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**NO.1 READING**

**29-35 STATION ROAD**

**NOISE AND VIBRATION ASSESSMENT**

Report 18082.NIA.01

For:

Station Road Dev Co Ltd

| First Issue date: 10/10/2018                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                         |                                                 |  |                                                 |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|-------------------------------------------------|--|-------------------------------------------------|--|
| Revision History<br>Report 18082.NIA.01                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                         |                                                 |  |                                                 |  |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 22/10/2018 addition of further criteria definitions                     | D                                               |  |                                                 |  |
| B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 24/10/2018 “hotel occupants” added in description of vibration criteria | E                                               |  |                                                 |  |
| C                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                         | F                                               |  |                                                 |  |
| Written by:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                         | Checked by:                                     |  | Approved by:                                    |  |
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| 18082.Front.Daytime andNight-time.L90  | Representative background statistical analysis |
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## 1.0 INTRODUCTION

KP Acoustics has been commissioned by Station Road Development Company Ltd, to assess the suitability of the site at 29-35 Station Road, Reading, RG1 1LG, for the demolition of the existing building and erection of replacement mixed use building comprised of hotel (Class C1), office (Class B1a) and flexible ground floor retail use (Classes A1, A2, A3, A4 and A5 use), with associated servicing from Garrard Street, 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.

## 2.0 SITE SURVEYS

### 2.1 Site Description

The site is bounded by Station Road to the East, Garrard Street to the North, parking and services area to the West serving properties along station Road and Friar Street, and the attached Brunel Reading building to the South. Entrance to the site is located at Station Road. At the time of the survey, the background noise climate was dominated by road traffic noise from Station Road.

### 2.2 Environmental Noise and Vibration Survey Procedure

Noise and vibration surveys were undertaken on the proposed site as shown in Figures 2.1 and 2.2 and locations described in Table 2.1. The location were chosen in order to collect data representative of the worst-case levels expected on the site due to all nearby sources.

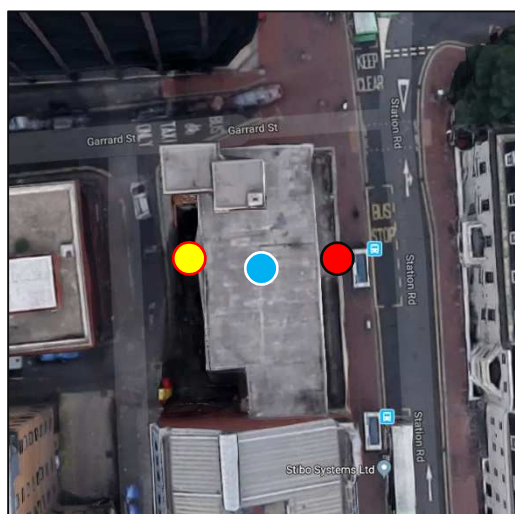


Figure 2.1. Aerial picture of the site showing noise (red and yellow) and vibration (blue) survey locations. (Image: Google maps)



**Figure 2.2. Noise survey location 1 at front façade (left picture) and location 2 to the rear façade (right picture) of the existing building on site.**

|                                       | Description                                                                                                                                                                                                      |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Noise survey Location 1</b>        | The meter was installed on a window on the first floor of the front façade, as shown in Figure 2.2. A correction of 3dB has been applied to account for non-free field conditions                                |
| <b>Noise survey Location 2</b>        | The meter was installed on the wall at high level on the ground floor of the rear façade, as shown in figure 2.1. A correction of 3dB has been applied to account for non free-field conditions                  |
| <b>Vibration Measurement location</b> | The accelerometer was attached with manufacturer issued mounting wax to a steel cube. The cube was then placed on the concrete slab and near a structural column at Ground floor level inside the site building. |

**Table 2.1 Measurement positions and descriptions**

Continuous automated monitoring was undertaken for the duration of the noise and vibration surveys between 13:00 on 01/10/2018 and 13:00 on 02/10/2018.

Weather conditions were generally dry with light winds and therefore suitable for the measurement of environmental noise. The measurement procedure complied with ISO 1996-2:2007 Acoustics *“Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels”*.

The acceleration vibration and vibration dose values (VDV) measurement procedure complied with the guidelines outlined in BS6472-1:2008 *“Guide to evaluation of human exposure to vibration in buildings”*.

The vibration measurements were made of vertical (z-axis) and horizontal (x - y axes) vibration levels.

### 2.3 Equipment

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

| Location                       | Measurement instrumentation                                                                                       |
|--------------------------------|-------------------------------------------------------------------------------------------------------------------|
| Noise survey Location 1        | Svantek Type 957 Class 1 Sound Level Meter<br>Svantek 2v12L free-field microphone<br>Svantek External windshield  |
| Noise survey Location 2        | Svantek Type 977A Class 1 Sound Level Meter<br>Svantek 2v12L free-field microphone<br>Svantek External windshield |
| Vibration Measurement location | Svantek Type 958A Class 1 Sound Level Meter<br>CI PCB Piezotronics Accelerometer                                  |
| Sound Calibrator               | B&K Type 4231 Class 1 Calibrator                                                                                  |
| Vibration Calibrator           | Svantek SV110 Calibrator                                                                                          |

**Table 2.2 Measurement instrumentation**

### 2.4 Noise Maps

A 3D model of the proposed development and neighboring buildings and roads has been generated using proprietary environmental acoustic modeling software (Sound Plan 8.0). The noise levels measured during the environmental noise survey have been used to calibrate the model.

In a following stage, the model has been fed with additional noise sources such as the plant units installed on the roof of the neighbouring building Thames Tower that could affect the highest floor levels of the hereby proposed development. The specifications of the plant units have been based on the information provided in the Mechanical Service Plant Noise Impact Assessment (report reference: 20523R04KDmdw) produced by Environoise for the planning application of the Thames Tower development.

The results of the 3D propagation acoustic model have enabled to predict noise levels on all façades at different floor levels.

### **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 surveys. Measured noise levels at the front and rear side of the building are shown as a time history in Figure 18082.TH1 and 18082.TH2 respectively. Average daytime and night time noise levels are shown in Table 4.1.

#### **3.2 Vibration Survey**

The results of the background vibration measurements are shown as a time history Figures 18082.VS1 as acceleration levels over the broadband frequency range.

#### **3.3 Noise Maps**

Noise maps obtained from the 3D acoustic modelling of the proposed development area have been deemed representative of noise exposure levels expected to be experienced by the proposed development. The aforementioned noise maps are shown in Appendix B.

### **4.0 NOISE AND VIBRATION ASSESSMENT GUIDANCE**

#### **4.1 Noise Policy Statement For England**

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 123 of the NPPF states that planning policies and decisions should aim to:

- Avoid noise from giving rise to significant adverse impacts (see Explanatory Note to the Noise Policy Statement for England (DEFRA)) on health and quality of life as a result of new development;
- Mitigate and reduce to a minimum other adverse impacts (see Explanatory Note to the Noise Policy Statement for England (DEFRA)) on health and quality of life arising from noise from new development, including through the use of conditions;
- Recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land use since they were established (Subject to the provisions of the Environmental Protection Act 1990 and other relevant law); and

- Identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

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 BS8233:2014 – Internal Spaces

BS8233:2014 “*Sound insulation and noise reduction for buildings*” describes recommended internal noise levels for hotels and rooms for residential purposes. 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**

BS8233:2014 also provides some examples of design criteria adopted by hotel groups for indoor ambient noise levels for hotel bedrooms. These are as follows:

| Period                   | Noise Level              |
|--------------------------|--------------------------|
| Daytime (07:00-23:00)    | 30-40 dB $L_{Aeq,1hour}$ |
| Night-time (23:00-07:00) | 25-35 dB $L_{Aeq,1hour}$ |
| Night-time (23:00-07:00) | 45-55 dB $L_{Amax}$      |

**Table 4.2 Example of criteria adopted by some hotel groups**

BS8233:2014 recommends that ambient noise levels in non-domestic buildings should not normally exceed the design ranges given in Table 4.3

| Location                                              | Design Range dB $L_{Aeq, T}$ |
|-------------------------------------------------------|------------------------------|
| Department store, Cafeteria, Canteen, Kitchen         | 50-55                        |
| Concourse, Corridor, Circulation space                | 45-55                        |
| Library, gallery, museum                              | 40-50                        |
| Staff/meeting room, training room                     | 35-45                        |
| Executive office                                      | 35-40                        |
| Place of worship, counselling, meditation, relaxation | 30-35                        |

**Table 4.3 Example of criteria adopted by non-domestic buildings**

The external building fabric would need to be carefully designed to achieve these recommended internal levels. It is currently assumed that the non-glazed external building fabric elements of the proposed development would be comprised of brick faced columns and floor slabs edges covered with reconstituted stoned.

### 4.3 BS6472-1-2008 - Vibration Assessment

BS6472 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, hotels, office or workshop.

Table 4.4 shows the different likelihoods, as per BS6472 document, of adverse comment from nearby vibration sources on residential occupants, which in this case would be applied to hotel occupants.

| Place and time                 | Low probability of adverse comment<br>m.s <sup>-1.75</sup> | Adverse comment possible<br>m.s <sup>-1.75</sup> | Adverse comment probable<br>m.s <sup>-1.75</sup> |
|--------------------------------|------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------|
| 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 4.4 Likelihood of comment on vibration perceived within habitable spaces

## 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 the anticipated levels obtained in the noise maps 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.

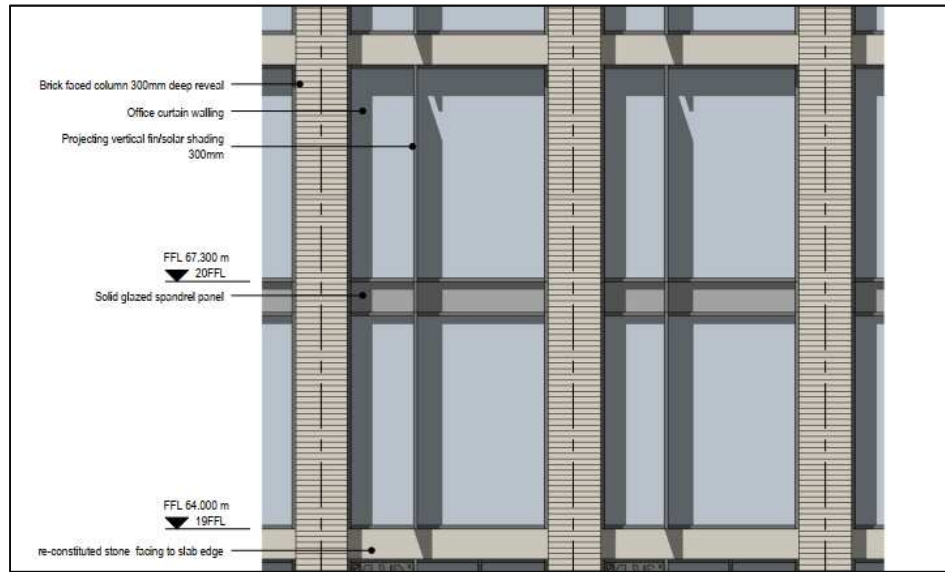
As a more robust assessment,  $L_{Amax}$  spectrum values of night-time peaks have also been considered and incorporated into the glazing calculation in order to cater for the interior limit of 45 dB  $L_{Amax}$  for individual events, as recommended in WHO Guidelines.

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 would be comprised of brick faced columns and floor slabs edges covered with reconstituted stoned as shown in Figure 5.1. It is anticipated that the non-glazed elements would provide a sound reduction

performance of at least the figures shown in Table 5.1 when tested in accordance with BS EN ISO, 140-3:1995.



**Table 5.1 non-glazed elements of the External building fabric. Drawing provided by Broadway Malyan**

| Element                | Octave band centre frequency SRI, dB |       |       |      |      |      |
|------------------------|--------------------------------------|-------|-------|------|------|------|
|                        | 125Hz                                | 250Hz | 500Hz | 1kHz | 2kHz | 4kHz |
| Non glazed element SRI | 27                                   | 38    | 45    | 49   | 50   | 50   |

**Table 5.1 Anticipated 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.

| Glazing Type | Octave band centre frequency SRI, dB |       |       |      |      |      | $R_w(C;C_{tr})$ , dB |
|--------------|--------------------------------------|-------|-------|------|------|------|----------------------|
|              | 125Hz                                | 250Hz | 500Hz | 1kHz | 2kHz | 4kHz |                      |
| Type A       | 27                                   | 26    | 33    | 39   | 39   | 47   | 36 (-1,-3)           |
| Type B       | 23                                   | 26    | 30    | 38   | 42   | 44   | 36 (-2,-5)           |
| Type C       | 26                                   | 22    | 28    | 38   | 41   | 42   | 33 (-1,-4)           |
| Type D       | 22                                   | 20    | 26    | 36   | 39   | 31   | 31 (-1,-4)           |

**Table 5.2 Required glazing performance**

The location of the different types of glazing are shown in the glazing location plan 18082.SP1

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.

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.

No further mitigation measures would be required to achieve good internal noise levels.

### 5.3 Ventilation Strategy

It is understood that the strategy for ventilation would be whole house mechanical ventilation (WHMV). This type of system usually comprises a low speed fan within a ducted system, providing fresh air supply to habitable spaces (hotel rooms, bedrooms, living rooms, etc.), as well as extract from kitchens and toilets. WHMV systems can also include heat recovery (i.e. MVHR) capabilities. In this case, external noise break-in to the habitable spaces via the ventilation ducts will be negligible (when compared to the glazing), due to the fact that the system is fully ducted.

## 6.0 VIBRATION ASSESSMENT

Table 6.1 compares the measured VDV levels on site against vibration dose value ranges outlined in BS6472-1 2008 “*Guide to evaluation of human exposure to vibration in buildings*”

| Position     | Period     | Period Time | Duration of measurement | Measured VDV level<br>m.s <sup>-1.75</sup> | Likelihood of comment        |
|--------------|------------|-------------|-------------------------|--------------------------------------------|------------------------------|
| Ground Floor | Daytime    | 07:00-23:00 | 16 h                    | 0.006                                      | No adverse comments expected |
|              | Night-time | 23:00-07:00 | 8 h                     | 0.004                                      | No adverse comments expected |

**Table 6.1 Measured VDV levels and likelihood of comment in accordance with BS6472-1 2008**

As shown from the calculated dose values, there would be no adverse comments expected from future occupiers within the development.

With regards to structural or cosmetic damage to the building, this is considered significant in the frequency range above 4Hz. The small increase at the very low frequency end which is seen in the attached Figures would not be considered to present any danger to the shell of the proposed buildings.

## 7.0 PRELIMINARY COMPLIANCE REVIEW FOR PLANT UNIT INSTALLATIONS

It is understood that the proposed development would entail the installation of mechanical ventilation systems which would serve retail, office and hotel floors and extraction systems for the Hotel restaurant. The installation of the plant units would be distributed between the Basement, Ground Floor, Third Floor and Roof level.

The requirement of Reading Borough Council for noise emissions of new plant is based on the British Standard BS4142 and it is as follows:

*'A BS4142:2014 acoustic assessment should demonstrate that the plant noise rating level will not cause an increase of the existing background noise level ( $L_{A90}$ ) by more than 0 dB at any time, as measured from / prediction calculations carried out, at the nearest noise sensitive receptor (i.e. the nearest residential property window). This is achieved by ensuring that noise from the plant unit has a noise rating level of 10dB below the background level.'* This would require an acoustic assessment to be carried out specific to the site and premises in line with the relevant British Standard (BS4142:2014)."

|                          | Representative background noise level $L_{90}$ (dBA) |             |
|--------------------------|------------------------------------------------------|-------------|
|                          | Front Façade                                         | Rear Façade |
| Daytime (07:00-23:00)    | 59                                                   | 50          |
| Night-time (23:00-07:00) | 55                                                   | 48          |

**Table 7.1: Measured representative background noise level in the area**

The representative background noise level shown in Table 7.2 is based upon the most frequently occurring measured  $L_{90,5min}$  background noise level between 07:00 and 23:00 for daytime and between 23:00 and 07:00 hours for night-time figures. The statistical analysis is shown in the attached figures 18082.Front.Daytime.L90, 18082.Front.Night-time.L90, 18082.Rear.Daytime.L90 and 18082.Rear.Night-time.L90.

In order to comply with the aforementioned Reading Borough Council requirements, the noise emission levels of the different plant unit installations should not exceed the limits shown in Table 7.2. The specific noise criterion figure would depend on the location of the closest receiver related to the plant unit installation location.

|                                          | Noise Criteria (dBA)                          |                                                                   |
|------------------------------------------|-----------------------------------------------|-------------------------------------------------------------------|
|                                          | For residential receivers facing Station Road | For residential receivers to the rear of the proposed development |
| Daytime (07:00-23:00) $L_{eq}$ 1 hour    | 49                                            | 40                                                                |
| Night-time (23:00-07:00) $L_{eq}$ 15 min | 45                                            | 38                                                                |

**Table 7.2: Proposed Noise Emissions Criteria**

It is usually possible to achieve the levels shown in Table 7.2, however the addition of some mitigation measures, such as acoustic louvres, acoustic enclosures or barriers, may be necessary.

Currently, the exact details of the proposed plant 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 7.2 and, hence, comply with the Reading Borough Council requirements.

## **8.0 CONCLUSION**

An environmental noise and vibration survey has been undertaken at 29-35 Station Road, Reading, RG1 1LG 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.

Vibration measurement of road and train activity indicates that vibration levels are below the threshold of human perception in the z-axis, in accordance with BS6472: 2008 and no adverse comments are expected.

In addition to the environmental noise assessment, a preliminary analysis of the impact of noise emissions from plant units to be installed at the proposed development on neighbouring residential units has been presented. A full acoustic review of the proposed plant units installation will be issued once all M&E proposals have been finalised in further stages to ensure compliance with the Reading Borough Council requirements.

29-32 Station Road, Reading. Front facade  
Environmental Noise Time History  
From 01 October 2018 To 02 October 2018

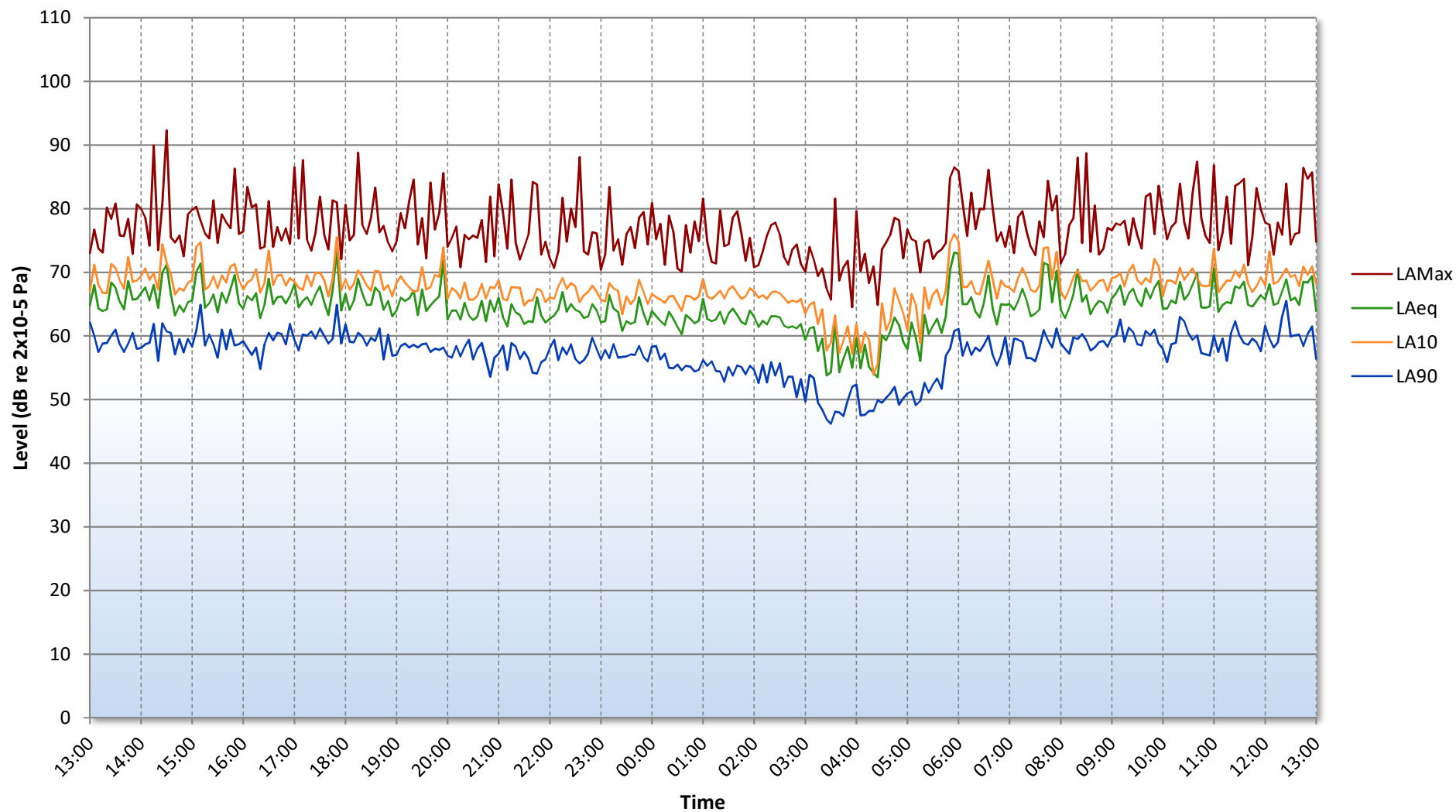


Figure 18082.NTH1

29-32 Sation Road, Reading. Rear Façade  
Environmental Noise Time History  
From 01 October 2018 To 02 October 2018

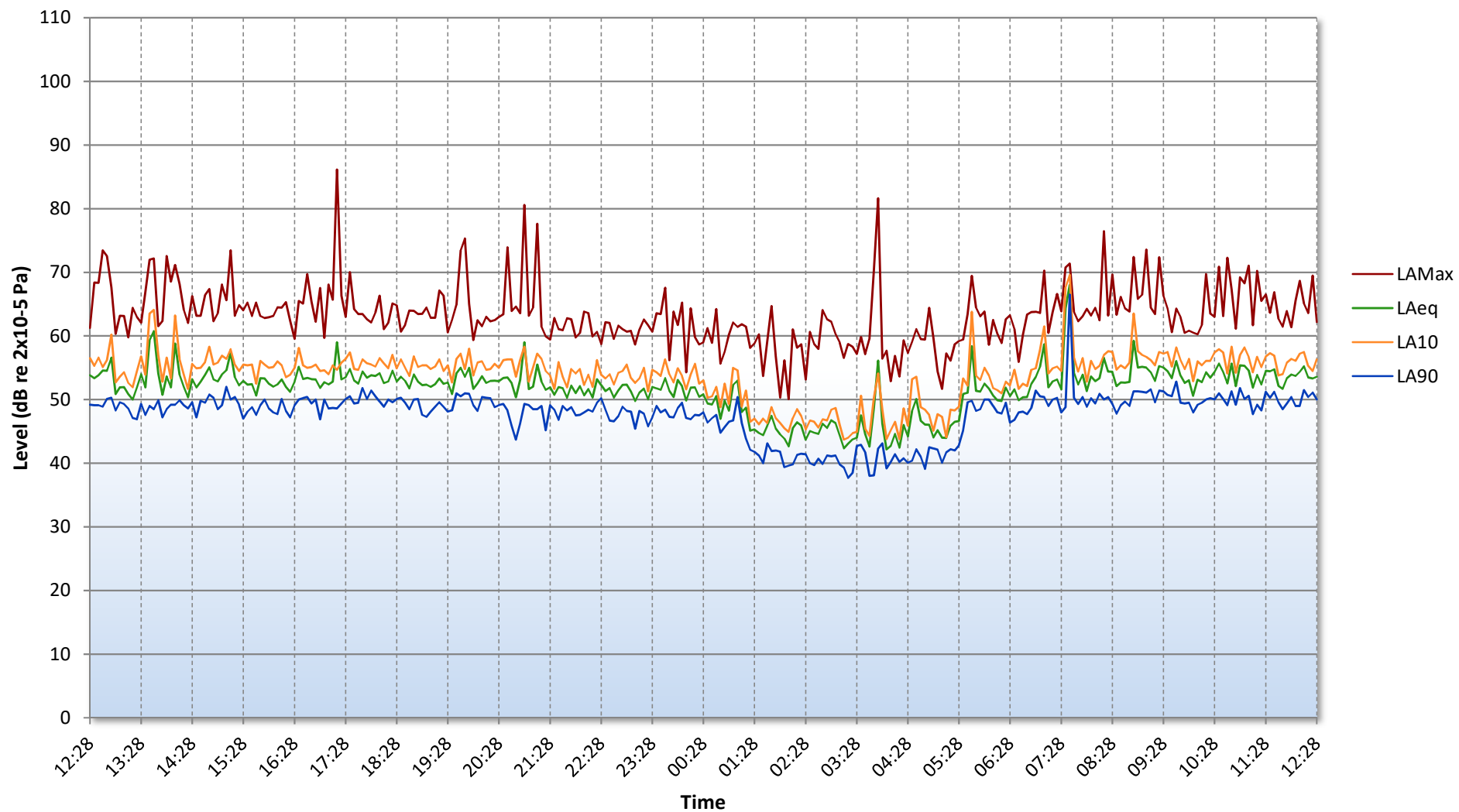


Figure 18082.NTH2

29-35 Station Road, Reading.  
Internal Measurements at Ground Floor Level  
RMS Vibration Acceleration  
1<sup>st</sup> to 2<sup>nd</sup> October 2018

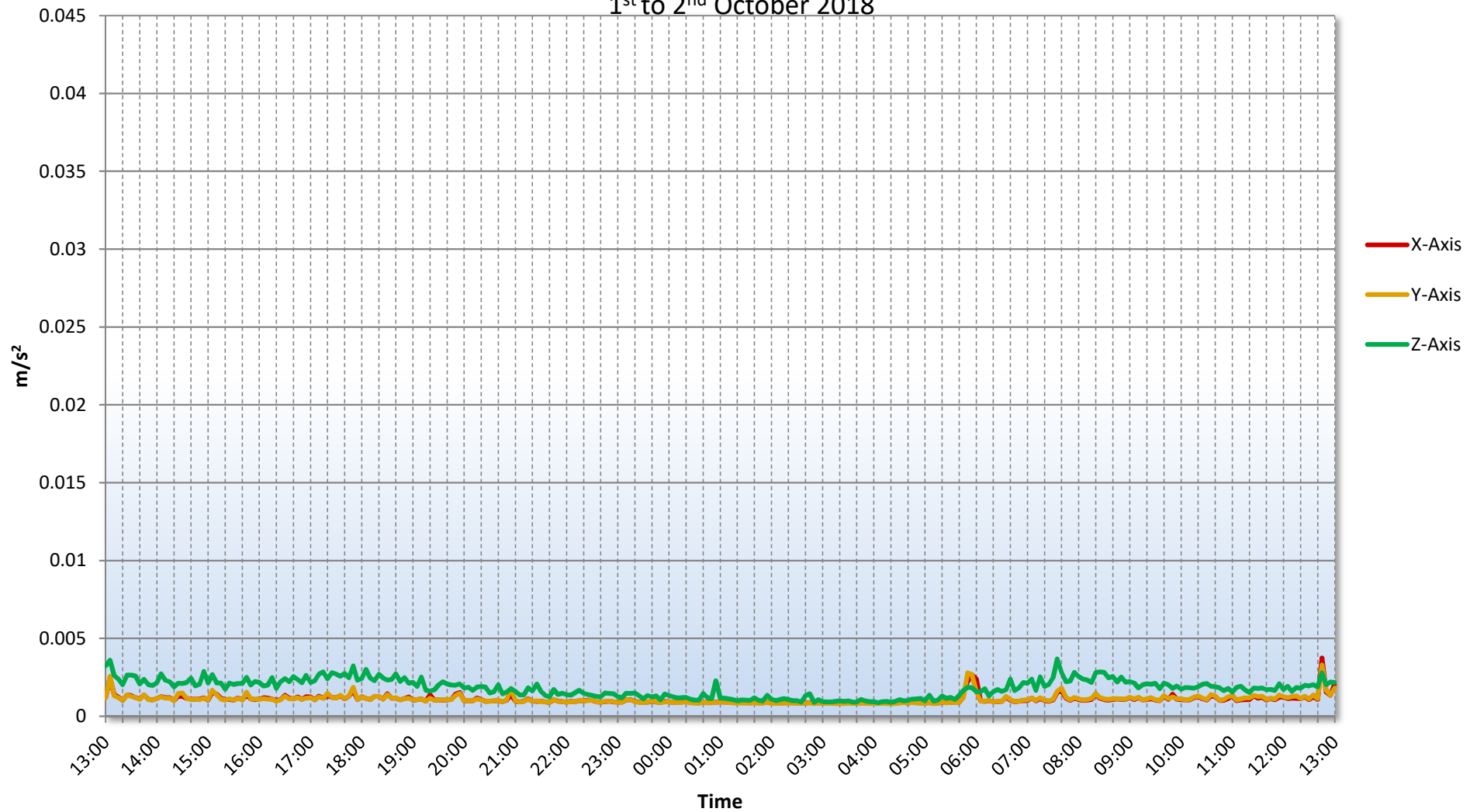


Figure 18082.VTH1

29-32 Station Road, Reading. Front facade  
Representative Daytime Background Noise Level  
From 01 October 2018 To 02 October 2018

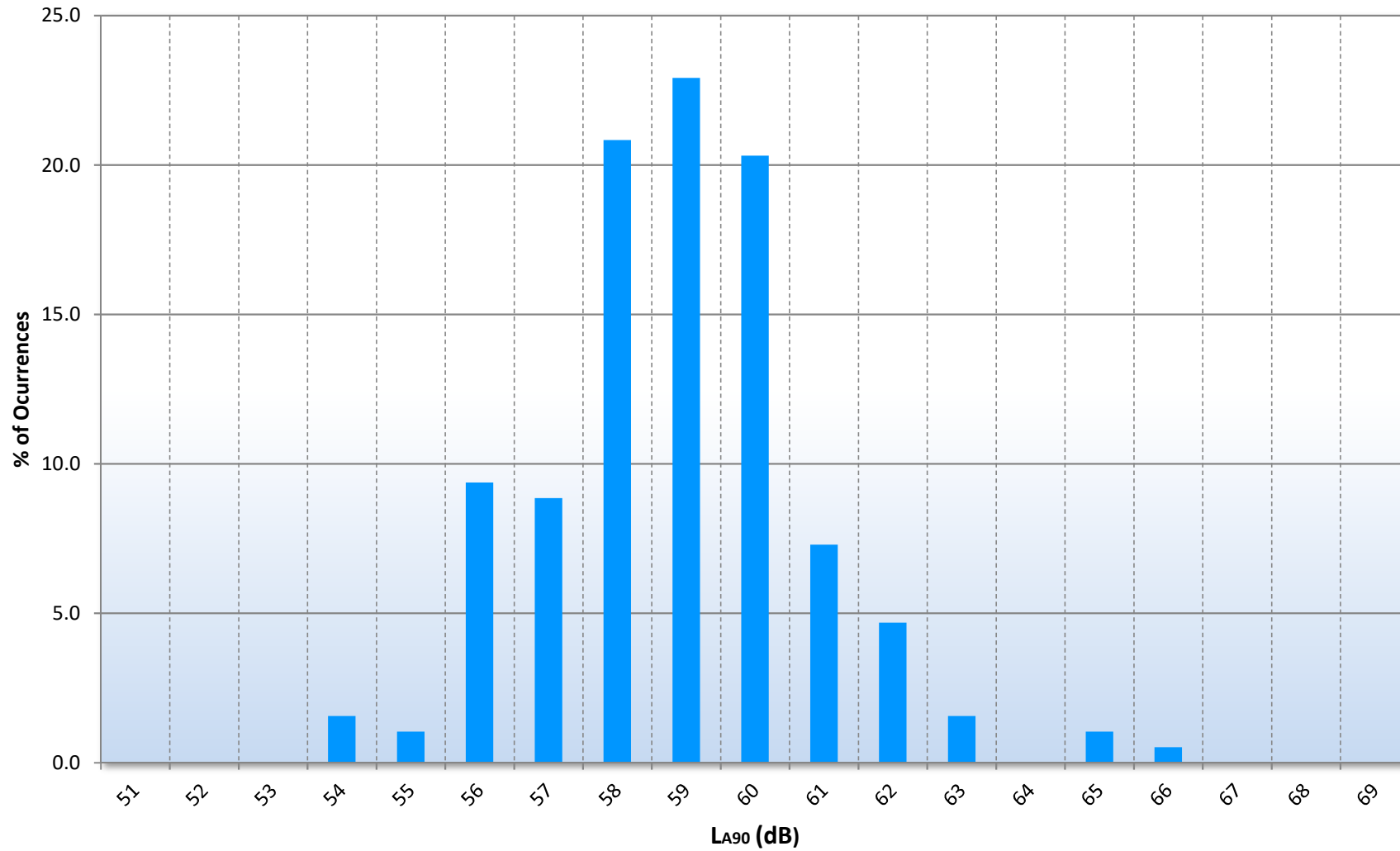


Figure 18082.Front.Daytime.L90

29-32 Station Road, Reading. Front facade  
Representative Night-time Background Noise Level  
From 01 October 2018 To 02 October 2018

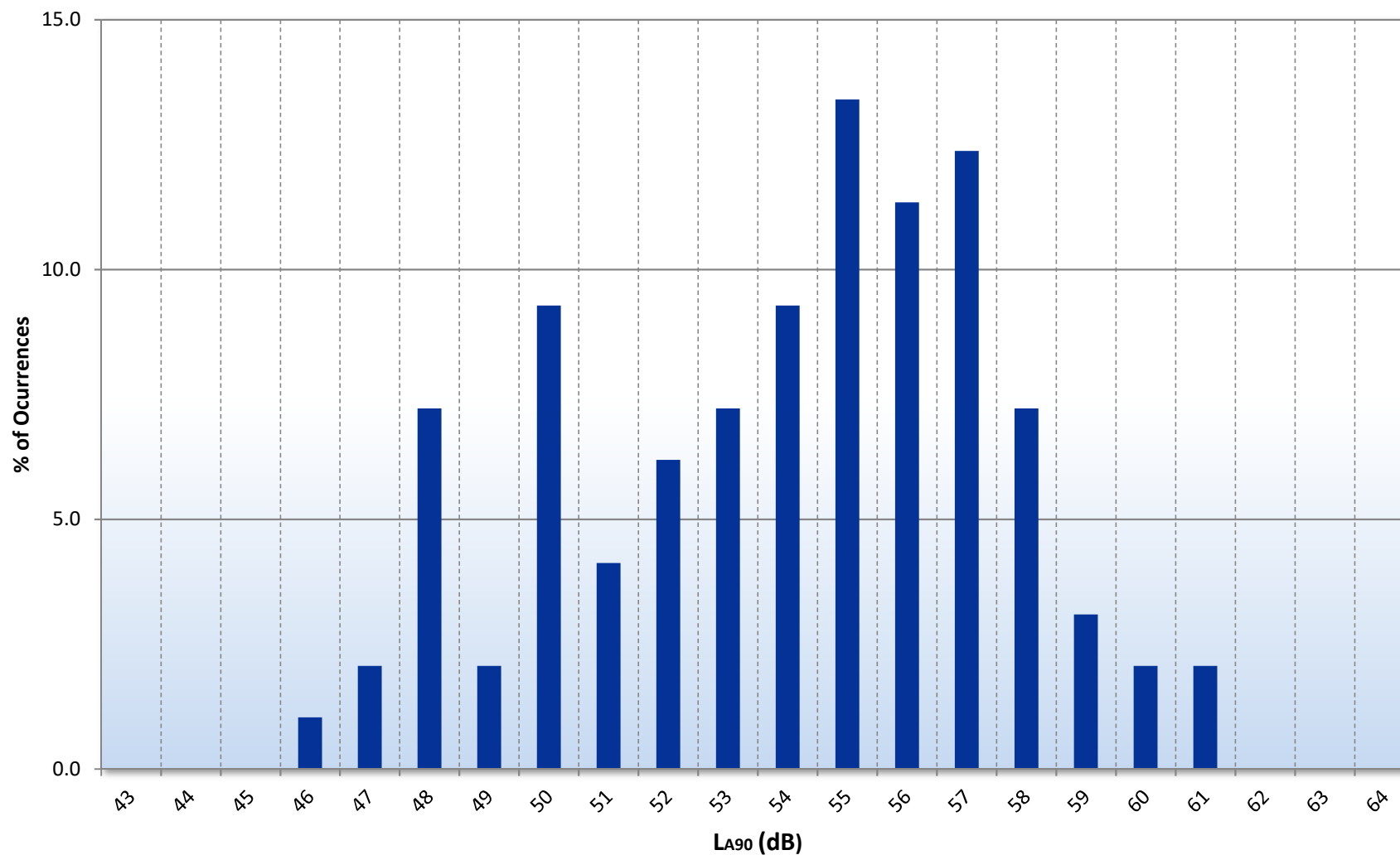


Figure 18082.Front.Night-time.L90

29-32 Sation Road, Reading. Rear Façade  
Representative Daytime Background Noise Level  
From 01 October 2018 To 02 October 2018

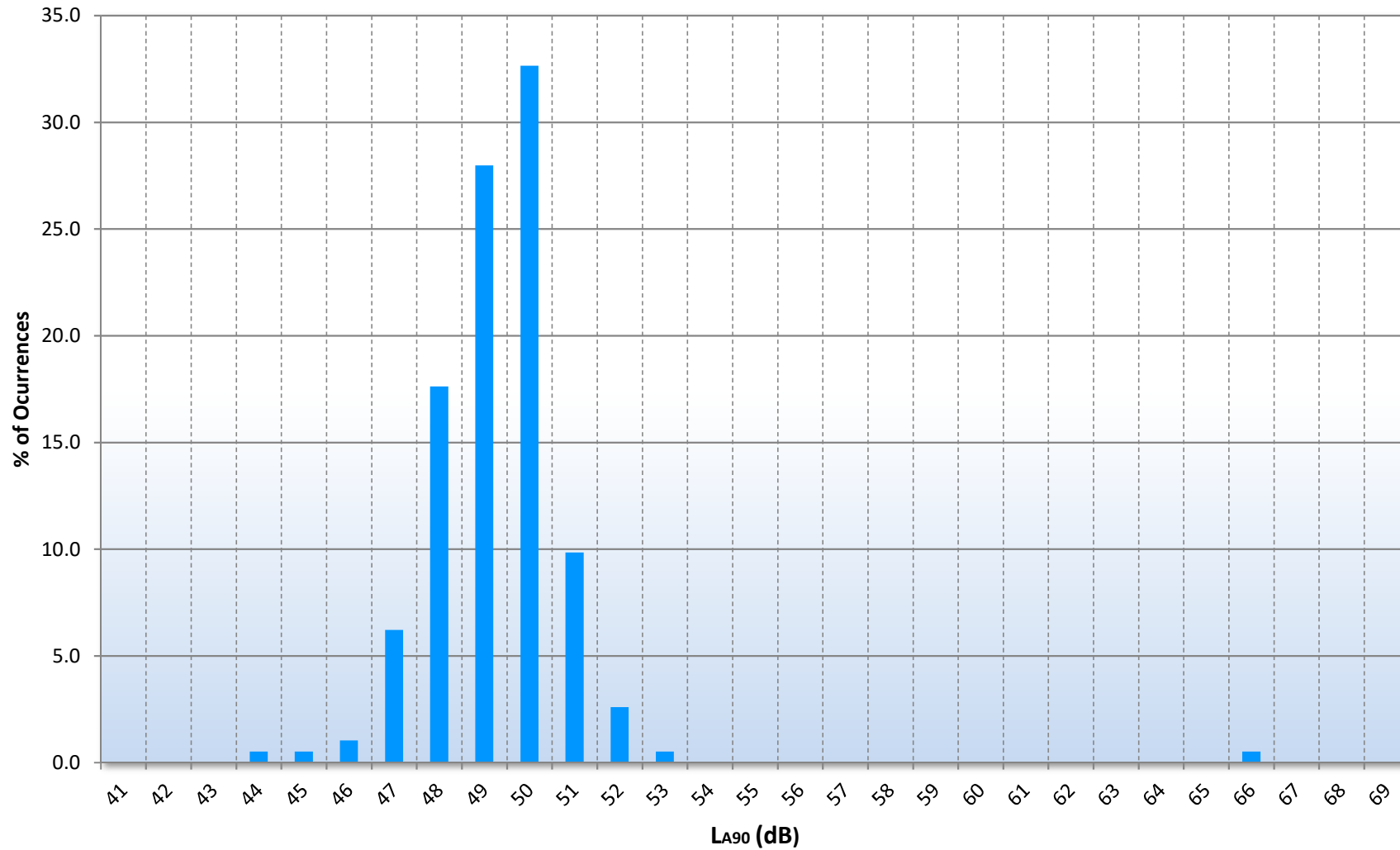


Figure 18082.Rear.Daytime.L90

29-32 Sation Road, Reading. Rear Façade  
Representative Night-time Background Noise Level  
From 01 October 2018 To 02 October 2018

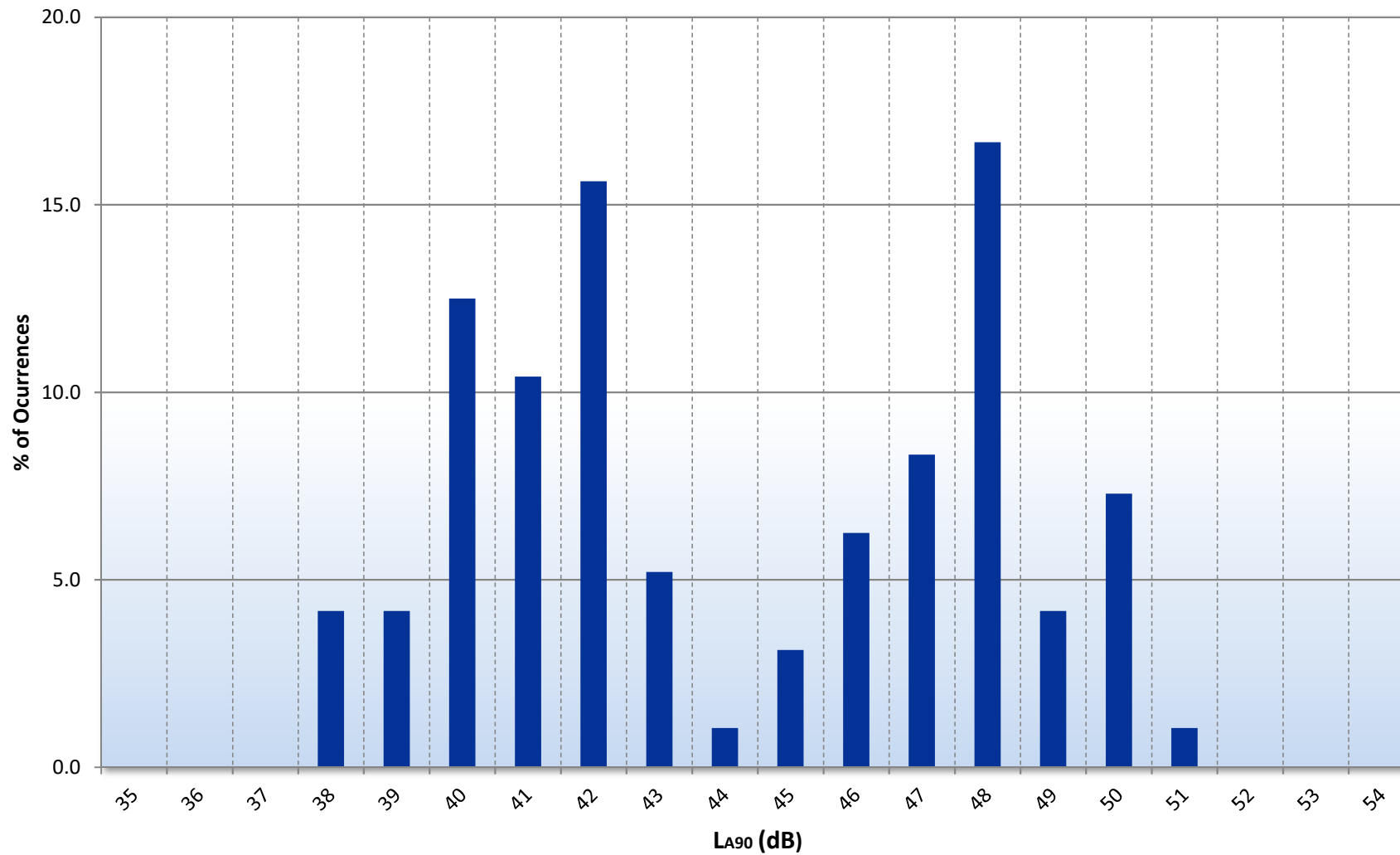
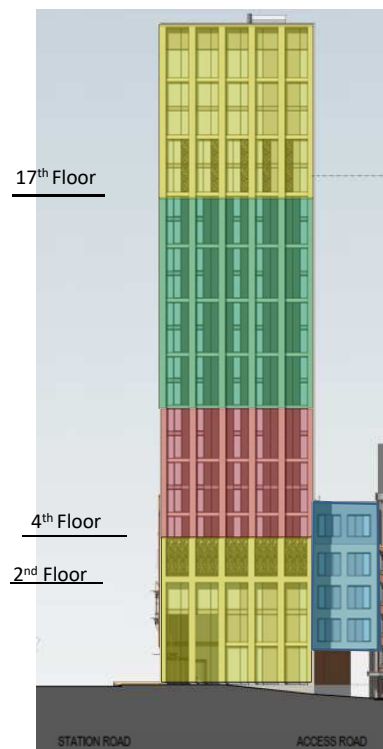


Figure 18082.Rear.Night-time.L90

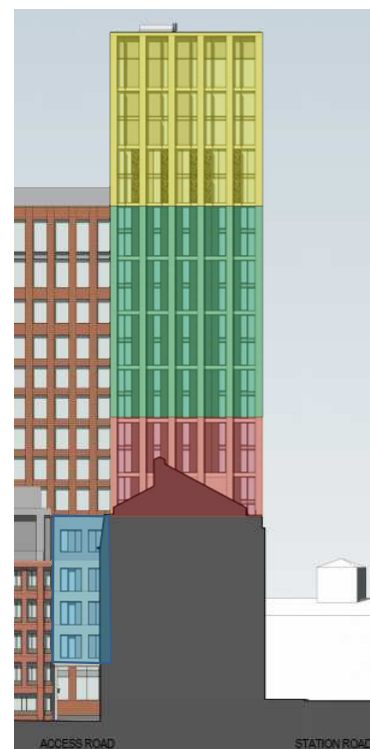
North Façade



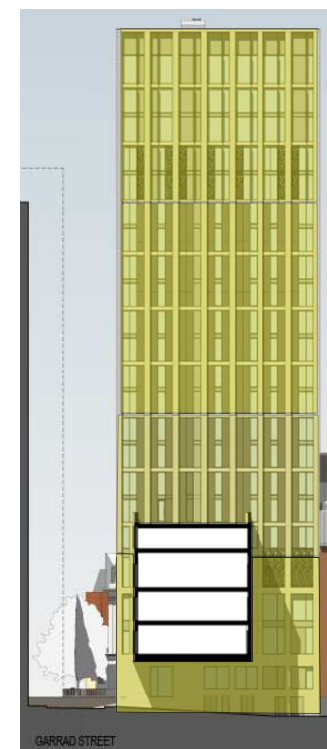
East Facade



South Façade



West Façade



|  |        |                            |
|--|--------|----------------------------|
|  | TYPE A | $R_w$ (C, Ctr): 36 (-1,-3) |
|  | TYPE B | $R_w$ (C, Ctr): 36 (-2,-5) |
|  | TYPE C | $R_w$ (C, Ctr): 33 (-1,-4) |
|  | TYPE D | $R_w$ (C, Ctr): 31 (-1,-4) |

**Title:** Proposed glazed element scheme

**Date:** 10 October 2018

**FIGURE 18082.SP1**



## 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.

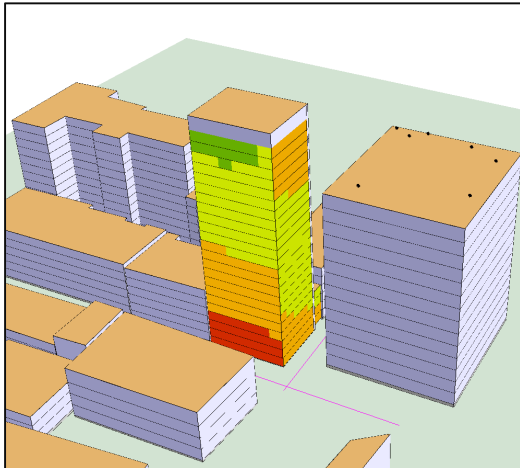
### Sound insulation - Absorption within porous materials

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.

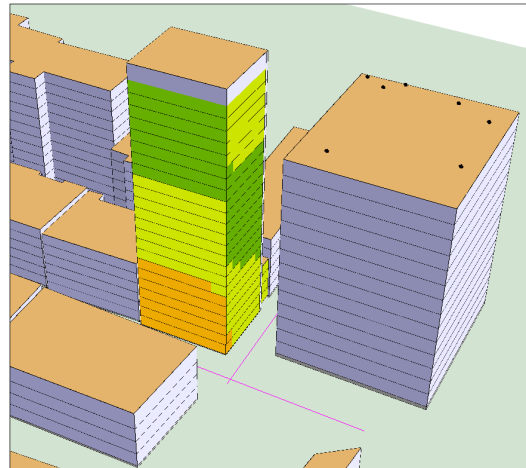
## APPENDIX B

### Noise Maps

#### Perspective from North East

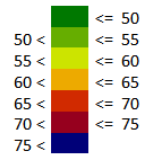


Daytime  $L_{eq,16h}$

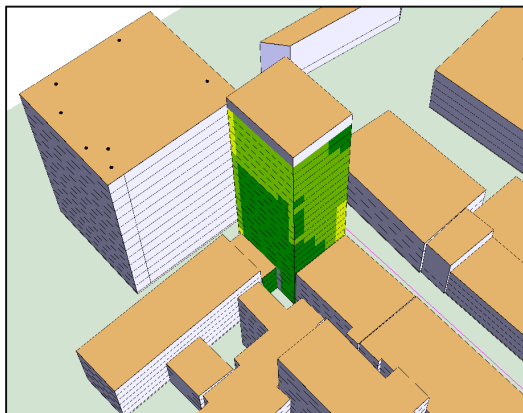


Night-time  $L_{eq,8h}$

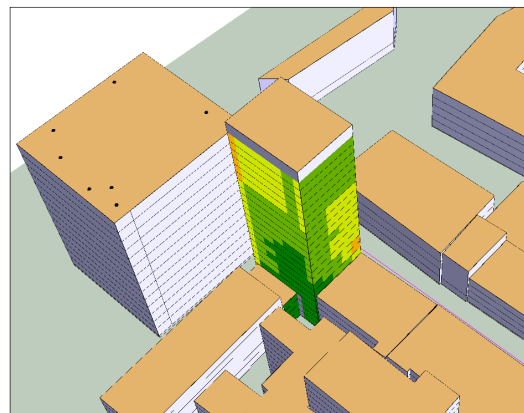
Noise level  
in dB(A)



#### Perspective from South West



Daytime  $L_{eq,16h}$



Night-time  $L_{eq,8h}$