Report VA3439.211112.NIA2.1

Waterperry Court, Banbury

Noise and Vibration Assessment

18 November 2021

Waterperry Court Developments Ltd
7 Royal Hill Court
229 Greenwich High Road
London
SE10 8PH

VENTA ACOUSTICS

01962 461016
0203 8650332
mail@ventaacoustics.com

registered company no. 10139494

Contents

Attachments

1. Introduction

It is proposed to extend and convert the office building at Waterperry Court, Banbury for use as a hotel.

Venta Acoustics has been commissioned by Waterperry Court Developments Ltd to undertake an assessment of the current environmental noise impact on the site in support of an application for planning permission.

An environmental noise survey has been undertaken to determine the noise levels incident on the site. These levels are then used to undertake an assessment of the likely impact in accordance with the National Planning Policy Framework with reference to relevant standards, guidance and the planning requirements of Cherwell District Council. Vibration will be assessed in accordance with BS 6472: Part 1: 2008 *Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting*.

This assessment also considers comments made on a previous application for the site by Cherwell District Council Environmental Health Department, and clarifies and addresses these comments.

Outline mitigation measures are considered and an appraisal of the requirements of external building fabric elements are provided where appropriate.

2. Guidance and Legislation

2.1 The National Planning Policy Framework (2021)

The revised *National Planning Policy Framework* (NPPF), published in July 2021, sets out the Government's planning polices for England, superseding all previous planning policy statements and guidance.

In respect of noise, the NPPF states that the planning system should contribute to and enhance the natural and local environment by preventing both new and existing developments from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of noise pollution.

Hence, Paragraph 185 states that *planning policies and decisions should also ensure 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:*

a) 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

b) identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason

In regards to the term adverse impact, reference is made to the Noise Policy for England:

2.2 Noise Policy Statement for England (2010)

The Noise Policy Statement for England (NPSE) sets out the long term vision of Government noise policy: to promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.

This vision is supported by the following aims:

- *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 terms “significant adverse” and “adverse” are related to the following concepts:

No Observed Effect Level (NOEL) - *the level below which no effect on health and quality of life can be detected*.

Lowest Observed Adverse Effect Level (LOAEL) - *the level above which adverse effects on health and quality of life can be detected*.

Significant Observed Adverse Effect Level (SOAEL) - *the level above which significant adverse effects on health and quality of life occur*.

The guidance acknowledges that it is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations, but will be different for different noise sources, receptors and times.

In order to enable assessment of impacts in line with these requirements, reference should be made to other currently available guidance.

2.3 WHO Guidelines for Community Noise (1999)

The guidance in this document details suitable noise levels for various activities within residential and commercial buildings. There are no specific guidelines stated for hotels, and so typically the same requirements as for a residential dwelling are used for average and maximum internal noise levels from external sources.

The relevant sections of this document are shown in Table 2.2.

Criterion	Environment	Design range $L_{Aeq,T}$ dB
Maintain speech intelligibility and avoid moderate annoyance, daytime and evening	Living Room	35 dB
Prevent sleep disturbance, night time	Bedrooms	30 dB

Table 2.1 – Excerpt from WHO [dB ref. 20µPa]

This guidance also states:

> *For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45dB L_{Amax} more than 10-15 times a night (Vallet & Vernet 1991).*

For sleep disturbance, i.e. in bedrooms at night, the NOEL can, therefore, be taken as anything below 30dB(A), whilst the onset of the LOAEL occurs at 30dB(A) and above. The SOAEL cannot be inferred from this information.

2.4 BS8233:2014

BS8233 *Guidance on sound insulation and noise reduction for buildings* provides guidance as to desirable internal ambient noise levels for different areas within residential buildings.

The relevant section of the standard is shown below in Table 2.2.

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

Table 2.2 – Excerpt from BS8233:2014 - Indoor ambient noise levels for dwellings [dB ref. 20µPa]

2.5 BS4142:2014

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 fixed installations comprising mechanical and/or electrical plant and equipment;

The assessment methodology considers the Specific Sound Level, as measured or calculated at a potential noise sensitive receptor, due to the source under investigation. A correction factor is added to this level to account for the acoustic character of the sound as follows:

Tonality – A correction of up to 6dB depending on the prominence of tones;

Impulsivity - A correction of up to 9dB depending on the prominence of impulsivity;

Other sound characteristics - A 3dB correction may be applied where a distinctive acoustic character is present that is neither tonal nor impulsive;

Intermittency - A 3dB correction may be applied where the specific sound has identifiable on/off conditions.

An estimate of the impact of the source is obtained by subtracting the typical background noise level from the corrected Specific Sound Level.

- 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. 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.

2.6 BS6472-1:2008

BS6472 specifies building vibration with respect to human response to be measured and assessed in the form of a 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 is to be evaluated for the axis in which the magnitude of weighted acceleration is greatest, against the values in Table 2.3.

Place and Time	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
16h day (07:00 – 23:00)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
8h night (23:00 – 07:00)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

Table 2.3 – VDV ranges with regard to risk of probable comment [values ref. $m/s^{-1.75}$]

3. Site Description

As illustrated on attached site plan VA3439/SP1, the site is a large office building spread over five levels, with the north bounded by Bridge Street and Merton Street, and Banbury Station to the south. To the west of the building is a Royal Mail depot.

The dominant noise sources expected to affect the site are road and rail, with a contribution from the Royal Mail site. It was noted whilst on site that announcements from the station speakers were one of the clearest noise sources affecting the local area, although it should be noted that rail movements were much louder.

4. Environmental Noise Survey

4.1 Survey Procedure & Equipment

In order to establish the existing noise levels at the site, a noise survey was carried out between Wednesday 25th and Friday 27th November 2020 at the locations shown in site plan VA3439/SP1.

These locations were chosen to be representative of the ambient and background noise level at the proposed new hotel.

Continuous 5-minute samples of the L_{Aeq}, L_{Amax}, L_{A10} and L_{A90} sound pressure levels were undertaken at each of the measurement locations.

The weather during the survey period was generally dry with light winds. The background noise data is not considered to have been compromised by these conditions.

Measurements were made generally in accordance with ISO 1996 2:2017 *Acoustics - Description, measurement and assessment of environmental noise – Part 2: Determination of sound pressure levels*.

The following equipment was used in the course of the survey:

Manufacturer	Model Type	Serial No	Calibration	
			Certificate No.	Date
NTi Class 1 Integrating SLM	XL2	A2A-11461-E0	UCRT20/1699	27/7/20
Svantek Class 1 Integrating SLM	958A	59177	Sound: UCRT19/1108 Vibration: TCRT19/1061	23/1/19 21/1/19
Larson Davis calibrator	CAL200	13069	UCRT20/1562	26/6/20

Table 4.1 – Equipment used for the survey

The calibration of the sound level meter was verified before and after use with no significant calibration drift observed.

4.2 Results

The measured sound levels are shown as time-history plots on the attached charts VA3439/TH1-2 for position 1 and VA3439/TH3-4 for position 2.

The average and typical background noise levels for the Daytime and Night-time periods, as measured at the automated monitoring position were:

Monitoring Period	$L_{Aeq,T}$		Typical $L_{A90,\ 5mins}$	
	Position 1	Position 2	Position 1	Position 2
07:00 – 23:00 hours	64 dB	64 dB	52 dB	47 dB
23:00 – 07:00 hours	60 dB	63 dB	47 dB	40 dB

Table 4.2 – Average ambient noise levels at measurement locations **[dB ref. 20µPa]**

[1] The typical L_{A90} value is taken as the 10th percentile of all L_{A90} values measured during the relevant period.

The typical night time L_{Amax} events, generated by vehicle and train passbys to the north of the site were recorded to be in the order of 80dB $L_{Amax,fast}$, increasing to 86dB $L_{Amax,fast}$ at the rear of the building, where there is a clear line of sight to the station and rail lines.

5. Vibration Survey

An automated vibration monitor was installed at the position shown on the attached Site Plan VA3439/SP1 to record vibration levels due to train movements.

The transducer was set to record vibration levels as acceleration in three perpendicular axes, from which Vibration Dose Values were determined for day and night-time periods following the procedures described in BS 6472: Part 1: 2008 *Guide to evaluation of human exposure to vibration in buildings: Vibration sources other than blasting*.

The measurement location was at the nearest position available (with a structure with good adhesion with the surrounding geology) to the nearest proposed hotel façade to the railway line. On this basis, worst case results, with regard to levels across the site, would be obtained. All measurements were made generally in accordance with BS6472 and ANC guidelines for vibration measurement.

Vibration levels were monitored at site over consecutive 5-minute periods in three axes.

5.1 Results

Axis	Period	VDV	Probability of Comment
X	16h day (07:00 – 23:00)	0.01	Less than a low probability of adverse comment
Y		0.01	Less than a low probability of adverse comment
Z		0.08	Less than a low probability of adverse comment
X	8h night (23:00 – 07:00)	0.01	Less than a low probability of adverse comment
Y		0.01	Less than a low probability of adverse comment
Z		0.07	Less than a low probability of adverse comment

Table 5.1 – VDV ranges with regard to risk of probable comment [values ref. $m/s^{-1.75}$]

The vibration levels measured on site are substantially lower than levels with a low probability of adverse comment. BS6472-1:2008 states that 'below these ranges adverse comment is not expected' and hence, conditions on site are within acceptable limits.

6. BS4142 Noise Impact Assessment

The site to the east of the site is a Royal Mail depot, which is serviced by lorries and vans throughout the day and night-time period.

6.1 Noise Level Data

The following noise source data has been used for the adjacent site. No plant was noted on the rear of the building as being operational during the site visits, or is apparent on the noise survey time histories.

Noise Source	Measurement Distance	Measured L_{Aeq}	Notes
Lorry manoeuvring	8m	73dB	Library data
Lorry loading/ unloading	5m	61dB	Library data – include noise from cages on concrete

Table 6.1 – Noise source data used for assessment

6.2 Acoustic Character Correction

The subjective method of allocating corrections to the sound source has been used following the methodology provided in BS4142:2014 and summarised in section 2.5.

Noise Source	Subjective Description	Allocated Corrections
Lorry Manoeuvring	Intermittent deliveries, diesel engine broadband, not tonal and not impulsive	Tonality: 0dB Impulsivity: 0dB Intermittency: +3dB
Lorry unloading/loading	Impulsive noise from occasional bangs, clatters, from loading. Intermittent nature of deliveries.	Tonality: 0dB Impulsivity: +6dB Intermittency: +3dB

Table 6.2 – Acoustic character corrections

These penalties are applied to the specific noise level in section 6.3 to obtain the rating noise level.

6.3 Rating Noise Level and Assessment

The rating noise levels at the assessment locations are compared against the relevant background noise levels to assess the notional significance of the noise impact as follows. Operations are adjusted to the appropriate on times during the night time period (T=15 mins).

Table 6.3 and Table 6.4 show the assessments for deliveries on the most affected façade of the new hotel.

Results		Relevant Clause	Commentary
Source Sound Levels	73dB @ 8m	7.3.4	Lorry Manoeuvring
Distance Loss (25m)	-10dB	7.3.5	Assumed a point source
Specific Sound Level	L_{Aeq} 63 dB		
Assume 2 minutes of a 15 minute period	-9dB	7.2	Allowance made for multiple HGV movements in a 15 minute period
Acoustic feature correction	+3 dB	9.2	+3dB for intermittency
Rating level	L_{Ar} 57 dB	9.2	
Night-time background sound level	L_{A90} 40 dB	8	
Excess of rating over background sound level	+17 dB	11	
Assessment indicates adverse impact		11	Depending on context

Table 6.3 – BS4142 Assessment – Lorry Manoeuvring

The time period of 2 minutes per 15 minute period is based upon a realistic assumption of 2-3 vehicles arriving and reversing in a 15 minute period. Should this be increased to a highly pessimistic assumption of 50% of the time, the excess would increase to +23dB, which would still show an

adverse impact over the time period, but would not change the actual noise level of the activity emanating from the site.

Results		Relevant Clause	Commentary
Source Sound Levels	61dB @ 5m	7.3.4	Lorry unloading
Distance Loss (40m)	-18dB	7.3.5	Assumed a point source
Screening loss	-10		Provided by mail building
Specific Sound Level	L_{Aeq} 33 dB		
No time correction	0dB	7.2	Assuming loading constantly through 15 minute period
Acoustic feature correction	+9 dB	9.2	+6 for impulsivity, +3dB for intermittency
Rating level	L_{Ar} 42 dB	9.2	
Night-time background sound level	L_{A90} 40 dB	8	
Excess of rating over background sound level	+2 dB	11	
Assessment indicates low/marginal impact		11	Depending on context

Table 6.4 – BS4142 Assessment – Lorry Loading/Unloading

6.4 Context

The site is located in a predominantly commercial area, with residential dwellings to the north and north east of the site.

Within this context, the estimated impact of the sound sources is expected to remain valid.

The BS4142 standard aims to cover a wide variety of situations under the same base assessment methodology and so has some inherent shortcomings. To allow for this, the guidance encourages consideration of the site context as a means of adapting the base assessment to specific scenarios.

The base assessment methodology is considered to be weighted towards the more sensitive case of assessing industrial noise upon an existing residential receiver. The introduction of a new hotel use to an area with existing sources of commercial noise provides an opportunity to provide appropriate mitigation against the noise sources.

Mitigation at the source or along the propagation path for the noise sources within the adjacent Royal Mail yard would not be achievable in this situation within the practical constraints of the site. However, the redevelopment of the site provides an opportunity to provide mitigation in the form of appropriately specified external building fabric elements. This would allow appropriate internal noise levels to be achieved such that the commercial noise source is not considered to be disruptive.

This allows the impact to be significantly reduced for occupants within the hotel and is considered in section 7. The new hotel is not proposed to have any external amenity areas and hence internal noise levels are how future residents would experience the noise.

6.5 Uncertainty

This section considers the variable in the assessment that may cause variations within the final results and describes how these have been addressed.

- Use of Class 1 sound level meters is considered to reduce instrument error to insignificant levels as compared with environmental variations. The calibration of the instrumentation was confirmed before and after the noise surveys.
- The background measurements were undertaken under suitable weather conditions over a period designed to include reasonable temporal variations in background noise levels. Two monitoring locations were selected to minimise local acoustic phenomenon that may affect a single measurement location. These measurement locations were selected to be representative of the background noise levels expected to be experienced by the proposed hotel without being unduly influenced by extraneous noise sources.
- Where library data has been used, propagation calculations have been used to correct noise levels to the relevant distance at the receiver.

Overall, the uncertainty is considered to have been minimised to a suitable range so as not to risk significant variations in the impact assessment of typical operations.

7. Mitigation/Internal Noise Assessment

A review of the JWA Architects drawings for the proposed scheme has been undertaken.

The assessment has been undertaken considering the average noise levels incident upon the site, as well as the maximum events related to the railway (high speed train pass-bys), and noise from the Royal Mail site, of which HGV movements show the greatest impact. Noise from the other sources, such as the tannoy, are at a lower level, and so would be controlled sufficiently by ensuring the loudest noise sources are mitigated.

Average internal noise levels have been targeted to achieve the requirements of BS8233: 2014 and the WHO Guidelines, with maximum events to be controlled to lower than the recommended limits in the WHO Guidelines.

The comments from the Council's EH department for the previous residential scheme mentioned the use of barriers to reduce noise levels to the new building. Line of site calculations have been undertaken to evaluate if screening could reduce the noise level to the building from the railway. However, due to the elevated nature of the building in relation to the railway, as well as the height of the buildings, the reductions provided by screening would be small, and so the noise exposure realistically is best controlled through the use of the building envelope.

7.1 Sound Reduction Performances of Building Elements

It has been assumed that all the non-glazed elements, i.e. walls and roof systems, will be capable of providing the following minimum sound insulation performance, when tested in accordance with BS EN ISO 10140-2:2010 *Acoustics - Laboratory measurement of sound insulation of building elements – Part 2: Measurement of airborne sound insulation*.

Building Element	Single figure weighted sound reduction index, dB
Masonry	R_w 51

Table 7.1 – Assumed sound reductions performances of non-glazed elements

7.2 Sound Reduction Performance of Windowsets and Vents

The monitoring data along with the architectural drawings have been used to calculate the required sound insulation performance for the windowsets (glazing and frame combination) and open ventilators for the building. These are summarised in Table 7.2 below.

Glazing Reference	Required Glazing SRI, dB	Ventilator Performance, dB
North, Guestrooms	R_w 41	$D_{n,e,w}$ 42
North, Guestrooms	R_w 50	$D_{n,e,w}$ 51

Table 7.2 – Required minimum sound reduction indices for glazing and ventilators

In order that windows may remain closed to maintain the internal noise levels, it is expected that attenuated means of background ventilation will be required. If trickle vents are used the performance shown in Table 7.2 will be required. The figures stated are for a single vent per room. If multiple vents are required, then the performance requirement shown in Table 7.2 will increase by a value equal to +10log(*N*), with N being the total number of vents serving the room. It should be noted that there is no reason why windows could not be opened as a matter of personal preference or for purge ventilation.

7.2.2 Windowset Performances

It is important that the performance shown in Table 7.2 are achieved by the entire windowset including frames, ventilators, seals, etc. Glass performance alone would not be likely to show compliance with the specification as the other elements typically provide the weakest noise transmission path.

The ventilator performances provided would need to be achieved with the vents open.

Due to the high noise levels from trains and, to a lesser extent, speaker announcements to the rear of the site, it is likely that a mechanical ventilation solution would be required to guestrooms on this façade so that windows may remain closed.

With the above recommendations implemented, the noise levels within the proposed rooms would be expected to be in line with recommendations given in the WHO 1999 and BS8233:2014 guidance. Internal noise levels can therefore be considered to be between the NOEL the LOAEL levels.

7.3 Areas of External Amenity

The development does not include any external amenity areas and so this is not considered in this assessment.

8. Conclusion

A baseline noise survey has been undertaken by Venta Acoustics to establish the prevailing noise climate in the locality of Waterperry Court, Banbury in support of a planning application for the proposed development of a new hotel.

The measured levels have been assessed against the National Planning Policy Framework and currently available standards and guidance documents including World Health Organisation *Guidelines for Community Noise* (1999) and BS8233:2014 *Guidance on sound Insulation and noise*.

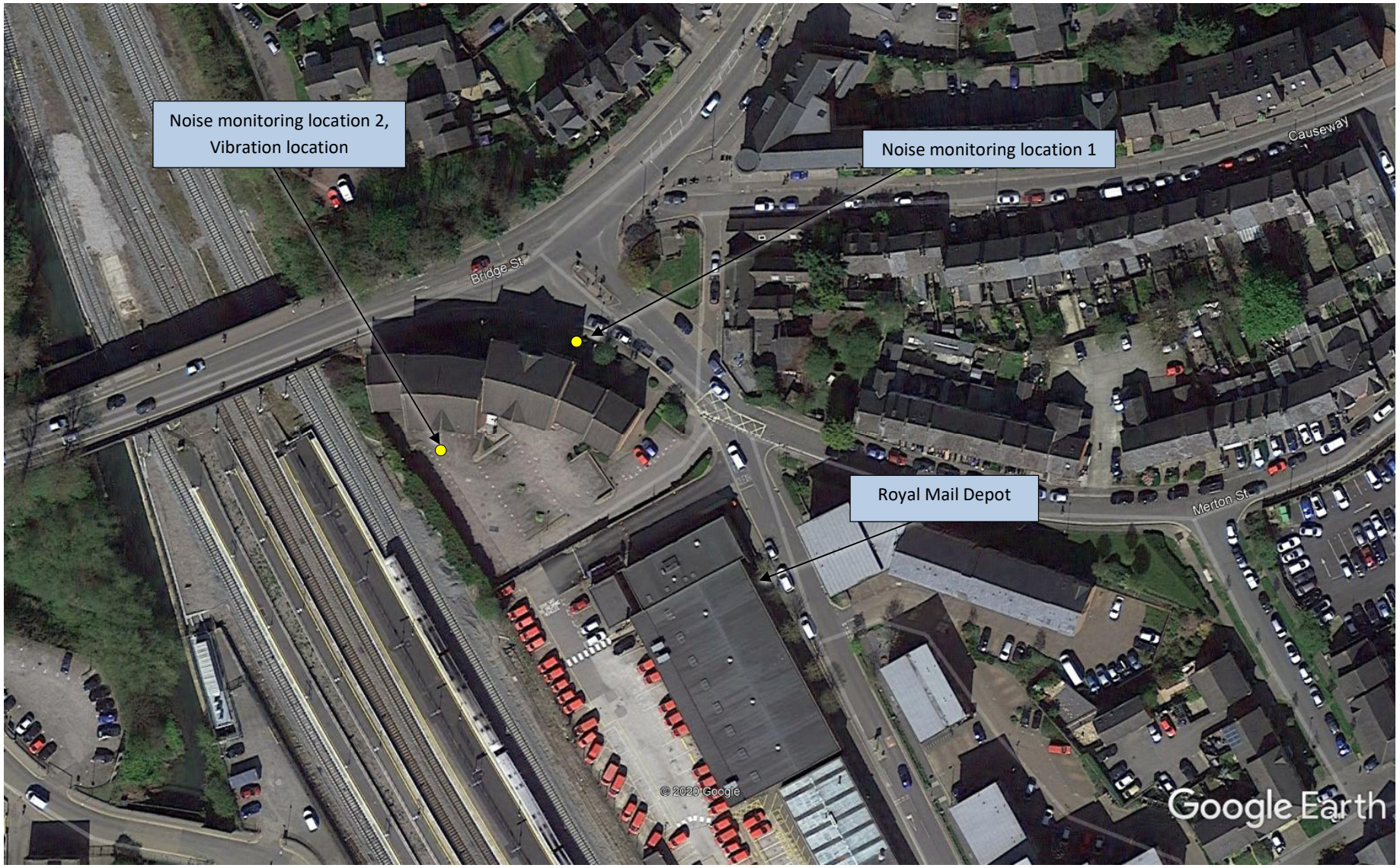
Appropriate external and internal noise criteria have been considered to minimise adverse impacts on health and quality of life as a result of the new development.

An assessment of noise from the adjacent Royal Mail depot has been assessed using BS4142 and has indicated potential for an adverse impact. A discussion of the limitations of the methodology has been included with regards to new noise sensitive receivers coming to a commercial noise source.

Appropriate mitigation measures have been outlined to ensure average and maximum noise levels would meet the desired noise levels including proprietary thermal double-glazing and attenuated ventilators and mechanical ventilation.

With the above measures implemented, the proposed scheme is not expected to experience an adverse noise impact and the site is considered acceptable for the proposed hotel use.

Jamie Duncan MIOA



Indicative Site Plan

Waterperry Court, Banbury

Environmental Noise Time History: 1

Location 1

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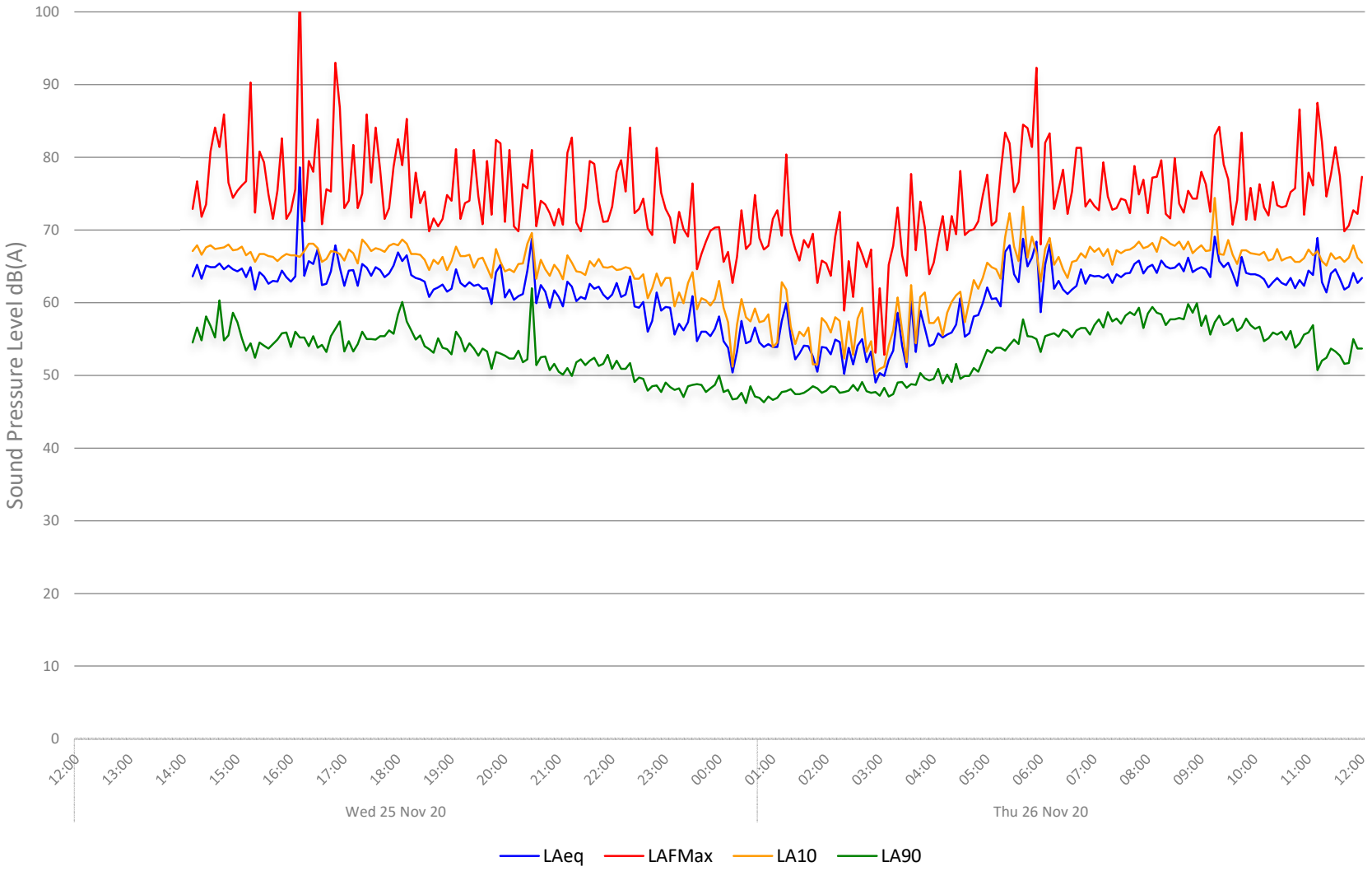
Figure VA3439/TH1



Waterperry Court, Banbury

Environmental Noise Time History: 2

Location 1

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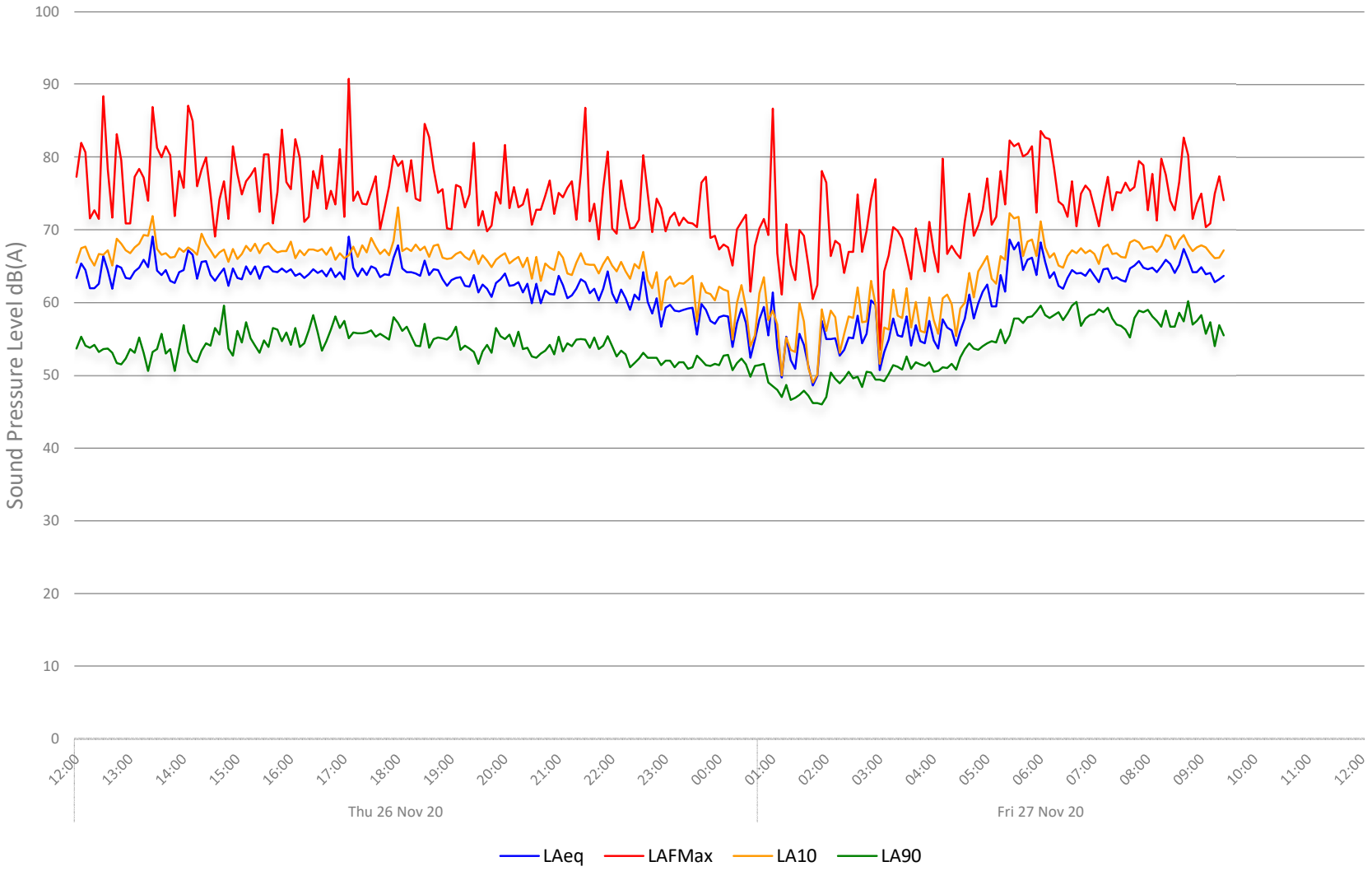
Figure VA3439/TH2



Waterperry Court, Banbury

Environmental Noise Time History: 3

Position 2

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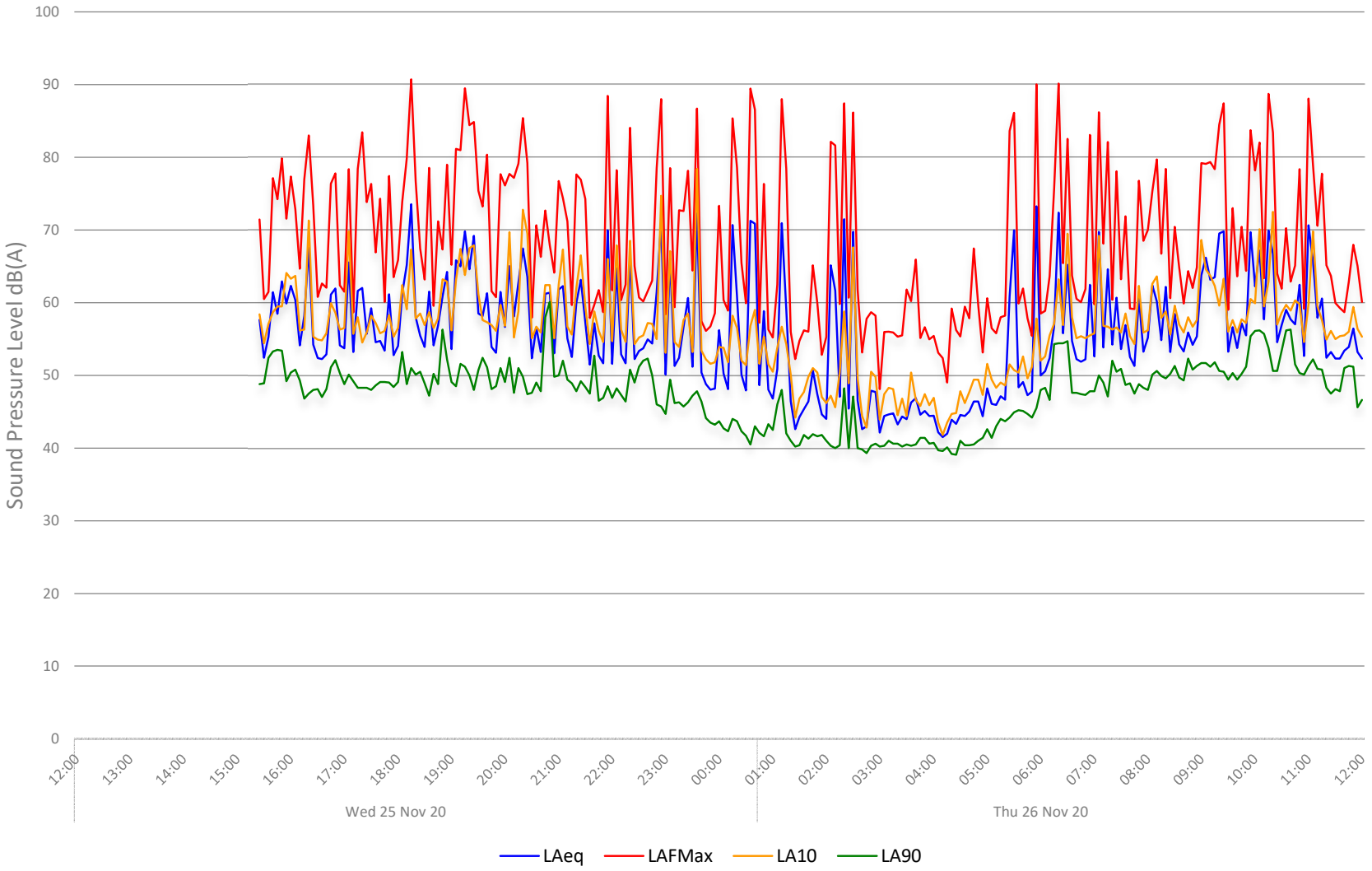
Figure VA3439/TH3



Waterperry Court, Banbury

Environmental Noise Time History: 4

Position 2

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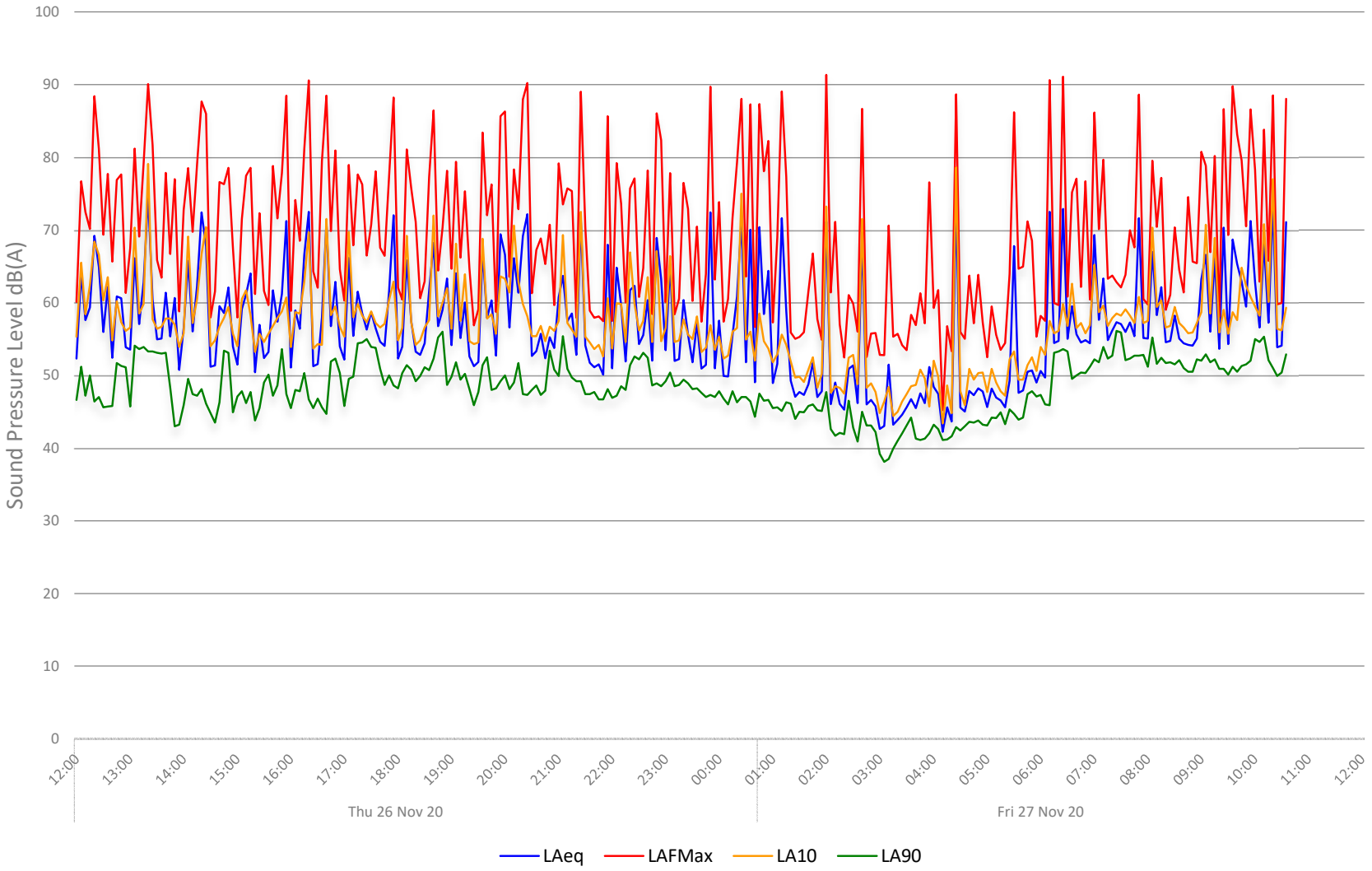
Figure VA3439/TH4



APPENDIX A

Acoustic Terminology & Human Response to Broadband Sound

1.1 Acoustic Terminology

The human impact of sounds is dependent upon many complex interrelated factors such as 'loudness', its frequency (or pitch) and variation in level. In order to have some objective measure of the annoyance, scales have been derived to allow for these subjective factors.

Sound	Vibrations propagating through a medium (air, water, etc.) that are detectable by the auditory system.
Noise	Sound that is unwanted by or disturbing to the perceiver.
Frequency	The rate per second of vibration constituting a wave, measured in Hertz (Hz), where 1Hz = 1 vibration cycle per second. The human hearing can generally detect sound having frequencies in the range 20Hz to 20kHz. Frequency corresponds to the perception of 'pitch', with low frequencies producing low 'notes' and higher frequencies producing high 'notes'.
dB(A):	Human hearing is more susceptible to mid-frequency sounds than those at high and low frequencies. To take account of this in measurements and predictions, the 'A' weighting scale is used so that the level of sound corresponds roughly to the level as it is typically discerned by humans. The measured or calculated 'A' weighted sound level is designated as dB(A) or L_A.
L_{eq} :	A notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the actual, fluctuating sound measured over that period (e.g. 8 hour, 1 hour, etc). The concept of L_{eq} (equivalent continuous sound level) has primarily been used in assessing noise from industry, although its use is becoming more widespread in defining many other types of sounds, such as from amplified music and environmental sources such as aircraft and construction. Because L_{eq} is effectively a summation of a number of events, it does not in itself limit the magnitude of any individual event, and this is frequently used in conjunction with an absolute sound limit.
L_{10} & L_{90} :	Statistical L_n indices are used to describe the level and the degree of fluctuation of non-steady sound. The term refers to the level exceeded for n% of the time. Hence, L_{10} is the level exceeded for 10% of the time and as such can be regarded as a typical maximum level. Similarly, L_{90} is the typical minimum level and is often used to describe background noise. It is common practice to use the L_{10} index to describe noise from traffic as, being a high average, it takes into account the increased annoyance that results from the non-steady nature of traffic flow.
R	*Sound Reduction Index.* Effectively the *Level Difference* of a building element when measured in an accredited laboratory test suite in accordance with the procedures laid down in BS EN ISO 10140-2:2010 and corrected for its size and the reverberant characteristics of the receive room.

1.2 Octave Band Frequencies

In order to determine the way in which the energy of sound is distributed across the frequency range, the International Standards Organisation has agreed on "preferred" bands of frequency for sound measurement and analysis. The widest and most commonly used band for frequency measurement and analysis is the Octave Band. In these bands, the upper frequency limit is twice the lower frequency limit, with the band being described by its "centre frequency" which is the average (geometric mean) of the upper and lower limits, e.g. 250 Hz octave band extends from 176 Hz to 353 Hz. The most commonly used octave bands are:

Octave Band Centre Frequency Hz	63	125	250	500	1000	2000	4000	8000

1.3 Human Perception of Broadband Noise

APPENDIX A

Acoustic Terminology & Human Response to Broadband Sound

Because of the logarithmic nature of the decibel scale, it should be borne in mind that sound levels in dB(A) do not have a simple linear relationship. For example, 100dB(A) sound level is not twice as loud as 50dB(A). It has been found experimentally that changes in the average level of fluctuating sound, such as from traffic, need to be of the order of 3dB before becoming definitely perceptible to the human ear. Data from other experiments have indicated that a change in sound level of 10dB is perceived by the average listener as a doubling or halving of loudness. Using this information, a guide to the subjective interpretation of changes in environmental sound level can be given.

Change in Sound Level dB	Subjective Impression	Human Response
0 to 2	Imperceptible change in loudness	Marginal
3 to 5	Perceptible change in loudness	Noticeable
6 to 10	Up to a doubling or halving of loudness	Significant
11 to 15	More than a doubling or halving of loudness	Substantial
16 to 20	Up to a quadrupling or quartering of loudness	Substantial
21 or more	More than a quadrupling or quartering of loudness	Very Substantial