

Acoustics Planning Report
2 - 4 Whitworth Street

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Executive Summary

This Acoustics Planning Report has been prepared by Hilson Moran to accompany the planning application being submitted by the Applicant. The planning application is for a new Hotel located in Manchester city centre.

This document presents the results of environmental noise and vibration surveys at the proposed development Site and provides an assessment of the results in context of Manchester City Council's (MCC) noise requirements.

The surrounding area comprises a mixture of property types including; residential apartments, commercial office spaces, retail and leisure (including night-clubs), a train station and a tram stop.

It was found that ambient around the site are very high were dominated by sources comprising road traffic noise, rail traffic noise and entertainment noise from leisure venues. To the south of the Site is Deansgate Train Station and the associated railway viaduct. To the north of the Site is Whitworth St. West and the Deansgate Locks nightclubs.

Specific brand standards of the proposed hotel have not been considered as part of this assessment and therefore only the criteria set down by MCC were used as a basis of design.

MCC require that internal noise levels within habitable rooms including hotel guestrooms do not exceed 35 dB $L_{Aeq,16hour}$ during the daytime. During the night, the criteria are 30 dB $L_{Aeq,8hour}$ and 45 dB L_{AFmax} (not to be exceed more than 15 times during the night). MCC also have separate noise limit requirements for entertainment noise where internal noise levels within residential/hotel rooms in the 63Hz and 125Hz octave centre frequency bands shall not exceed of 47dB and 41dB L_{eq} respectively.

Preliminary sound insulation specifications applicable to the Proposed Development's external glazing have been established.

Using a secondary glazing system with a very high sound insulation performance it was found that the MCC criteria for entertainment noise will still be exceeded by 3 dB within the 63 Hz octave band. The glazing system used for assessment is considered representative of the highest practicable performance obtainable from glazing.

The MCC criteria for 35 dB $L_{Aeq,16hour}$ during the daytime and 30 dB $L_{Aeq,8hour}$ are considered achievable using a secondary glazing system. In addition, predicted internal ambient noise levels resulting from rail noise are predicted to be borderline with regard to the MCC night-time 45 dB L_{AFmax} noise limit.

By assessment it was determined that internal noise levels resulting from rail movements have two contributing paths, airborne noise via the façade, and groundborne vibration re-radiated noise transferred via the building structure. In order to sufficiently reduce the internal re-radiated noise levels, it is recommended that vibration mitigation is incorporated into the building structure.

MCC require an assessment of noise from fixed plant items to be introduced as part of the Proposed Development. It is recommended that the cumulative Rating Sound Level, $L_{Ar,Tr}$ does not exceed 5 dB below the typical Background Sound Level, $L_{A90,T}$ at the nearest Noise Sensitive Receptors. Receptors have been developed with daytime plant noise limits being 45 and 47 dB $L_{Ar,Tr}$ and night time limits of 52 and 47 dB $L_{Ar,Tr}$.

1. Introduction

Hilson Moran Partnership Ltd has been commissioned by Jones Lang LaSelle to undertake a noise and vibration assessment. The assessment is in support of a application to obtain full planning permission to redevelop the land currently occupied at 2 – 4 Whitworth Street West (split by Rowendale St), Manchester, M1 5WY (hereafter 'the Site') into a 6 floor hotel, with ground floor commercial use (Use Class A3/A5).

This report considers the Site's suitability for the nature of the proposed uses through measurement of existing noise and vibration levels affecting the Site, which have been used to carry out the following works:

- A preliminary façade sound insulation assessment to provide early indication of the necessary façade construction required to achieve appropriate internal noise levels. The assessment was conducted in accordance with, BS 8233:2014[1], WHO: 1999[2] and the planning requirements of Manchester City Council (hereafter referred to as MCC);
- Assessment of the degree to which the Proposed Development will be affected by tactile vibration (with reference to BS 6472:2008[3]) and structure borne re-radiated noise (SBN) (with reference to ANC guidance[4]) from train movements along the rail viaduct bounding the Site to the south;
- The setting of maximum noise emission limits to be met at the nearest noise sensitive receptors (NSRs) based on the results of the environmental noise survey and the plant noise requirements of MCC (with reference to BS 4142: 2014[5]). Future permitted residential developments have been considered in the identification of the NSRs; and
- Where necessary, provision of outline mitigation design advice to demonstrate how noise and/or vibration impacts may be satisfactorily controlled.

Appendix A presents an explanation of the acoustic terminology used within this report, whilst graphs showing the noise monitoring results are included in Appendix B.

[1] British Standards Institution (BSI) (2014); British Standard (BS) 8233 *'Sound insulation and noise reduction for buildings',* BSI.
[2] World Health Organisation (WHO) (1999); *'Guidelines for Community Noise'*, WHO, Geneva.
[3] BSI (2008); BS 6472 *'Guide to evaluation of human exposure to vibration in buildings (1Hz to 80Hz)'*, BSI, London.
[4] Association of Noise Consultants (ANC) (2012); *'Measurement and assessment of ground-borne noise and vibration'*, ANC.
[5] BSI (2014); BS 4142:2014 *'Methods for rating and assessing industrial and commercial sound'*, BSI, London.

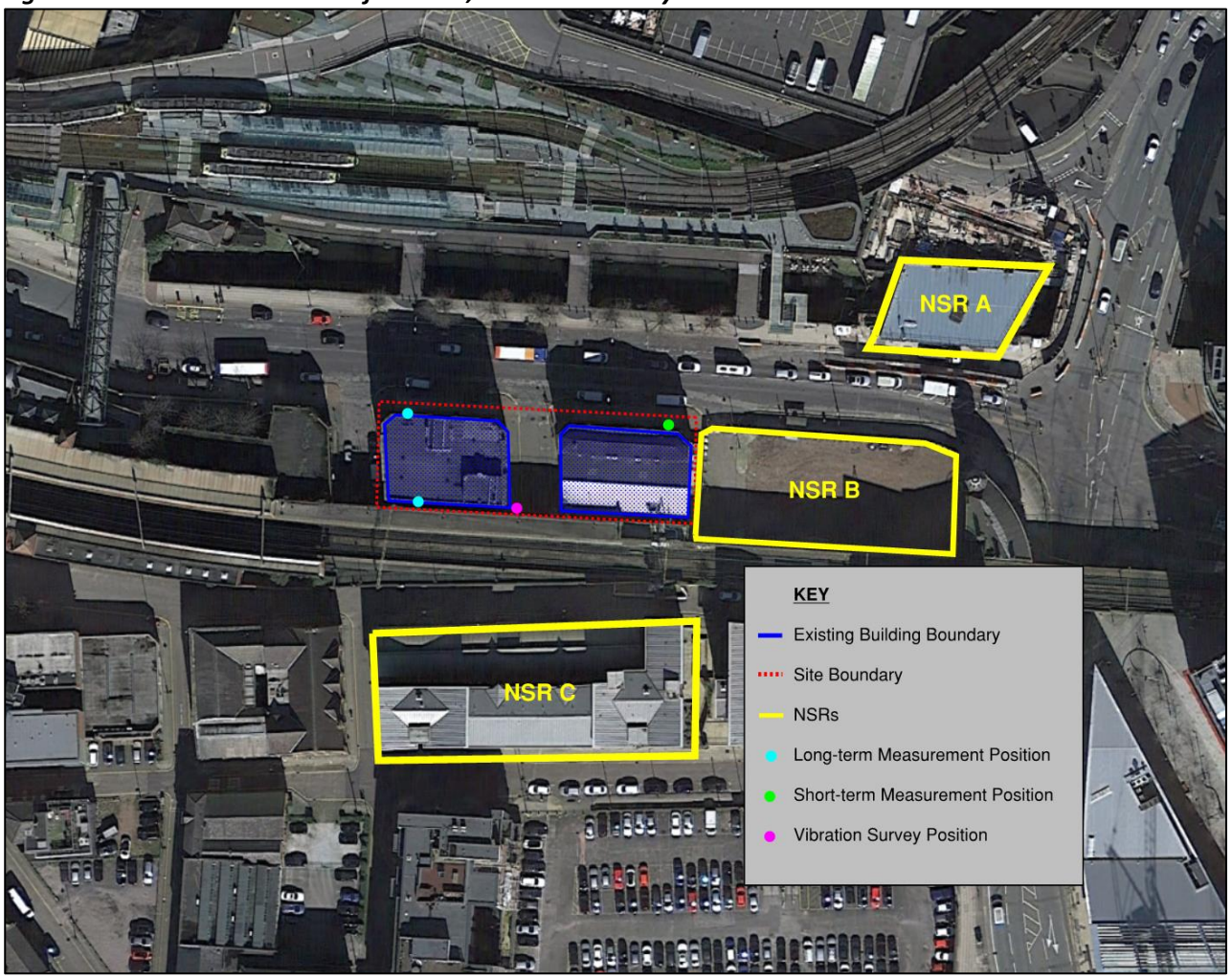
2. The Site and the Proposed Development

2.1. Site Description

The application Site (National Grid Reference: SJ 835975) is currently occupied by two buildings, one is occupied by a graphics company (no 4), whilst the other remains vacant (no 2). The Proposed Development will be situated adjacent to the platform of Deansgate Train Station to the south of the site, whilst Whitworth St West borders the north of the Site. Cameron St and Bugle St are located due east and west of the site respectively. Across the opposite side of Whitworth Street West is Deansgate Locks, a busy strip of late night bars and clubs. One late night club, Rebellion is located on the western side of the development adjacent to Deansgate Station.

A site location plan is provided as Figure 2.1, showing the location of the Site and orientation with respect to other existing developments, major transport links and identified NSRs.

Figure 2.1: Location Plan of the Site, NSRs and Survey Locations



2.2. Noise Climate Summary

The noise climate of the area is dominated by noise from road traffic flows along Whitworth Street West and train movements through Deansgate Station to the south of the site. Train movements through Deansgate Station are noted to comprise a mixture of passenger and freight trains travelling at varying speeds in both eastbound and westbound directions. Passenger trains through Deansgate Station typically run between 06:00 and 00:00 hours and so materially influence the night-time noise climate at the Site, particularly along the proposed southern facade. Freight trains were observed to run through the station regularly throughout daytime and night-time periods.

Road traffic flows along Whitworth Street West remain constant throughout much of the day, with particularly high volumes experienced during peak commuting periods. Evening and night-time noise climates are affected by entertainment noise emanating from the late night venues of Deansgate Locks directly to the north of the Site along with Rebellion Club directly west of the Site together with elevated traffic volumes associated with the collection of patrons of the entertainment venues.

2.3. Noise Sensitive Receptors

There are a number of existing and consented residential properties in the vicinity of the development that are considered to be noise sensitive. The closest NSRs are detailed in Table 2.1 and their locations are illustrated on the Site plan in Figure 2.1.

Table 2.1 Noise Sensitive Receptors

Receptor Location (Figure 2.1)	Name / Location	Approximate Distance to Site Boundary (m)
NSR A	Consented Axis Tower residential development bound by Rochdale Canal Tow Path and Albion Street	43
NSR B	Consented residential tower at 10-12 Whitworth Street West	14
NSR C	The Ropeworks residential development on Little Peter Street	24

3. Assessment Criteria

3.1. Noise

3.1.1. Environmental Noise Ingress – Hotel Rooms

Table 3.1 presents the noise ingress criteria applicable to the hotel rooms.

Table 3.1: Summary of Environmental Noise Ingress Design Limits

Organisation	External sources	Room Space	Internal Noise Level, dB(A)	
			Daytime (T=07.00 – 23.00 hrs)	Night-time (T=23.00 – 07.00 hrs)
MCC [1]	All sources	Bedrooms	35 dB $L_{Aeq,T}$	30 dB $L_{Aeq,T}$ 45 dB $L_{Amax,F}$ [2]
	All sources	Living rooms	35 dB $L_{Aeq,T}$	-

Notes: [1] It is understand that MCC planning criteria for environmental noise ingress is taken from BS 8233:2014 and WHO:1999, as stated in their Planning & Noise Technical Guidance document. [2] not to be exceeded more than 15 times per night-time by individual, regular noise events.

3.1.2. Entertainment Noise Ingress – Hotel Rooms

Noise from entertainment venues and nightclubs along Deansgate locks and Whitworth St West shall be controlled to achieve the following noise standards of MCC presented in Table 3.2.

Table 3.2: Summary of Entertainment Noise Ingress Design Limits

Organisation	Room Space	Noise Level, dB Leq	
		Daytime (07.00 – 23.00 hrs)	Night-time (23.00 – 07.00 hrs)
MCC	Habitable rooms	Internal noise levels in the 63Hz and 125Hz octave centre frequency bands shall be design to achieve internal levels of 47dB and 41dB respectively.	

3.2. Vibration

3.2.1. Tactile Vibration

Manchester City Council (MCC) recommend that the guidance provided within BS 6472-1: 2008 *Guide to Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration Sources Other Than Blasting*' is followed when evaluating the exposure.

Tactile vibration is that which is perceived as mechanical motion. Vibration is assessed in terms of the equivalent 'vibration dose value' (VDV in $m/s^{1.75}$), which relates to the level, the duration and the number of events through a daytime or night-time period.

The VDV levels set out in BS 6472-1, present the probability of adverse comment within residential buildings resulting from tactile vibration. The VDV categories in accordance with BS 6472-1 are presented in Table 3.3. The values are presented as ranges to reflect the differing susceptibility to vibration evident among members of the population.

Table 3.3: BS 6472-1:2008 Probability of Adverse Comment Due to Vibration

Vibration dose values (VDV in $m/s^{1.75}$) above which might result in various degrees of adverse comment within residential buildings			
Place and Time Affected	**Low Probability of Adverse Comment [1]**	**Adverse Comment Possible**	**Adverse Comment Probable**
Residential Buildings 16hr Day	0.2 – 0.4	0.4 – 0.8	0.8 – 1.6
Residential Buildings 8hr night	0.1 – 0.2	0.2 – 0.4	0.4 – 0.8

Notes: [1]BS 6472-1:2008 states that adverse comment is not expected for VDVs below these ranges.

3.2.2. Structure-Borne Re-Radiated Noise

SBN commonly originates from vibrating or impacting sources coupled to the building structure and occurs when surfaces re-radiate the vibration energy as noise. MCC do not provide specific criteria for vibration induced re-radiated noise. However, internal noise levels produced by external vibration sources have been considered cumulatively with noise ingress from external sources, as they are expected to occur at the same time.

As such, the internal ambient noise limits seen in Table 3.1 should be considered cumulative of all external sources including airborne and vibrating sources.

SBN from road traffic along Whitworth Street West is expected to be insignificant and imperceptible within any part of the Development. However, significant levels of SBN levels are anticipated to arise from train movements along the adjacent railway, day and night.

In order to facilitate a practicable façade design we propose SBN levels are controlled so as not to exceed 34 dB $L_{Amax,F}$ in any hotel bedroom. This gives headroom for contribution from airborne noise from rail noise which is significant at the Site.

3.3. External Building Services Plant Noise

It is understood, based on the information contained in MCC's Planning & Noise Technical Guidance document that the council require the following standards to be achieved in relation to the control of external building services noise.

'Externally mounted ancillary plant, equipment and servicing shall be selected and/or acoustically treated in accordance with a scheme designed so as to achieve a rating level of 5 dB (L_{Aeq}) below the typical background (L_{A90}) level at the nearest noise sensitive location.'

MCC specify that noise emissions from building services shall be assessed in accordance with BS 4142:2014, with the plant Specific Sound Level (notated $L_{Aeq,T}$) being corrected for acoustic features such as tonality, impulsivity and intermittency at the assessment location, thus establishing a Rating Sound Level (notated $L_{Ar,Tr}$).

To obtain BREEAM 2014 Credit *'Pol 05: Reduction of Noise Pollution'*, it is required that the noise level from the assessed building (as measured at the nearest noise sensitive receptor) is a difference no greater than +5 dB during the day (07.00 hr to 23.00 hr) and +3 dB during the night (23.00 hr to 07.00 hr) compared to the background noise level.

With reference to the above, through compliance with the MCC requirements, the less stringent BREEAM Pol 05 criteria would be achieved.

4. Baseline Conditions

4.1. Environmental Noise Survey

A comprehensive noise survey was undertaken at the Site in order to establish and quantify the existing noise climate at, and within the vicinity of the Site.

Long term unattended noise monitoring was undertaken over a four day period between Thursday 26th July and Monday 20th July 2018 at two key locations described in Table 4.1 and illustrated in Figure 2.1. Supplementary short term measurements were undertaken over 10 minute periods to establish the spatial variation of noise level around the Site, as described in Table 4.1 and illustrated in Figure 2.1. Short term measurements, undertaken 26th July were synchronised with the long term measurements.

Table 4.1: Description of Noise Survey Monitoring Positions

Monitoring Position	Description	Observations and Predominant Noise Sources
LT1 (Deansgate Station)	Measurements at the southern boundary of the Site adjacent to Deansgate Station platform. Microphone located at first floor level, approximately 1.5m from façade of existing building.	Noise from passing trains going through/ stopping at Deansgate Station dominates. Station noise such as PA systems also contribute to the noise climate. Contributory noise from road traffic along major roads, namely Whitworth Street West, A5103 and human activities in the area.
LT2 (Whitworth Street West)	Measurements at northern boundary of the Site, overlooking Whitworth Street West and Deansgate Locks. Microphone located at first floor level, approximately 1m from façade of existing building.	Dominated by road traffic noise from Whitworth Street West, with night-time levels affected also by noise from nightclubs of Deansgate Locks and associated human activities. Contributory noise from road traffic on local major roads.
ST1 (Whitworth Street West)	Measurement at North Eastern boundary of the Site, overlooking Whitworth Street West and Deansgate Locks. Microphone located on tripod 1.5m above ground floor level.	Dominated by road traffic noise from Whitworth Street West.

Noise measurements were undertaken in general accordance with the guidance given in British Standard BS 7445-1: 2001 *"Description and measurement of environmental noise – Part 1: Guide to quantities and procedures".*

All noise measurements were taken with a calibrated precision grade (Class 1) frequency (one-third-octave band) sound level meter. The sound level meters were set-up to record over consecutive 5 and 10-minute periods the L_{eq}, L_{90}, L_{10}, L_1 and L_{max} noise indices in the A-weighting network over 125 ms fast response time constant intervals for the duration of the survey. The indices are described in Appendix A of this report, but roughly translated they describe in turn the average, background, road traffic, maximum noise level excluding one off events and maximum noise levels. Full details of the instrumentation used for the noise measurements, including equipment calibration certificates can be provided upon request.

Weather conditions, whilst not actively measured during the survey period, were monitored remotely throughout. Overall, weather conditions were appropriate for the measurement of noise, it being mostly warm, clear and dry. Northerly and south-easterly winds predominated, being light to moderate, typically ranging between 1 to 10 m/s, with only occasional gusts noted. Neither the light rain nor occasional gusts of wind are considered to have adversely affected the noise monitoring results.

4.1.1. Baseline Environmental Noise Results

The full results of the baseline environmental noise surveys are displayed graphically in time-history format in Appendix B, whilst a summary of the measured daytime (07.00 to 23.00 hrs) and night-time (23.00 to 07.00 hrs) noise levels for the survey period are provided in Table 4.2.

Table 4.2: Summary of Baseline Noise Monitoring Results

Monitoring Position	Period	Duration	$L_{Aeq,T}$ dB	$L_{A90,T}$ dB	$L_{A10,T}$ dB	L_{AFmax} dB
			Ave(Max)[1]	10th %ile[2]	Ave[3]	Min – Max (95th %ile[4])
LT1 (Deansgate Station)	Day	16 hr	69 (75)	52	68	52 – 109(86)
	Night	8 hr	64 (73)	48	58	49 – 107(80)
LT2 (Whitworth Street West)	Day	16 hr	67 (74)	57	68	60 – 102(81)
	Night	8 hr	69 (75)	50	51	52 – 101(84)
ST1	Day	10 mins	66	59	69	55 – 85(71)

Notes: [1] Logarithmic average over the day / night periods (maximum measured $L_{Aeq,1hr}$); [2] The lowest 10th percentile $L_{A90,1min}$ value is presented, which is considered representative of the typical lowest daytime / night-time background levels experienced; [3] Arithmetic average over the day / night periods; [4] The 95th percentile $L_{AFmax,1min}$ value presented and considered representative of typical L_{AFmax} levels experienced. All figures are rounded to the nearest whole decibel.

4.1.2. Entertainment Noise Results – Deansgate Locks

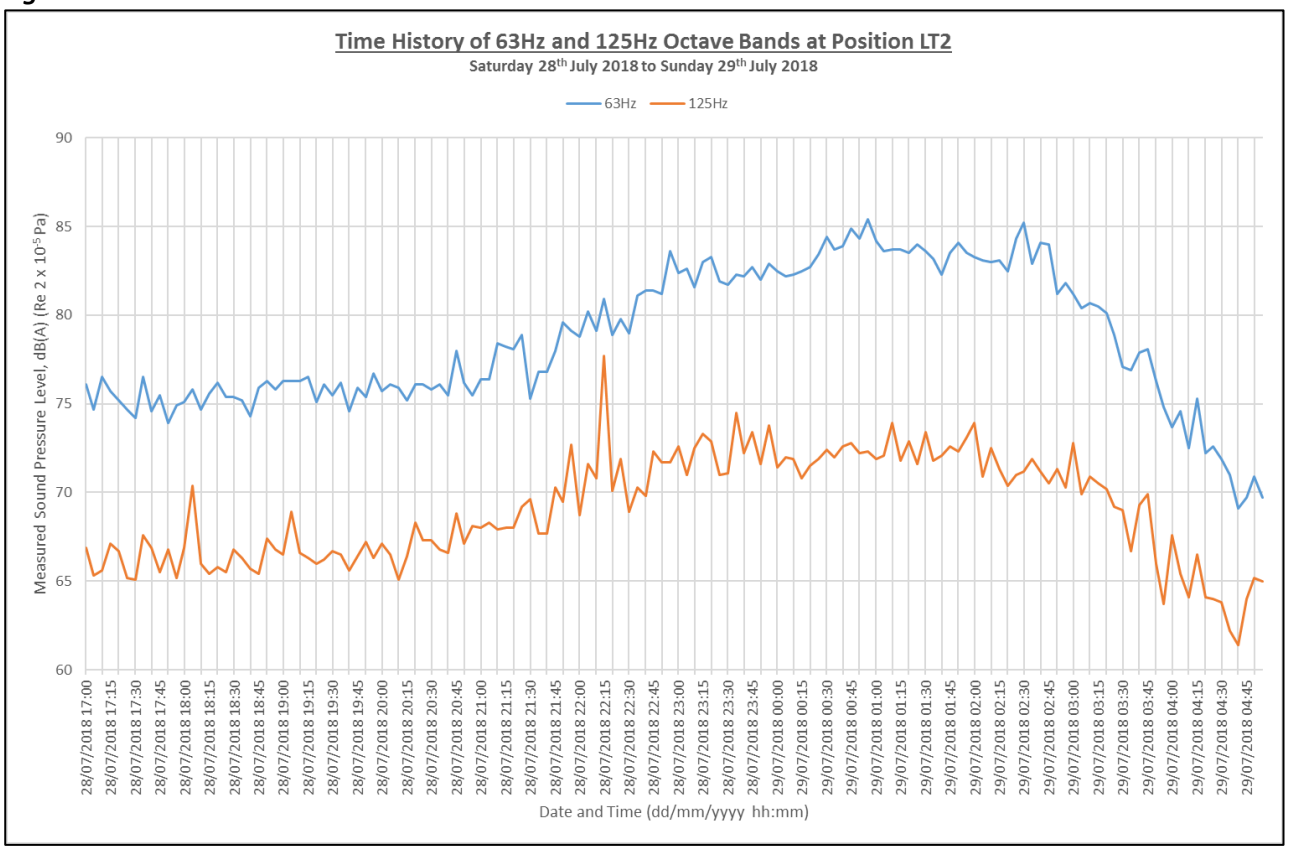
Entertainment noise levels have been established using the data captured at position LT1 and account for all major entertainment noise sources, including the venues along Deansgate Locks and the adjacent Rebellion club. Noise levels were measured during the nights of Friday 27th July, Saturday 28th July 2018 and early morning hours of Sunday 29th July 2018. The Saturday night and the early hours of the Sunday are considered the busiest night-time period with respect to activities generating entertainment noise. The captured levels are considered representative of a typical weekend period.

During the operation of the night clubs, high volumes of traffic and human activities are typically present along Whitworth Street West. In order to establish the noise levels solely from entertainment noise sources, the measured data has been corrected for the presence of residual noise sources in the area.

Noise levels measured between 23:00 and 03:00 hours were chosen to represent levels heavily influenced by entertainment and residual noise sources, whilst noise levels between 21:00 and 22:00 hours were chosen to represent residual noise levels without contribution from entertainment sources.

In selecting appropriate representative time periods, the measured noise levels (L_{eq}) in the 63 Hz and 125 Hz octave bands were analysed between 17:00 hours and 03:00 hours and are presented in Figure 4.1. Upon review, the time at which low frequency entertainment noise becomes dominant is clearly identifiable and as such the selected time periods are considered appropriate. A-weighted entertainment noise levels at measurement location LT2 can clearly be seen in Appendix B.

Figure 4.1: Measured Noise Levels in 63Hz and 125Hz Octave Bands at Location LT2



Based on the above, Table 4.3 presents the entertainment noise levels (L_{eq} and $L_{max,F}$) predicted to be incident on the façade of the proposed building. The $L_{max,F}$ levels are assumed to be dominated by entertainment noise sources such that no corrections have been made for residual noise.

Table 4.3: Summary of Measured Entertainment Noise Levels

Parameter	Measured Sound Pressure Level (dB) at Octave Band Centre Frequency (Hz)							dBA
	63	125	250	500	1k	2k	4k	
L_{eq}	80	67	64	64	64	61	43	68
$L_{max,F}$	91	78	74	75	72	77	83	86

4.2. Vibration Survey

Attended vibration measurements were undertaken at the Site on the 26th July adjacent to the railway viaduct, as illustrated in Figure 2.1.

Vibration measurements were undertaken in general accordance with the guidance given in British Standard BS 7385-1: 1990 *"Evaluation and measurement for vibration in buildings – Part 1: Guide for measurement of vibrations and evaluation of the effects on buildings"*.

A summary of captured baseline vibration acceleration levels used for the purposes of assessment can be seen in Figure 5.1.

5. External Noise & Vibration Ingress

5.1. Noise Intrusion

On the basis of the measured noise levels as presented in Table 4.2 and the design criteria summarised in Section 3.1, calculations have been undertaken to establish the minimum sound reduction specification for the residential facades.

The measured noise levels have been corrected as follows:

- Minus 2 dB to account for reflections from the existing façade constructions during the measurements, based on the methodology in British Standard (BS) 8233:2014, to establish free-field noise levels;

The following drawings were used for the purposes of calculation:

- 2068-A-SK-180813-02

External noise ingress calculations are dependent upon façade element sizes, the proposed façade constructions and internal room dimensions. The predicted overall performance of the non-glazed façade is R_w 65 dB, the build-up assumed for our calculations is as follows:

- Outer panel of 100 mm concrete (min density 2,340 kg/m^3)
- Average 100 mm cavity with full fill insulation (min 10kg/m3)
- Inner panel of 150 mm concrete (min density 2,340 kg/m3)
- An independent lightweight lining system comprising 35mm cavity with 25 mm APR 1200 (or equivalent) finished with one layer of 12.5 mm Gyproc Soundbloc (min 10.6 kg/m2).

It has been assumed in our calculations that there are no rigid connections between the outer and inner concrete panels. Ceiling heights of 2.6m have been assumed. It is understood that the northern and southern facades are the only facades which contain glazing. Glazing areas to all rooms have been limited to no more than 2m^2 and windows are to be sealed.

In order to achieve MCC criteria a high performance secondary glazing system is required. From calculation, the system construction that is capable of meeting the necessary criteria comprises the following:

- 6mm/10mm/6mm (glass/air/glass) primary unit
- 200mm lined cavity
- 6mm float glass.

The above construction has an overall system performance of 54 dB R_w. However, it should be noted that the individual octave band performances of the glazing system should be considered as well as the overall system performance when deviating from the above construction.

Based on our calculations, the majority of noise ingress limits are achieved but minor exceedances (2 – 5 dB) of the most onerous requirements relating to individual rail events and entertainment noise are predicted. We feel this is inevitable given the noise constraints of the site. Furthermore, given the development's commercially desirable location, we would consider there to be reasonable grounds upon which to deviate from MCC's requirements.

Table 5.1 provides a summary of the predicted exceedances of the target criteria.

Table 5.1: Summary of MCC Criteria Exceedances

Organisation	Façade	Related External Source	Criteria	Predicted Exceedance
MCC	North (Whitworth Street West)	Entertainment noise	Entertainment noise levels L_{eq} of 47 dB and 41 dB in the 63 Hz and 125 Hz octave bands, respectively	3 dB exceedance in the 63 Hz octave band (50 dB)

The MCC criteria for entertainment noise aims for inaudibility / virtual inaudibility in the 63Hz and 125Hz octave bands within the habitable rooms. Based on our analysis of the entertainment levels affecting the site, achievement of inaudibility is not considered practicable in this lively part of Manchester. In-audibility could only be achieved with the introduction of box-in-box constructions installed in conjunction with extreme glazing systems, typical of recording studios. It can be seen that a minor exceedance (3 dB) of the MCC entertainment noise limit at 63 Hz is predicted. The exceedance of the limits is considered to be acceptable based on the following points:

- An exceedance of 3 dB is generally considered to be within design tolerances and subjectively such changes in low frequency noise would be barely noticeable, if at all,
- The internal noise from building services would likely be designed to a level no less than NR 25, the reference curve of which has a value of 55 dB at 63 Hz. The predicted internal entertainment level is therefore 5 dB below the internal NR level at 63 Hz in hotel bedrooms, resulting in a 1 dB increase when combined with the ambient noise climate in lieu of entertainment noise sources. Such changes in noise level are widely considered imperceptible.

Using building services noise to mask the entertainment noise has been discussed with and agreed to in principle by Laura Miller, MCC's environmental health officer covering the development.

It is understood that guestrooms will be mechanically ventilated and cooled, with no passive wall openings. Where mechanical systems intake/discharge from the building envelope, suitable levels of in-duct attenuation should be applied to control levels of noise ingress via the ventilation system.

It should be highlighted that apart from the discussed criteria in Table 5.1, the remaining criteria detailed in Table 3.1 are considered achievable based upon the above outlined design.

Consideration should also be given to the Agent of Change Principle within the NPPF2. This states that planning policies and decisions should ensure that new developments can be integrated effectively with existing business including entertainment and leisure venues.

The measures and approaches outlined in this report, highlight that the scheme can be developed so that the surrounding established uses are unlikely to be impacted in terms of noise disturbance.

5.2. Vibration

5.2.1. Tactile Vibration

Using measured baseline vibration and noise data, predictions could be made for levels of tactile vibration within the currently proposed most exposed guestrooms. Baseline vibration data was captured at the foot of a railway viaduct arch adjacent to the proposed development on the eastern side of Deansgate Station. Measurements captured vibration levels from passenger and freight train movements along both east-bound and west-bound tracks.

In addition to the data captured for the Proposed Development, Hilson Moran also have an extensive amount of vibration data captured at the adjacent site, 10-12 Whitworth St. This data was used to supplement the captured data at the Site.

Assessments have been based on the following building characteristics:

- Coupling corrections between the ground and foundations and from the foundations into the superstructure
- Bedrooms located on the first floor of the building
- A concrete framed building
- Masonry piles

Vibration levels differ between train movements depending largely upon the following factors:

- Mass of train/bogies/carriages
- Length of train
- Speed of train
- Track conditions
- The track which the train is travelling along

The number of vibration events impacts the overall VDV and as such, the number of vibration events was based on the amount of train movements. The amount of movements was established by evaluating weekday noise monitoring data, from which, train events can be identified. During the detailed design stages, it is recommended that timetable data and potential future changes to the timetable is obtained from Network Rail via the Freedom of Information Act.

It was found that loaded freight trains produced the highest levels of vibration, in particular aggregate freight train movements. The predicted VDV values for both passenger and freight movements have been combined to give predicted typical day and night VDV levels as seen in Table 5.2 below.

Table 5.2: Predicted VDV Levels

Period	VDV $m/s^{1.75}$
Day (07.00 – 23.00)	0.09
Night (23.00 – 07.00)	0.07

It can be seen that the VDV upper limits seen in Table 3.4 can be achieved without the need for mitigation.

5.2.2. Vibration Induced Re-radiated Noise

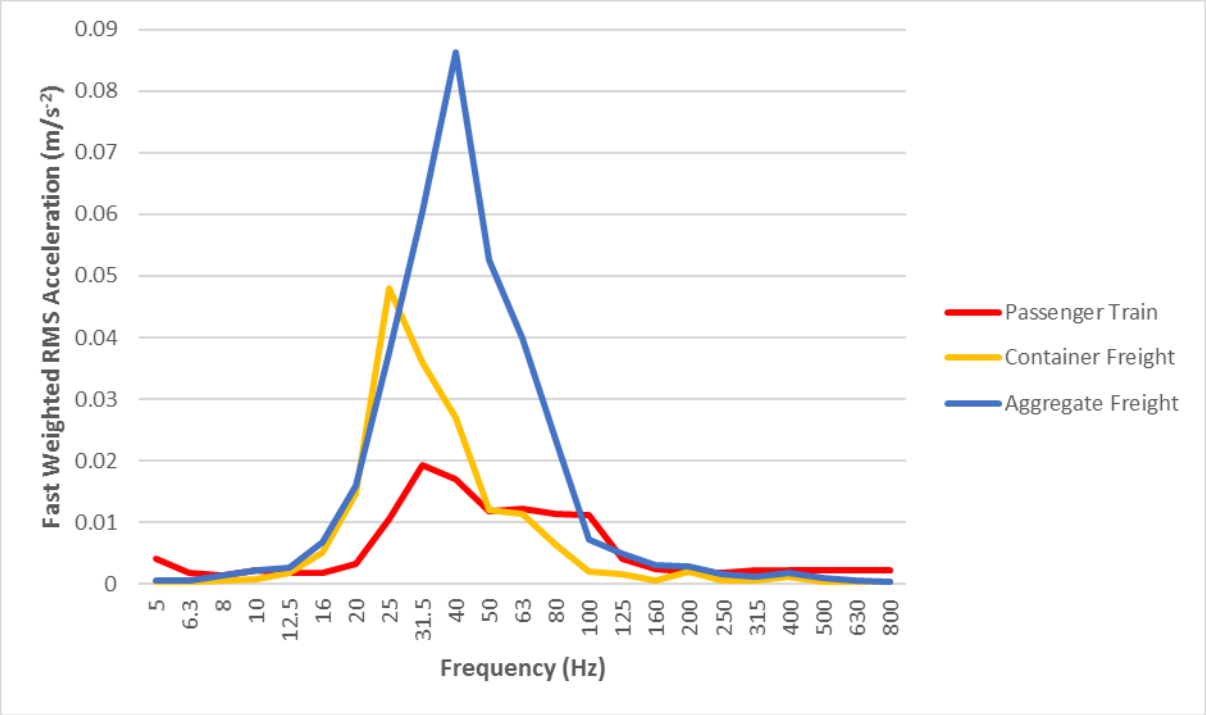
Using captured baseline vibration data, predictions were made for the level of vibration induced SBN within the most exposed guestrooms. Calculations for SBN were based on the following factors:

- Floor area of approximately $17m^2$

- Masonry piles
- A concrete framed building
- Plasterboard soffit, carpet floor finishes
- Low amplitude transfer corrections for floor slabs (the extent to which floors respond to incoming vibration, largely dependent on construction and floor spans)
- Bedrooms located on the first floor of the building
- Coupling corrections between the ground and foundations and from the foundations into the superstructure
- Calculations have also been corroborated using the ANC method based on the amplification factors in the Transportation Noise Reference book.

The SBN level assessment has been based upon the captured L_{Fmax} vibration data since the L_{Fmax} target criterion seen in Table 3.1 is the most onerous to achieve. Figure 5.1 below presents the fast weighted maximum RMS acceleration values captured for a series of typical train movements. These values formed the basis of the re-radiated noise predictions.

Figure 5.1: Captured Vibration Levels



In addition to ANC's *Transportation Noise Reference* book, empirical formula from *A Prediction Procedure for Rail Transportation Ground-borne Noise and Vibration – Nelson 1987* and *Handbook for Urban Noise and Vibration Control – Saurenman, Nelson, Wilson* were also used.

The acceleration levels detailed in Figure 5.1 were converted to decibels (ref $1x10^{-6}$) in order to calculate re-radiated noise levels. The ground floor is anticipated to be double height, with guestrooms being located on the first floor. Therefore an appreciable loss of approximately 3 dB can be expected between ground and first floor.

The empirical prediction methods outlined above were not developed for high rise deep piled buildings with high structural loadings. As such, where results are borderline or where vibration mitigation is not desirable, finite element modelling could be undertaken to assess in detail the likely propagation of vibration through the building.

Table 5.3 below presents the predicted re-radiated noise levels within a 1st floor guestroom on the southern façade of the building.

Table 5.3: Predicted SBN Levels

Train Movement Along Nearside Line	Predicted Approximate SBN Level dB L_{Afmax}
Passenger Train	40
Container Freight Train	44 – 45
Aggregate Freight Train	49 – 50

The levels seen in Table 5.3 are based on the typical worst case movement for each type of train. However, it is anticipated that most train movements will exceed the target SBN level of 30-32 dB L_{Afmax}.

The MCC criteria is less onerous allowing up to 15 exceedances over 45 dB L_{AFmax} during the night-time. When the cumulative effect of airborne noise ingress is considered, the target for SBN to meet the MCC criteria should be 15 exceedances over 40 dB L_{AFmax}.

Using the profiles of captured noise data obtained between the 26th and 30th of July 2018 it was possible to determine the type of train movement.

There are approximately 10-12 freight movements per typical weekday night-time period (23.00 – 07.00) and more passenger rail movements, therefore it is also likely that 40 dB L_{AFmax} will be exceeded more than 15 times. When the SBN level is combined with the airborne façade ingress level it is unlikely that the MCC criteria will be met without any vibration mitigation, i.e. there are likely to be 15 or more exceedances of 45 dB L_{AFmax}.

Due to the empirical nature of predicting SBN levels within buildings there is a degree of uncertainty to the results. Therefore calculations and assumptions have been treated conservatively reducing the likelihood of actual SBN levels being higher than those reported in Table 5.3.

5.2.3. Vibration Mitigation Measures

It is recommended that building vibration mitigation is incorporated into the scheme. Introducing mitigation into the scheme will decrease the levels of vibration induced re-radiated noise in dB L_{AFmax}. The following vibration mitigation proposals should be explored for the scheme.

- Building vibration isolation typically using an isolating layer between the piles and the cast ground floor slab
- Elastomeric bearings
- Independent isolation for floors throughout the building, similar to a jack-up floor system
- Further detailed analysis using finite element (FE) model analysis, which provides more accurate results but requires detailed information and time to conduct

Considering the internal noise levels predicted from vibration induced SBN it is likely the FE analysis will still confirm that vibration mitigation is required in order to control the internal ambient noise levels.

The empirical predictions contained within this report indicate that the MCC criterion may just be exceeded without mitigation. However, FE modelling may reveal that the MCC criterion is achievable without the need for vibration isolation.

6. Building Services Plant Noise Limits

At this stage in the design of the Proposed Development, specific fixed building services plant details are not sufficiently developed to undertake noise predictions to determine the significance of the likely effects (e.g. the type, number and configuration of plant are not known). Consequently, suitable plant noise emission limits have been set based on surveyed background (L_{90}) noise levels (Section 4.1) and the plant noise requirements of MCC (Section 3.3).

The noise limits to which fixed building services plant should adhere have been set and are presented in Table 6.1.

Table 6.1: External Building Services Plant Noise Limits

Noise Sensitive Receptor	Period	Background Noise Level, dB $L_{A90,T}$ [1]	Plant Noise Limit, dB $L_{Ar,T}$ [2]
NSR A	Daytime (07:00 – 23:00)	50	45
	Night-time (23:00 – 07:00)	57	52
NSR B & C	Daytime (07:00 – 23:00)	52	47
	Night-time (23:00 – 07:00)	48	43

Notes: [1] The lowest 10th percentile $L_{A90,10}$ min is presented, which is considered representative of the typical lowest daytime / night-time background levels experienced; [2] Expressed as a plant Sound Rating Level in accordance with BS 4142:2014.

The plant noise limits apply to the total contribution of noise from all external plant items associated with the Proposed Development that may run during any particular period and are to be met at 1 m from the nearby NSRs.

In respect of emergency generation plant (e.g. standby generators) and life safety plant (e.g. smoke extracts), it is recommended that noise emitted from this plant should be designed to not exceed 10 dB above the lowest background noise level (expressed as the lowest 24 hour $L_{A90,15min}$) 1 m outside any noise sensitive premises. Testing times of emergency plant should only be carried out for up to one hour in a calendar month and only between 09:00 and 17:00 hours Monday to Friday and not at all on bank or public holidays.

Given the nature of the development and likely fixed plant to be installed, the limits seen in Table 6.1 are considered to be achievable.

Appendix A – Acoustic Terminology

This document provides a layperson's explanation of the acoustics terms that commonly appear in reports. It is not intended to give full scientific definitions and explanations or go into detail on how and why things are as they are. Some obsolete terms and abbreviations have been included as they still appear in documents from time to time.

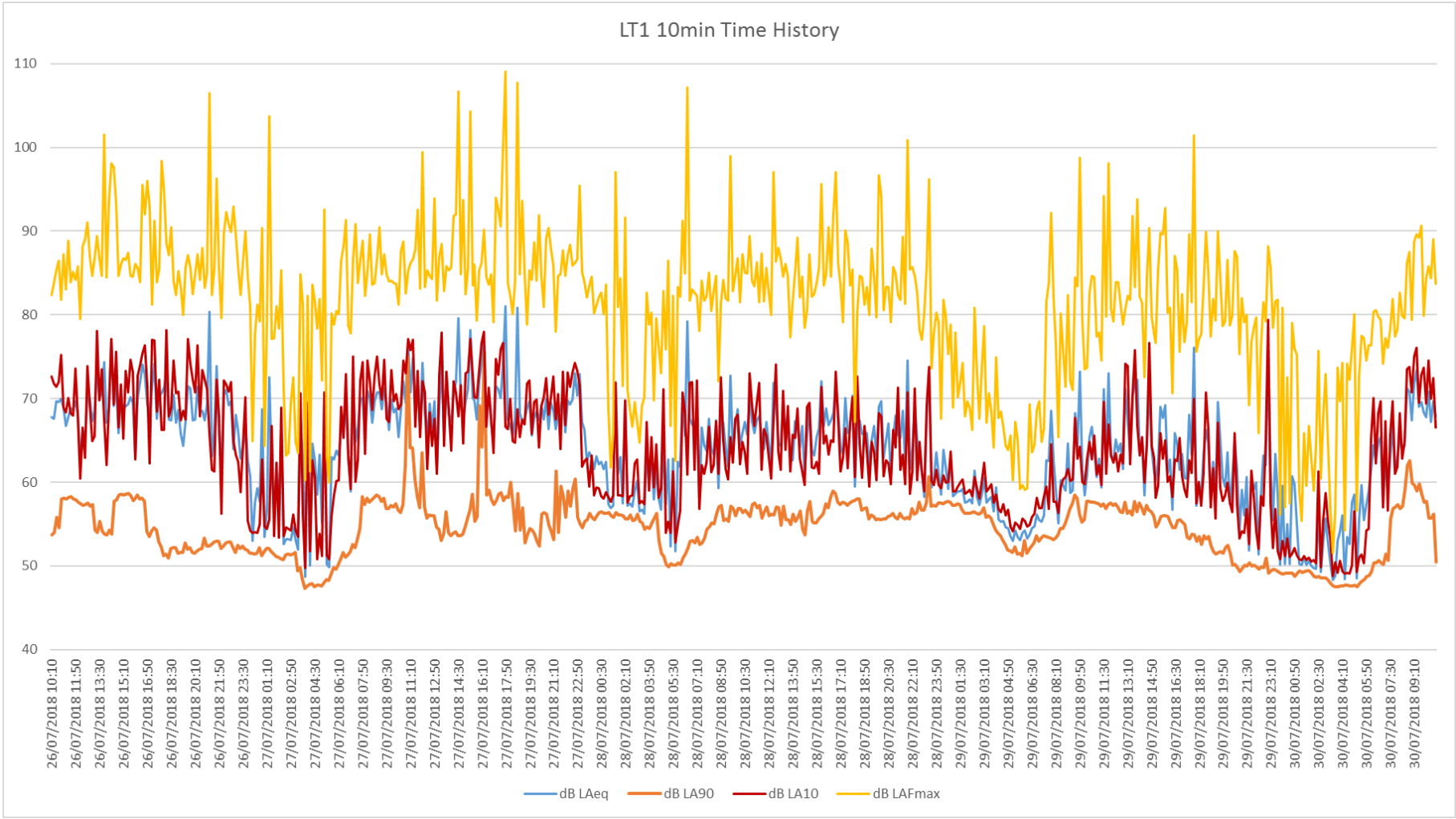
Term	Description
Decibel, dB	The decibel is a logarithmic unit of measurement used for quantifying sound. It is derived from the logarithm to base 10 of the ratio of two quantities. Use of a logarithmic scale has the advantage that it compresses the very wide range of sound pressures to which the ear may typically be exposed to a more manageable range of numbers.
Frequency, Hz	In sound, the number of cycles per second of a pressure fluctuation and frequency in sound is proportional to its pitch. Different frequencies are divided into octave and one third octave bands.
Sound Pressure Level, *Lp*	This is the unweighted or linear level which is measured prior to any weightings being applied. The sound pressure level is 20 times the logarithm to base 10 of the ratio of the reference sound pressure ($2x10^{-5}$) and the measured sound pressure.
Sound Power Level, L_w	This is the total sound energy radiated from a given source. The sound power Level is 10 times the logarithm to base 10 of the ratio of the reference sound power level ($1x10^{-12}$) and the measured power.
Frequency Weightings	Weightings can be applied to a spectrum of sound and act as a filter to account for different sensitivities and conditions.
Time Weightings	A time weighting to denote the response of the sound level meter. For most measurements the Fast time weighting is selected (F) however, a slow time weighting (S) is often used to for the measurement train noise and vibration.
A-weighted sound pressure level, L_{pA}	The sound pressure level with the A-weighting applied. The A-weighting is used for most environmental noise measurements and is used to weight a spectrum of sound to match the sensitivity of the human ear.
Equivalent continuous A-weighted sound pressure level, $L_{Aeq,T}$	The L_{Aeq} is an energy average and defined as the level of sound which, over a given period of time, would equate to the same A-weighted sound energy as the actual fluctuating sound.
Octave Bands	A band of frequencies in which the upper limit of the band is twice the frequency of the lower limit.
Maximum noise Level, L_{AFmax}	The maximum instantaneous noise level measured during a given period of time. The time weighting to which the meter is set for this measurement parameter is always indicated by either an F or S.
Minimum Noise level, L_{AFmin}	The minimum instantaneous noise level measured during a given period of time. The time weighting to which the meter is set for this measurement parameter is always indicated by either an F or S.
Percentile level, $L_{AN,T}$	A-weighted sound pressure level obtained using time-weighting F, which is exceeded for N% of a specified time interval. An example of this is background noise which is quantified with the L_{A90} descriptor, which is the A-weighted level which is exceeded for 90% of the measurement period.

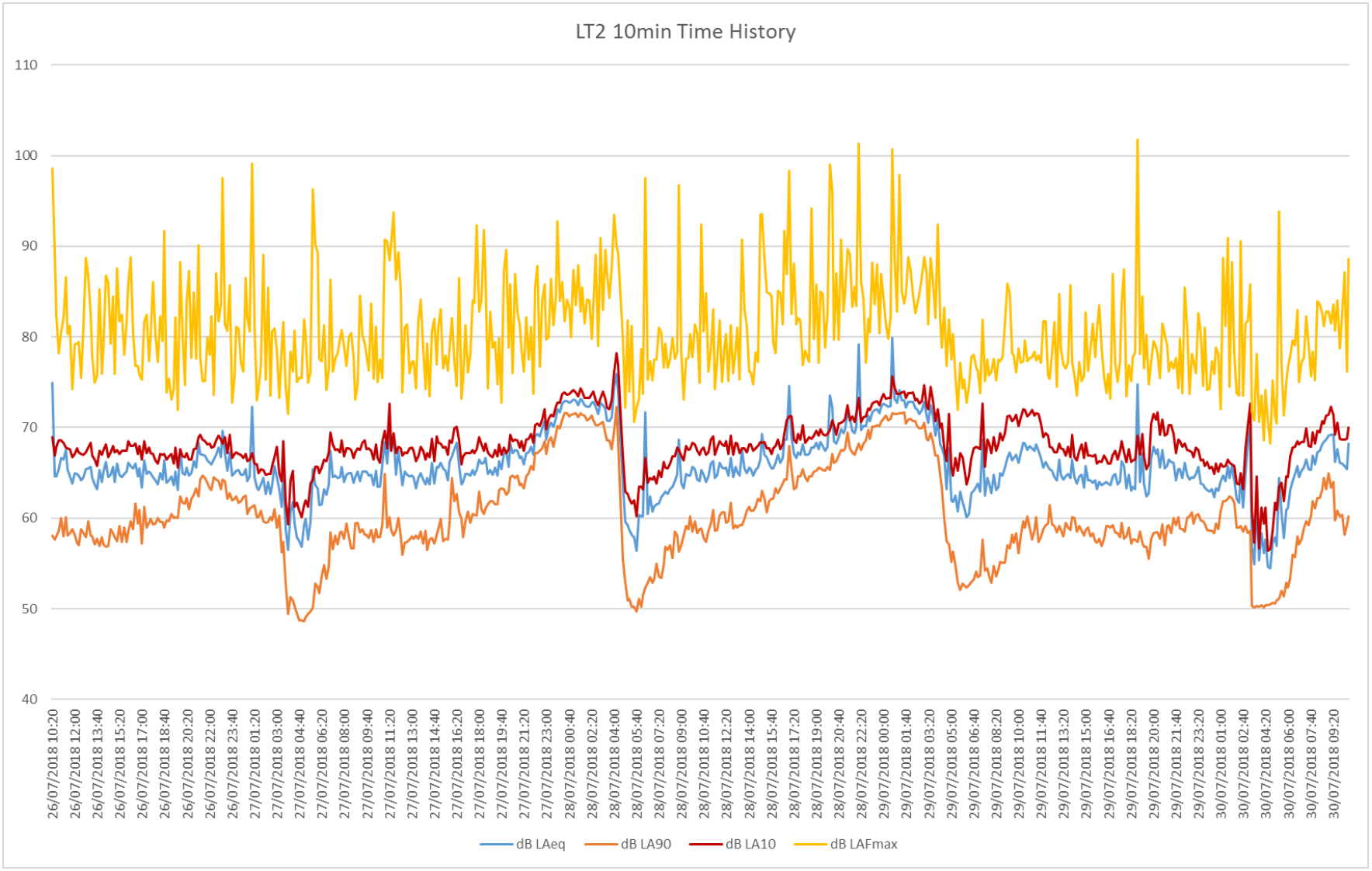
Sound exposure level L_{AE}	A level of a sound, of 1 s duration, that has the same sound energy as the actual noise event considered.
Rating Level, $L_{Ar,Tr}$	The equivalent continuous A-weighted sound pressure level of the noise, plus any adjustment for the characteristic features of the noise.
Ambient Noise Level	The noise level in a given environment whilst it is subject to all of its normal sources of noise.
Background Sound / Noise Level, L_{A90}	These are amongst the lowest noise levels measured over a given period of time and exclude short term, intermittent noise sources. The background noise level is quantified by the L_{A90} descriptor and is therefore the level which is exceeded for 90% of a given period of time.
Reverberation Time, T	The time that would be required for the sound pressure level to decrease by 60 dB after the sound source has stopped. The descriptor T, often includes other nomenclature to describe the type of reverberation time measurement or if the reverberation time is an average taken for specific frequencies. For example a T_{mf} is the mid-frequency reverberation time.
Absorption Coefficient, α	The fraction of reverberant sound energy absorbed by a material. It is expressed as a value between 1.0 which equates to perfect absorption and 0 which equates to zero absorption.
Absorption, A	The acoustic absorption derived from the multiplication of the absorption coefficient by the surface area of a given material.
Acoustic Class, A - E	Classification of sound absorbers into Sound Absorption Classes A-E, according to BS EN ISO 11654, including frequencies 200-5000 Hz
NRC	A single-number rating system used to compare the sound-absorbing characteristics of building materials. A measurement of the acoustical absorption performance of a material, calculated by averaging its Sound Absorption Coefficients at 250, 500, 1000 and 2000 Hz
Sound Reduction Index, R	The laboratory measured sound insulation properties of a material or building element in octave or third octave bands.
Weighted Sound Reduction Index, R_w	A single number which represents the sound reduction of a material. It is derived by plotting the sound reduction index against a set of reference curves. The curves are shifted until a best-fit is established and the curve which best fits the sound reduction spectrum is used to represent the single figure value.
Weighted Level Difference, D_w	The weighted level difference between a pair of rooms, stated as a single figure.
Standardized Weighted Level Difference, $D_{nT'w}$	The standardized, weighted difference in sound level between a pair of rooms, stated as a single figure. The level difference in octave bands is first normalized to a reference reverberation time and then plotted against a set of reference curves to establish a single figure value.
Weighted, Normalised Flanking Level Difference, D_{nFw}	The normalised, weighted difference in sound level between a pair of rooms via a flanking element, such as mullion or ceiling detail. The level difference in octave bands is first normalized to a reference amount of absorption and then plotted against a set of reference curves to establish a single figure value.

Normalised Element Level Difference D_{ne}	The normalised difference in sound level between a pair of rooms via a small element such as a trickle ventilator. The level difference in octave bands is normalized to a reference amount of absorption.
Weighted, Normalised Element Level Difference, D_{new}	The normalised, weighted difference in sound level between a pair of rooms via a small element such as a trickle ventilator, stated as a single figure. The level difference in octave bands is normalized to a reference amount of absorption and then plotted against a set of reference curves to establish a single figure value.
C_{tr}	A correction term applied to the sound insulation single-number values (R_w, D_w, and $D_{nT,w}$). Applying the C_{tr} penalises a construction's performance if its low frequency performance is poor in relation its performance at higher frequencies.
Impact Sound	The noise generated by an impact on a structure. This is normally used to describe the noise created by people walking on a floor structure.
Weighted standardized impact sound pressure level, $L_{nT,w}$	A single-number quantity used to characterize the impact sound insulation of floors over a range of frequencies.
Cross-talk	Noise transmission between one room and another room or space via a duct or other path.
Insertion Loss, IL	The reduction of noise level due to the presence of a noise control device such as an attenuator, excluding any regeneration noise created by its presence.
Dynamic Insertion Loss, DIL	The reduction of noise level due to the presence of a noise control device such as an attenuator, including any regeneration noise created by its presence.
NR	The Noise Rating level. This is a single figure value derived by plotting a noise spectrum against a set of curves. The curve under which the spectrum fits is the resulting NR level.
Vibration	The vibratory motion of a surface can be characterised by: (a) displacement (m), (b) velocity (m/s), or (c) acceleration(m/s^2). The magnitude of the vibration can be quantified in several ways: **Peak to Peak** - The total excursion of the oscillation about the zero datum. **Peak** - This value gives the maximum excursion of the oscillation above or below the zero datum. **r.m.s.** - This value gives the root mean square of the time history over a specific time interval (time constant). **dB** - Vibration levels can be expressed in dB. A reference level of 10-6 m/s^2 r.m.s. is usually used for acceleration.
Ground borne noise	Audible noise caused by the vibration of elements of a structure, for which the vibration propagation path from the source is partially or wholly through the ground
Structure borne noise	Audible noise caused by the vibration of elements of a structure, the source of which is within a building or structure with common elements.

V.D.V,	The VDV is the Vibration Dose a person is expected to be exposed to over the course of the day or night. The VDV is given by the fourth root of the time integral of the fourth power of the acceleration after it has been frequency-weighted.
eVDV	The estimated vibration dose value based on short duration measurements of transients with known durations and occurrences

Appendix B – Long-Term Measurement Time History




LT2 10min Time History
110
100
90
80
70
60
50
40
26/07/2018 10:20
26/07/2018 12:00
26/07/2018 13:40
26/07/2018 15:20
26/07/2018 17:00
26/07/2018 18:40
26/07/2018 20:20
26/07/2018 22:00
26/07/2018 23:40
27/07/2018 01:20
27/07/2018 03:00
27/07/2018 04:40
27/07/2018 06:20
27/07/2018 08:00
27/07/2018 09:40
27/07/2018 11:20
27/07/2018 13:00
27/07/2018 14:40
27/07/2018 16:20
27/07/2018 18:00
27/07/2018 19:40
27/07/2018 21:20
27/07/2018 23:00
28/07/2018 00:40
28/07/2018 02:20
28/07/2018 04:00
28/07/2018 05:40
28/07/2018 07:20
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29/07/2018 18:20
29/07/2018 20:00
29/07/2018 21:40
29/07/2018 23:20
30/07/2018 01:00
30/07/2018 02:40
30/07/2018 04:20
30/07/2018 06:00
30/07/2018 07:40
30/07/2018 09:20
dB LAeq
dB LA90
dB LA10
dB LAFmax