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3 HAMPSHIRE STREET
LONDON, NW5 2SS

RETROSPECTIVE PLANNING APPLICATION FOR RETENTION OF AIR CONDITIONING UNITS

PLANT NOISE IMPACT ASSESSMENT

OCTOBER 2018

the journey is the reward

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PLANT NOISE IMPACT ASSESSMENT

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Project Code:	**FNHampshireStreet(N).9**
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3 Hampshire Street, London, NW5 2SS
Retrospective Planning Application for
Retention of Air Conditioning Units
Plant Noise Assessment

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1 Introduction

1.1 On 23 May 2018, the London Borough of Camden issued a letter to Fashion Nation (UK) Limited, regarding the installation of nine condenser units to the rear of 3 Hampshire Street, London. (London Borough of Camden ref. RS/PE/EN18/0228). The letter confirmed that the Council's records did not show that planning permission had been obtained for the plant. In addition to drawing attention to the Council's concerns regarding the *"siting, quantity and appearance"* of the installed plant, the Council's letter asserts *"The units also have potential to cause harm to neighbouring amenity through noise and vibration"*.

1.2 Mayer Brown Limited has been instructed by Fashion Nation UK Limited to assess the potential noise and vibration impact of the plant.

1.3 This report is structured as follows:

- **Section 2** describes the location of the site and its environs;
- **Section 3** discusses national and local planning policy;
- **Section 4** outlines noise monitoring and calculations to determine the specific sound level of the installed plant;
- **Section 5** presents the results of automated noise monitoring to determine typical background noise levels characterising the site;
- **Section 6** assesses the "acceptability" of noise emissions;
- **Section 7** discusses planning control implications;
- Conclusions are presented in **Section 8**.

1.4 A glossary of the acoustic terminology used in this report is attached at **Appendix A**.

Suitably Qualified Acoustic Consultant/Engineer

1.5 This report has been prepared by Mayer Brown Limited, a multi-disciplinary practice providing Transport Planning, Infrastructure Design and Environmental Consultancy Services.

1.6 This report has been prepared by Harry Russell-Lees (Assistant Consultant) who holds Associate Membership of the Institute of Acoustics (AMIOA). The preparation of the report has been supervised, reviewed and approved by Paul Gray (Technical Director). Paul has held corporate membership of the Institute of Acoustics (MIOA) since 1994 and has over twenty seven year's practical experience in acoustic consultancy.

2 Site Location

2.1 The location of the site is shown in **Figure 2.1** below.

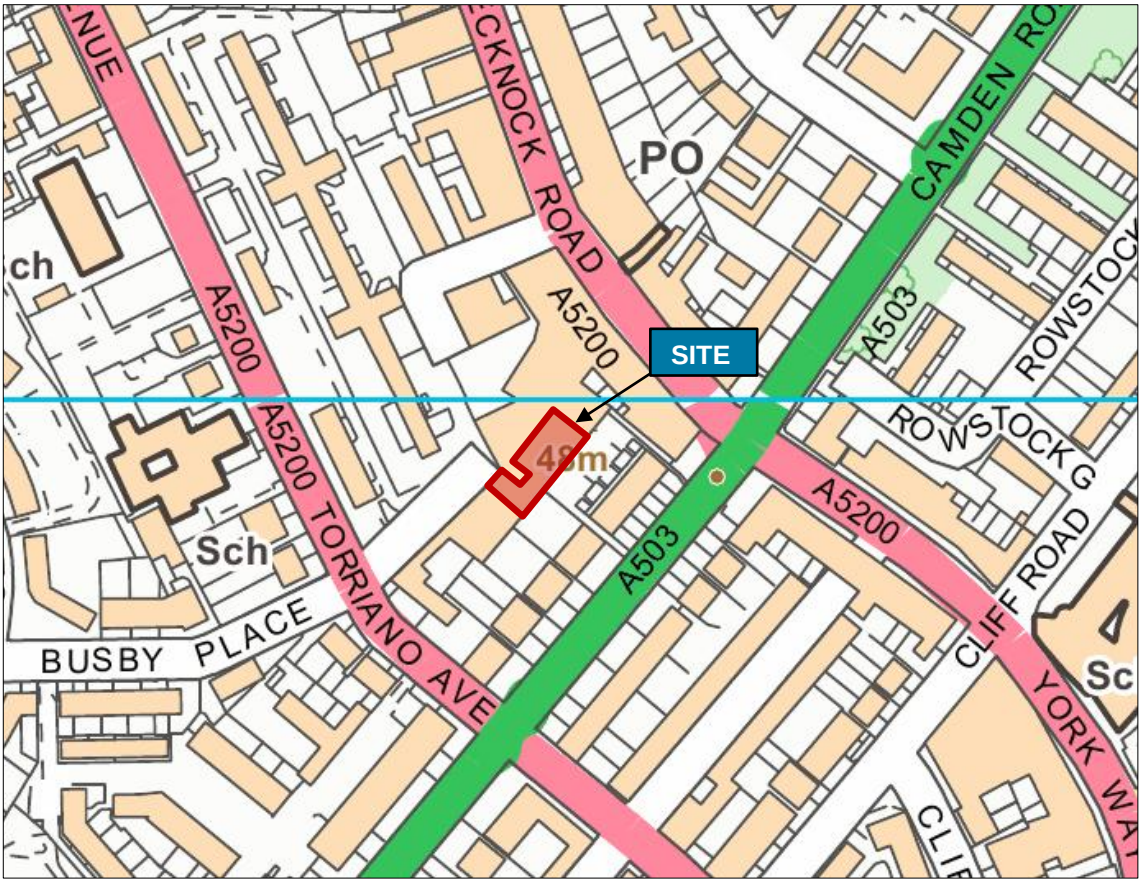


Figure 2.1: Site Location

2.2 3 Hampshire Street is a mixed use building with commercial use on the ground floor (occupied by Fashion Nation UK Limited) with residential flats above.

2.3 The condenser units are located on the south east elevation of the ground floor, overlooking a car park to the rear of 217 -225 Camden Road.

2.4 A total of 9 condenser units are installed:

- 2 at high level above an external store at the north-western corner of the car park; and
- 7 wall mounted units towards the middle of the north-western boundary of the car park.

2.5 The general arrangement of the units is shown in the photograph in **Figure 2.2** below:

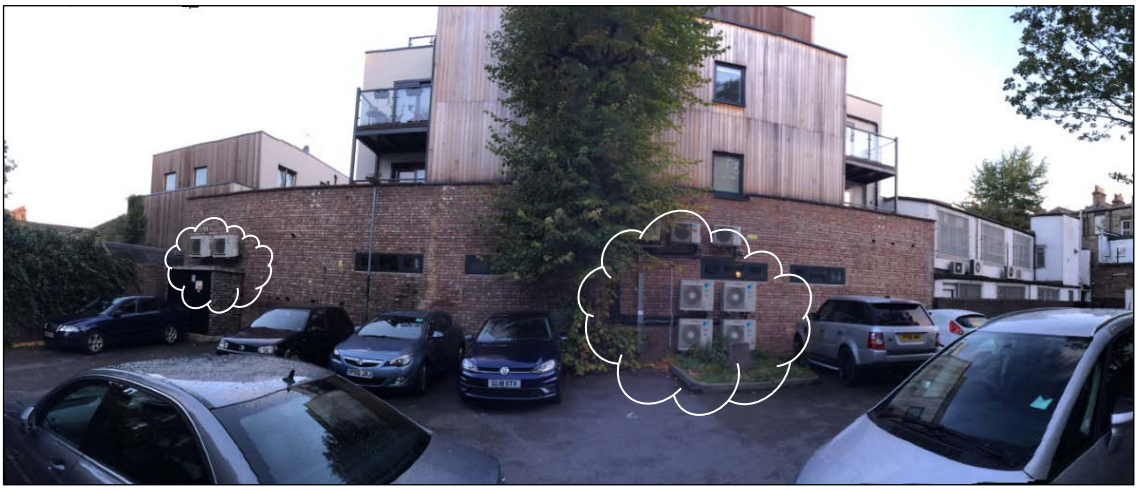


Figure 2.2: Installed Air Conditioning Condenser Units

2.6 The existing plant includes:

- 2 no. Daikin RXM50M3V1B9
- 5 no. Daikin AZAS71M2VAB
- 2 no. Daikin RXM25M3V1B9

2.7 Manufacturer's noise data for these units indicate that each unit will typically generate a sound level of around 47-49 dB(A) at a distance of 1m directly (measured "on-axis" in front of the discharge fan). "Off-axis" are typically substantially lower than "on-axis" noise levels).

3 Planning Policy Context and Acoustic Design Criteria

National Planning Policy Framework, (NPPF, 2018)

3.1 Current governmental guidance for the determination of planning applications is given in the revised *"National Planning Policy Framework"* (NPPF), published on 24 July 2018.

3.2 Paragraph 170 of the NPPF advises:

> *"Planning policies and decisions should contribute to and enhance the natural and local environment by:*
>
> *….. e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability.*

3.3 With specific regard to noise, paragraph 180 of the NPPF states:

> *"Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:*
>
> *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; and*
>
> *c) limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation.*

3.4 Paragraph 182 of the NPPF draws specific attention to the need to ensure that new development is compatible with existing businesses and community facilities and introduces and "agent of change" principle:

> *"Planning policies and decisions should ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs). Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of*

development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed."

3.5 With regard to 'adverse' impacts and 'significant adverse' impacts, the NPPF directs the reader to the advice contained in DEFRA's *"Noise Policy Statement for England"* (NPSE). This Policy Statement introduces the concept of a *"Significant Observed Adverse Effect Level"* (SOAEL), *"Lowest Observed Adverse Effect Level"* (LOAEL) and "No Observed Adverse Effect Level" (NOAEL). These are concepts aligned with toxicology outcomes derived from guidance given by the World Health Organisation.

Camden Council

3.6 The Camden Local Plan was adopted on 3rd of July 2017.

3.7 With regard to noise generated by commercial activities (including plant), the local plan states:

'A relevant standard or guidance document should be referenced when determining values for LOAEL and SOAEL for non-anonymous noise. Where appropriate and within the scope of the document it is expected that British Standard 4142:2014 'Methods for rating and assessing industrial and commercial sound' (BS 4142) will be used. For such cases a 'Rating Level' of 10 dB below background (15dB if tonal components are present) should be considered as the design criterion).

Existing Noise sensitive receptor	*Assessment location*	*Design period*	*LOAEL (Green)*	*LOAEL to SOAEL (Amber)*	*SOAL (Red)*
*Dwellings***	*Garden used for main amenity (free field) and Outside living or dining or bedroom window (façade)*	*Day*	*'Rating level' 10dB* below background*	*'Rating level' between 9dB below and 5dB above background*	*'Rating level' greater than 5dB above background*

*Dwellings***	*Outside bedroom window (façade)*	*Night*	*'Rating level' 10dB* below background and no events exceeding 57dBL_{Amax}*	*'Rating level' between 9dB below and 5dB above background or noise events between 57dB and 88dB L_{Amax}*	*'Rating level' greater than 5dB above background and/or events exceeding 88dBL_{Amax}*

**10dB should be increased to 15dB if the noise contains audible tonal elements. (day and night). However, if it can be demonstrated that there is no significant difference in the character of the residual background noise and the specific noise from the proposed development then this reduction may not be required. In addition, a frequency analysis (to include, the use of Noise Rating (NR) curves or other criteria curves) for the assessment of tonal or low frequency noise may be required.*

***levels given are for dwellings, however, levels are use specific and different levels will apply dependent on the use of the premises.*

The periods in Table C correspond to 0700 hours to 2300 hours for the day and 2300 hours to 0700 hours for the night. The Council will take into account the likely times of occupation for types of development and will be amended according to the times of operation of the establishment under consideration.

There are certain smaller pieces of equipment on commercial premises, such as extract ventilation, air conditioning units and condensers, where achievement of the rating levels (ordinarily determined by a BS:4142 assessment) may not afford the necessary protection. In these cases, the Council will generally also require a NR curve specification of NR35 or below, dependant on the room' (based upon measured or predicted Leq,5mins noise levels in octave bands) 1 metre from the façade of affected premises, where the noise sensitive premise is located in a quiet background area.'

BS 4142: 2014: "Methods for Rating and Assessing Industrial and Commercial Sound"

3.8 Camden's noise guidance makes specific reference to the assessment methodology of BS 4142: 2014.

3.9 The assessment procedure initially compares the ***'Rating Level'*** of the source with the '***Background*** Noise ***Level'*** when the source is not present.

3.10 The ***'Rating*** Level' (L_{Ar}) referred to is the specific noise level of the noise source under investigation (in terms of the L_{Aeq} noise index), to which corrections are applied if the noise has certain audible characteristics. The following corrections (based on a subjective assessment of noise source characteristics is given:

Character Correction				
Feature / Perception	**Tonality**	**Impulsivity**	**Intermittency**	**Other acoustic characteristics**
Just Perceptible	+2dB	+3dB	When the specific sound has identifiable On/Off conditions that are readily distinctive. +3dB	+3dB
Clearly Perceptible	+4dB	+6dB		
Highly Perceptible	+6dB	+9dB		

Table 3.1: BS4142 Character Correction for Rating Level Calculation

3.11 The 'Background Noise Level' (L_{A90}) represents the noise level that is exceeded for 90% of the stated measurement period. For assessment purposes, the background noise level needs to be determined without the noise source under investigation operating.

3.12 The time of operation needs to be taken into account. During the day (normally taken to be 07.00 to 23.00 hours) a one hour measurement period is considered appropriate. During the night (normally taken to be 23.00 – 07.00 hours) a 15 minute time period is normally used.

3.13 The following guidance is then offered based on the outcome of this initial assessment:

- 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 is likely to 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 the specific sound source will have an adverse impact or a significant 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, depending on the context.

3.14 In light of the above guidance, it can be seen that the recommendations set out in Camden's Local Plan are generally more stringent than the "significance" outcomes

indicated in BS 4142. For example, BS 4142 suggests that a SOAEL would be indicated where the difference between rating level and background level was 10dB and suggests that there would be a low impact (i.e. LOAEL) where the rating level does not exceed the background level.

4 Plant Noise Levels

4.1 In order to assess the acceptability of noise emissions from the existing plant, noise monitoring has been undertaken at the site, including an attended noise survey and automated noise monitoring to provide detailed information regarding diurnal fluctuations in background noise.

Flats Above 3 Hampshire Place

4.2 Attended noise monitoring was undertaken at the site between approximately 07.30 to 10.00 hours on 21 September 2018.

4.3 Noise levels were measured at the closest residential window above the proposed condenser units, as shown in **Figure 4.1** and **4.2** below

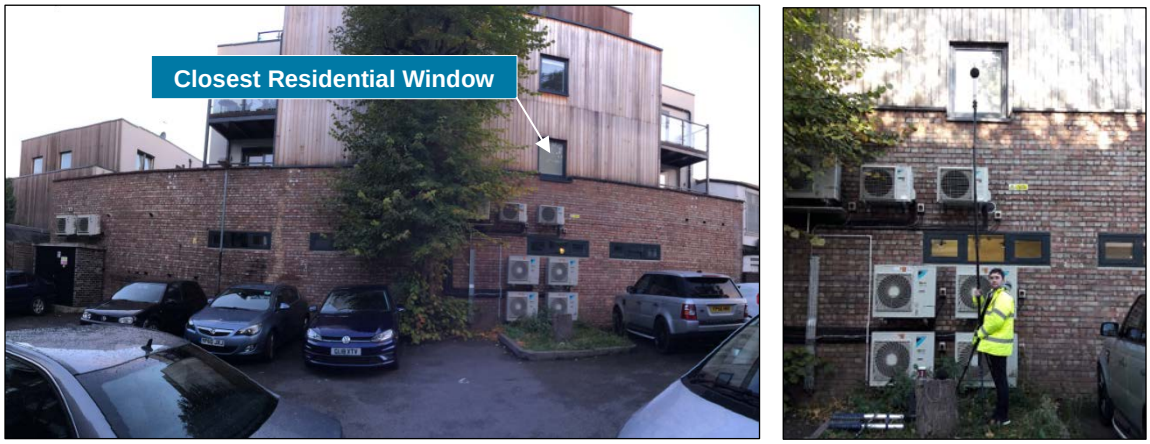


Figure 4.1: Measurement Location at Closest Residential Window

4.4 Comparative noise measurements were made with all units switched off and all units switched on (having lowered the temperature on the internal thermostats within the building to prompt a cooling load on the condenser units).

4.5 The following instrumentation was used:

Description	Make	Model	Serial No.	Calibration Date
Sound Level Analyser	Svantek	SVAN 971	55550	04/06/2018
Microphone		7052E	63684	
Preamplifier		SV18	57249	
Outdoor Microphone Kit		SA271U	n/a	n/a
Calibrator	Norsonic	Nor 1251	34058	24/03/2018

Table 4.1: Measurement Instrumentation Details

4.6 The sound level analyser was calibrated prior to the survey and the calibration checked upon completion. No draft in calibration was observed.

4.7 The sound level analyser as configured to log the L_{AeqT} sound levels at 1 second intervals, together with corresponding octave band sound levels.

4.8 Two sample sets of measurements were undertaken to determine the specific noise level of the operational plant. Based on site observations, it was clear that plant noise did not contribute significantly to the ambient noise levels and that other noise sources, such as passing road traffic, could have a significant influence on the measurement results. In order to reduce uncertainty in relation to the estimation of the specific plant noise level, the sample measurements have therefore been post-processed using Svantek SvanPC++ software to exclude "extraneous" noise events and provide a more robust estimation of plant noise. The results of comparative on/off measurements are presented in **Table 4.2** below:

Measurement Parameter	$L_{Aeq,T}$ Sound Level	
	Sample 1	Sample 2
Measured Ambient Sound Level (Plant On)	53.7	54.0
Measured Residual Sound Level (Plant Off)	53.5	53.8
Calculated Specific Plant Sound Level	40.2	40.5

Table 4.2: Calculation of Plant Specific Sound Level

4.9 Even with a precautionary approach of removing extraneous traffic noise, the measurement results show very small (less than 3dB) differences between the ambient and residual sound levels. Notwithstanding this, both sample measurements yield very similar results and are therefore considered to provide reasonable confidence in the determination of the specific sound level.

4.10 All other residential and balconies to flats above 3 Hampshire Street are located further away and will therefore be subject to additional attenuation due to the increased distance. The balconies to the flats above 3 Hampshire Place are also further away and will therefore be subject to additional attenuation and potential screening associated with the glazed ballustrades to the balconies and general arrangement of the building.

4.11 In light of the above, the noise levels calculated above are considered to represent an absolute "worst case" impact.

Flats at 215-225 Camden Road

4.12 As noted earlier, the plant is located on the north-western side of the car park to the rear of 215 to 225 Camden Road. Subjectively, noise associated with the plant was not perceptible in the context of existing ambient noise levels at the time of the survey. In accordance with paragraph 7.3.6 of BS 4142, it is therefore considered more appropriate to calculate the specific noise level likely to be experienced by these properties based on manufacturer's noise data (and which reflect the "on-axis" location of these dwellings relative to the units).

4.13 Manufacturer's noise data for all units is summarised in **Table 4.3** below:

Plant Ref.	Manufacturer's Sound Pressure Level at 1m								dB(A)
	63	125	250	500	1k	2k	4k	8k	
Daikin RXM25M3V1B9	50	51	49	47	43	38	34	27	47
Daikin RXM50M3V1B9	49	49	47	45	44	39	33	24	49
Daikin AZAS71M2VAB	52	48	42	47	42	35	31	26	47

Table 4.3: Summary of Manufacturers' Plant Noise Data

4.14 Based on the above, the worst case specific noise level for the flats at 215 to 225 Camden Road is calculated to be 38dB $L_{Aeq,T}$. This value is considered to represent an absolute worst case, assuming that all plant is simultaneously operational at full capacity.

5 Background Noise Levels

General

5.1 In order to determine existing background noise levels characterising the site, automated noise monitoring was undertaken over a notional five day period between approximately 10:45 hours on Friday 21st September 2018 to 15:30 hours on Tuesday 25th September 2018.

Measurement Location

5.2 Noise levels were monitored at the perimeter of a first floor balcony to one of the flats above 3 Hampshire Street, overlooking the car park to the rear of 215-225 Camden Road, as shown in **Figure 4.1** below.

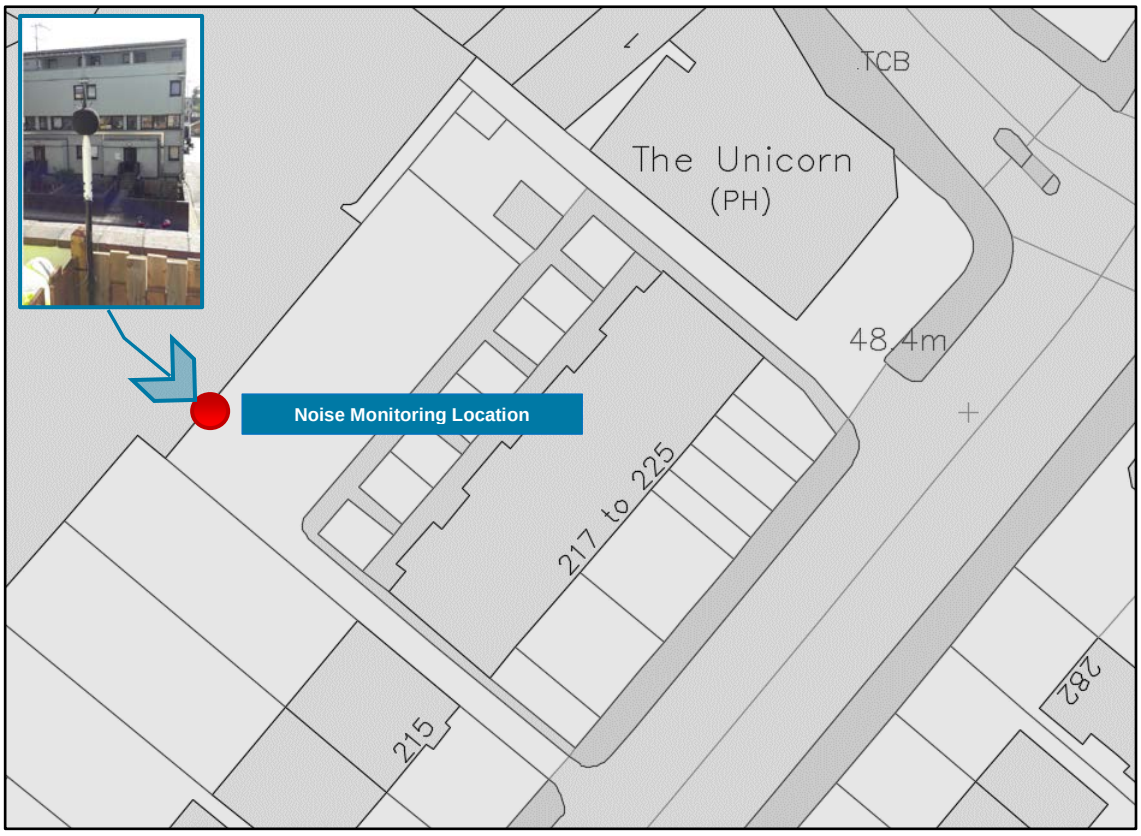


Figure 5.1: Noise Monitoring Location

5.3 The measurement microphone was attached to the balcony fencing, positioned approximately 1.5m above floor level.

Survey Procedure

5.4 The sound level analyser was configured to record the L_{A90} sound level over consecutive 15 minute periods to provide a detailed time history profile showing fluctuations in noise levels.

5.5 The sound level analyser was calibrated prior to use and the calibration was checked on completion. No drift in calibration was observed.

Instrumentation

5.6 The following instrumentation was used for the survey:

Description	Make	Model	Serial No.	Calibration Date
Sound Level Analyser	Svantek	SVAN 71	55550	04/06/2018
Microphone		7052E	63684	
Preamplifier		SV18	57249	
Outdoor Microphone Kit		SA271U	n/a	n/a
Calibrator	Norsonic	Nor 1251	34058	24/03/2018

Table 5.1: Instrumentation Details

Noise Monitoring Results

5.7 Measured noise levels (over consecutive 15-minute periods) are presented in **Figure 5.2**

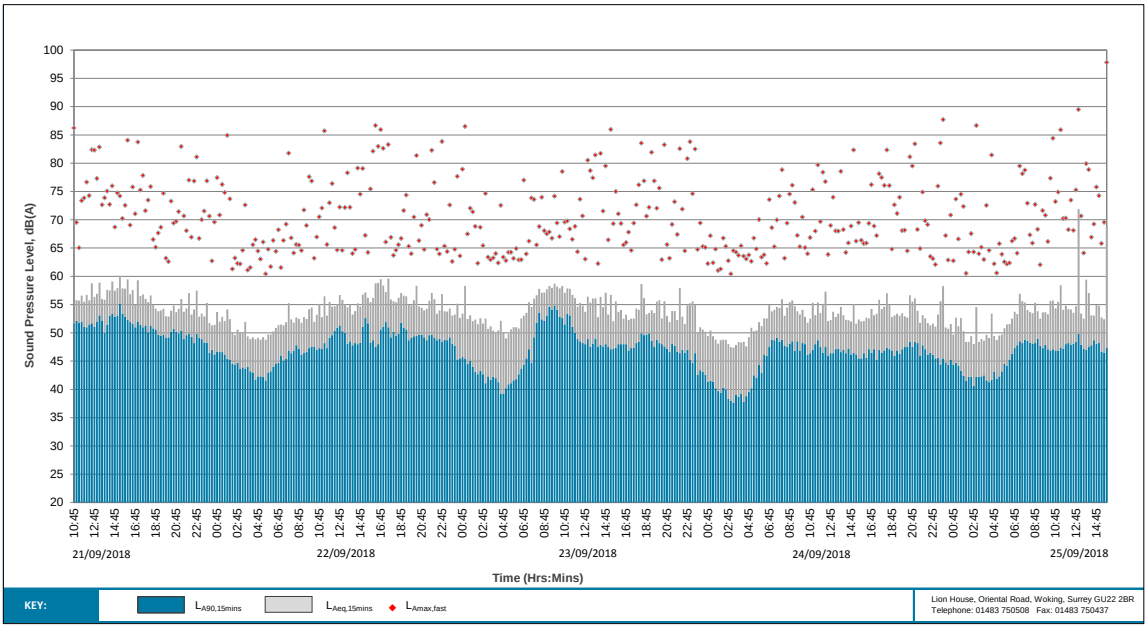


Figure 5.2: Noise Measurement Data

5.8 A higher resolution image of the above time history graph is attached at **Appendix B**.

Weather

5.9 Due to the nature of the survey, i.e. unmanned, it is not possible to accurately comment on the weather conditions throughout the entire survey period. However, observations at the time of site attendances and publicly available historic online data, suggest that weather conditions were typically characterised as set out in **Table 5.3** below:

Date	Temperature		Pressure		Average Wind Speed (kph)	Wind Direction	Rainfall (mm)
	Max.	Min.	Max.	Min.			
21/09/18	17	7	1032	1016	3	NW	4.0
22/09/18	17	9	1016	1003	6	W	2.1
23/09/18	15	8	1011	1003	4	SW	2
24/09/18	19	11	1022	1012	4	WSW	2
25/09/18	19	8	1025	1022	3	W	0

Table 5.2: Weather Conditions During Survey

Observations and Discussion

5.10 During site attendances, it was observed that noise levels were generally influenced by local and distant road traffic noise (in particularly the A503 Camden Road), and noise associated with activities at the neighbouring property uses.

Statistical Analysis of Measurement Data

5.11 The installed plant is controlled to operate between 08.00 to 18.00 hours only.

5.12 Whilst the attended noise measurements suggest that existing plant noise emissions from the plant did not have any significant influence on existing ambient noise levels, in order to provide a robust determination of the typical background noise level, the measurement data for the periods 07.00 to 08.00 and 18.00 to 19.00 hours (i.e. one hour before and one hour after the operational hours of the plant) has been statistically analysed. The resulting distribution is shown in **Figure 5.3** Below.

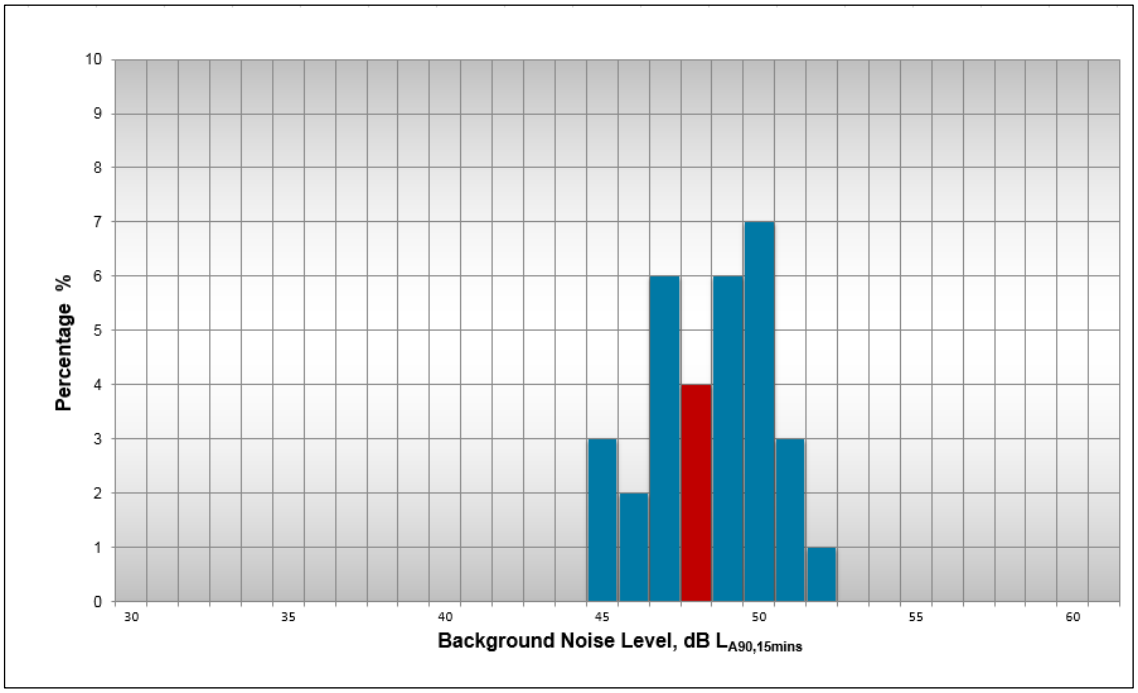


Figure 5.3: Statistical Analysis of Daytim

5.13 Based on the above, the typical background noise level characterising the site during the operational hours of the plant is assessed to be 48dB $L_{A90,15mins}$.

6 Plant Noise Assessment

Noise Emissions to Flats Above 3 Hampshire Street

6.1 The worst case plant noise level at the closest residential window to the proposed plant is calculated to be 40dB $L_{Aeq,T}$.

6.2 Based on subjective observations at the time of site attendances, the plant did not exhibit any characteristics or features that were considered to increase the potential significance of resulting noise levels in the context of the prevailing noise environment.

6.3 On this basis, the rating level of plant noise at the nearest residential window is assessed to be 40 dB L_{Ar}.

6.4 The typical background noise level during the operational hours of the plant is assessed as 48dB $L_{A90,15mins}$.

6.5 Based on the above, on site measurements indicate that the rating level of plant noise will be 8dB lower than the typical background noise level.

6.6 As noted earlier, BS 4142 indicates that *"where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact"*.

6.7 To put the above assessment conclusion into context, it is generally accepted that the average human ear cannot perceive a sound level difference of less than 3dB(A), that a difference of 5dB(A) will be "noticeable" and that a sound level difference of 10dB(A) would be perceived as a subjective "doubling" / "halving" of loudness. In light of the above, it can be seen that existing plant noise levels are approaching a level that is subjectively half as loud as a level that BS 4142 would indicate as having a low impact.

6.8 As noted earlier, noise guidance in Camden's Local Plan takes a more stringent approach to the consideration of the potential significance of impacts. The guidance suggests that a LOAEL from plant noise would be indicated in a situation where the rating level of plant is 10dB below the typical background noise level, and that SOAEL would be indicated where the rating level is 10dB above the typical background noise level. If such indications are taken at face value, then on-site noise monitoring confirms existing plant noise levels:

- Are not at a level defined as being a *"Significant Observed Adverse Effect Level"* (SOAEL) in Camden's adopted Local Plan; and

- Are just 2dB above the value Camden define as a *"Lowest Observed Adverse Effect Level"* (LOAEL).

6.9 Taken in context, this latter conclusion is not considered to be significant given that:

- The average human ear is not generally capable of discerning a sound level difference of 3dB(A); and
- Camden's definition of LOAEL is significantly more stringent that the guidance presented in BS 4142.

6.10 In addition to the above, guidance in Camden's Local Plan also suggests that it may also be material to consider the absolute level of noise in situations where background noise levels are "low", suggesting that plant noise levels should not exceed a noise rating level of NR 35. For typical building services installations, this noise rating level would approximately equate to a sound level of around 41dB(A)[1]. Therefore, whilst the site is not considered to be in a low noise area, it can be seen that, based on Camden's local plan guidance, the absolute level of the installed plant would not be expected to have a material adverse impact on neighbouring dwellings.

6.11 In light of the above, noise emissions from the plant are not considered to cause any material harm to the closest dwellings (flats above 3 Hampshire Street) and are compliant with national noise and planning policy objectives.

Noise Emissions to 215-225 Camden Road

6.12 A slightly lower noise rating level (38dB L_{Ar}) is calculated at the rear of 215 – 225 Camden Road.

6.13 Based on the typical background sound level of 48dB $L_{A90,15mins}$, it is concluded that:

- The rating level of plant noise would be 10dB below the typical background noise level;
- The rating is significantly lower than a value at which BS 4142: 2014 indicates that a low impact would be expected;
- The rating level would comply with the definition of LOAEL set out in Camden's adopted Local Plan;
- The absolute value would be below Camden's precautionary recommendations for more stringent control in areas characterised by low noise levels.

[1] Guidance in Annex B of BS 4142: 2014: *"Guidance on Sound Insulation and Noise Reduction for Buildings"* indicates that the dB(A) sound level can be determined by the approximate dB(A) = NR + 6.

6.14 In light of the above, noise emissions from the plant are not considered to cause any material harm to the closest dwellings (dwellings at 215-225 Camden Road) and are compliant with national noise and planning policy objectives.

Vibration

6.15 The condenser units are mounted on a conventional “Unistrut” support system as shown in **Figure 6.1** below:

Figure 6.1: Condenser unit

6.16 Given the design of the building, it is considered unlikely that the operation of the units would give rise to adverse structureborne noise and vibration transmission and it is understood that Fashion Nation UK Limited are unaware of any complaints or concerns that have been raised by their neighbours.

6.17 Notwithstanding this, it would be possible from an engineering point of view to introduce a resilient vibration isolation/noise stop pad and bolt isolation to the existing arrangement, which could further minimise any risk to the flats above 3 Hampshire Street. Whilst this is not considered necessary, if the LPA consider that the introduction of such works was technically justified, this could be controlled and enforced through the use of an appropriate planning condition.

6.18 Given that dwellings at 215-225 Camden Road are on the opposing side of the car park, there is no material risk of structureborne noise and vibration transfer to these properties.

7 Planning Control

7.1 Based on the above analysis, it is concluded that noise emissions from the existing plant installations complies with national and local planning policy objectives and should not constitute a reason for refusal of the retrospective planning permission being sought for the retention of the plant.

7.2 However, the conclusions set out in this report are based on an assumption that the plant will only operate between 08.00 and 18.00 hours (in line with existing operations). As such, it would be reasonable for the LPA to impose a planning condition restricting the operation of the plant in line with these hours, to prevent the potential for an adverse impact that could be caused by the plant operating at other times when background noise levels may be lower.

7.3 As noted earlier, whilst it is considered unlikely that the installed equipment poses any significant concern in relation to potential structureborne noise and vibration, if the Council considered that the concern expressed in their letter of 23 May 2018 was justified, this could be controlled and enforced through the use of an appropriate planning condition requiring the retro-fitting of appropriate vibration isolation.

7.4 In light of the above, the existing plant installations are considered compliant with national noise and planning policy objectives.

8 Conclusions

8.1 Comparative noise measurements and calculations have been undertaken to determine the specific level of plant noise at residential properties closest to and neighbouring the existing plant installations.

8.2 Automated noise monitoring has also been undertaken to determine typical background noise levels characterising the site during the current operational hours of the plant.

8.3 The potential acceptability of plant noise has been assessed in accordance with the guidance of BS 4142: 2014 and the London Borough of Camden's standard noise control policy requirements, as set out in their adopted Local Plan.

8.4 It is concluded that noise emissions from the plant should not cause any material harm to existing residential receptors.

8.5 Whilst structureborne noise and vibration from the plant is considered unlikely to pose any material risk of an adverse impact, such transmission could be controlled through the use of an appropriate planning condition, if the Council considered that the concern expressed in their letter of 23 May 2018 was justified.

8.6 It is concluded that noise and vibration associated with the existing plant installations is controlled in line with national and local planning policy objectives and should not constitute a reason for refusal of the retrospective planning permission being sought for the retention of the plant.

APPENDIX A

Glossary of Acoustic Terminology

GLOSSARY OF ACOUSTIC TERMINOLOGY

General

A vibrating surface or turbulent fluid flow will cause pressure fluctuations in the surrounding air. These pressure fluctuations are perceived by the human ear as “sound”.

Measurement Units

The human ear can detect sound pressures as low as about 20 µPa, and can tolerate (for short periods) sound pressures as high as 200 Pa, an amplitude range of 10 million times. To take account of this huge amplitude range, sound pressure levels (often written in “acoustic shorthand” as SPL or Lp) are quantified using a logarithmic scale, the decibel (dB) scale. This is based on a reference pressure of 20µPa, thus a sound pressure of 20µPa would equate to 0dB and a pressure of 200Pa would equate to 140dB.

Frequency (Pitch) Characteristics

The sound received at any particular location is not solely influenced by the sound pressure level, the frequency characteristics (pitch) of the noise is also an important factor. Noise audible to a human (with “normal” hearing), typically covers the frequency range 20 Hertz to 20,000 Hertz. Hertz (Hz) are defined as the number of times the sound pressure fluctuates in one second. “Low” pitched sounds fluctuate less times per second than “high” pitched sounds. Whilst humans are capable of detecting a wide range of frequencies, the ear is not equally sensitive to all frequencies – the ear is most sensitive at frequencies towards the middle of the audible range and less sensitive to the lower and higher frequencies.

To take account of this frequency response, sound pressure fluctuations are normally quantified by applying a frequency-weighting network or filter which simulates the frequency response of the ear. In essence, this means that more significance is given to the frequencies at which the ear is most sensitive and less significance to those at which the ear is less sensitive. Noise measurements relating to human reaction are generally made using an “A-weighting” network. These measurements are reported as A-weighted decibels or dB(A). The A-weighted sound pressure level is written in “acoustic shorthand” as L_A.

Variation of Sound with Time

It will be appreciated that the sound pressure level of most noise sources will fluctuate with time. In order to take account of the way in which the human ear perceives noise, it is normal for the sound pressure level to be quantified using a time weighting network, to mimic the speed of response of the human ear. The standardised setting for most types of noise is a “Fast” time weighting.

The manner in which sound fluctuates with time can also influence the subjective manner in which noise is perceived. Noise can be continuous (showing no significant variation with time as in the case of a fan), intermittent (i.e. the noise is transient in it’s nature, such as a train pass-by) or impulsive (i.e. there is a sudden build up of noise - this can range from “clanking” types sounds as might be experienced next to railway goods yard or a high energy discharge such as an explosion)

Measurement of Sound

Sound pressure levels are measured using equipment comprising a pressure-sensitive microphone, associated amplifier, frequency weighting network, time weighted network and output indicator. In its simplest form this is a small hand-held instrument called a sound level meter. More sophisticated instrumentation (a sound level analyser) is also available which allows the real-time output of the frequency characteristics of the sound to be quantified.

Comparison of Sound Levels

To put the significance of noise measurement into context, the following Table presents the A-weighted sound pressure level of some typical sources:

Sound Pressure Level, dB(A)	Typical Noise Source . Activity
160	Saturn Rocket Taking Off
140	Military Jet Taking Off at 30m
100	Nightclub
90	Heavy goods vehicle driving past at 7m
80	Busy urban road
70	Domestic vacuum cleaner at 3m
60	Busy office environment
55	Normal speech at 1m
40	Whispered conversation at 2m
30	Bedroom at night (BS 8233: 1999)
20	Remote country location
0	Threshold of hearing – a very eery silence

Addition of Sound Levels

It is important to note that the use of a logarithmic scale to describe noise does not allow normal arithmetic addition. This means that two noise sources each generating a level of, say, 60dB(A) will not generate a combined sound level of 120dB(A). The values must be added logarithmically, which would actually yield a combined sound level of 63dB(A) in this example.

Subjective Perception of Sound Levels Changes

With regard to the human perception of sound level changes, the human ear:

- Cannot generally perceive a sound level difference of less than 3dB(A)
- Will perceive a sound level difference of 4-5dB(A) as “noticeable”
- Will perceive a sound level difference of 10dB(A) as a doubling (or halving) of loudness.

Acoustic Terminology

As stated previously, most sources of noise will fluctuate with time. In order to characterize such noise, it is therefore normal to represent the noise climate using a variety of noise parameters and statistical indices. The most commonly adopted noise parameters are described below:

$L_{Aeq,T}$ This is the equivalent continuous A-weighted sound level measured over a specified time period "T". This is the notional continuous sound level which, over the time T, contains the same amount of energy as the actual fluctuating sound being measured. This parameter is widely accepted as being the most appropriate noise descriptor for most environmental noise and the effects of noise on humans.

$L_{Amax,fast}$ This is maximum A-weighted sound pressure measured with a fast frequency response recorded during the stated measurement period. It is typically used to characterise the highest sound level caused during a noise event.

$L_{A90,T}$ This is the A-weighted sound pressure level exceeded for 90% of the specified time period "T". It is normally used to describe the underlying background noise level of an environment since it inherently excludes the effects of transient noise sources.

Noise Rating (NR) Level

When describing noise from building services installations, it is common to express noise levels in terms of a Noise Rating (NR) Level. The NR level is determined by plotting the measured frequency spectrum of a noise against a series of reference curves, which roughly approximate to equal loudness values. This method permits higher sound levels at low frequencies corresponding to the sensitivity of the human ear. The NR level is defined as the value of the highest curve "touched" by the plotted frequency spectrum. For typical sources of building services noise, the overall A-weighted sound level is numerically around 5-6dB higher than the NR level of the noise.

Airborne Sound Insulation Measurement Parameters

The ability of a building element to reduce airborne noise can be described by a number of different parameters relevant to both laboratory and on-site performance evaluation. In general, the higher these values, the better the resistance of the construction to the transmission of airborne sound. The most commonly used parameters include:

R_w The **"Weighted Sound Reduction Index"** (R_w) is a single value measure of the intrinsic sound reduction capabilities of a construction, as measured in an acoustic laboratory. Measurement values are determined in accordance with the BS EN ISO 10140 series of standards and weighted in accordance with BS EN ISO 717-1: 2013.

R'_w The **"Weighted Apparent Sound Reduction Index"** (R'_w) is a single value measure of the apparent sound reduction capabilities of a construction, when installed on-site (which will normally be some way lower than the laboratory value due to less favourable installation conditions, the quality of workmanship, etc.). Measurement values are determined in accordance with the BS EN ISO 10140 series of standards and weighted in accordance with BS EN ISO 717-1: 2013. In practice, the R'_w of a construction can only be reliably determined if "direct" sound transfer through the partition can confidently be taken as the dominant noise transfer path (i.e. there is no "flanking" sound transmission.

D_w The **"Weighted Sound Level Difference"** (D_w) is a single value measure of the on-site sound reduction between two rooms. This value inherently includes "direct" sound transmission through any separating construction and "flanking" transmission through other building elements. Measurement values are determined in accordance with BS EN ISO 140-4: 1998 (for Building Regulations compliance purposes) or BS EN ISO 16283-1: 2014 and weighted in accordance with BS EN ISO 717-1: 2013.

$D_{n,fw}$ The "**Weighted Normalised Flanking Level Difference**" ($D_{nf,w}$) is a single figure measure of the sound reduction between two rooms solely due to sound transmission through a specified flanking path. This parameter is frequently used to provide an indication of the sound reduction capabilities of suspended ceiling and raised access floor constructions where there is common void between adjacent rooms or as a measure of sound that may be transmitted between rooms through external curtain walling. Measurements are undertaken in accordance with BS EN ISO 10848-2: 2017 and weighted in accordance with BS EN ISO 717-1: 2013.

Impact Sound Insulation Measurement Parameters

Some building elements also have the potential to generate "impact" noise, for example due to human "footfall" on floor structures, or the impact of rainfall on lightweight roofing components. A variety of parameters are again available to define the amount of noise likely to be generated. In general, the lower these values, the less sound the construction will generate as a result of impacts. Typical measurements parameters include:

$L_{nT,w}$ The "**Standardised Impact Sound Pressure Level**" is a "single number" rating describing the intrinsic impact sound insulation capabilities of a construction (such as a floor system) as measured in an acoustics laboratory. Values are determined in a vertical sound transmission suite by locating a "tapping machine" in the upper room of the suite and measuring the amount of sound radiated by the floor in the room below. Measurement values are determined in accordance with the BS EN ISO 10140 series of standards and weighted in accordance with BS EN ISO 717-2: 2013.

$L_{nf,w}$ The "**Normalised Flanking Impact Sound Pressure Level**" is a "single number" rating describing the amount of flanking sound that would be transmitted to an adjoining space (separated by a partition) due to impacts on the test sample. It is, for example, used to indicate the amount of noise that may be generated due to footfall noise on a raised access floor system. Values are determined in a horizontal sound transmission suite by locating a "tapping machine" one side of a separating partition built off the test sample and measuring the amount of noise radiated by the floor in the adjoining space on the other side of the partition. Measurement values are determined in accordance with BS EN ISO 10848-2: 2017 and weighted in accordance with BS EN ISO 717-2: 2013.

Room Acoustic Measurements

T The "**Reverberation Time**" (T) of a room is defined as the time taken for the sound energy produced by a source Time (RT)to decay by 60 dB after the source has been switched off. The reverberation time of a space can be calculated by considering the volume of the room and the areas and sound absorption qualities of room surface finishes. Small, "soft" rooms tend to give low reverberation times, whilst large, "hard" rooms tend to give long reverberation times.

α_p The "**Practical Acoustic Absorption Coefficient**" (α_p) is a measure of how much sound energy is absorbed by a building element at a particular frequency, as measured in accordance with BS EN ISO 354: 2003.

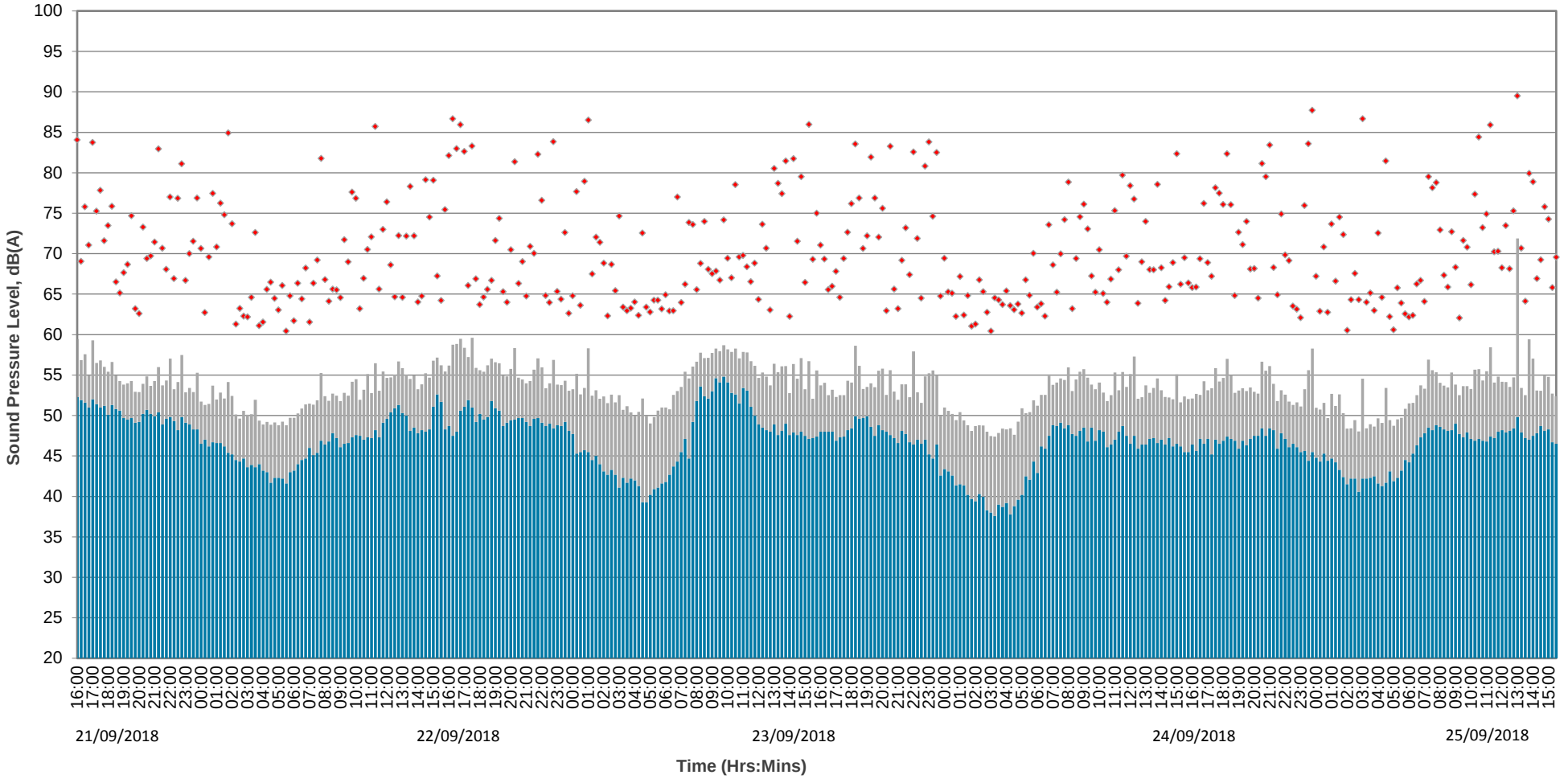
α_w The "**Weighted Absorption Coefficient**" (α_w) is a single figure measure of the overall sound absorption capabilities of a building element determined in accordance with BS EN ISO 11654: 1997.

APPENDIX B

Automated Noise Monitoring Data

Time History Graph A1

Project:	3 Hampshire Street
Measurement Location:	First Floor Residential Balcony
Survey Period:	21/09/2018 to 25/09/2018



KEY: $L_{A90,15mins}$ $L_{Aeq,15mins}$ $L_{Amax,fast}$

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