurement positions

Position	***Description of measurement position***
VB1	Located on carpark at the approx. position of the northern rail side corner of Plot 1, approx. 16.5m from the closest rail line.
VB2	Located on carpark at the approx. position of the northern rail side corner of Plot 2, approx. 12m from the closest rail line.

5.3 Results

A summary of the surveyed train pass-by events used for the purposes of determining the groundborne noise and vibration at the closest building locations to the rail line are presented in Table 7 below.

Table 7: Vibration survey event reference number and pass-by type

Event Number	***Position***	***Event start time***	***Train details****
1	VB1	10:56	Passenger train arriving
2	VB1	11:04	Passenger train departing
3	VB1	11:09	Passenger train arriving
4	VB1	11:11	Passenger train arriving
5	VB1	11:19	Passenger train arriving
6	VB1	11:31	Passenger train departing
7	VB1	11:41	Passenger train departing
8	VB2	12:31	Passenger train departing (far track)
9	VB2	12:38	Passenger train arriving (far track)
10	VB2	12:46	Passenger train departing (far track)
11	VB2	13:04	Passenger train departing (near track)
12	VB2	13:06	Passenger train arriving (near track)
13	VB2	13:10	Passenger train departing (far track)

** Train designated as arriving or departing with reference to direction of travel to Barnsley Transport Interchange station.*

The vibration data obtained during the survey has been used to inform indicative predictions of groundborne noise and vibration levels upon the Project; details of the prediction results are provided in Section 7.5.

6. 3D Noise Modelling

Indicative 3D noise prediction models have been created using CadnaA noise modelling software to evaluate the potential increase in noise levels that could be experienced at the upper storeys of the proposed Plot 1 building overlooking Eldon St (due to the potential for reduced screening of traffic noise from Eldon St at upper storeys) and the potential reduction in noise levels that could be experienced on the western elevations of the proposed buildings that would be self-screened from the dominant noise sources (due to the self-screening of train pass-by noise).

A baseline model has been developed to enable validation of the indicative model to the environmental noise survey data collected.

The proposed plot boundaries and storey heights of Plots 1 and 2 have been used to develop simplified block models of the proposed buildings, and an open site has been assumed, i.e. no account is taken for the acoustic screening that would be provided by any future development buildings on the site.

The results of the noise survey and the indicative modelling exercise have been used to assess the on-site noise levels in terms of the feasibility of and potential implications associated with future residential development at the site.

7. Analysis

7.1 Façade incident noise levels

Based on the results of the sample measured noise levels and the indicative 3D noise modelling exercise, the eastern elevations exposed to the dominant local noise sources (i.e. the train line, Eldon St traffic, and bus activity at the Transport Interchange) are expected to experience worst case noise levels in the region of:

- $L_{Aeq,16hr}$ 54 – 63 dB during the daytime;
- $L_{Aeq,8hr}$ 51 – 57 dB during the night-time;
- L_{AMax} 61 – 84 dB from train pass-by events during the night-time.

Based on indicative modelling predictions of the noise reduction due to building screening, worst case noise levels on the western elevations that would be self-screened from the local dominant noise sources (i.e. the train line and Transport Interchange) are anticipated to be in the region of:

- $L_{Aeq,16hr}$ 51 – 52 dB during the daytime;
- $L_{Aeq,8hr}$ 48 – 52 dB during the night-time;
- L_{AMax} 50 – 73 dB from train pass-by events during the night-time.

7.1.1 Train pass-by events

The following table summarises the typical number and type of trains expected to pass-by Plots 1 and 2 during the night-time period (23:00 – 07:00 hrs). This information has been taken from the train timetable information presented on the website www.realtimetrains.co.uk for the period Sunday 26/06/2022 – 02/07/2022, and has been used to inform the assessment of night-time L_{Amax} events at the worst case facades which are assumed to be controlled by train pass-by events.

Note that no freight train pass-by events took place during the sample day and night-time measurement periods. The timetable information below indicates that as a worst case there may be up to 3 freight train pass by events during the night-time period. The analysis of night-time internal L_{Amax} events has therefore factored in the potential for up to 3 freight train pass-by events per night.

Table 8: Summary of night-time (23:00 – 07:00 hrs) train pass-by events assumed for assessment of proposed L_{Amax} internal night-time noise criteria

Date	Passenger Trains	Freight Trains	Total Train pass-bys
Sun 26-Jun	7	1	8
Mon 27-Jun	11	3	14
Tue 28-Jun	9	2	11
Wed 29-Jun	9	3	12
Thu 30-Jun	9	2	11
Fri 01-Jul	9	1	10
Sat 02-Jul	3	0	3

7.2 Noise break-in calculations

Indicative noise break-in calculations have been undertaken to assess the expected sound insulation requirements of the building envelope elements (e.g. glazing and ventilation).

The following assumptions were used for the purposes of the noise break-in calculations:

- External noise levels based on the environmental noise survey data and indicative 3D noise modelling results.
- Predicted building screening reduction of measured noise levels for western elevations screened from the railway line.

- The 4th highest external L_{Amax} (79 dBA) measured at positions 1, 2 and 3 during both day and night-time noise surveys has been used to assess the internal L_{Amax} criteria. When allowance has been made for the potentially 3 additional higher L_{Amax} events associated with the expected 3 freight train night-time pass-by events, this is expected to result in the scheme being assessed to the 7th highest train pass-by L_{Amax} expected during the night-time period.
- The acoustic criteria outlined in Section 3.1.
- Calculations were based on a nominal bedroom area with assumed dimensions of 4m x 3m x 2.4m, an exposed façade of 4m x 2.4m incorporating 33% glazed area, and an internal reverberation time of 0.5 seconds.
- A nominal rainscreen cladding external envelope construction providing a minimum airborne sound insulation performance of R_w + Ctr 44 dB
- Background ventilation requirements provided via standard trickle ventilation with minimum combined ventilator area 0.010m^2.

7.3 Internal noise levels

When considering the proposed internal noise criteria (refer Section 3), on the basis of the measured on-site noise data, the most onerous acoustic condition relates to the anticipated night-time maximum (L_{AMax}) noise levels associated with rail movements between 23:00 - 07:00 hrs.

In order to facilitate appropriate acoustic conditions for any residential development at the site, a suitable acoustic design strategy should be adopted. On the basis of the maximum night-time noise levels controlling the acoustic requirements of any proposed residential development buildings, the following measures are likely to be required to be given consideration at a future design stage:

7.3.1 Eastern elevations

Residential units in close proximity to and overlooking the rail line (e.g. residential units on the eastern elevations) are expected to require the following indicative sound insulation measures to achieve the proposed internal noise criteria:

- All Bedrooms to incorporate mechanical background ventilation and window assemblies with a minimum sound insulation performance of R_w+C_{tr} 37 dB.
- Plot 1 Living areas (i.e. non-sleeping areas) to incorporate acoustically attenuated natural background ventilation with a minimum sound insulation performance of $D_{ne,w}$+C_{tr} 42 dB (e.g. Ryton AAH125HP acoustic vent) and window assemblies with a minimum sound insulation performance of R_w+C_{tr} 32 dB to mitigate against the increased exposure to Eldon St traffic and bus activity noise from the Transport Interchange.
- Plot 2 Living areas (i.e. non-sleeping areas) to incorporate standard background trickle ventilation and standard thermal double glazed window assemblies, e.g. minimum R_w+C_{tr} 29 dB.

Whilst the above measures would allow the proposed criteria to be achieved, it should be noted that the acoustic performance of the building envelope will be reduced in the event windows are opened for cooling or purge ventilation purposes. It is likely that internal noise level criteria would be exceeded should thermal cooling ventilation be provided by means of opening windows.

7.3.2 Western elevations

Residential units with facades screened from the rail line (e.g. residential units on the western elevations) are expected to require the following indicative sound insulation measures to achieve the proposed internal noise criteria:

- All Bedroom and Living areas (i.e. non-sleeping areas) to incorporate conventional background trickle ventilation and conventional thermal double glazed window assemblies, minimum of R_w+C_{tr} 29 dB.

Whilst the above measures would allow the proposed criteria to be achieved, it should be noted that the acoustic performance of the building envelope will be reduced in the event windows are opened for cooling or purge ventilation purposes. It is likely that internal noise level criteria would be exceeded should thermal cooling ventilation be provided by means of opening windows.

7.3.3 Proposed future site developments

We understand that planning applications for a multi-storey car park (MSCP) and an Active Travel Hub (ATH) primarily to provide cycle storage on the Project site are proposed. The proposed MSCP building will be located approx. 13m from the northern boundary of Plot 2 and the proposed ATH building will be located approx. 17m from the southern boundary of Plot 1.

The potential noise emissions from the proposed MSCP and ATH buildings will require consideration when developing the detailed design of the proposed residential Plots 1 and 2, however it is expected that where required, appropriate mitigation could be provided in the form of suitably specified sound insulation performance ratings for window and ventilation elements for the proposed residential units.

7.4 External amenity areas

Based on the results of the measured noise levels, the ground floor areas closest and most exposed to the dominant local noise sources (i.e. the eastern elevations) are anticipated to experience external noise levels in the region of $L_{Aeq,16hr}$ 54 – 56 dB during the daytime.

Based on the indicative 3D noise modelling predictions of the screening afforded by the proposed development buildings, external noise levels in areas that are screened from and do not have a line of sight to the local dominant noise sources (e.g. the train line and Transport Interchange) are anticipated to be in the region of $L_{Aeq,16hr}$ 50 dB during the daytime.

Based on the above, it is expected that the proposed development has the potential to provide external amenity areas that experience noise levels below the upper guideline limit of 55 dB $L_{Aeq,T.}$

Where possible, it is recommended that gardens and communal external amenity spaces are located on opposite sides of dwellings to the railway lines, so that the external amenity spaces are afforded acoustic screening by the proposed buildings.

7.5 Vibration levels

Using the vibration data collected during the BDP vibration survey, predictions of groundborne noise and VDV resulting from rail vehicle traffic have been undertaken.

7.5.1 Groundborne noise level prediction results

Indicative groundborne $L_{Amax,S}$ noise levels have been predicted from the sample site vibration measurements at positions VB1 and VB2 using calculation methodologies outlined in the ANC Guidelines. The results of the predictions are presented in Table 9. The groundborne noise prediction methodology is presented in Appendix III

Table 9: Predicted groundborne noise levels resulting from train pass-by events occurring during the monitoring at survey positions VB1 and VB2

Event Number	Position	Event start time	Train direction*	Predicted groundborne $L_{Amax,S}$ (dB)
1	VB1	10:56	Train arriving	30
2	VB1	11:04	Train departing	33
3	VB1	11:09	Train arriving	20
4	VB1	11:11	Train arriving	32
5	VB1	11:19	Train arriving	23
6	VB1	11:31	Train departing	35
7	VB1	11:41	Train departing	34
8	VB2	12:31	Train departing (far track)	19
9	VB2	12:38	Train arriving (far track)	19
10	VB2	12:46	Train departing (far track)	17
11	VB2	13:04	Train departing (near track)	35
12	VB2	13:06	Train arriving (near track)	31
13	VB2	13:10	Train departing (far track)	19

Comparison of the criteria with the indicative prediction results presented above indicates that without any vibration mitigation measures applied, groundborne noise levels within the proposed residential buildings will be equal to or below the LOAEL values.

We recommend that further detailed vibration measurements and subsequent groundborne noise analysis is undertaken at later design stages (e.g. when specific building types, locations, and foundation proposals are developed) in order to further verify that vibration mitigating measures are not required.

7.5.2 VDV prediction results

Indicative VDV predictions have been undertaken on a sample measurement period between 10:49 and 11:13 hrs. This 24 minute sample period included 4 train pass-by events measured at position VB1. This is expected to represent a reasonable worst case monitoring position for the proposed development given the proximity of the measurement position to the rail track junction.

It should be noted that the VDV prediction for the night-time period 23:00 – 07:00 hrs is based on a vibration measurement period with a higher frequency of train pass-by events than is schedule to occur in night time periods.

The results of the indicative VDV predictions are presented in Table 10. The VDV prediction methodology is presented in Appendix III.

Table 10: Predicted VDVs for the proposed residential accommodation

Building	Time period, t	Predicted $VDV_{b,t}$ ($ms^{-1.75}$)
Plots 1 and 2	16 hour Day (07:00 to 23:00 hours)	0.06
	8 hour Night (23:00 to 08:00 hours)	0.05

Note: Predicted VDVs were highest in the z-axis

7.5.3 VDV assessment

Comparison of the criteria with the indicative prediction results above indicates that without any vibration mitigation measures applied, VDVs within the proposed residential accommodation are expected to be below the LOAEL values.

As per our recommendation for groundborne noise, we recommend that further detailed vibration measurements and subsequent groundborne vibration analysis is undertaken at later design stages (e.g. when specific building types, locations, and foundation proposals are developed) in order to further verify that vibration mitigating measures are not required.

8. Summary

BDP Acoustics has been commissioned by Barnsley Metropolitan Borough Council (BMBC) to undertake an environmental noise and vibration assessment to support an outline planning application for the proposed residential development of Plots 1 and 2 of Phase 1 of The Seam Digital Campus, Barnsley (the 'Site').

8.1 Noise levels

Using noise survey data gathered on-site and indicative 3D noise modelling predictions, noise break-in calculations have been undertaken to undertaken to assess the outline sound insulation requirements of the building envelope elements (e.g. glazing and ventilation). Based on these findings, a high level appraisal of the likely design considerations anticipated to be required to facilitate residential development has been undertaken.

The following outline design considerations are recommended in order to achieve the proposed internal noise criteria:

- Plot 1 Living areas (i.e. non-sleeping areas) in close proximity to, and overlooking the rail line / Eldon St / Transport Interchange (i.e. the eastern elevations) to incorporate acoustically attenuated natural background ventilation with a minimum sound insulation performance of $D_{ne,w}+C_{tr}$ 42 dB (e.g. Ryton AAH125HP acoustic vent) and window assemblies with a minimum sound insulation performance of R_w+C_{tr} 32 dB.

- Plot 2 Living areas (i.e. non-sleeping areas) in close proximity to, and overlooking the rail line (i.e. the eastern elevations) to incorporate standard background trickle ventilation and standard thermal double glazed window assemblies, minimum R_w+C_{tr} 29 dB.

- For both plots, Bedrooms in close proximity to, and overlooking the rail line (i.e. the eastern elevations) should incorporate mechanical background ventilation and window assemblies with a minimum sound insulation performance of R_w+C_{tr} 37 dB.

- For both plots, all Bedroom and Living areas (i.e. non-sleeping areas) on the western elevations that are screened from the dominant site noise sources to incorporate standard background trickle ventilation and standard thermal double glazed window assemblies, minimum R_w+C_{tr} 29 dB.

Whilst the above measures are expected to allow the proposed internal noise criteria to be achieved, it should be noted that the acoustic performance of the building envelope will be reduced in the event windows are opened for cooling or purge ventilation purposes. It is likely that internal noise level criteria would be exceeded should thermal cooling ventilation be provided by means of opening windows.

Based on the results of the measured noise levels and indicative 3D noise modelling estimates of noise reduction due to self-screening of the dominant local noise sources from the proposed residential buildings, it is expected that the proposed development has the potential to provide external amenity areas that are below the upper guideline limit of 55 dB $L_{Aeq,T}$..

8.2 Vibration

Our assessment indicates that without any vibration mitigation measures applied, groundborne noise levels within the proposed residential buildings will be equal to or below the LOAEL values.

Our assessment indicates that without any vibration mitigation measures applied, VDVs within the proposed residential accommodation are expected to be below the LOAEL values.

We recommend that further detailed vibration measurements and subsequent groundborne noise and vibration analysis is undertaken at later design stages (e.g. when specific building types, locations, and foundation proposals are developed) in order to further verify that vibration mitigating measures are not required.

Appendix I – Glossary of Acoustic Terms

A-Weighting

Normal hearing covers the frequency range from about 20 Hz to 20 kHz but sensitivity is greatest between about 500 Hz and 8 kHz. The 'A-Weighting' is an electronic filters network incorporated in sound level meters which approximately corresponds to the frequency response of the ear. The unit of measurement of A-weighted sound level is dBA.

Decibel, dB

This is the unit to measure sound. The human ear has an approximately logarithmic response to acoustic pressure over a very large dynamic range (typically 20 micro-Pascals to 100 Pascals). We therefore use a logarithmic scale to describe sound pressure level, intensities and sound power levels. Subjectively, an increase of 10 dB corresponds to a doubling in the perceived loudness of sound.

Equivalent Continuous Sound Level L_{eq} or L_{Aeq}

The continuous equivalent sound level, L_{Aeq} is a notional sound level. It is the sound level, which, if maintained for a given length of time, would produce the same acoustic energy as a fluctuating noise over the same time period. The A-weighted L_{eq} is widely used to measure any environmental noise which varies considerably with time and is denoted as the L_{Aeq}.

Octave and Third Octave Bands

The human ear is sensitive to sound over a range of approximately 20 Hz to 20 kHz, and is generally more sensitive to medium and high frequencies than to low frequencies. In order to define the frequency content of a noise, the spectrum is divided into frequency bands, and the sound pressure level is measured in each band. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. (For instance the octave bands above and below the 500 Hz octave band are 1 kHz and 250 Hz respectively). For finer analysis, each octave band may be split into three one-third octave bands or in some cases, fine frequency bands.

Reverberation Time, RT

The RT is defined as the time taken for an impulsive sound to decrease by 60 dB. The sound waves are reflected many times from each surface in the room, and are partly reduced at each reflection, the amount of reduction depending on the acoustic absorption of the surface. Acoustic absorption is measurable and is defined by a coefficient between 0 (totally reflective) and 1 (totally absorbent) at each frequency. Although an anomaly in the standard laboratory test procedure can lead to absorption coefficients higher than 1, this is not achievable in real installations.

Statistical Level: L_{90}

Sound pressure level that is exceeded for 90% of the measurement time. Consequently it is indicative of the general background noise level in the absence of any higher level short duration events that occur during the period.

Weighted Sound Reduction Index, R_w

This is a weighted single figure descriptor of the sound insulation performance of a partition measured under laboratory conditions. The sound reduction index in each of the one-third octave bands from 100 Hz to 3150 Hz is compared with a standard set of curves. The value of Rw for a given partition is obtained from the standard curve which when compared with the measured SRI values produces an adverse deviation as close to -32 dB as possible. Only the SRI values which fall below a particular standard curve are considered in the sum. Positive deviations from the standard curve are not taken into account.

Appendix II – Glossary of vibration terms

Groundborne vibration

Vibration generated from an external vibratory source (e.g. vehicle on rail), propagated through the ground or structure into a receiving building.

Groundborne noise

Noise generated inside a building by groundborne vibration.

Root Mean Square (rms)

The rms value of a set of numbers is the positive square root value of the average of their squares; for a sound or vibration waveform the rms value over a given time period is the square root of the average of the square of the waveform over that time period.

Vibration

A motion which oscillates about a fixed equilibrium position.

Vibration Acceleration

The standard unit for vibration acceleration is metres per second squared (or m/s2) and this is normally expressed as a form of average known as root-mean-squared (rms).

Frequency analysis of vibration acceleration is frequently undertaken in terms of 1/3 octave bands in order to determine the presence of vibration modes and to take account of the variations in threshold of human perception of vibration.

Vibration Dose Value (VDV)

The effect of building vibration on the people within is assessed by finding the appropriate vibration dose. Present knowledge shows that this type of vibration is best evaluated with the vibration dose value (VDV).

The VDV defines a relationship that yields a consistent assessment of continuous, intermittent, occasional and impulsive vibration and correlates well with subjective response.

The vibration dose value is defined as

$$VDV_{b/d,day/night} = \left(\int_0^T a^4(t)dt\right)^{0.25}$$

Where:

$VDV_{b/d,day/night}$ is the vibration dose value (in $m^{-1.75}$);

a(t) is the frequency-weighted acceleration (in ms^{-2}), using W_b or W_d as appropriate;

T is the total period of the day or night (in s) during which vibration can occur.

NOTE: The VDV should be identified with the vibration acceleration weighting function applied by adding a subscript, that is, VDV_b or VDV_d as appropriate. Where other identifying subscripts are necessary, they should follow the weighting function subscript, separated from it by a comma, e.g. $VDV_{b,day}$.

Appendix III – Groundborne noise and vibration prediction methods and assumptions

Groundborne noise level predictions

The vibration baseline survey data has been used to predict groundborne noise levels that would result in the proposed residential buildings.

The following assumptions have been adopted to derive the predicted groundborne noise levels:

Assumptions adopted for proposes new build buildings

- Groundborne noise levels have been predicted using the measured vibration levels and applying Equation D.2 of the ANC Guidelines, replicated below:

$$L_p = 20log_{10}\left[\frac{A_{rms}}{A_{ref}}\right] - 20log_{10}(f) + 37$$

where:

L_p is the calculated one-third octave band sound pressure level in the room (dB re 2 x 10^{-5}Pa);

A_{rms} is the RMS acceleration in g in the one-third octave frequency band measured on the floor of the room under consideration;

A_{ref} = g x 10^{-6} (ms^{-2}), where g is the gravatational acceleration constant (9.81 ms^{-2}); and

f is the one-third octave band centre frequency (Hz).

- The measured A_{rms} used to derive L_p is the A_{rms} measured over the entire train pass-by event. Based on guidance in Greer, R.J (1993). '*Methodology for the prediction of re-radiated noise in buildings from trains travelling in tunnels*', Proceedings of Inter-Noise '93, the derived L_p from the A_{rms} of the train event is assumed to be equivalent to an L_{eq} of the train pass-by event. Based on the guidance in the ANC Guidelines an additional +2 dB correction has been applied to this value to obtain the predicted L_{Smax}.

- The predicted groundborne noise levels inside the residential apartments within the proposed development buildings have been derived from the third-octave band vertical axis acceleration levels measured at survey positions VB1 and VB2.

- No ground surface to foundation coupling loss corrections have been applied to the measured acceleration levels.

- No correction has been applied for floor to floor vibration attenuation.

- The predicted groundborne noise levels inside the residential apartments within the building have been derived from the third-octave band vertical axis acceleration levels measured at the survey positions.

Uncertainty in predicted groundborne noise levels

The ANC Guidelines identifies that there is considerable uncertainty associated with the use of a single-figure correction to derive the sound level from vibration and the use of the referenced transfer functions.

As no developed building design information is available at this time, no mitigation measures or transfer functions have been applied to determine potential groundborne vibration attenuation or amplification effects related to the buildings structure.

We therefore recommend that further detailed vibration measurements and subsequent groundborne noise analysis is undertaken at later design stages (e.g. when specific building types, locations, and foundation proposals are developed) in order to further verify that vibration mitigating measures are not required.

VDV prediction methods

The following assumptions have been made to derive the VDV predictions:

Assumptions adopted for proposed new build buildings

- 16 hour and 8 hour VDVs on the floor of the residential apartments of the buildings have been predicted using Equation 2 from BS6472, replicated below:

  Where the vibration conditions are constant or repeated regularly, only one representative sample, of duration τ seconds, needs to be measured. If the vibration dose value determined is $VDV_{b/d,\tau}$ then the total vibration dose value for the day, $VDV_{b/d,day}$ will be given by the following equation:

$$VDV_{b/d,day} = \left(\frac{t_{day}}{t_{\tau}}\right)^{0.25} \times VDV_{b/d,\tau}$$

where:

t_{day} is the duration of exposure per day.

- $VDV_{b/d,\tau}$ has been assumed to be the z-axis VDV_b measured at position VB1.

- No ground surface to foundation coupling loss corrections have been applied to the measured acceleration levels, due to the same reasons discussed in the groundborne noise level prediction assumptions.

- No correction has been applied for floor to floor vibration attenuation.

Uncertainty in predicted VDV levels

As no developed building design information is available at this time, no mitigation measures or transfer functions have been applied to determine potential groundborne vibration attenuation or amplification effects related to the buildings structure.

We therefore recommend that further detailed vibration measurements and subsequent groundborne vibration analysis is undertaken at later design stages (e.g. when specific building types, locations, and foundation proposals are developed) in order to further verify that vibration mitigating measures are not required.