GILLIERON SCOTT
ACOUSTIC DESIGN

**Report No:**
LSHTM - Noise Impact Assessment 26012018

**Date:**
26/01/2018

**For:**
LSHTM (London School of Hygiene and Tropical Medicine)

**Report Title:**

# LSHTM - KEPPEL STREET

# NOISE IMPACT ASSESSMENT

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## REVISION SCHEDULE

| Document Revision | Date | Document Title | Details | Prepared by | Approved by |
|---|---|---|---|---|---|
| 00 | 26/01/2018 | LSHTM - Noise Impact Assessment 26012018 | ISSUED | Ben Claridge  | Tim Scott  |

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## Introduction

The Keppel Street premises of the London School of Hygiene and Tropical Medicine (LSHTM) are to carry out refurbishment works and provide a new plant deck and external services installations above roof level. Gillieron Scott Acoustic Design (GSAD) have been commissioned to undertake a noise impact assessment in line with the Local Authority's adopted noise policy.

The existing roof of the courtyard building is to be refurbished to make provision for the new plant equipment.

GSAD have undertaken a background noise survey at a fixed monitoring location from 11:00 Tuesday 23th January 2018 to 10:15 Friday 26th January 2018. The microphone location was chosen to be representative of the closest residential receptors, courtyard facing rooms of Bonham Carter House.

GSAD understand the plant will have the capability to operate 24 hours a day and so night-time background noise levels have been considered in the assessment. Since the plant has not yet been designed, GSAD have set out a cumulative noise emission limit such to satisfy the London Borough of Camden's adopted noise policy, BS4142:2014.

If required calculations demonstrating compliance of London Borough of Camden's adopted noise policy will be undertaken once the full schedule of plant and locations are finalised.

The site location, plant area and nearest residential receptors are indicated in Appendices A, B and C.

## 1.0 Brief

- Undertake noise measurements at a fixed monitoring location over an extended period of time;
- Undertake weather measurements;
- Identify noise sensitive dwellings located in the vicinity of the site and assess the topography of the intervening ground;
- Analyse the site-acquired data and determine the appropriate criteria to adopt from the London Borough of Camden Council's noise policy.
- Provide a technical report detailing findings of the noise survey.
- Set cumulative noise emission limits for the new items of plant.

## 2.0 Context

The LSHTM is located in the in proximity of Gower Street and Keppel Street, in the London Borough of Camden. The buildings surrounding the site are predominantly residential and commercial in nature.

The acoustic environment at the residential receptors near the building comprises of various typical urban noise sources, including road traffic noise, air traffic noise, building works and street noise. It is worth noting that there is a large amount of existing plant equipment on the roof of the LSHTM and all surrounding buildings. During the night-time plant noise is expected to be the dominant noise source.

## 3.0 Summary

GSAD have undertaken a background noise survey at a fixed monitoring location from 11:00 Tuesday 23th January 2018 to 10:15 Friday 26th January 2018. The microphone location was chosen to be representative of the closest residential receptors, courtyard facing rooms of Bonham Carter House.

GSAD understand the plant will have the capability to operate 24 hours a day and so night-time background noise levels have been considered in the assessment. Since the plant has not yet been designed, GSAD have set out a cumulative noise emission limit such to satisfy the London Borough of Camden's adopted noise policy, BS4142:2014.

Using methodology outlined in BS4142:2014, representative background sound levels $L_{A90,15min}$ have been determined over the period of 23:00-07:00.

The site location, measurement position and measured results are presented in the following Sections and Appendices.

## 4.0 Noise Assessment Criteria

It is understood that the London Borough of Camden adopt BS4142:2014 in their noise policy.

**BS4142:2014 Methods for Rating and Assessing Industrial and Commercial Sound**
BS4142:2014 provides methods for rating and assessing industrial and commercial sound. The standard is used to rate sound from fixed installations. The standard requires a "Specific Sound Level", in terms of $L_{Aeq}$, which is determined either by measurement or calculation at a receptor location. This Specific Sound Level may then be corrected for the character of sound and is then termed the "Rating Level".

Once the Rating Level has been determined, the background sound level is subtracted from it and the greater the difference, the greater the likelihood of an 'adverse impact'. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact. The standard advocates that each site and situation should take the context of the scenario into consideration and that "not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact".

The standard provides reference periods over which the assessment should take place which have been reproduced in the table below.

**Table 1 - BS 4142 Reference periods**

| Period | Hours | Assessment Period |
|---|---|---|
| Typical Daytime | 0700 – 2300 | 1-hour assessment period |
| Typical Night-time | 2300 – 0700 | 15-minute assessment period |

## 5.0 Survey Details and Results

A background noise survey was undertaken from 11:00 Tuesday 23th January 2018 to 10:15 Friday 26th January 2018 at a position deemed to be representative of the closest residential receptors. This is on the top level of the courtyard external fire escape staircase. The closest residential receptor is at the same level in Bonham Carter House with approximately equal screening from existing items of plant on the surrounding roofs.

The levels were recorded as A-weighted and octave band $L_{eq}$, $L_{max}$ and $L_{90}$. The clock on the sound level meter was synchronised to the correct time before deployment. The meter was then set to integrate sound levels over 15-minute periods in synchronisation mode. A list of the equipment is reported in Appendix J.

The equipment was calibrated at the beginning and end of the survey period and no drift in calibration was noted.

An automatic logging weather station was deployed as part of the assessment to ensure all data used in the determination of the representative background sound level occurred during conditions that are considered conducive to acoustic measurement.
Therefore, the data between 12:30 and 00:00 of Wednesday 24th January has been excluded from the analysis because of the high-intensity rain occurred during this time window. Weather data is presented in Appendix I.

Full survey results to one decimal place are presented in the Appendix H. A graphical representation of the results is presented in Appendices D and E.

Logged background sound levels have been plotted as histogram for the 23:00-07:00 period to determine the representative $L_{A90}$ value. A summary of the results is reported in the table below for the most sensitive noise receptors, according to the BS4142:2014 standard.

| **Receptor** | **Background Noise Level $L_{A90}$** |
|---|---|
| | **23:00-07:00** |
| Position 1 – Courtyard escape staircase | 53 dB(A) |

This background noise level will be used in the assessment of noise from plant items in the following section.

## 6.0 Noise Assessments

The proposed plant items and their associated manufacturer noise levels have not been selected, therefore, a backward assessment is conducted to determine the maximum cumulative sound pressure level at 1m and 10m allowed. The closest residential receptor is deemed to be on the top floor of Bonham Carter House approximately 24.5m from the proposed plant. This is calculated from the vector (11.0 m, 20.5 m, 7.7 m) (X, Y, Z) taking the closest point of the plant to the centre of the window.

The cumulative plant noise assessment for the closest residential window has been carried out in the table below.

| Element | Adjustment | Cumulative Level | Comments |
|---|---|---|---|
| Background Noise Level | - | 53 dB(A) | From background noise survey. |
| Target Rating Level | - 5 dB | 48 dB(A) | 10 dB below existing background noise. |
| Distance Attenuation | + 28 dB | 76 dB(A) | Point source distance attenuation -20 $\log_{10}$ (r). 24.5m from receptor |
| Barrier Attenuation | + 0 dB | 76 dB(A) | No screening |
| Acoustic Feature Correction | - 5 dB | 71 dB(A) | 2 dB for Tonality, 3 dB for Intermittency. See Appendix K for details |
| Reflective Surfaces | - 3 dB | 68 dB(A) | 3 dB if the source is in proximity to 1 reflective surface. |
| **SPL @ 1 m** | **68 dB(A)** | | Maximum cumulative SPL @ 1 m allowed for the proposed units |
| **SPL @ 5 m** | **54 dB(A)** | | Maximum cumulative SPL @ 5 m allowed for the proposed units |

The plant noise impact assessment has determined that the maximum SPL at 1 m allowed for all proposed units to be installed is 68 dB(A), in order to achieve the required noise levels at the closest residential receptor.

Due to the radiating area of plant, GSAD recommend the target of 54 dB(A) at 5 m is used for the specification of plant.

## 7.0 Statement of Competence

The assessment of the industrial sound has been undertaken by the author of this report: Ben Claridge MEng. (Hons.), AMIOA an acoustic consultant with Gillieron Scott Acoustic Design with 2+ years' experience since completing a Master's degree in Acoustical Engineering at the ISVR, University of Southampton and several years in acoustics consultancy prior to this. The author of this report has undertaken numerous assessments according to the 1997 revision of the British Standard and the most recent 2014 revision of the Standard.

The assessment has been checked by: Tim Scott BSc (Hons.), MIOA a senior acoustic consultant with Gillieron Scott Acoustic Design with 15+ years' experience since completing a degree in Audio Technology at the University of Salford in the late 1990's. The author of this report has undertaken numerous assessments according to the 1997 revision of the British Standard and the most recent 2014 revision of the Standard.

## 8.0 Conclusions

The LSHTM, is to be refurbished, adding new items of plant on the rooftop of the courtyard building. Gillieron Scott Acoustic Design (GSAD) have been commissioned to undertake a noise impact assessment in line with the Local Authority's adopted noise policy.

GSAD have undertaken a background noise survey at two fixed monitoring locations from 11:00 Tuesday 23th January 2018 to 10:15 Friday 26th January 2018. The microphone location was chosen to be representative of the closest residential receptors.

Survey results are presented within this report.

Representative background noise levels at the most sensitive receptors have been determined over the night-time, since the operational hours of the proposed units are 24 hours.

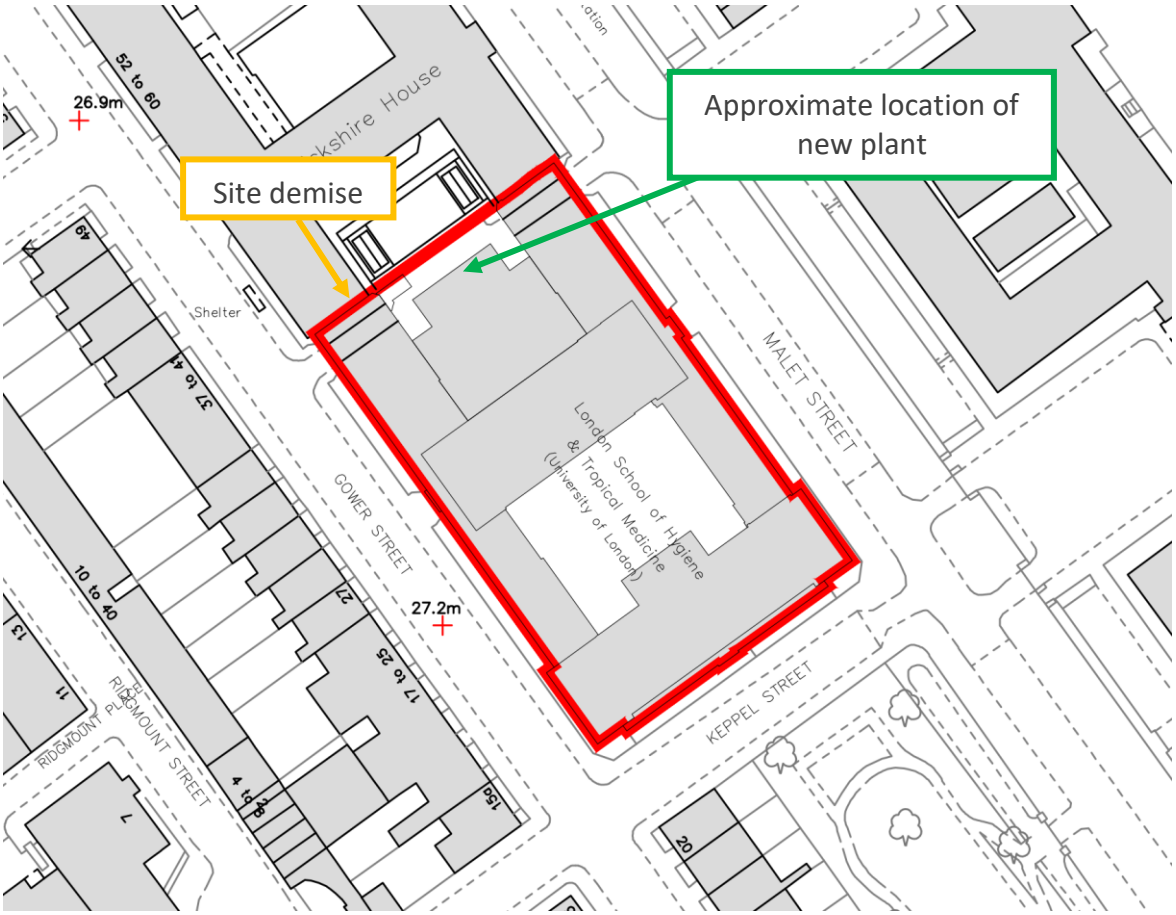
A plant noise impact assessment has been carried out based on the topography of the intervening ground between newly proposed plant items and noise sensitive residential dwellings. The plant noise impact assessment has set a cumulative emission limit of 68 dB(A) for the new item(s) of plant at 1 m. This would result in a Rating Level 5 dB below the typical night-time background sound level, indicating a low impact within the context of the acoustic environment at the worst affected residential dwelling.

If required calculations demonstrating compliance of London Borough of Camden's adopted noise policy will be undertaken once the full schedule of plant and locations are finalised.

Uncertainty in the assessment is deemed to be low and not have significantly affected the outcome.

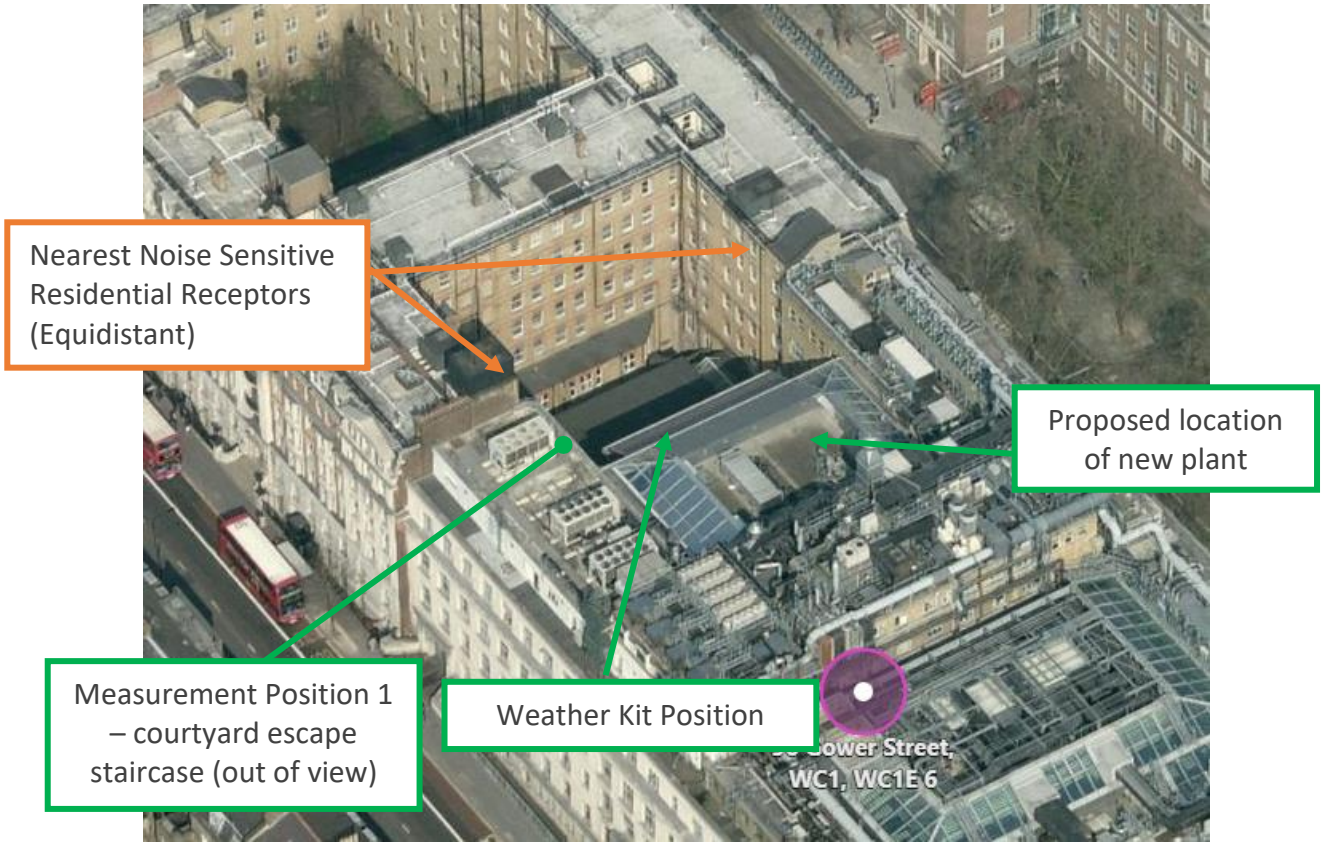
# APPENDICES

## APPENDIX A: Site Demise



## APPENDIX B: Measurement Position, Receptor Location

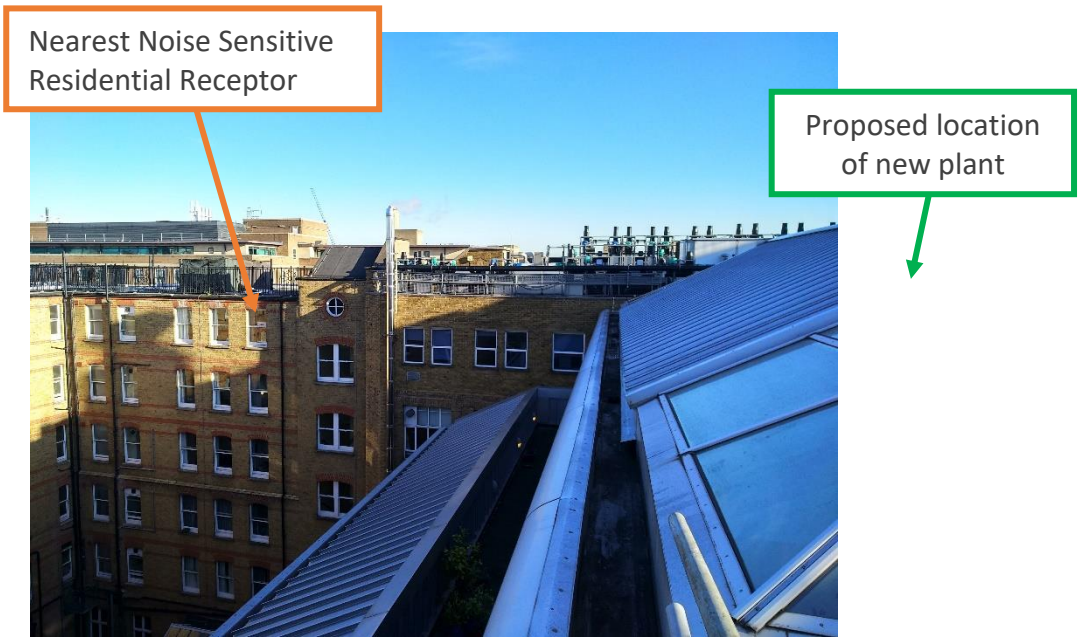
*Birds-eye view of the Building*



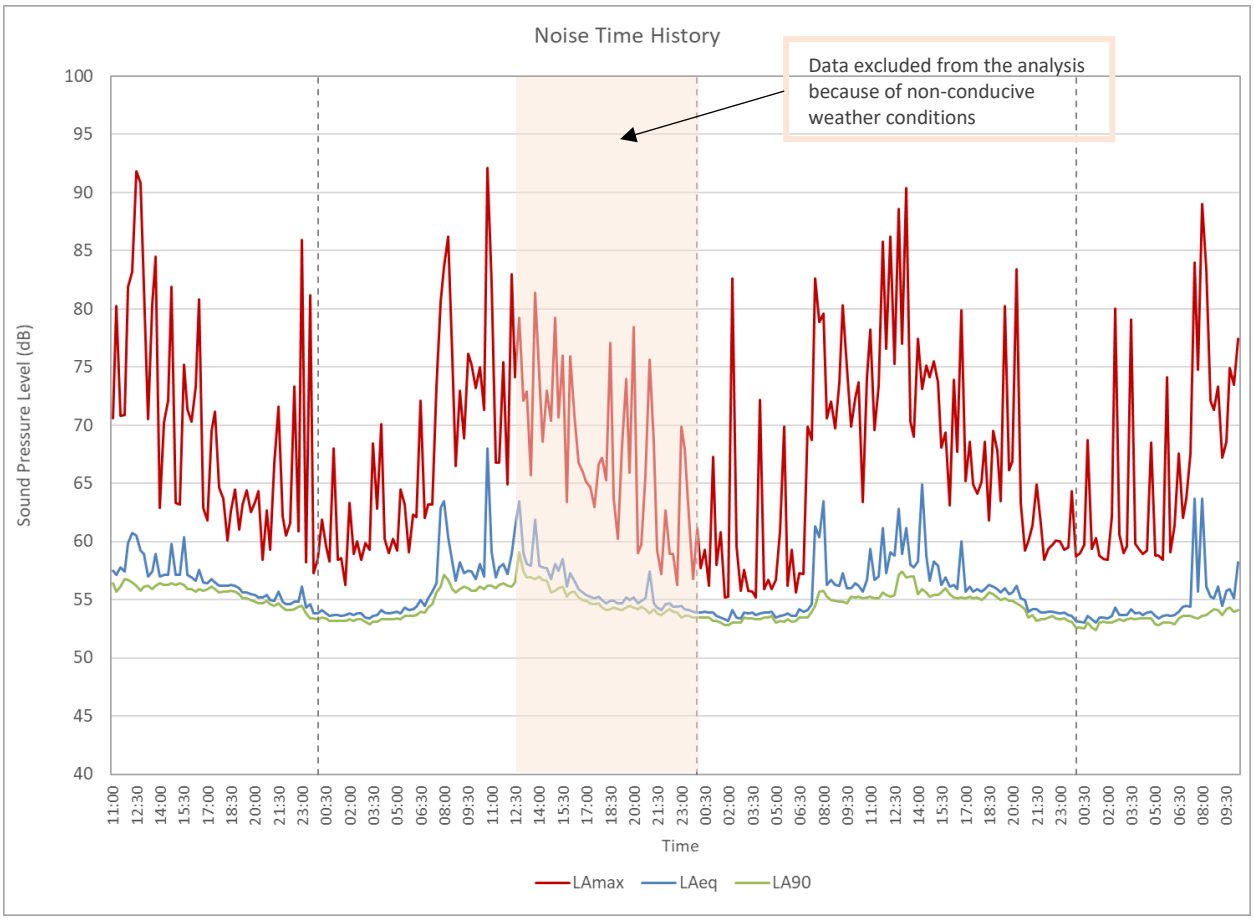

*Birds-eye view of the Building*

## APPENDIX C: Measurement Position Photograph

*Position 1*

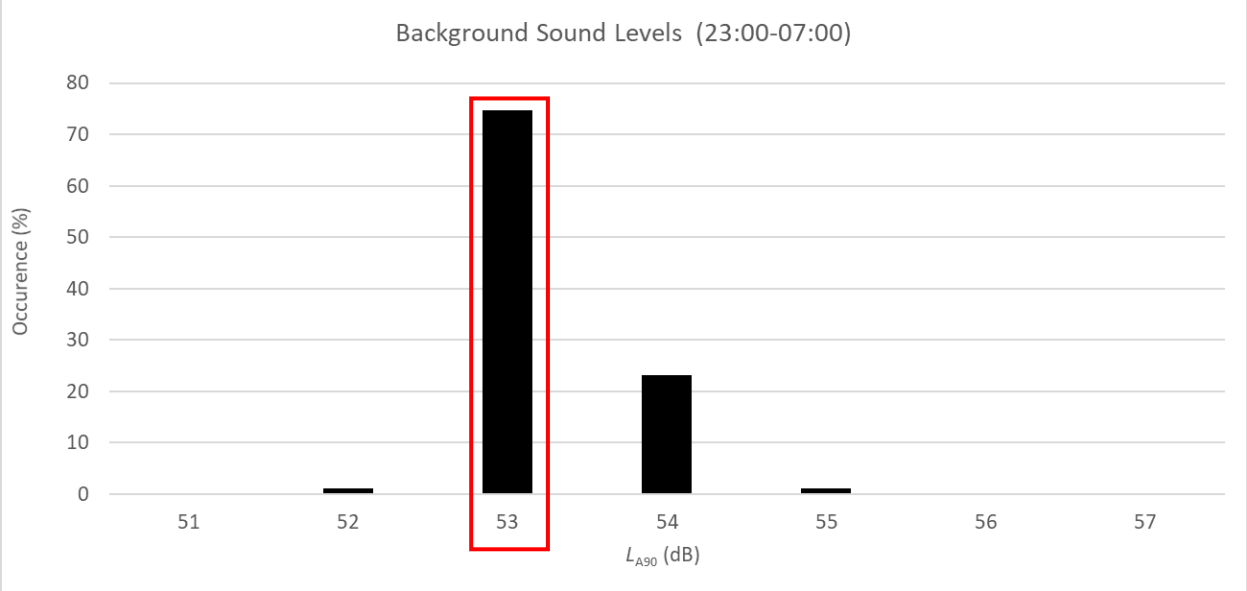



## APPENDIX D: Time Series Graph

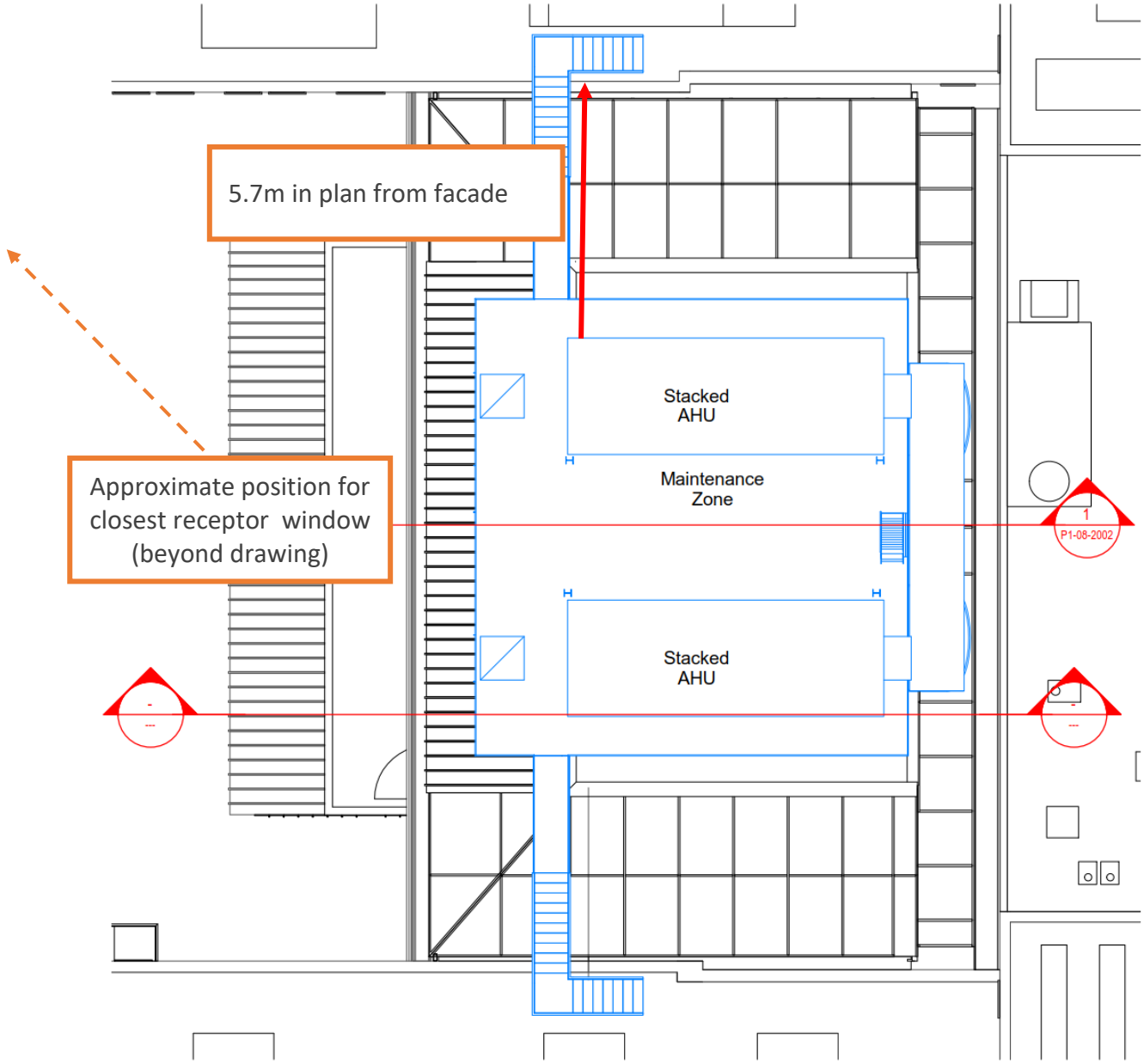


## APPENDIX E: Histogram Plot

*23:00-07:00 period*



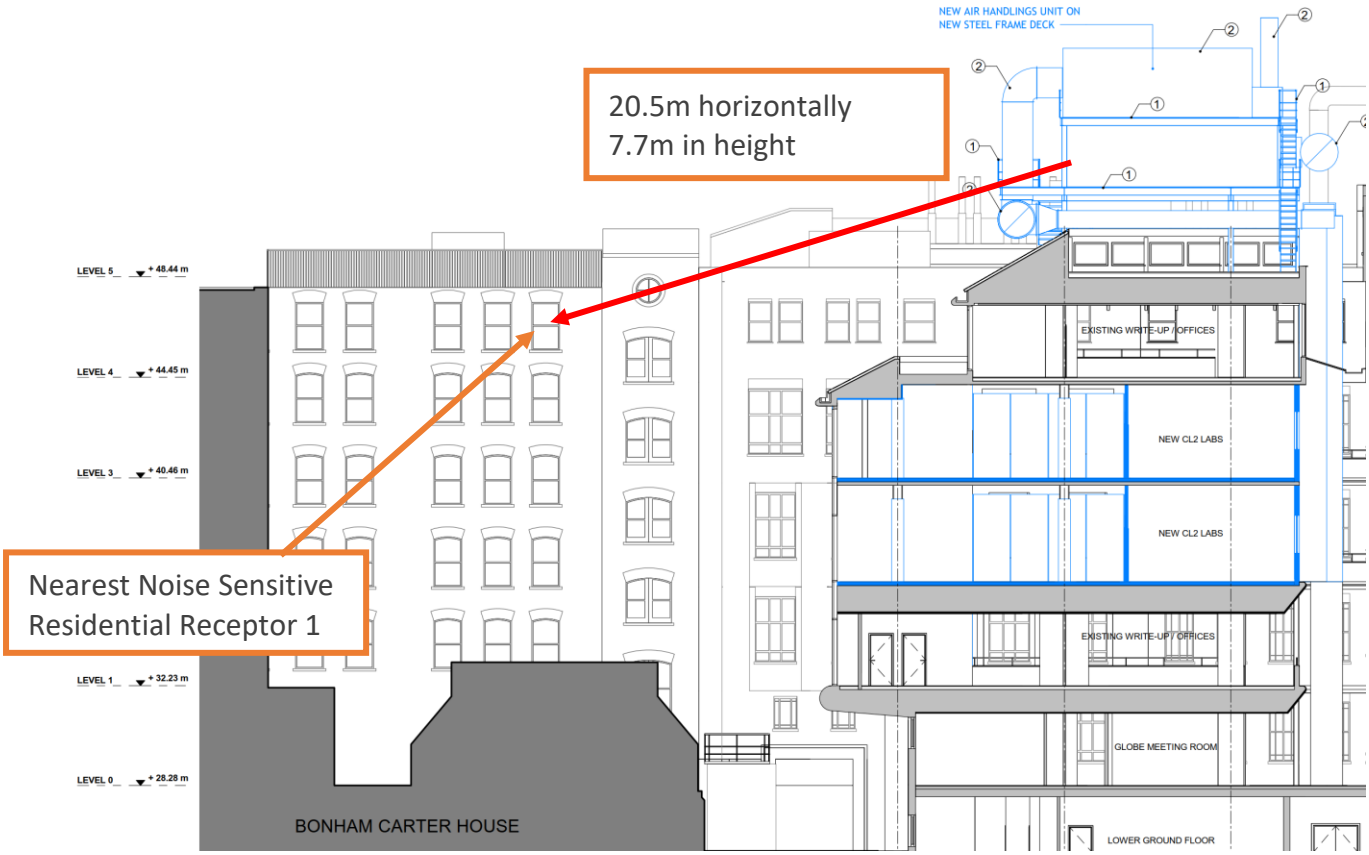
## APPENDIX F: Proposed Plan for New Plant




2 North Courtyard Building - Proposed Plant Deck Plan
1 : 100

## APPENDIX G: Source-Receptor Path Diagram

*Elevation*



# APPENDIX H: Survey Results

| Date | Time | $L_{Aeq}$ | $L_{Amax}$ | $L_{A10}$ | $L_{A90}$ |
|---|---|---|---|---|---|
| 23/01/2018 | 11:00 | 57.5 | 70.6 | 57.8 | 56.4 |
| 23/01/2018 | 11:15 | 57.1 | 80.2 | 57.8 | 55.7 |
| 23/01/2018 | 11:30 | 57.8 | 70.8 | 58.2 | 56.1 |
| 23/01/2018 | 11:45 | 57.4 | 70.9 | 57.8 | 56.8 |
| 23/01/2018 | 12:00 | 59.9 | 81.9 | 60.9 | 56.7 |
| 23/01/2018 | 12:15 | 60.7 | 83.2 | 61.6 | 56.5 |
| 23/01/2018 | 12:30 | 60.5 | 91.8 | 58.7 | 56.2 |
| 23/01/2018 | 12:45 | 59.2 | 90.8 | 57.7 | 55.8 |
| 23/01/2018 | 13:00 | 58.9 | 81.9 | 58.8 | 56.1 |
| 23/01/2018 | 13:15 | 57.0 | 70.5 | 57.5 | 56.2 |
| 23/01/2018 | 13:30 | 57.4 | 80.4 | 57.2 | 55.9 |
| 23/01/2018 | 13:45 | 58.9 | 84.5 | 57.8 | 56.2 |
| 23/01/2018 | 14:00 | 57.0 | 62.9 | 57.6 | 56.4 |
| 23/01/2018 | 14:15 | 57.1 | 70.2 | 57.5 | 56.3 |
| 23/01/2018 | 14:30 | 57.1 | 72.1 | 57.4 | 56.3 |
| 23/01/2018 | 14:45 | 59.8 | 81.9 | 58.5 | 56.4 |
| 23/01/2018 | 15:00 | 57.1 | 63.3 | 57.7 | 56.3 |
| 23/01/2018 | 15:15 | 57.1 | 63.2 | 57.7 | 56.4 |
| 23/01/2018 | 15:30 | 60.4 | 75.2 | 58.6 | 56.3 |
| 23/01/2018 | 15:45 | 57.1 | 71.4 | 57.6 | 55.9 |
| 23/01/2018 | 16:00 | 56.9 | 70.3 | 57.1 | 55.9 |
| 23/01/2018 | 16:15 | 56.6 | 73.3 | 56.9 | 55.7 |
| 23/01/2018 | 16:30 | 57.6 | 80.8 | 57.1 | 55.9 |
| 23/01/2018 | 16:45 | 56.5 | 62.9 | 57.1 | 55.8 |
| 23/01/2018 | 17:00 | 56.4 | 61.8 | 56.9 | 55.9 |
| 23/01/2018 | 17:15 | 56.8 | 69.5 | 57.0 | 56.1 |
| 23/01/2018 | 17:30 | 56.5 | 71.2 | 56.9 | 55.9 |
| 23/01/2018 | 17:45 | 56.2 | 64.6 | 56.6 | 55.6 |
| 23/01/2018 | 18:00 | 56.2 | 63.7 | 56.6 | 55.7 |
| 23/01/2018 | 18:15 | 56.2 | 60.1 | 56.6 | 55.7 |
| 23/01/2018 | 18:30 | 56.3 | 62.6 | 56.7 | 55.8 |
| 23/01/2018 | 18:45 | 56.2 | 64.5 | 56.7 | 55.7 |
| 23/01/2018 | 19:00 | 56.0 | 61.0 | 56.4 | 55.5 |
| 23/01/2018 | 19:15 | 55.6 | 63.2 | 56.0 | 55.1 |
| 23/01/2018 | 19:30 | 55.6 | 64.4 | 56.1 | 55.1 |
| 23/01/2018 | 19:45 | 55.5 | 62.5 | 55.9 | 55.0 |
| 23/01/2018 | 20:00 | 55.4 | 63.4 | 55.8 | 54.8 |
| 23/01/2018 | 20:15 | 55.2 | 64.3 | 55.6 | 54.7 |
| 23/01/2018 | 20:30 | 55.2 | 58.4 | 55.6 | 54.7 |
| 23/01/2018 | 20:45 | 55.4 | 62.7 | 55.7 | 54.9 |
| 23/01/2018 | 21:00 | 55.0 | 59.3 | 55.4 | 54.6 |
| 23/01/2018 | 21:15 | 54.9 | 66.7 | 55.3 | 54.5 |
| 23/01/2018 | 21:30 | 55.7 | 71.6 | 55.8 | 54.7 |
| 23/01/2018 | 21:45 | 54.8 | 62.2 | 55.2 | 54.3 |
| 23/01/2018 | 22:00 | 54.6 | 60.5 | 55.0 | 54.1 |
| 23/01/2018 | 22:15 | 54.6 | 61.6 | 54.9 | 54.1 |
| 23/01/2018 | 22:30 | 54.8 | 73.3 | 55.0 | 54.2 |
| 23/01/2018 | 22:45 | 54.8 | 60.9 | 55.2 | 54.4 |
| 23/01/2018 | 23:00 | 56.1 | 85.9 | 55.3 | 54.5 |
| 23/01/2018 | 23:15 | 54.3 | 58.2 | 54.9 | 53.8 |
| 23/01/2018 | 23:30 | 54.6 | 81.2 | 54.3 | 53.4 |
| 23/01/2018 | 23:45 | 53.8 | 57.3 | 54.3 | 53.4 |
| 24/01/2018 | 00:00 | 53.8 | 58.5 | 54.2 | 53.3 |
| 24/01/2018 | 00:15 | 54.1 | 61.9 | 54.5 | 53.5 |
| 24/01/2018 | 00:30 | 53.8 | 59.6 | 54.2 | 53.4 |
| 24/01/2018 | 00:45 | 53.6 | 58.3 | 54.1 | 53.2 |
| 24/01/2018 | 01:00 | 53.7 | 68.0 | 54.1 | 53.2 |
| 24/01/2018 | 01:15 | 53.7 | 58.4 | 54.2 | 53.2 |
| 24/01/2018 | 01:30 | 53.6 | 58.6 | 54.1 | 53.2 |
| 24/01/2018 | 01:45 | 53.7 | 56.3 | 54.1 | 53.2 |
| 24/01/2018 | 02:00 | 53.8 | 63.3 | 54.2 | 53.3 |
| 24/01/2018 | 02:15 | 53.7 | 58.9 | 54.1 | 53.2 |
| 24/01/2018 | 02:30 | 53.8 | 60.0 | 54.2 | 53.3 |
| 24/01/2018 | 02:45 | 53.8 | 58.4 | 54.3 | 53.3 |

| Date | Time | $L_{Aeq}$ | $L_{Amax}$ | $L_{A10}$ | $L_{A90}$ |
|---|---|---|---|---|---|
| 24/01/2018 | 03:00 | 53.5 | 59.9 | 54.0 | 53.1 |
| 24/01/2018 | 03:15 | 53.4 | 59.3 | 53.9 | 52.9 |
| 24/01/2018 | 03:30 | 53.6 | 68.4 | 54.0 | 53.1 |
| 24/01/2018 | 03:45 | 53.7 | 62.8 | 54.2 | 53.1 |
| 24/01/2018 | 04:00 | 54.1 | 70.1 | 54.5 | 53.3 |
| 24/01/2018 | 04:15 | 53.9 | 60.2 | 54.4 | 53.3 |
| 24/01/2018 | 04:30 | 53.8 | 59.0 | 54.3 | 53.3 |
| 24/01/2018 | 04:45 | 53.9 | 60.2 | 54.4 | 53.3 |
| 24/01/2018 | 05:00 | 54.0 | 59.2 | 54.5 | 53.4 |
| 24/01/2018 | 05:15 | 53.8 | 64.5 | 54.4 | 53.3 |
| 24/01/2018 | 05:30 | 54.3 | 63.2 | 54.9 | 53.6 |
| 24/01/2018 | 05:45 | 54.1 | 59.1 | 54.6 | 53.6 |
| 24/01/2018 | 06:00 | 54.2 | 62.3 | 54.9 | 53.6 |
| 24/01/2018 | 06:15 | 54.4 | 62.1 | 55.1 | 53.7 |
| 24/01/2018 | 06:30 | 55.0 | 72.1 | 55.3 | 54.0 |
| 24/01/2018 | 06:45 | 54.5 | 62.0 | 55.0 | 53.9 |
| 24/01/2018 | 07:00 | 55.1 | 63.2 | 55.6 | 54.3 |
| 24/01/2018 | 07:15 | 55.7 | 63.2 | 56.3 | 54.6 |
| 24/01/2018 | 07:30 | 56.4 | 73.3 | 57.1 | 55.6 |
| 24/01/2018 | 07:45 | 62.9 | 80.6 | 65.7 | 56.1 |
| 24/01/2018 | 08:00 | 63.5 | 83.6 | 66.1 | 57.1 |
| 24/01/2018 | 08:15 | 60.4 | 86.2 | 62.1 | 56.7 |
| 24/01/2018 | 08:30 | 58.2 | 75.8 | 60.1 | 55.9 |
| 24/01/2018 | 08:45 | 56.6 | 66.5 | 57.3 | 55.6 |
| 24/01/2018 | 09:00 | 58.2 | 73.0 | 59.4 | 55.9 |
| 24/01/2018 | 09:15 | 57.3 | 68.9 | 58.2 | 56.1 |
| 24/01/2018 | 09:30 | 57.5 | 76.1 | 58.2 | 56.0 |
| 24/01/2018 | 09:45 | 57.4 | 75.2 | 57.9 | 55.8 |
| 24/01/2018 | 10:00 | 56.8 | 73.2 | 57.5 | 55.8 |
| 24/01/2018 | 10:15 | 58.1 | 75.0 | 58.9 | 56.1 |
| 24/01/2018 | 10:30 | 57.0 | 71.3 | 57.9 | 55.9 |
| 24/01/2018 | 10:45 | 68.0 | 92.1 | 62.8 | 56.2 |
| 24/01/2018 | 11:00 | 59.1 | 82.2 | 60.6 | 56.2 |
| 24/01/2018 | 11:15 | 56.9 | 66.8 | 57.6 | 56.0 |
| 24/01/2018 | 11:30 | 57.8 | 66.8 | 59.3 | 56.3 |
| 24/01/2018 | 11:45 | 58.1 | 75.4 | 59.0 | 56.4 |
| 24/01/2018 | 12:00 | 57.2 | 64.9 | 58.1 | 56.2 |
| 24/01/2018 | 12:15 | 58.9 | 83.0 | 59.0 | 56.1 |
| 24/01/2018 | 12:30 | 61.2 | 74.1 | 63.5 | 56.5 |
| 24/01/2018 | 12:45 | 63.5 | 79.2 | 64.8 | 59.1 |
| 24/01/2018 | 13:00 | 59.0 | 72.1 | 59.8 | 57.4 |
| 24/01/2018 | 13:15 | 58.1 | 72.9 | 58.5 | 56.9 |
| 24/01/2018 | 13:30 | 57.9 | 65.7 | 58.7 | 56.9 |
| 24/01/2018 | 13:45 | 61.9 | 81.4 | 59.3 | 56.8 |
| 24/01/2018 | 14:00 | 57.9 | 74.3 | 58.5 | 57.0 |
| 24/01/2018 | 14:15 | 57.8 | 68.6 | 59.1 | 56.7 |
| 24/01/2018 | 14:30 | 57.7 | 73.0 | 58.2 | 56.6 |
| 24/01/2018 | 14:45 | 56.8 | 70.4 | 57.6 | 55.6 |
| 24/01/2018 | 15:00 | 58.1 | 79.2 | 58.6 | 55.8 |
| 24/01/2018 | 15:15 | 57.5 | 70.7 | 58.0 | 56.0 |
| 24/01/2018 | 15:30 | 58.5 | 76.0 | 58.1 | 56.1 |
| 24/01/2018 | 15:45 | 56.1 | 63.4 | 56.7 | 55.3 |
| 24/01/2018 | 16:00 | 57.3 | 75.9 | 57.1 | 55.6 |
| 24/01/2018 | 16:15 | 56.6 | 70.8 | 57.0 | 55.7 |
| 24/01/2018 | 16:30 | 55.9 | 66.8 | 56.4 | 55.2 |
| 24/01/2018 | 16:45 | 55.6 | 66.0 | 56.0 | 55.0 |
| 24/01/2018 | 17:00 | 55.4 | 65.1 | 55.9 | 54.9 |
| 24/01/2018 | 17:15 | 55.3 | 64.7 | 55.7 | 54.7 |
| 24/01/2018 | 17:30 | 55.1 | 63.0 | 55.5 | 54.6 |
| 24/01/2018 | 17:45 | 55.3 | 66.6 | 55.7 | 54.7 |
| 24/01/2018 | 18:00 | 55.0 | 67.2 | 55.5 | 54.3 |
| 24/01/2018 | 18:15 | 54.7 | 65.3 | 55.1 | 54.1 |
| 24/01/2018 | 18:30 | 54.9 | 77.1 | 55.2 | 54.2 |
| 24/01/2018 | 18:45 | 54.9 | 63.7 | 55.3 | 54.3 |
| 24/01/2018 | 19:00 | 54.7 | 60.2 | 55.1 | 54.2 |
| 24/01/2018 | 19:15 | 54.7 | 68.2 | 55.1 | 54.1 |
| 24/01/2018 | 19:30 | 55.2 | 74.0 | 55.5 | 54.3 |

Data excluded from the analysis because of non-conducive weather conditions

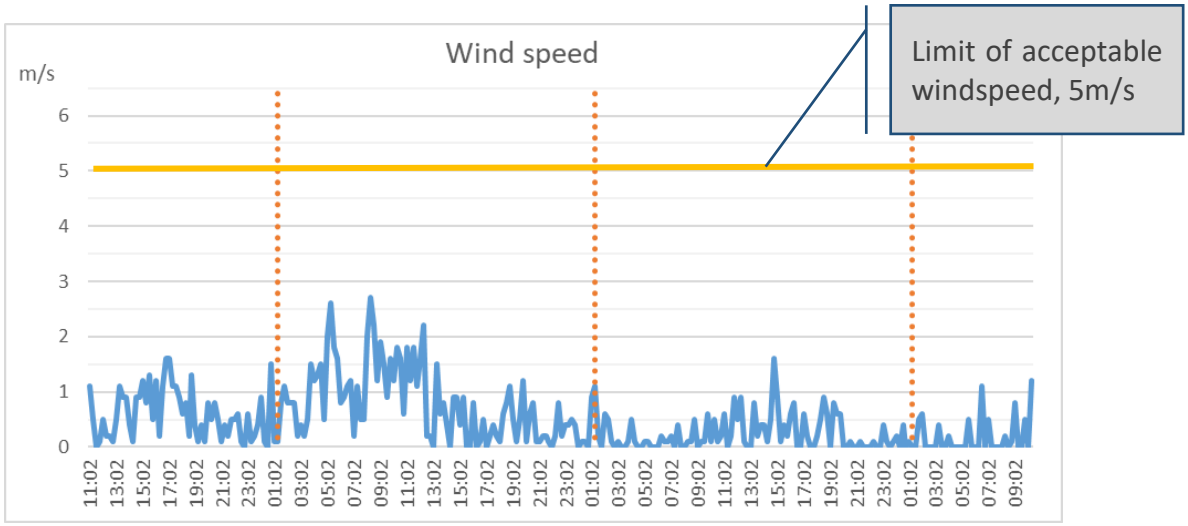
| Date | Time | $L_{Aeq}$ | $L_{Amax}$ | $L_{A10}$ | $L_{A90}$ |
|---|---|---|---|---|---|
| 24/01/2018 | 19:45 | 55.0 | 65.9 | 55.4 | 54.5 |
| 24/01/2018 | 20:00 | 55.2 | 78.4 | 55.3 | 54.3 |
| 24/01/2018 | 20:15 | 54.7 | 59.0 | 55.2 | 54.2 |
| 24/01/2018 | 20:30 | 54.9 | 59.7 | 55.3 | 54.4 |
| 24/01/2018 | 20:45 | 55.1 | 65.7 | 55.7 | 54.2 |
| 24/01/2018 | 21:00 | 57.4 | 75.6 | 55.5 | 53.8 |
| 24/01/2018 | 21:15 | 54.7 | 68.5 | 55.0 | 54.2 |
| 24/01/2018 | 21:30 | 54.3 | 59.2 | 54.7 | 53.8 |
| 24/01/2018 | 21:45 | 54.1 | 57.2 | 54.6 | 53.7 |
| 24/01/2018 | 22:00 | 54.6 | 62.7 | 55.1 | 54.0 |
| 24/01/2018 | 22:15 | 54.7 | 58.9 | 55.1 | 54.2 |
| 24/01/2018 | 22:30 | 54.4 | 58.9 | 54.8 | 54.0 |
| 24/01/2018 | 22:45 | 54.4 | 56.3 | 54.7 | 53.9 |
| 24/01/2018 | 23:00 | 54.5 | 69.9 | 54.7 | 53.5 |
| 24/01/2018 | 23:15 | 54.2 | 67.9 | 54.5 | 53.6 |
| 24/01/2018 | 23:30 | 54.1 | 62.1 | 54.6 | 53.6 |
| 24/01/2018 | 23:45 | 54.0 | 56.8 | 54.3 | 53.5 |
| 25/01/2018 | 00:00 | 53.9 | 61.2 | 54.3 | 53.5 |
| 25/01/2018 | 00:15 | 53.9 | 57.7 | 54.3 | 53.5 |
| 25/01/2018 | 00:30 | 54.0 | 59.3 | 54.5 | 53.5 |
| 25/01/2018 | 00:45 | 53.9 | 56.2 | 54.2 | 53.5 |
| 25/01/2018 | 01:00 | 53.9 | 67.3 | 54.2 | 53.2 |
| 25/01/2018 | 01:15 | 53.6 | 58.0 | 53.9 | 53.2 |
| 25/01/2018 | 01:30 | 53.5 | 60.8 | 54.0 | 53.0 |
| 25/01/2018 | 01:45 | 53.3 | 55.2 | 53.7 | 52.8 |
| 25/01/2018 | 02:00 | 53.2 | 55.3 | 53.6 | 52.8 |
| 25/01/2018 | 02:15 | 54.1 | 82.6 | 53.8 | 53.0 |
| 25/01/2018 | 02:30 | 53.5 | 59.6 | 53.9 | 53.0 |
| 25/01/2018 | 02:45 | 53.4 | 55.8 | 53.9 | 53.0 |
| 25/01/2018 | 03:00 | 53.9 | 57.6 | 54.2 | 53.5 |
| 25/01/2018 | 03:15 | 53.8 | 55.8 | 54.2 | 53.4 |
| 25/01/2018 | 03:30 | 53.9 | 55.7 | 54.3 | 53.4 |
| 25/01/2018 | 03:45 | 53.7 | 55.2 | 54.0 | 53.3 |
| 25/01/2018 | 04:00 | 53.8 | 72.2 | 54.1 | 53.3 |
| 25/01/2018 | 04:15 | 53.9 | 55.9 | 54.2 | 53.5 |
| 25/01/2018 | 04:30 | 53.9 | 56.7 | 54.3 | 53.5 |
| 25/01/2018 | 04:45 | 54.0 | 55.9 | 54.4 | 53.6 |
| 25/01/2018 | 05:00 | 53.5 | 56.7 | 53.9 | 53.0 |
| 25/01/2018 | 05:15 | 53.6 | 60.9 | 54.0 | 53.2 |
| 25/01/2018 | 05:30 | 53.7 | 69.9 | 54.1 | 53.1 |
| 25/01/2018 | 05:45 | 53.8 | 56.2 | 54.1 | 53.3 |
| 25/01/2018 | 06:00 | 53.6 | 59.3 | 54.0 | 53.1 |
| 25/01/2018 | 06:15 | 53.6 | 55.6 | 54.0 | 53.2 |
| 25/01/2018 | 06:30 | 54.2 | 57.3 | 54.7 | 53.5 |
| 25/01/2018 | 06:45 | 54.0 | 57.2 | 54.4 | 53.5 |
| 25/01/2018 | 07:00 | 54.1 | 69.9 | 54.5 | 53.5 |
| 25/01/2018 | 07:15 | 54.6 | 68.7 | 55.0 | 54.0 |
| 25/01/2018 | 07:30 | 61.3 | 82.6 | 62.7 | 54.5 |
| 25/01/2018 | 07:45 | 60.4 | 78.9 | 59.2 | 55.7 |
| 25/01/2018 | 08:00 | 63.5 | 79.6 | 66.6 | 55.8 |
| 25/01/2018 | 08:15 | 56.3 | 70.6 | 57.0 | 55.3 |
| 25/01/2018 | 08:30 | 56.7 | 72.0 | 57.0 | 55.0 |
| 25/01/2018 | 08:45 | 56.3 | 69.7 | 57.0 | 54.9 |
| 25/01/2018 | 09:00 | 56.2 | 73.7 | 57.2 | 54.8 |
| 25/01/2018 | 09:15 | 57.3 | 80.3 | 57.7 | 54.8 |
| 25/01/2018 | 09:30 | 56.0 | 75.0 | 56.6 | 54.7 |
| 25/01/2018 | 09:45 | 56.0 | 69.9 | 56.5 | 55.3 |
| 25/01/2018 | 10:00 | 56.4 | 72.3 | 56.5 | 55.2 |
| 25/01/2018 | 10:15 | 56.2 | 73.7 | 56.6 | 55.3 |
| 25/01/2018 | 10:30 | 55.7 | 63.4 | 56.2 | 55.1 |
| 25/01/2018 | 10:45 | 56.7 | 74.1 | 56.5 | 55.2 |
| 25/01/2018 | 11:00 | 59.4 | 78.2 | 61.2 | 55.3 |
| 25/01/2018 | 11:15 | 56.7 | 69.6 | 58.2 | 55.1 |
| 25/01/2018 | 11:30 | 57.0 | 73.4 | 57.3 | 55.1 |
| 25/01/2018 | 11:45 | 61.2 | 85.8 | 62.4 | 55.6 |
| 25/01/2018 | 12:00 | 57.3 | 76.6 | 57.8 | 55.4 |
| 25/01/2018 | 12:15 | 59.1 | 86.2 | 59.3 | 55.3 |

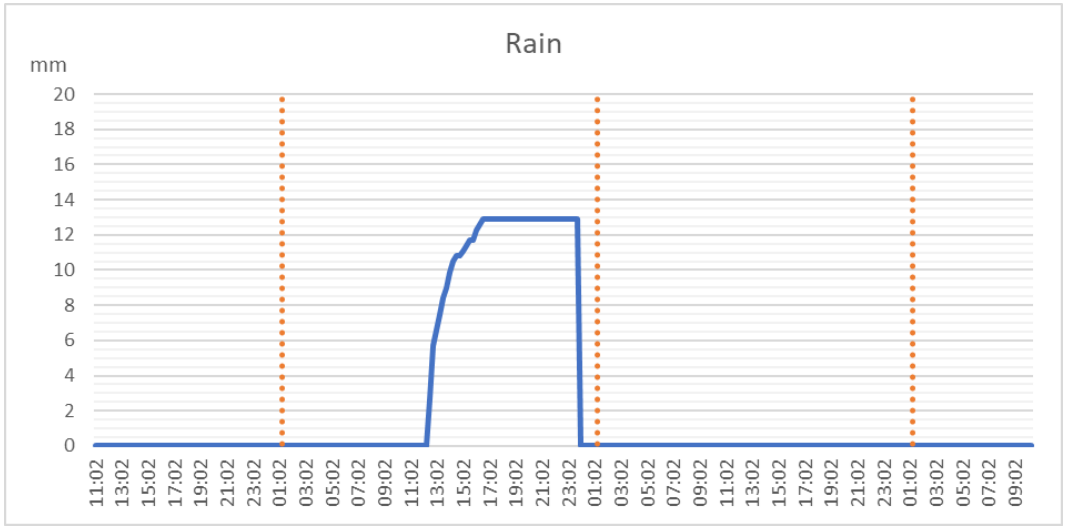
Data excluded from the analysis because of non-conducive weather conditions

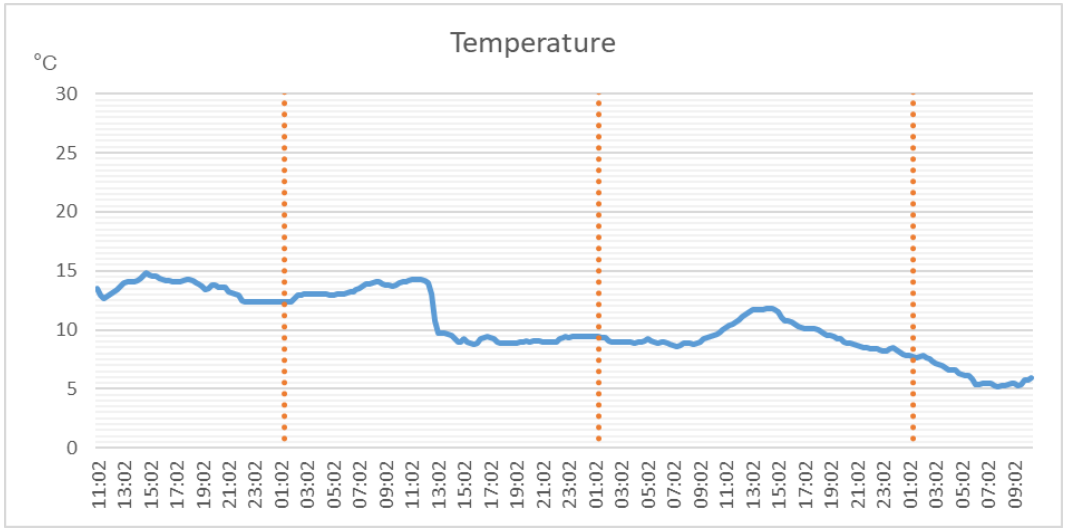
| Date | Time | $L_{Aeq}$ | $L_{Amax}$ | $L_{A10}$ | $L_{A90}$ |
|---|---|---|---|---|---|
| 25/01/2018 | 12:30 | 58.8 | 75.3 | 59.7 | 55.4 |
| 25/01/2018 | 12:45 | 62.8 | 88.6 | 63.2 | 57.1 |
| 25/01/2018 | 13:00 | 58.9 | 77.0 | 59.8 | 57.4 |
| 25/01/2018 | 13:15 | 61.2 | 90.4 | 59.2 | 56.9 |
| 25/01/2018 | 13:30 | 58.0 | 70.3 | 58.4 | 57.0 |
| 25/01/2018 | 13:45 | 57.8 | 69.0 | 58.3 | 57.0 |
| 25/01/2018 | 14:00 | 58.3 | 77.4 | 58.6 | 55.5 |
| 25/01/2018 | 14:15 | 64.9 | 73.1 | 67.4 | 55.9 |
| 25/01/2018 | 14:30 | 58.8 | 75.1 | 61.4 | 55.6 |
| 25/01/2018 | 14:45 | 56.6 | 74.1 | 57.1 | 55.3 |
| 25/01/2018 | 15:00 | 58.3 | 75.5 | 60.1 | 55.4 |
| 25/01/2018 | 15:15 | 57.9 | 73.7 | 59.3 | 55.4 |
| 25/01/2018 | 15:30 | 56.3 | 68.1 | 56.7 | 55.6 |
| 25/01/2018 | 15:45 | 56.9 | 69.4 | 57.5 | 56.0 |
| 25/01/2018 | 16:00 | 56.1 | 63.1 | 56.6 | 55.5 |
| 25/01/2018 | 16:15 | 56.3 | 73.9 | 56.7 | 55.2 |
| 25/01/2018 | 16:30 | 55.9 | 67.7 | 56.4 | 55.1 |
| 25/01/2018 | 16:45 | 60.0 | 79.9 | 57.7 | 55.2 |
| 25/01/2018 | 17:00 | 55.7 | 65.2 | 56.3 | 55.1 |
| 25/01/2018 | 17:15 | 56.1 | 68.6 | 56.5 | 55.3 |
| 25/01/2018 | 17:30 | 55.7 | 64.9 | 56.2 | 55.1 |
| 25/01/2018 | 17:45 | 55.9 | 64.1 | 56.4 | 55.2 |
| 25/01/2018 | 18:00 | 55.7 | 65.1 | 56.3 | 55.0 |
| 25/01/2018 | 18:15 | 55.9 | 68.6 | 56.8 | 55.2 |
| 25/01/2018 | 18:30 | 56.3 | 61.8 | 56.9 | 55.6 |
| 25/01/2018 | 18:45 | 56.1 | 69.5 | 56.6 | 55.5 |
| 25/01/2018 | 19:00 | 55.9 | 67.8 | 56.5 | 55.2 |
| 25/01/2018 | 19:15 | 55.6 | 63.5 | 56.1 | 55.0 |
| 25/01/2018 | 19:30 | 56.0 | 80.2 | 56.2 | 55.1 |
| 25/01/2018 | 19:45 | 55.5 | 66.1 | 56.0 | 54.9 |
| 25/01/2018 | 20:00 | 55.6 | 66.9 | 56.0 | 54.9 |
| 25/01/2018 | 20:15 | 56.2 | 83.4 | 56.1 | 54.7 |
| 25/01/2018 | 20:30 | 55.1 | 63.3 | 55.6 | 54.5 |
| 25/01/2018 | 20:45 | 55.0 | 59.2 | 55.7 | 54.2 |
| 25/01/2018 | 21:00 | 54.0 | 60.0 | 54.5 | 53.5 |
| 25/01/2018 | 21:15 | 54.2 | 61.4 | 54.6 | 53.7 |
| 25/01/2018 | 21:30 | 54.2 | 64.9 | 54.9 | 53.2 |
| 25/01/2018 | 21:45 | 53.9 | 61.5 | 54.3 | 53.3 |
| 25/01/2018 | 22:00 | 53.9 | 58.4 | 54.3 | 53.3 |
| 25/01/2018 | 22:15 | 54.0 | 59.4 | 54.5 | 53.5 |
| 25/01/2018 | 22:30 | 54.0 | 59.7 | 54.4 | 53.6 |
| 25/01/2018 | 22:45 | 53.9 | 60.1 | 54.4 | 53.4 |
| 25/01/2018 | 23:00 | 53.8 | 60.0 | 54.2 | 53.3 |
| 25/01/2018 | 23:15 | 53.9 | 59.3 | 54.4 | 53.4 |
| 25/01/2018 | 23:30 | 53.7 | 59.5 | 54.1 | 53.2 |
| 25/01/2018 | 23:45 | 53.6 | 64.3 | 54.1 | 53.1 |
| 26/01/2018 | 00:00 | 53.2 | 58.7 | 53.7 | 52.6 |
| 26/01/2018 | 00:15 | 53.1 | 59.0 | 53.5 | 52.6 |
| 26/01/2018 | 00:30 | 53.0 | 59.7 | 53.5 | 52.5 |
| 26/01/2018 | 00:45 | 53.6 | 68.7 | 53.9 | 53.0 |
| 26/01/2018 | 01:00 | 53.3 | 59.4 | 53.9 | 52.6 |
| 26/01/2018 | 01:15 | 53.0 | 60.3 | 53.5 | 52.4 |
| 26/01/2018 | 01:30 | 53.5 | 58.8 | 54.0 | 53.0 |
| 26/01/2018 | 01:45 | 53.5 | 58.5 | 53.9 | 53.1 |
| 26/01/2018 | 02:00 | 53.4 | 58.4 | 53.8 | 53.0 |
| 26/01/2018 | 02:15 | 53.6 | 62.2 | 54.1 | 53.0 |
| 26/01/2018 | 02:30 | 54.3 | 80.0 | 54.0 | 53.2 |
| 26/01/2018 | 02:45 | 53.7 | 60.6 | 54.0 | 53.3 |
| 26/01/2018 | 03:00 | 53.7 | 59.0 | 54.1 | 53.2 |
| 26/01/2018 | 03:15 | 53.7 | 59.6 | 54.1 | 53.3 |
| 26/01/2018 | 03:30 | 54.2 | 79.1 | 54.4 | 53.4 |
| 26/01/2018 | 03:45 | 53.8 | 59.8 | 54.3 | 53.3 |
| 26/01/2018 | 04:00 | 53.9 | 59.3 | 54.2 | 53.4 |
| 26/01/2018 | 04:15 | 53.7 | 58.9 | 54.1 | 53.4 |
| 26/01/2018 | 04:30 | 53.9 | 59.2 | 54.3 | 53.4 |
| 26/01/2018 | 04:45 | 54.0 | 68.5 | 54.4 | 53.4 |
| 26/01/2018 | 05:00 | 53.6 | 58.8 | 54.1 | 52.9 |

| Date | Time | $L_{Aeq}$ | $L_{Amax}$ | $L_{A10}$ | $L_{A90}$ |
|---|---|---|---|---|---|
| 26/01/2018 | 05:15 | 53.4 | 58.8 | 54.0 | 52.8 |
| 26/01/2018 | 05:30 | 53.6 | 58.4 | 54.1 | 53.0 |
| 26/01/2018 | 05:45 | 53.7 | 74.1 | 53.9 | 53.0 |
| 26/01/2018 | 06:00 | 53.6 | 59.1 | 54.1 | 53.0 |
| 26/01/2018 | 06:15 | 53.7 | 61.4 | 54.4 | 52.9 |
| 26/01/2018 | 06:30 | 54.0 | 67.6 | 54.4 | 53.4 |
| 26/01/2018 | 06:45 | 54.4 | 62.0 | 55.1 | 53.6 |
| 26/01/2018 | 07:00 | 54.5 | 63.7 | 55.0 | 53.6 |
| 26/01/2018 | 07:15 | 54.4 | 67.6 | 54.9 | 53.6 |
| 26/01/2018 | 07:30 | 63.7 | 84.0 | 65.1 | 53.5 |
| 26/01/2018 | 07:45 | 55.7 | 74.8 | 55.3 | 53.4 |
| 26/01/2018 | 08:00 | 63.7 | 89.0 | 66.5 | 53.6 |
| 26/01/2018 | 08:15 | 56.1 | 83.3 | 55.4 | 53.7 |
| 26/01/2018 | 08:30 | 55.3 | 72.1 | 55.5 | 54.0 |
| 26/01/2018 | 08:45 | 55.1 | 71.3 | 55.4 | 54.2 |
| 26/01/2018 | 09:00 | 56.1 | 73.3 | 56.1 | 54.1 |
| 26/01/2018 | 09:15 | 54.5 | 67.2 | 55.2 | 53.7 |
| 26/01/2018 | 09:30 | 55.8 | 68.6 | 57.2 | 54.2 |
| 26/01/2018 | 09:45 | 55.9 | 74.9 | 56.6 | 54.3 |
| 26/01/2018 | 10:00 | 55.1 | 73.5 | 55.7 | 54.0 |
| 26/01/2018 | 10:13 | 58.2 | 77.4 | 57.0 | 54.1 |

## APPENDIX I: Weather Data



## APPENDIX J: Equipment

- NTi XL2 Real Time Analyser
- NTi Outdoor Microphone kit
- Tripod
- Norsonic 1251 Calibrator 114 dB @ 1 kHz
- Weather Station Watson.

Calibration certificates are available on request.

## APPENDIX K: Acoustic Feature Corrections

A rating penalty has been established based on a subjective assessment of characteristics. Penalties have been applied based on GSAD's previous experience of air handling units.

Tonality: typical condenser units can have tonal components that are perceptible. Tonal components may or may not be audible at the receptors located at distances of 24.5 m, however, a correction has been applied to adopt a cautious approach.

Intermittency: condenser units turn on/off during operation. On/off states may or may not be perceptible at the receptors located at distances of 24.5 m, however, a correction has been applied to adopt a cautious approach.

## APPENDIX L: Glossary of Acoustic Terms

DECIBEL (dB) - A unit of sound pressure measurement
Sound Pressure Level in dB (*L*p) = 20 log (Measured sound pressure/Reference sound pressure = 20 µPa)

dB(A) - The A -weighted sound pressure level, the weighting network reduces low frequency sound in a similar way to the human ear.

REVERBERATION TIME (RT or *T*) – decay of sound in rooms
The time taken for a sound, once terminated, to fall through 60dB i.e. to one millionth of its original sound intensity. *T*30 – RT for first 30dB of decay. $RT_{500}$ - Mid frequency RT.
HERTZ (Hz) - a unit of frequency measurement. The normal range of hearing is from 20Hz to about 15kHz.

ABSORPTION COEFFICIENT – degree to which a material absorbs sound.
The ratio of absorbed to incident sound energy (perfect absorber = 1)

SOUND REDUCTION INDEX *R* – quantity which describes a material's ability to reduce the sound pressure level across it (e.g. a wall or floor)

$R = L1 - L2 + 10\log (S/A)$

*L*1 - Average sound pressure level in source room (averaged from 100 Hz – 3150 Hz)
*L*2 - Average sound pressure level in receiving room (averaged from 100 Hz – 3150 Hz)
*S* – Wall Area ($m^2$)
*A* – Total absorption in receiving room ($m^2$ units)

*R*w – weighted sound reduction index

AVERAGE ROOM TO ROOM LEVEL DIFFERENCE – *D*, dB = *L*1 – *L*2, averaged 1/3 octave bands from 100Hz – 3150kHz.

*D*w – weighted value of D (usually 2 - 3dB higher)

*D*nT, w – *D*w corrected for reverberation time of receiving room

NOISE RATING CURVES (NR CURVES) – set of curves used to describe optimum background noise levels for different tasks.

*L*10/90 LEVEL (dB) - The level in dB of a time varying sound pressured level (e.g. traffic) exceeded for 10%/90% of the time of measurement.
*L*90 is usually called the BACKGROUND NOISE LEVEL.

*L*eq AVERAGE SOUND PRESSURE LEVEL – level dB of a time varying sound pressure level with equal amounts of energy above and below it, for the time of measurement.

TONAL NOISE – noise of a single frequency (or a narrow band of frequencies that can be perceived as a tone), audible above the broad band noise background. Noise which is at least 5dB above the average of the 1/3 octave band sound pressure levels immediately on either side of it.