

Seven Sisters, Warehouse living Haringey London



Noise and Vibration Impact Assessment Report
Report 25436.NVA.01 Rev B

Provewell Ltd

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1.0 INTRODUCTION

KP Acoustics Ltd has been commissioned by Provewell Ltd to assess the suitability of the site at for a residential development in accordance with the provisions of the National Planning Policy Framework and the Noise Policy Statement for England (NPSE).

This report presents the results of the environmental survey undertaken in order to measure prevailing background noise and vibration levels and outlines any necessary mitigation measures.

This report also presents calculations in accordance with BS4142 to provide an indication as to the likelihood of the noise emissions from HGV deliveries serving the adjacent light industrial site and van delivery operations serving the proposed commercial units having an adverse impact on the closest noise sensitive receivers. Mitigation measures will be outlined as appropriate.

2.0 SITE SURVEYS

2.1 Site Description

The site is bounded by residential and industrial properties to the north and east, a car park to the west and Eade Road and Seven Sisters Road to the south. Entrance to the site is located to the south. At the time of the survey, the background noise climate was dominated by road traffic noise from Eade Road and Seven Sisters Road.

2.2 Environmental Noise Survey Procedure

A noise survey was undertaken on the proposed site as shown in Figure 2.1. The location was chosen in order to collect data representative of the worst-case levels expected on the site due to all nearby sources.

Continuous automated monitoring was undertaken for the duration of the survey between 17:30 on 08/11/2022 and 16:00 on 09/11/2022.

Weather conditions were generally dry with light winds and therefore suitable for the measurement of environmental noise. The measurement procedure complied with ISO 1996-2:2017 Acoustics '*Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels*'.

2.3 Vibration Survey Procedure

Continuous automated vibration monitoring was undertaken in conjunction with the noise survey between 17:30 on 08/11/2022 and 16:00 on 09/11/2022 at the position shown in Figure 2.1. Measurements were made of vertical (z-axis) and horizontal (x - y axes) vibration dose value levels.

This survey addressed road traffic vibration from the nearby vibration source. The character of the vibration would be considered to be continuous.

The vibration monitoring position was chosen in order to capture worst case expected levels of vibration as stated within BS6472-1:2008 *“Guide to evaluation of human exposure to vibration in buildings”*.

2.4 Measurement Locations

Measurement positions are as described within Table 2.1 and shown within Figure 2.1.

Icon	Descriptor	Location Description
	Noise Measurement Position	The microphone was installed on a tripod at the ground floor level in-free field conditions as shown in Figure 2.1
	Manual Noise Measurement Position	The microphone was installed on a tripod at the ground floor level at a location representative of the proposed south façade, as shown in Figure 2.1. the microphone position is considered to be in a free-field position.
	Vibration Measurement Position	The accelerometer was installed at a distance of 3m from the proposed south façade on a steel cube and attached with manufacturer magnetic plate

Table 2.1 Measurement positions and descriptions



Figure 2.1 Site measurement positions (Image Source: Google Maps)

2.5 Equipment

The equipment calibration was verified before and after use and no abnormalities were observed. The equipment used is described within Table 2.2.

Measurement instrumentation		Serial no.	Date	Cert no.
Noise Kit 5	Svantek Type 977 Class 1 Sound Level Meter	46459	24/01/2022	1501654-1
	Free-field microphone Aco Pacific 7052H	43114		
	Preamp Svantek SV12L	18929		
	Svantek External windshield	-	-	-
Noise & Vibration Kit 4	Svantek Type 958A Class 1 Sound & Vibration Level Meter	36554	27/09/2022	1503350-1v
	Accelerometer 356M232	P212226		
B&K Type 4231 Class 1 Calibrator		2147411	24/05/2022	UCRT22/1581

Table 2.2 Measurement instrumentation

3.0 RESULTS

3.1 Noise Survey

The $L_{Aeq}: 5min$, $L_{Amax}: 5min$, $L_{A10}: 5min$ and $L_{A90}: 5min$ acoustic parameters were measured throughout the duration of the survey. Measured levels are shown as a time history in Figure 25436.TH1.

Measured noise levels are representative of noise exposure levels expected to be experienced by all facades of the proposed development, and are shown in Table 3.1.

Time Period	Noise Measurement Position (Measured Noise level – dBA)	Noise Measurement Position (Derived Noise level – dBA)	Manual Noise Measurement Position (Measured Noise level – dBA)
Daytime $L_{Aeq,16hour}$	60	55	66
Night-time $L_{Aeq,8hour}$	58	53	NA

Table 3.1 Site average noise levels for daytime and night time

Noise levels at the North Elevations have been derived from the South Elevations results with a 5 dB reduction from shielding of the development from the building itself. This is considered to be a worst-case scenario.

3.2 Vibration Survey

The results of the vibration measurements captured during the automated survey period are shown as a time history in Figure 25436.VH1 as VDV levels over the full survey period. It should be noted that vibration was not subjectively felt on site during the equipment installation and collection periods.

4.0 NOISE AND VIBRATION ASSESSMENT GUIDANCE

4.1 Noise Policy Statement For England 2021

The National Planning Policy Framework (NPPF) has superseded and replaces Planning Policy Guidance Note 24 (PPG24), which previously covered issues relating to noise and planning in England. Paragraph 174 of NPPF 2021 states that planning policies and decisions should aim to:

- preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans

In addition, Paragraph 185 of the NPPF states that *‘Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should’:*

- Mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life
- Identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason

The Noise Policy Statement for England (NPSE) was developed by DEFRA and published in March 2010 with the aim to ‘Promote good health and good quality of life through the effective management of noise within the context of Government policy on sustainable development.’

Noise Policy Statement England (NPSE) noise policy aims are as follows:

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

- *Avoid significant adverse impacts on health and quality of life;*
- *Mitigate and minimise adverse impacts on health and quality of life; and*
- *Where possible, contribute to the improvement of health and quality of life*

The Noise Policy Statement England (NPSE) outlines observed effect levels relating to the above, as follows:

- NOEL – No Observed Effect Level
 - This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.
- LOAEL – Lowest Observed Adverse Effect Level
 - This is the level above which adverse effects on health and quality of life can be detected.
- SOAEL – Significant Observed Adverse Effect Level

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

As stated in The Noise Policy Statement England (NPSE), it is not currently possible to have a single objective based measure that defines SOAEL that is applicable to all sources of noise in all situations. Specific noise levels are not stated within the guidance for this reason, and allow flexibility in the policy until further guidance is available.

4.2 The London Plan: Policy D12 Agent of Change

The London Plan states the following with regards to existing noise generating sources and new residential developments:

- A. *The Agent of Change principle places the responsibility for mitigating impacts from existing noise-generating activities or uses on the proposed new noise-sensitive development.*
- B. *Boroughs should ensure that planning decisions reflect the Agent of Change principle and take account of existing noise-generating uses in a sensitive manner when new development, particularly residential, is proposed nearby.*
- C. *Development proposals should manage noise and other potential nuisances by:*
 - *Ensuring good acoustic design to mitigate and minimise existing and potential impacts of noise generated by existing uses located in the area*
 - *Exploring mitigation measures early in the design stage, with necessary and appropriate provisions secured through planning obligations*
 - *Separating new noise-sensitive development where possible from existing noise-generating businesses through distance, screening, internal layout, soundproofing and insulation, and other acoustic design measures.*
- D. *Development should be designed to ensure that established noise-generating venues remain viable and can continue or grow without unreasonable restrictions being placed on them.*
- E. *New noise-generating development, such as industrial uses, music venues, pubs, rail infrastructure, schools and sporting venues proposed close to residential and other noise-sensitive development should put in place measures such as soundproofing to mitigate and manage any noise impacts for neighbouring residents and businesses.*

F. Boroughs should refuse development proposals that have not clearly demonstrated how noise impacts will be mitigated and managed.'

4.3 ProPG: Planning and Noise

As outlined above, the National Planning Policy Framework encourages improved standards of design, although it provides no specific noise levels which should be achieved on site for varying standards of acoustic acceptability, or a prescriptive method for the assessment of noise.

ProPG: Planning and Noise was published in May 2017 in order to encourage better acoustic design for new residential schemes in order to protect future residents from the harmful effects of noise. This guidance can be seen as the missing link between the current NPPF and its predecessor, PPG24 (Planning Policy Guidance 24: Planning and Noise), which provided a prescriptive method for assessing sites for residential development, but without the nuance of 'good acoustic design' as outlined in ProPG.

ProPG allows the assessor to take a holistic approach to consider the site's suitability, taking into consideration numerous design factors which previously may not have been considered alongside the noise level measured on site, for example the orientation of the building in relation to the main source of noise incident upon it.

It should be noted this document is not an official government code of practice, and neither replaces nor provides an authoritative interpretation of the law or government policy, and therefore should be seen as a good practice document only.

4.4 BS8233:2014

BS8233:2014 'Sound insulation and noise reduction for buildings' describes recommended internal noise levels for residential spaces. These levels are shown in Table 4.1.

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living Rooms	35 dB(A)	-
Dining	Dining Room/area	40 dB(A)	-
Sleeping (daytime resting)	Bedrooms	35 dB(A)	30 dB(A)

Table 4.1 BS8233 recommended internal background noise levels

It should be noted that the recommended internal noise levels outlined above are not applicable under "purge ventilation" conditions as defined by Approved Document F of the Building Regulations, as this should only occur occasionally (E.G. to remove odour from

painting or burnt food). However, the levels above should be achieved whilst providing sufficient background ventilation, either via passive or mechanical methods.

The external building fabric would need to be carefully designed to achieve these recommended internal levels.

In addition to guidance on internal levels, BS8233:2014 also states the following with regards to noise within external amenity spaces:

‘For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50 dB $L_{Aeq,T}$, with an upper guideline value of 55 dB $L_{Aeq,T}$, which would be acceptable in noisier environments. However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. 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.’

As outlined above, the resulting noise levels in external amenity areas should not be a reason for refusal, providing that the noise levels are designed to be as low as practically possible within external amenity areas.

Expected levels within the proposed external amenity areas are outlined in Section 7.0 in more detail.

4.5 WHO Guidelines for Community Noise (1999)

WHO Guidelines for Community Noise (1999) recommends that internal noise levels for individual events should not exceed 45dB L_{Amax} more than 10-15 times per night.

It should be noted that this impact is increasingly being regarded as ‘LOAEL’ for this number of exceedances, as described in Section 4.1.

The external building fabric would need to be carefully designed to ensure that the above guidance is achieved.

○ **Approved Document O (ed. 2021)**

Approved Document O (ADO) supports Part O of Schedule 1 to the Building Regulations 2010. ADO introduces requirements for residential premises in order to prevent overheating from occurring. There are two specific requirements from ADO:

Requirement O1 (1):

To limit unwanted solar gains in summer and to provide adequate means to remove heat from the indoor environment.

Requirement O1 (2):

- (a) Account must be taken of the safety of the occupant, and their reasonable enjoyment of the residence.
- (b) Mechanical cooling may only be used where sufficient heat cannot be removed from the indoor environment without it.

The statutory guidance to support Requirement O1(2)(a) contains requirements relating to noise at night.

4.5.1 Application

The guidance within ADO applies to new residential buildings only and are defined within the following table:

Title	Purpose for which the building is intended to be used.
Residential (dwellings)	Dwellings, which includes both dwellinghouses and flats.
Residential (institutions)	Home, school or other similar establishment, where people sleep on the premises. The building may be living accommodation for the care or maintenance of any of the following. A. Older and disabled people, due to illness or other physical or mental condition. B. People under the age of 5 years.
Residential (other)	Residential college, hall of residence and other student accommodation, and living accommodation for children ages 5 years or older.

Table 4.2 Residential buildings within the scope of ADO (ref. Table 0.1 of Approved Document O)

Paragraphs 3.2 and 3.3 of ADO specifically refer to noise within bedrooms at night. Whilst any habitable room could be used as a bedroom, it is proposed that the scope is confined to those rooms specifically designated as bedrooms.

4.5.2 Internal Noise Level Targets

ADO sets internal noise level targets within Paragraph 3.3 of the document:

“Windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the following limits.

- a. 40dB $L_{Aeq,T}$ averaged over 8 hours (between 11pm and 7am)*
- b. 55dB L_{AFmax} more than 10 times a night (between 11pm and 7am).”*

Where an openable window for the removal of excess heat is predicted to result in the above internal noise levels to be exceeded, then the overheating mitigation strategy must adopt one of the alternative means listed within Paragraph 2.10 of ADO (presented within Section 4.7.3 of this report). This constraint applies regardless of which method is used to demonstrate compliance with Requirement O1 (1).

4.5.3 Methods to Remove Excess Heat

Paragraph 2.10 of ADO lists the means for removing excess heat from dwellings according to the following:

- Openable windows
- Ventilation louvres in external walls
- A mechanical ventilation system
- A mechanical cooling system

4.6 BS6472-1-2008 - Vibration Assessment

BS 6472 provides guidance on predicting human response to vibration in buildings over the frequency range 0.5 Hz to 80 Hz. 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.

Table 4.3 shows the different likelihoods of adverse comment from nearby vibration sources on residential occupants.

Place and time	Low probability of adverse comment $m.s^{-1.75}$	Adverse comment possible $m.s^{-1.75}$	Adverse comment probable $m.s^{-1.75}$
Residential buildings 16h day	0.2-0.4	0.4-0.8	0.8-1.6
Residential buildings 8h night	0.1-0.2	0.2-0.4	0.4-0.8

Table 4.3 Likelihood of comment on vibration perceived within residential dwellings

It should be noted that the vibration levels outlined in Table 4.3 are at the point of entry into the human body, and not the point of entry of vibration into the structure itself. In the cases where the proposed structure is not yet built and vibration measurements cannot be taken inside the building, losses should be accounted for due to the transfer function between the ground and building structure and its foundations. As ground conditions, foundation types, building construction, and floor construction and loading are all variables in terms of transfer function and losses, this report will assume piled foundations in rock and a negligible loss as a worst-case scenario.

In addition to potential losses as vibration passes from unloaded ground into the structure, amplification of vibration can occur as the vibration propagates across a suspended floor, such as in upper floors of the proposed building. As this is fully dependent on the input frequency of vibration and the natural frequency of the receiving structure, VDV levels would only be considered on the ground floor of the proposed development within this assessment.

4.7 Re-Radiated Noise Criteria

At present, there are no British Standards which provide guidance on assessing groundborne, structureborne or re-radiated noise associated with train pass-bys.

Re-radiated noise is of concern in scenarios where the VDV level is below the level of adverse comment, but the structure-borne noise associated with the vibration input could negatively impact the amenity of future residents in terms of noise.

The impact of re-radiated noise is particularly important to consider in scenarios where the dominant noise source cannot be seen, such as underground trains or surface trains in tunnels.

In this instance, the proposed building would directly overlook the existing railway line, and therefore there would be an airborne and structure borne noise contribution with regards to the overall noise level expected within the residence. Due to this fact, it is important to

understand the level of re-radiated noise in order to ensure that it does not contribute to the overall airborne level to which the future residents of the building would experience.

In the absence of British Standard guidance, the criteria outlined in 'Crossrail 2: A Technical Guide For Developers' for the description of groundborne noise impacts inside dwellings due to underground train pass-bys are shown in Table 4.4.

Building	Groundborne Noise Level, $L_{Amax, f}$
Residential buildings	35dB

Table 4.4 CR2 Operational groundborne noise design criterion in residential buildings

4.8 BS4142: 2014 'Methods for rating and assessing industrial and commercial sound'

British Standard BS4142:2014 'Methods for rating and assessing industrial and commercial sound' describes a method for rating and assessing sound of an industrial and/or commercial nature, which includes:

- Sound from industrial and manufacturing processes
- Sound from fixed installations which comprise mechanical and electrical plant and equipment
- Sound from the loading and unloading of goods and materials at industrial and/or commercial premises, and
- Sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes.

This Standard compares the Rating Level due to the noise source/s under assessment for a one-hour period during the daytime (07:00 – 23:00 hours) and a fifteen-minute period during the night-time (23:00 – 07:00 hours) with the existing background noise level in terms of an L_{A90} when the noise source is not operating.

It should be noted that the Rating Level is the Specific Sound Level in question ($L_{Aeq, Tr}$), including any relevant acoustic feature corrections, as follows:

- **Tonality** – *'For sound ranging from not tonal to prominently tonal the Joint Nordic Method gives a correction of between 0dB and +6dB for tonality. Subjectively, this can be converted to a penalty of 2dB for a tone which is just perceptible at the noise receptor, 4dB where it is clearly perceptible, and 6dB where it is highly perceptible'*

- **Impulsivity** – *‘A correction of up to +9dB can be applied for sound that is highly impulsive, considering both the rapidity of the change in sound level and the overall change in sound level. Subjectively, this can be converted to a penalty of 3dB for impulsivity which is just perceptible at the noise receptor, 6dB where it is clearly perceptible, and 9dB where it is highly perceptible’*
- **Intermittency** – *‘If the intermittency is readily distinctive against the residual acoustic environment, a penalty of 3dB can be applied’*
- **Other sound characteristics** – *‘Where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a penalty of 3dB can be applied’*

Once the Rating Level has been obtained, the representative background sound level is subtracted from the Rating Level to obtain an initial estimate of the impact, as follows:

- Typically, the greater this difference, the greater the magnitude of the impact
- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context
- A difference of around +5 dB could be an indication of an adverse impact, depending on the context
- The lower the rating level is relative to the measured background sound level, the less likely it is that there will be an adverse impact or significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound having a low impact, depending on the context

NOTE: Adverse impacts may include but not be limited to annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact.

The initial estimate of the impact may then be modified by taking consideration of the context in which the sound occurs.

We would suggest that the following rating level acceptability range is followed, taking into account the context of the environment with which the plant installation will be installed.

Assessment Location	Rating Level Acceptability Range		
	Green: noise is considered to be at an acceptable level	Amber: noise is observed to have an adverse effect level, but which may be considered acceptable when assessed in the context of other merits of the development	Red: noise is observed to have a significant adverse effect.
1m Outside living or dining or Bedroom window (façade)	10dB below background	9 dB below and 5dB above background	5dB above background

Table 4.5 Noise criteria for plant and machinery

5.0 EXTERNAL BUILDING FABRIC SPECIFICATION

Sound reduction performance calculations have been undertaken in order to specify the minimum performance required from glazed and non-glazed elements in order to achieve the recommended internal noise levels shown in Table 4.1, taking into account average and maximum noise levels monitored during the environmental noise survey.

Typical sized bedrooms with a high ratio of glazing to masonry have been used for all calculations in order to specify glazing.

- 9sqm First floor south facing single bedroom / 3sqm glazing
- 63sqm First floor south facing Living Room / 20sqm glazing

As a more robust assessment, L_{Amax} spectrum values of night-time peaks have also been considered and incorporated into the glazing calculation in order to cater for the interior limit of 45 dB L_{Amax} for individual events, as recommended in WHO Guidelines.

Please note that the glazed and non-glazed element calculations would need to be finalised once all design proposals are finalised.

5.1 Non-Glazed Elements

It is currently understood that the non-glazed building façade is comprised of the elements as shown within Table 5.1 based on the construction detail provided. The anticipated sound reduction index has been calculated, and would be expected to provide the minimum figures shown in Table 5.1 when tested in accordance with BS EN ISO, 140-3:1995.

Element	Octave band centre frequency SRI, dB					
	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Blockwork 140mm Rock wool insulation 210mm Ventilated cavity Cement board rainscreen cladding on metal	41	43	48	50	55	55

Table 5.1 Assumed sound reduction performance for non-glazed elements

5.2 Glazed Elements

Minimum octave band sound reduction index (SRI) values required for all glazed elements to be installed are shown in Table 5.2. The performance is specified for the whole window unit, including the frame and other design features such as the inclusion of trickle vents. Sole glass performance data would not demonstrate compliance with this specification.

Glazing performance calculations have been based both on average measured night-time noise levels as well as verified against the L_{Amax} spectrum of individual events in order to comply with a maximum internal noise level of 45dB(A) in bedrooms as recommended by World Health Organisation Guidelines. The combined most robust results of these calculations are shown in Table 5.2.

Elevation	Octave band centre frequency SRI, dB						$R_w (C; C_{tr})$, dB
	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	
North Bedroom Elevation and Living Room Elevations	26	22	28	38	41	42	33 (-1;-4)
South and East Bedroom Elevations	27	26	33	39	39	47	36 (-1;-3)

Table 5.2 Required glazing performance

The nominated glazing supplier should verify that their proposed window system meets the attenuation figures shown at each centre frequency band as shown in Table 5.2.

It is understood there is no windows within the West Elevations.

Example glazing types that would be expected achieve the above spectral values are shown in Table 5.3.

Elevation	Example glazing type
North Bedroom Elevation and Living Room Elevations	4/12/8
South and East Bedroom Elevations	6/12/10

Table 5.3 Example glazing types

All major building elements should be tested in accordance with BS EN ISO 140-3:1995.

Independent testing at a UKAS accredited laboratory will be required in order to confirm the performance of the chosen system for an actual configuration.

6.0 VENTILATION AND OVERHEATING

6.1 Ventilation Strategy

Based on the noise levels measured on site, appropriate ventilation systems are outlined in Table 6.1 below in order to ensure the internal noise environment is not compromised.

Ventilation System	Whole Dwelling Ventilation	Extract Ventilation
ADF System 1	Trickle vents providing a minimum performance of 32dB $D_{n,e,w}$	Intermittent extract fans
ADF System 3	Continuous mechanical extract (low rate) and trickle vents for supply providing a minimum performance of 32dB $D_{n,e,w}$	Continuous mechanical extract (high rate) with trickle vents providing inlet air
ADF System 4	Continuous mechanical supply and extract (low rate)	Continuous mechanical supply and extract (high rate)

Table 6.1 Ventilation systems

Where trickle vents are proposed, a typical number has been assumed based on the room size and number of windows. As trickle vents introduce a weak point in the building façade, it should be noted that increasing the number of trickle vents will reduce the composite performance of the facade. If more trickle vents are required, the required insulation should be increased by '+10*LOG(N)' where N is the number of vents proposed. If trickle vents are proposed, the total number of trickle vents for each sensitive space should be confirmed so that calculations can be accurately revised.

In the case of mechanical ventilation, systems should be designed to meet the internal noise levels as defined in CIBSE Guide A (2015), as shown in Table 6.2.

Room Type	L_{Aeq} , dB	NR
Bedrooms	30	25
Living Rooms	35	30
Kitchen	45-50	40-45

Table 6.2 CIBSE Guide A 2015 guidance levels for mechanical building services

In all cases, purge ventilation would be provided by openable windows. As outlined in Section 4.5, the internal noise level requirement would not be applicable during purge conditions as this would only occur occasionally.

6.2 Openable Windows

Approved Document O (ADO) only applies to Bedrooms during night. The advice within this section would therefore only apply to Bedrooms during night-time hours (23:00-07:00) to ensure that the internal noise level targets of 40dB(A) $L_{eq,T}$ and 55dB(A) L_{max} are not exceeded.

Table 6.3 presents the open area of the window as a % of the floor area which would need to be achieved to ensure that sufficient attenuation is provided from outside to inside.

Elevation	Sound Reduction Required to Achieve ADO Target Internal L_{Aeq} Noise Levels	Sound Reduction Required to Achieve ADO Target Internal L_{Amax} Noise Levels	Maximum Open Area of the Window as a Percentage of the Floor Area to Achieve ADO Target Internal Noise Levels
North	13 dB	10 dB	11 %
East	18 dB	15 dB	3 %
South	18 dB	15 dB	3 %

Table 6.3 Window open areas

The overheating model should inform the design team whether the % open areas above would be sufficient to remove excess heat. In the event they are insufficient, other options to limit solar gains into the building should be investigated (such as those outlined in Section 2.7 of Approved Document O), or other means of removing excess heat should be explored (as outlined in Section 2.10 of the Approved Document).

Note: Acoustic open area is the measurable, cross-sectional, geometric area of an opening. For a partially open window, this is considered to be the lesser of either the size of the hole in the window frame that is left by the opening light, or the combined cross-sectional area around the opening light through which air must pass to move from outside to inside. The area around a hinged opening light includes the triangular areas on the sides adjacent to the hinge, and the rectangular area on the side opposite the hinge. This should not be used for comparing the

air-flow performance of elements because this will also be dependent on factors such as depth (length of air-path), surface roughness and tortuosity.

6.3 Overheating Control Strategies

Where the open areas specified above are not sufficient for controlling overheating, then one or more of the following strategies will need to be adhered to:

- Fixed shading devices comprising any of the following:
 - Shutters
 - External blinds
 - Overhangs
 - Awnings
- Glazing design, involving any of the following solutions
 - Size
 - Orientation
 - G-value
- Building design, e.g. the placement of balconies
- Shading provided by adjacent buildings structures or landscaping.
- Ventilation louvres in external walls
- A mechanical ventilation system
- A mechanical cooling system

KP Acoustics would be happy to review any proposals to ensure that they adhere to the internal noise levels targeted within ADO.

7.0 HGV DELIVERY NOISE ASSESSMENT

7.1 Environmental Noise Survey

The $L_{Aeq}: 5min$, $L_{Amax}: 5min$, $L_{A10}: 5min$ and $L_{A90}: 5min$ acoustic parameters were measured throughout the duration of the survey. Measured levels are shown as a time history in Figure 25436.TH1.

Representative background noise levels are shown in Table 7.1 for daytime and night-time.

It should be noted that the representative background noise level has been derived from the most commonly occurring $L_{A90,5 min}$ levels measured during the environmental noise survey undertaken on site, as shown in 25436.Daytime.LA90 and 25436.Night-time.LA90 attached.

Time Period	Representative background noise level L_{A90} dB(A)
Daytime (07:00-23:00)	54
Night-time (23:00-07:00)	45

Table 7.1 Representative background noise levels.

7.2 Manual Noise Measurements

In order to accurately assess noise emissions caused by delivery operations, noise data from manual measurements undertaken at a historic KP Acoustics project at Screwfix, 7 Grand Union Industrial Estate, Abbey Road, Park Royal, London NW10 7UL were used. The aforementioned site measurement was chosen based on information provided by Caneparo Associates showing delivery vehicles being similar in terms of size and nature.

The delivery process included the arrival of the HGV, the movement of cages to the hydraulic lift, operation of the hydraulic lift, the movement of cages into the store, and the departure of the HGV. The aforementioned description has been assessed to represent a worst case scenario of the delivery drop off operation as movement of cages may not be comprised within our assessment.

$L_{Aeq:30\text{ second}}$ and $L_{Amax:30\text{ second}}$ acoustic parameters were measured throughout the duration of the survey between 05:35 and 06:05 on Monday 30th April 2018. Measured levels are shown as a time history in Figure 17455.TH2.

$L_{Aeq:30\text{ min}}$ levels for the full delivery operation are shown in Table 7.2.

$L_{Aeq:30\text{ min}}$ dB(A) of full delivery operation
72

Table 7.2 $L_{Aeq:30\text{ min}}$ of delivery operation

In order to assess whether the source would be considered tonal, the full spectral data of the 30 minute operation between 63Hz to 8kHz is shown in Table 7.3.

$L_{Aeq:30\text{ min}}$ (dB) in each Frequency Band							
63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
46	55	60	64	69	69	68	63

Table 7.3 Spectral $L_{Aeq:30\text{ min}}$ levels

Also, a second BS4142 assessment is presented to assess the impact of the light vans within the courtyard of the proposed development.

It is assumed a light van would produce a similar levels of noise to a car. Noise levels from the manual measurement undertaken on site have therefore been used for the van full delivery operation are shown in Table 7.4.

$L_{Aeq:30min}$ dB(A) of light van delivery operation
65

Table 7.4 $L_{Aeq:30min}$ of light van delivery operation

7.3 BS4142 ASSESSMENT – Existing Site Delivery Operation

It is predicted that the main source of noise from the adjacent existing light industrial site to the west of the development would be due to HGV deliveries. The main HGV operation being undertaken within the green area, as shown in Figure 7.1.

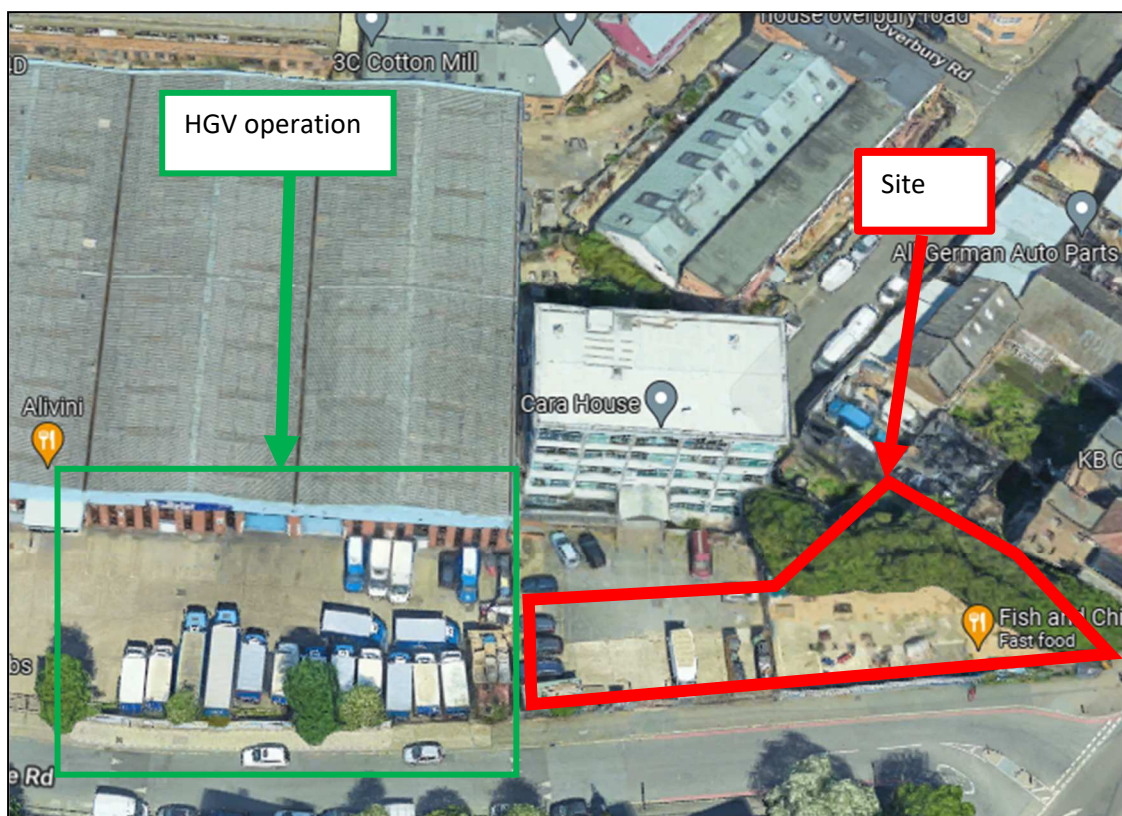


Figure 7.1 Closest noise sensitive receiver & HGV deliveries location (Image Source: Google Maps)

The closest window of the new receiver would be at an approximate direct distance of 39 metres from the HGV process.

It should be noted the location of HGV deliveries would be out of line of site of the receiving window due to screening from the building envelope.

It is assumed deliveries may occur during both daytime and night-time periods and the use of the deliveries to the existing site would be constant throughout the year. In order to create a realistic assessment scenario, we predict no more than one 30-minute delivery within any one hour period.

Table 7.2 shows the results of the predictions for the HGV delivery to the closest noise sensitive receiver, based on an assessment period of 1 hour for daytime as per BS4142:2014.

7.4 Calculations

The 'Specific Sound Level' of the light van has been calculated at 1m from the closest receiver using the noise levels shown in Table 7.5, and corrected due to different acoustic propagation features such as distance, reflective surfaces, screening elements, etc.

The 'Rating Level' of HGV operations have been assessed following the guidelines of BS4142 for the night-time period as a worst case scenario when the delivery process would be operational, with a subsequent conclusion taking into consideration the above context. The full BS4142 assessment is presented in Table 7.5.

BS4142 Assessment		
Source:	HGV operation at existing site	
Operating Period:	Night-Time	
Reference time interval (T_r):	15 minute	
Receiver:	First Floor proposed residential window	
Element	Level (dB)	Comment
Measured ambient sound level $L_a = L_{Aeq, T}$	$L_{Aeq, 30 \text{ minute}}$ 72dB	Equivalent continuous A-weighted sound pressure level of the totally encompassing sound including residual sound and specific sound
Acoustic feature corrections	+6dB	+3dB correction for intermittency, +3dB correction for impulsivity. Note that due to the distance from source to receiver, it would be anticipated that impulsive nature of cage noise would only be just perceptible at the receiver location

Attenuation provided by the building envelope	-10dB	Operations would be out of direct line of site of the closest receiver
Distance correction from operation to closest residential façade	-25dB	Approx. 18m direct distance from goods in entrance to closest residential façade
Specific Source Level at Residences	L_{Aeq}: 30min 43dB	Calculated operational source level including acoustic corrections
Representative Background Noise Level <i>L_{A90, T}</i>	54	Sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, <i>T</i> . Derived using the most common occurring levels <i>L_{A90, 5min}</i> during the environmental noise survey undertaken on site
Excess of rating over background sound level	(54-43) = -11 dB	For background levels during the hours of 23:00 to 07:00
Assessment Indication		
Noise from HGV operations would be 11dB below the background sound level at 1m from the façade of the closest residential dwelling (located within the future development site). Therefore, the external building fabric has been designed to ensure that residential amenity is protected from the adjacent delivery operation, and there would be a low likelihood of adverse impact.		

Table 7.5 BS4142 assessment

As shown in Table 7.5, the HGV delivery operations would be expected to have a low likelihood of adverse impact on the amenity of proposed nearby noise sensitive receivers.

7.5 BS4142 ASSESSMENT –Delivery Operation Serving Proposed Site

It is understood deliveries would be undertaken to the west of the development within, as shown in Figure 7.2.

The main manoeuvring process being undertaken within the green area.

The following figure shows the entry, manoeuvring and exit of the HGV delivery vehicles to the drop off only area.

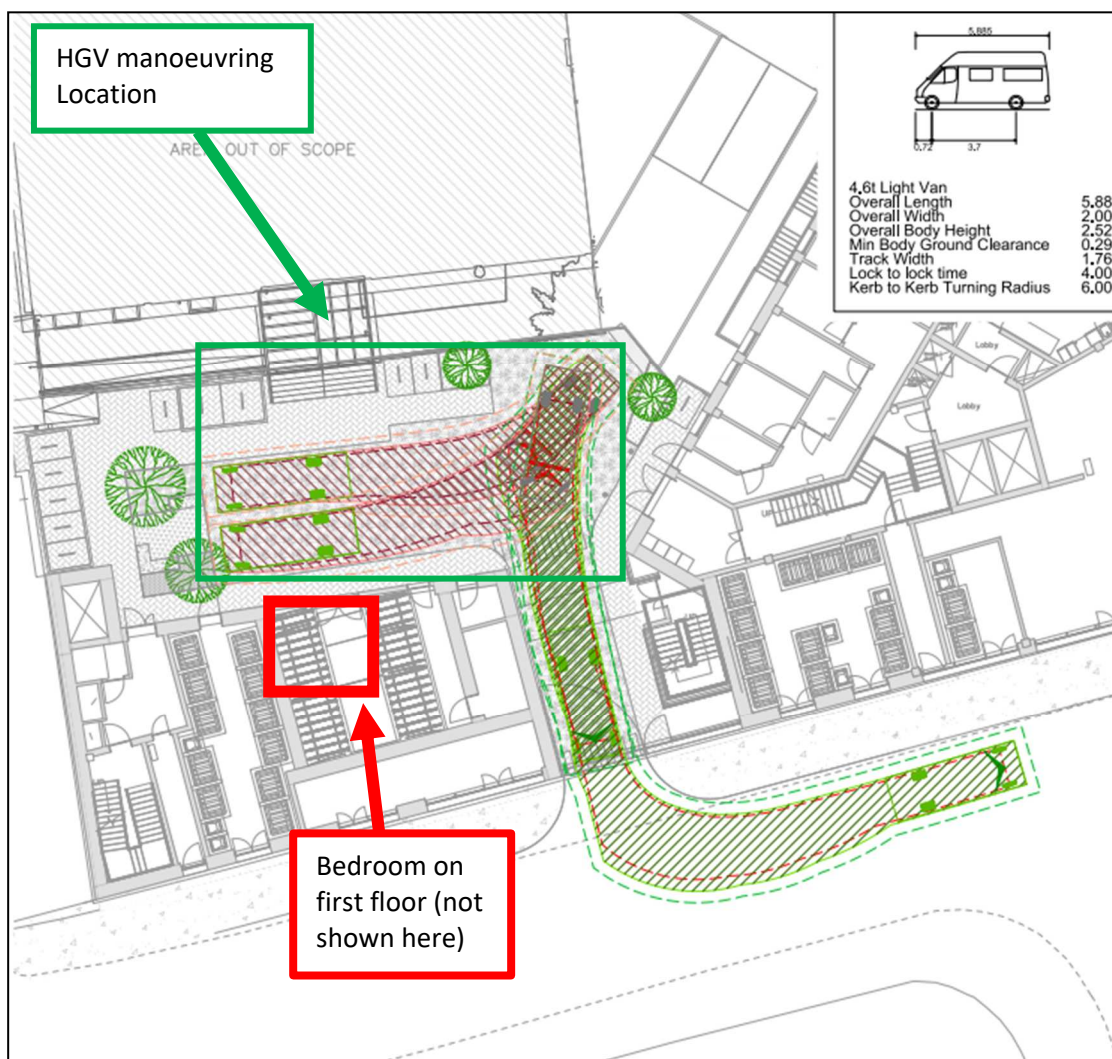


Figure 7.2 Closest noise sensitive receiver, HGV deliveries location (Image Source: Velocity Transport Planning Limited)

As shown in Figure 7.2, a new residential receiver is proposed to be located adjacent to the delivery drop off only area. The closest window of the new receiver would be at an approximate direct distance of 5 metres from the HGV process.

It is assumed deliveries would be only happening during the daytime period, between 07:00 and 23:00hrs. In order to create a realistic assessment scenario, we would expect no more than two, 30-minute deliveries within any one hour period.

Table 7.6 shows the results of the predictions for the delivery operation to the closest noise sensitive receiver, based on an assessment period of 1 hour for daytime as per BS4142:2014.

7.6 Calculations

The 'Specific Sound Level' of the light van has been calculated at 1m from the closest receiver using the noise levels shown in Table 7.6, and corrected due to different acoustic propagation features such as distance, reflective surfaces, screening elements, etc. Detailed calculations for each plant unit installation are shown in Appendix B.

The 'Rating Level' of a van operation have been assessed following the guidelines of BS4142 for the daytime period when the delivery process would be operational, with a subsequent conclusion taking into consideration the above context. The full BS4142 assessment is presented in Table 7.6.

BS4142 Assessment		
Source:	Light van within the rear courtyard	
Operating Period:	Daytime	
Reference time interval (T_r):	1 hour	
Receiver:	First Floor residential window	
Element	Level (dB)	Comment
Measured ambient sound level $L_a = L_{Aeq, T}$	$L_{Aeq, 30 \text{ minute}}$ 65dB	Equivalent continuous A-weighted sound pressure level of the totally encompassing sound including residual sound and specific sound
Acoustic feature corrections	+3dB	+3dB correction for intermittency
Rating Level	68 dB	Rating Level = Specific Sound Level + Acoustic Feature Corrections
Distance correction from operation to closest residential façade	-9dB	Approx. 3m direct distance from goods in entrance to closest residential façade
Specific Source Level at Residences	$L_{Aeq: 30min}$ 59dB	Calculated operational source level including acoustic corrections
Representative Background Noise Level $L_{A90, T}$	54	Sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T . Derived using the most common occurring levels $L_{A90, 5min}$ during the environmental noise survey undertaken on site
Excess of rating over background sound level	(59-54)=+5	

Assessment Indication
Noise from the delivery operation would increase the background sound level at 1m from the façade of the closest residential dwelling (located within the future development site). However, as stated in BS4142, context should be taken into consideration when assessing the likelihood of adverse impact. It should be noted that open window units are proposed for the dwelling directly adjacent to the HVG operation, with trickle vent ventilation system proposed to ensure that sufficient passive and purge ventilation is provided to the dwelling. Assuming that the proposed window system would provide a minimum of 30dB attenuation (as per a nominal double glazed system), this would result in an internal level in the region of 29dB(A). The interior noise limit during daytime hours, as stipulated in BS8233:2014, is 35dB(A). Therefore, the external building fabric has been designed to ensure that residential amenity is protected from the adjacent HGV delivery operation, and there would be a low likelihood of adverse impact.

Table 7.6 BS4142 assessment

As shown in Table 7.6, the proposed van delivery operation would be expected to have a low likelihood of adverse impact on the amenity of proposed nearby noise sensitive receivers.

8.0 VIBRATION ASSESSMENT

The measured results of the 24 hour survey have been aggregated to produce the VDV over the 16 hour daytime and 8 hour night time period. Table 8.1 compares the measured levels on site against VDV ranges outlined in Table 4.3 and BS6472-1 2008 '*Guide to evaluation of human exposure to vibration in buildings*'.

Axis	Vibration Measurement	Measured VDV Level $m/s^{1.75}$	Likelihood of Comment
x	VDV _{d,day}	0.019	Adverse comment is not expected
	VDV _{d,night}	0.008	Adverse comment is not expected
y	VDV _{d,day}	0.016	Adverse comment is not expected
	VDV _{d,night}	0.008	Adverse comment is not expected
z	VDV _{b,day}	0.053	Adverse comment is not expected
	VDV _{b,night}	0.046	Adverse comment is not expected

Table 8.1 Daytime and night-time VDV levels and likelihood of comment in accordance with BS6472

As shown in Table 8.1, the most dominant axis of vibration is the z-axis with a $VDV_{d,day}$ of $0.053m/s^{1.75}$ and $VDV_{d,night}$ $0.046m/s^{1.75}$, which correlates with adverse comment not being expected from future occupiers within the development.

8.1 Re-Radiated Noise Assessment

Various methods for calculating re-radiated noise from vibration are currently in use, as outlined within the ANC Guidelines for Measurement & Assessment of Groundborne Noise and Vibration.

As acceleration data has been collected on site, the calculation and guidance provided within the following documents has been used for this assessment:

- Toronto Transit Commission, Yonge subway northern extension noise and vibration study. Books 1 and 2, Report RD 115/3, 1976
- Kurzweil L.G., (1979) Groundborne noise and vibration from underground rail systems, Journal of Sound and Vibration, 66(3), 363-370

The ANC Guidelines for Measurement & Assessment of Groundborne Noise and Vibration presents the following equation within Appendix C.7 (p199), based on the aforementioned guidance:

$$L_p = 20\log_{10} (A_{rms}/10^{-6} g) - 20\log_{10} (f) + 37$$

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

g = gravitational acceleration constant (9.81 ms^{-2})

A_{rms} = rms acceleration in g in the one-third octave frequency band measured

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

Using the above calculation, the expected level of groundborne noise at ground floor level of the proposed building is shown in Table 8.2.

Building	Groundborne Noise Level, $L_{Amax, f}$
Ground Floor of Residential Building	35dB

Table 8.2 Groundborne noise level within proposed development site

Taking into account worst case vibration levels, the resultant groundborne noise level within a bedroom would be below the proposed noise criterion of 35dB L_{Amax} . Therefore, no

additional mitigation measures would be required in order to protect the proposed dwellings from groundborne noise.

It should be noted that the above calculation provides an estimate of groundborne noise levels only. More precise prediction can only be undertaken using numerical modelling methods based on finite-difference or finite-element techniques.

9.0 EXTERNAL AMENITY AREA ASSESSMENT

An external amenity area is proposed on first floor as a terrace outside the living room

Note that this terrace on the east and south facing elevation would be exposed to noise levels in the region of 58-60dB(A). Whilst winter gardens could reduce noise levels to below the upper guideline value, it is commonly accepted that small amenity spaces such as balconies need not comply with the BS8233 guideline values due to the benefit of having a private amenity area outweighing the noise levels experienced.

BS8233:2014 guidance states:

'it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. 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'

10.0 INTERNAL PARTITION SOUND INSULATION

At this stage of the report, the exact construction of the internal walls and floors is under development. The internal partitions are understood to be blockwork / concrete walls, and the floors will be a minimum of 200mm concrete slabs in addition to the necessary floor finishes and acoustic underlay.

In order to satisfy the requirements of the Building Regulations, the minimum sound insulation performance criteria, as shown in Table 10.1, should be met by all wall constructions (i.e. separating elements between different residential dwellings).

Element	Design Criteria – Dwelling-houses and Flats	
	Airborne	Impact
Wall	$D_{nT,w} + C_{tr} \geq 45 \text{ dB}$	N/A
Floor	$D_{nT,w} + C_{tr} \geq 45 \text{ dB}$	$L'_{nT,w} \leq 62 \text{ dB}$

Table 10.1 Building regulations requirements for new-build party elements

Due to the expected internal noise activity, understood to be music and live events, the client has expressed a preference to provide sound insulation levels that would exceed the Building Regulations requirements. Therefore, an increased sound performance criteria is recommended for separating floors and walls between residential premises and residential dwellings, as per Table 10.2.

Element	Additional Design Criteria – Dwelling-houses and Flats	
	Airborne	Impact
Party Walls and Floors	$D_{nT,w} + C_{tr} \geq 55 \text{ dB}$	$L'_{nTw} \leq 50 \text{ dB}$
Internal Wall separating habitable spaces (living rooms, bedrooms)	$R_w \geq 45 \text{ dB}$	NA

Table 10.2 Proposed requirements for elements separating dwellings

Proposed wall and floor types will be reviewed as they are developed to ensure compliance to the corresponding sound insulation criterion as displayed in Tables 10.1 and 10.2.

11.0 PLANT NOISE ASSESSMENT

A 24-hour environmental noise survey has been undertaken on site in order to prepare a noise impact assessment in accordance with BS4142:2014 'Method for rating and assessing industrial and commercial sound' as part of the planning requirements of the London Borough of Haringey.

This report presents the methodology and results from the environmental survey. This report will be reviewed once the M&E proposals have been finalised.

11.1 Results

The $L_{Aeq: 5min}$, $L_{Amax: 5min}$, $L_{A10: 5min}$ and $L_{A90: 5min}$ acoustic parameters were measured throughout the duration of the survey. Measured levels are shown as a time history in Figure 25436.TH1.

Representative background noise levels are shown in Table 3.1 for daytime and night-time.

It should be noted that the representative background noise level has been derived from the most commonly occurring $L_{A90,5 \text{ min}}$ levels measured during the environmental noise survey undertaken on site, as shown in 25436.Daytime L90.TH1 and 25436.Daytime L90.TH1 attached.

Time Period	Representative background noise level L_{A90} dB(A)
Daytime (07:00-23:00)	54
Night-time (23:00-07:00)	45

Table 11.1 Representative background noise levels

11.2 Local Authority Guidance

The criterion of London Borough of Haringey for noise emissions of new plant in this instance is as follows:

The criterion of the Council of The London Borough of Haringey for noise emissions of new plant states that the cumulative noise level L_{Aeq} arising from the proposed plant, measured or predicted at 1m from the façade of any residential premises shall be a rating level at least 5dB(A) below the background noise level L_{AF90} when assessed in accordance with BS4142:2014.

11.3 Noise Emissions Criterion

As the proposed air source heat pumps could be used at any time of the day or night, the criterion has been set as shown in Table 11.2 in order to comply with the above requirements.

Time Period	Maximum Plant Noise Emissions Criterion at Nearest Residential Receiver
Night-time (23:00 to 07:00)	40 dB(A)

Table 11.2 Proposed noise emissions criterion

11.4 Proposed Plant Installations

Currently, the exact location of the proposed air source heat pump units are unknown. Once all M&E proposals have been finalised, this report will be revised to include calculations which demonstrate compliance to the criterion set in Table 11.2.

12.0 CONCLUSION

An environmental noise and vibration survey has been undertaken at Seven Sisters, Harringay Warehouse District, London N16 5AX allowing the assessment of daytime and night-time levels likely to be experienced by the proposed development.

Measured noise levels allowed a robust glazing specification to be proposed which would provide internal noise levels for all residential environments of the development commensurate to the design range of BS8233.

No further mitigation measures should be required in order to protect the proposed habitable spaces from external noise intrusion.

Airborne and impact Sound Insulation performance criteria have been given for indicative purpose only and will be used to develop wall and floor types at the design stage. Internal acoustic partition detail requirements will be developed at the next stage.

Measurement of road and underground from train activity indicates that vibration levels are below the threshold of human perception in the z-axis, in accordance with BS6472: 2008.

Re-radiated noise due to underground train pass-bys would be below the guidance criteria provided within 'Crossrail 2: A Technical Guide For Developers', ensuring that the effects of structureborne noise would not contribute to the overall airborne noise level experienced within the property.

Additionally the results of the survey have enabled criteria to be set for noise emissions.

A maximum noise emissions criterion for the proposed plant unit installations has been set based on the requirements of London Borough of Haringey for new plant unit installations.

Further calculations would need to be undertaken once all M&E proposals are finalised in order to demonstrate compliance.

Seven Sisters - Warehouse living Haringey
Environmental Noise Time History
From 08 November 2022 To 09 November 2022

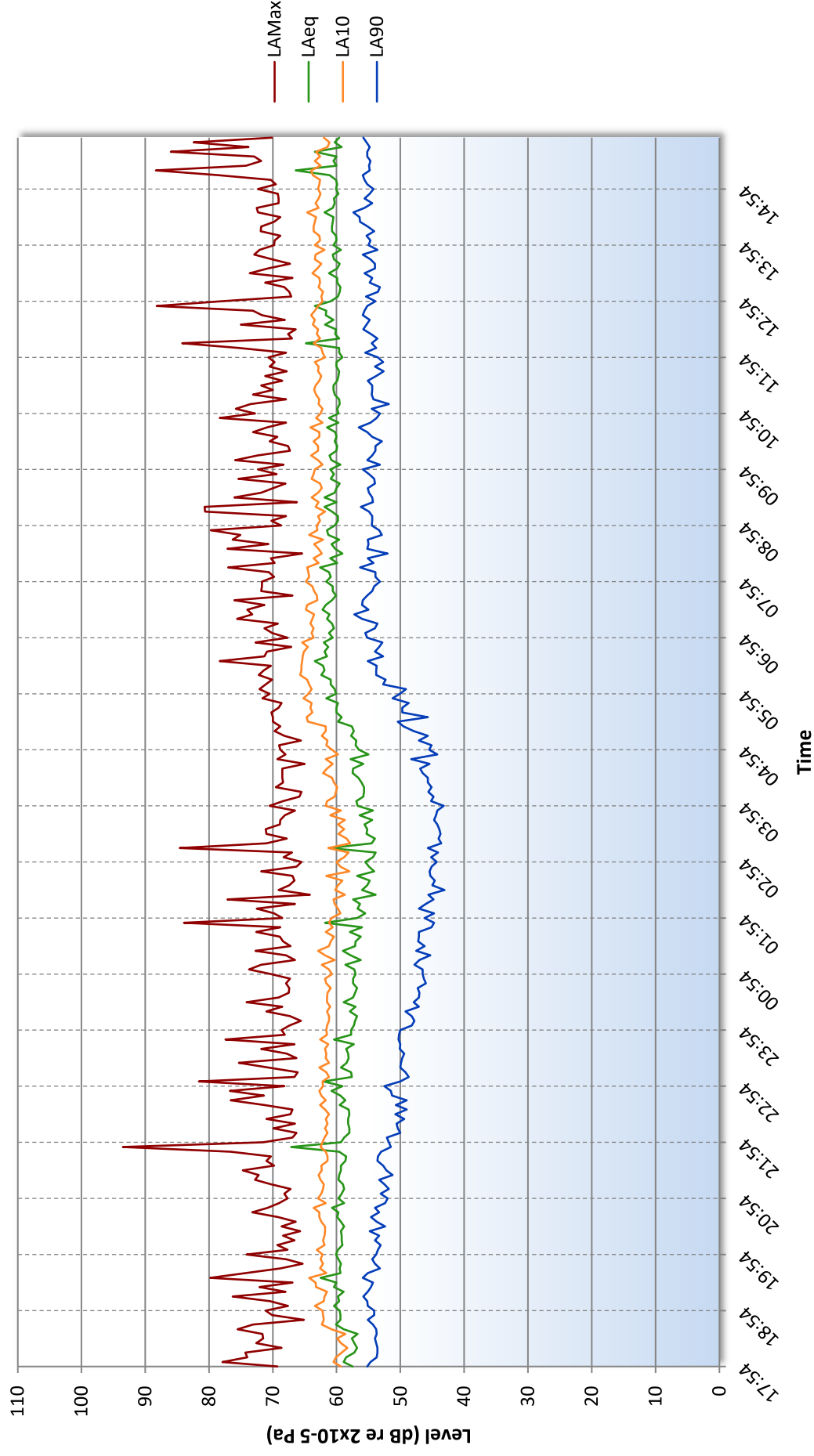


Figure 25436.TH1

Seven Sisters - Warehouse living Haringey
VDV Time History
From 08/11/2022 To 09/11/2022

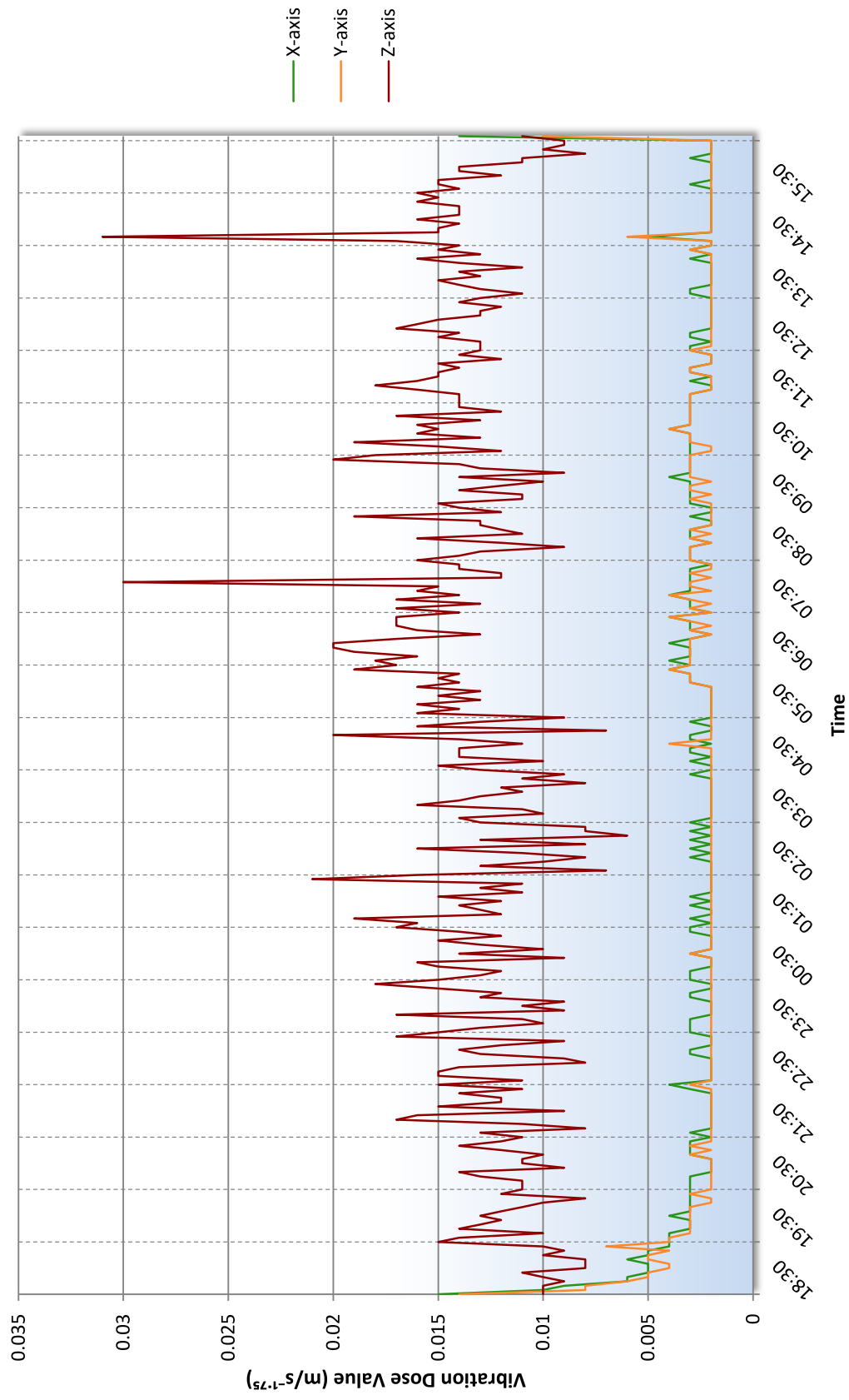


Figure 25436.VH1

GENERAL ACOUSTIC TERMINOLOGY

Decibel scale - dB

In practice, when sound intensity or sound pressure is measured, a logarithmic scale is used in which the unit is the 'decibel', dB. This is derived from the human auditory system, where the dynamic range of human hearing is so large, in the order of 10^{13} units, that only a logarithmic scale is the sensible solution for displaying such a range.

Decibel scale, 'A' weighted - dB(A)

The human ear is less sensitive at frequency extremes, below 125Hz and above 16Khz. A sound level meter models the ears variable sensitivity to sound at different frequencies. This is achieved by building a filter into the Sound Level Meter with a similar frequency response to that of the ear, an A-weighted filter where the unit is dB(A).

L_{eq}

The sound from noise sources often fluctuates widely during a given period of time. An average value can be measured, the equivalent sound pressure level L_{eq} . The L_{eq} is the equivalent sound level which would deliver the same sound energy as the actual fluctuating sound measured in the same time period.

L_{10}

This is the level exceeded for no more than 10% of the time. This parameter is often used as a "not to exceed" criterion for noise.

L_{90}

This is the level exceeded for no more than 90% of the time. This parameter is often used as a descriptor of "background noise" for environmental impact studies.

L_{max}

This is the maximum sound pressure level that has been measured over a period.

Octave Bands

In order to completely determine the composition of a sound it is necessary to determine the sound level at each frequency individually. Usually, values are stated in octave bands. The audible frequency region is divided into 11 such octave bands whose centre frequencies are defined in accordance with international standards. These centre frequencies are: 16, 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000 and 16000 Hertz.

Environmental noise terms are defined in BS7445, *Description and Measurement of Environmental Noise*.

APPLIED ACOUSTIC TERMINOLOGY

Addition of noise from several sources

Noise from different sound sources combines to produce a sound level higher than that from any individual source. Two equally intense sound sources operating together produce a sound level which is 3dB higher than a single source and 4 sources produce a 6dB higher sound level.

Attenuation by distance

Sound which propagates from a point source in free air attenuates by 6dB for each doubling of distance from the noise source. Sound energy from line sources (e.g. stream of cars) drops off by 3dB for each doubling of distance.

Subjective impression of noise

Hearing perception is highly individualised. Sensitivity to noise also depends on frequency content, time of occurrence, duration of sound and psychological factors such as emotion and expectations. The following table is a guide to explain increases or decreases in sound levels for many scenarios.

Change in sound level (dB)	Change in perceived loudness
1	Imperceptible
3	Just barely perceptible
6	Clearly noticeable
10	About twice as loud

Transmission path(s)

The transmission path is the path the sound takes from the source to the receiver. Where multiple paths exist in parallel, the reduction in each path should be calculated and summed at the receiving point. Outdoor barriers can block transmission paths, for example traffic noise. The effectiveness of barriers is dependent on factors such as its distance from the noise source and the receiver, its height and construction.

Ground-borne vibration

In addition to airborne noise levels caused by transportation, construction, and industrial sources there is also the generation of ground-borne vibration to consider. This can lead to structure-borne noise, perceptible vibration, or in rare cases, building damage.

Sound insulation - Absorption within porous materials

Upon encountering a porous material, sound energy is absorbed. Porous materials which are intended to absorb sound are known as absorbents, and usually absorb 50 to 90% of the energy and are frequency dependent. Some are designed to absorb low frequencies, some for high frequencies and more exotic designs being able to absorb very wide ranges of frequencies. The energy is converted into both mechanical movement and heat within the material; both the stiffness and mass of panels affect the sound insulation performance.