



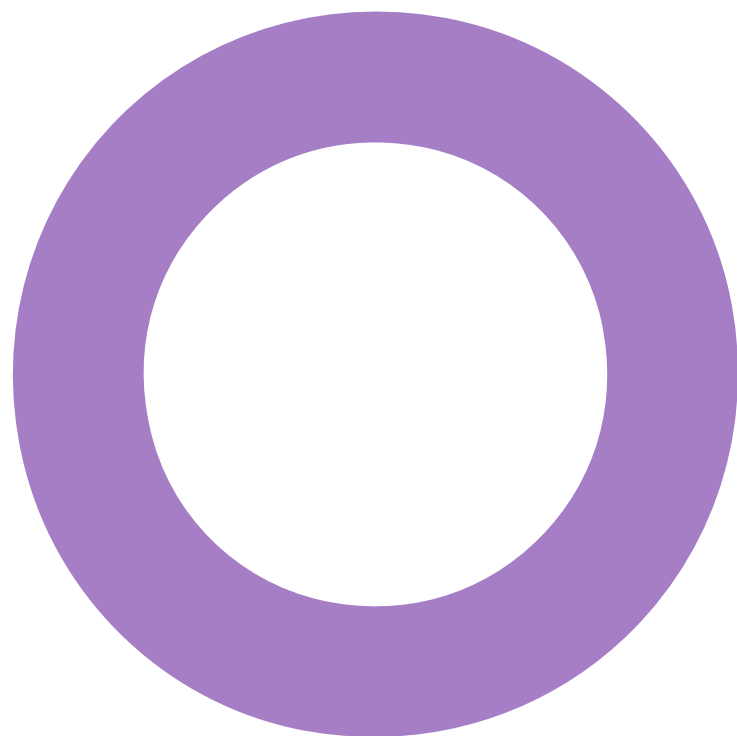
Manor Road / Richmond
Revised Noise & Vibration Impact
Assessment

Hoare Lea
November 2019

**Manor Road.
Richmond.**
Avanton Richmond Developments Ltd.

ACOUSTICS
REVISED NOISE & VIBRATION IMPACT ASSESSMENT

REVISION 06 - 21 NOVEMBER 2019



Audit sheet.

Rev.	Date	Description of change / purpose of issue	Prepared	Reviewed	Authorised
00	14/12/2018	Draft issue for comment	BD	BJ	BJ
01	16/01/2019	Updated with comments	BD	VdH	BJ
02	06/02/2019	Updated with further comments	BD	MB	BJ
03	25/10/2019	Draft issue - Updated to include changes to scheme	BD	-	-
04	07/11/2019	Draft issue – Pre updated design of Block E following TfL feedback	BD	-	-
05	18/11/2019	Draft issue – Following Block E redesign	BD	BJ	BJ
06	21/11/2019	Final issue for revised scheme	BD	DF	BJ

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Executive summary.

There are plans to redevelop the Homebase site located at Manor Road, North Sheen within the London Borough of Richmond upon Thames (LBRuT). The proposals are to demolish the existing Homebase retail unit to provide a new mixed-use development across five new blocks. The new development will provide residential units, flexible retail/community/office uses, a police facility and a bus layover with driver facilities, as well as public and private open spaces.

Environmental surveys.

Environmental sound and vibration surveys have been undertaken to establish the existing conditions. The results have been used to assess the impact of sound and vibration on the Amended Proposed Development. An assessment against LBRuT policy has been undertaken to identify any limits or specialist measures that may be required.

The environmental sound survey indicates that the site is exposed to relatively high levels of environmental sound, primarily governed by road and railway traffic activity in the local area. The results indicate that the background sound levels do not vary significantly between day to night periods.

The results of the environmental sound survey were used to validate a specialist acoustic model of the existing site. This modelling has been used to predict the sound levels incident on the proposed buildings and across the proposed site.

Control of external noise.

An assessment has been undertaken to understand the implications of the existing sound environment on the design of the facade and ventilation design. This has been summarised as follows:

- The sound reduction performance of the external façade will be controlled by the performance of the windows. Preliminary calculations have been undertaken and these indicate that, for Block A, B, C and D, facades overlooking the road and railway lines will require high-performance double-glazed systems.
- Mechanical ventilation is likely to be required for the majority of the development, with openable windows for purge ventilation.

Block E considerations.

The proposed bus layover area is located directly below residential apartments in Block E, with several facades directly overlooking the entrance and exit to the bus layover.

In order to help limit noise break in to bedrooms of apartments overlooking the entrance and exits of the bus layover, very high-performance window systems will be required in areas of the south and east façades of Block E. It is recommended that allowance is made for a secondary glazing system in these areas.

As the proposed bus layover area is located directly below residential apartments it is recommended that the separating floor construction between the bus layover area and the apartments above should achieve a very high sound insulation performance.

With the currently proposed slab depth, and an appropriate floor build-up above the slab, the recommended sound insulation performance should be achievable.

Impact on Manor Park.

The modelling has also been used to assess the impact of the proposed buildings on the neighbouring properties; particularly the residential properties to the south of the site on Manor Park. The modelling indicates that with the proposed buildings the noise levels incident on the properties on Manor Park are expected to remain the same as existing for the majority of the properties, even slightly decreasing for some properties.

Noise from building services.

Exact selections for the building services plant equipment are not available at this early stage. Guideline plant noise emission limits have been derived in line with LBRuT requirements. The plant emission limits proposed are not considered onerous and should be readily achieved with appropriate mitigation measures. It is reasonable to expect that these limiting levels can be enforced by a suitably worded planning condition.

Vibration from railways lines.

Vibration measurements have been undertaken at several ground floor locations, in-line with the proposed facades of buildings across the development. The results indicate that the levels of vibration measured on site from railway sources were below the threshold required by LBRuT and the British Standard threshold of *low probability of adverse comment*. As such, re-radiated sound from ground-borne vibration is not expected to require mitigation.

It is considered that any potentially significant environmental effects associated with the proposed development can be adequately controlled during the design stages, such that no significant effects would be likely.

1. Introduction.

There are plans to redevelop the Homebase site located at Manor Road, North Sheen within the London Borough of Richmond upon Thames.

On behalf of Avanton Richmond Development Ltd, a detailed planning application (ref. 19/0510/FUL) was submitted to the London Borough of Richmond Upon Thames (LBRuT) in February 2019 for the redevelopment of the Homebase store at 84 Manor Road, North Sheen.

The application was considered at LBRuT Planning Committee on 3 July 2019 and was recommended for refusal by LBRuT officers. The Planning Committee resolved that they were minded to refuse the Application in line with the officer's recommendation for six reasons relating to affordable housing; design; residential amenity; living standards; energy; and absence of a legal agreement.

On 29 July 2019 the Mayor issued a Direction pursuant to Article 7 of the Town and Country Planning (Mayor of London) Order 2008 and powers conferred by Section 2A of the Town and Country Planning Act (1990) that he would act as the LPA for the purposes of determining the Application.

Further to the Mayor's direction to take over the Planning Application for his determination, the Applicant, in consultation with the GLA and TfL, has taken the opportunity to review the scheme with the principle aim of increasing the delivery of affordable housing through additional density and addressing other issues raised in the Mayor's Stage 2 Report.

The Amended scheme now proposes a residential-led redevelopment of five buildings of between three and ten storeys. The development will provide 433 residential units (Class C3), flexible retail /community / office uses (Classes A1, A2, A3, D2, B1), a police facility (Use Class B1), a bus layover with driver facilities (Sui Generis Use), car and cycle parking, landscaping, public and private open spaces and other necessary enabling works.

The proposed changes necessitate an amendment to the Applications description of development. The revised description of development is as follows:

Demolition of existing buildings and structures and comprehensive phased residential-led redevelopment to provide residential units (Class C3), flexible retail /community / office uses (Classes A1, A2, A3, D2, B1), a police facility (Use Class B1), a bus layover with driver facilities (Sui Generis Use), provision of car and cycle parking, landscaping, public and private open spaces and all other necessary enabling works.

The amended scheme is referred as the 'Amended Proposed Development' and its previous iteration that was considered at LBRuT Planning Committee in 3 July 2019, is referred to as the 'Original Proposed Development'.

As part of the works undertaken for the Original Proposed Development, environmental sound and vibration surveys were conducted to establish the existing conditions. The results of the surveys remain valid for the Amended Proposed Development and have been used to assess the impact of sound and vibration on the proposed development. Comparisons have also been made with local authority policy to identify any limits or specialist measures that may be required.

The surveys and assessments have been undertaken in accordance with relevant British Standards, and this report has been prepared to support the planning application for the Amended Proposed Development.

A glossary of the acoustic terms used in the report is provided in Appendix A.

2. Site description.

2.1 Existing site.

The existing site is located on Manor Road, in North Sheen, London. The site is currently occupied by a Homebase retail unit, with supplementary surface level parking, and a bus terminal to the north east of the site.

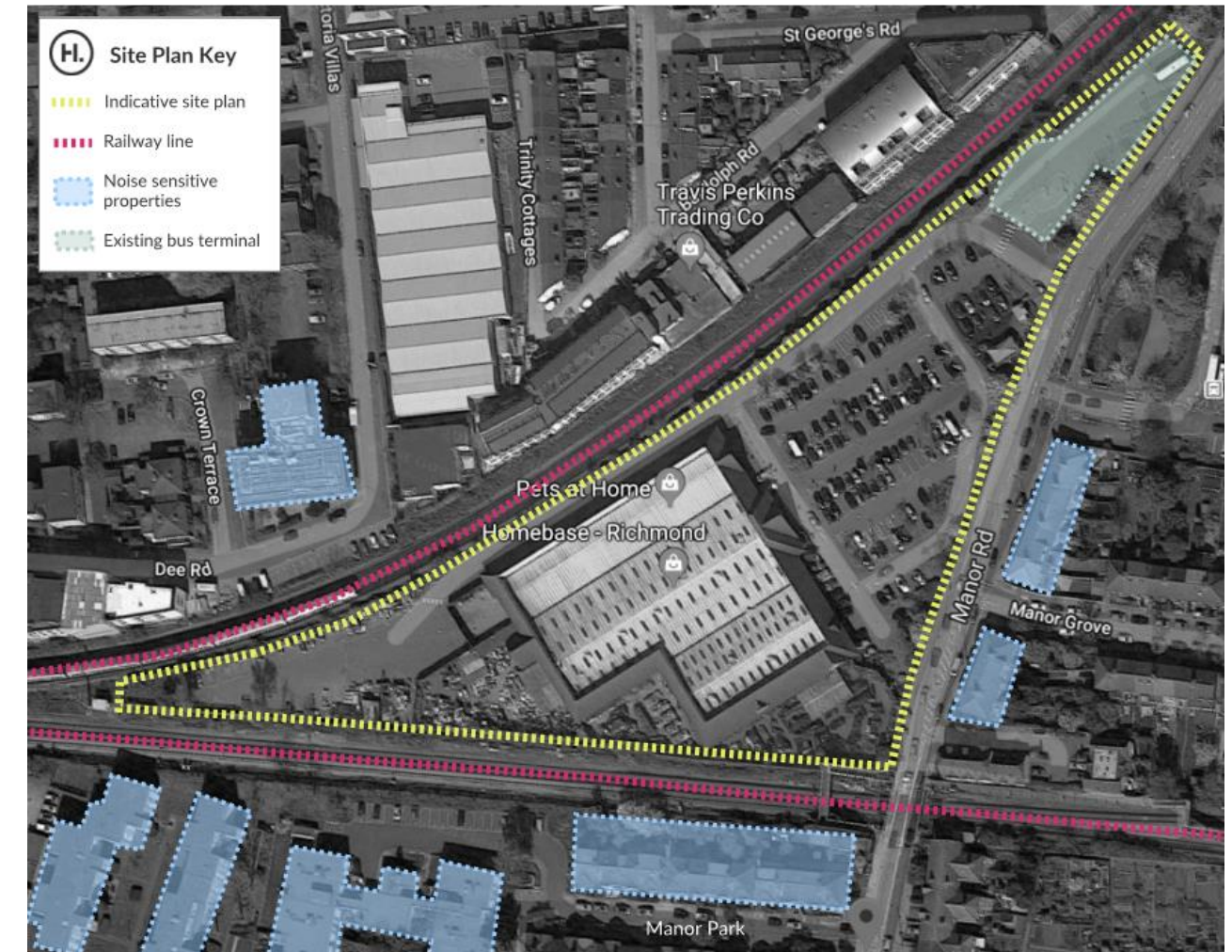


Figure 1 Indicative site plan

The site is bounded by railways to both the North and South. The east of the site is bounded by Manor Road.

The nearest noise sensitive properties to the site are the residential houses on Manor Park, directly to the south of the site. The site location, surrounding properties and the nearest noise sensitive receivers are illustrated in Figure 1.

2.2 Proposed development.

The revised proposals are to redevelop the existing Homebase retail unit to provide a new mixed-use development across five new blocks, ranging between three and ten storeys in height.

The new development is to provide 433 residential units (Class C3), flexible retail /community / office uses (Classes A1, A2, A3, D2, B1), a police facility (Use Class B1), a bus layover with driver facilities (Sui Generis Use), provision of car and cycle parking, landscaping and public and private open spaces.

The most significant change from the Original Proposed Development, from an acoustic perspective, is the inclusion of Block E, where residential apartments will be located directly above the proposed bus layover area. The implications of this are discussed in Section 5.2.2 of the report.

The proposed ground floor level of the development is shown in Figure 2 below.



Figure 2 Proposed ground floor of the new development

3. Basis of assessment.

The following policy and guidance have been used for the acoustic survey and assessment:

- London Boroughs of Hillingdon, Hounslow & Richmond Upon Thames, Draft Supplementary Planning Document (SPD) 'Development Control for Noise Generating & Noise Sensitive Development', 2016.
- Mayor of London, 'Draft London Plan', 2019.
- Mayor of London, Supplementary Planning Guidance (SPG) 'Sustainable Design and Construction', 2014.
- British Standard 8233, 'Guidance on sound insulation and noise reduction for buildings', 2014.
- British Standard 4142, 'Methods for rating and assessing industrial and commercial sound', 2014.
- National Planning Policy Framework (NPPF).
- World Health Organisation, 'Guidelines for Community Noise', 2012.
- British Standard 7445, 'Description and measurement of environmental noise', 2003.
- British Standard 6472, 'Guide to evaluation of human exposure to vibration in buildings', 2008.
- ANC Guidelines, Measurement & Assessment of Ground borne Noise & Vibration, 2nd edition, 2012.
- ISO/TS 14837-31, 'Mechanical vibration - Ground-borne noise and vibration arising from rail systems', 2017.
- Calculation of Railway Noise (CRN), 1995.
- Calculation of Road Traffic Noise (CRTN), 1988.

3.1 Internal sound levels.

3.1.1 Residential areas

The London Boroughs of Hillingdon, Hounslow & Richmond Upon Thames Draft Supplementary Planning Document (SPD) 'Noise Sensitive & Noise Generating Development' sets out the following guidance for internal noise levels in line with British Standard BS8233.

Table 1 Local Authority guidance on internal sound levels

Situation	Location	Daytime 07:00 - 23:00 hrs	Night-time 23:00 - 07:00 hrs
Resting	Living room	35 dB L _{Aeq,16hr}	-
Dining	Dining room/area	40 dB L _{Aeq,16hr}	-
Sleeping (daytime resting)	Bedroom	35 dB L _{Aeq,16hr}	30 dB L _{Aeq,8hr}
Sleeping	Bedroom	-	45 dB L _{AFmax} (several times in any one hour*)

*The SPD states that noise from individual events should not normally exceed 45 dB L_{AFmax} more than 10 times a night in sensitive rooms.

For reference, the guidance given in the SPD on internal sound levels is reproduced in full in Appendix B.

3.1.2 Commercial areas

For retail spaces, it is advised that internal ambient sound criteria are set in accordance with BS 8233. This varies depending on use, therefore, in order to maintain maximum flexibility for the future, at criteria of 40-45 dB L_{Aeq,T} is proposed.

3.2 External amenity spaces.

The Draft Supplementary Planning Document indicates the following guidance for sound in external amenity spaces:

“The acoustic environment of external amenity areas shall always be assessed and noise levels should ideally not be above the range 50 to 55dB LAeq,16hr. It may be necessary to carefully locate and design amenity areas and/or to provide acoustic screening in order to meet this goal.”

The SPD also notes that in some circumstances it may be appropriate to vary, or not to apply, these goals in order to meet wider planning objectives in line with guidance in British Standard BS 8233.

For reference, the guidance given in the SPD on sound levels in external amenity spaces is reproduced in full in Appendix B.

3.3 Plant noise emissions.

The SPD sets out the following guidance for the control of building services noise for industrial and commercial developments in line with guidance in British Standard BS 4142.

Table 2 Local Authority guidance on plant noise emissions

Noise impact from relevant proposed industrial or commercial premises or plant	Development outcome
Rating level (L _{Ar,Tr}) is at least 5 dB below the background level LA ₉₀	Normally acceptable
Rating level (L _{Ar,Tr}) is no more than 5 dB above the background level LA ₉₀	Acceptable only if there are overriding economic or social reasons for development to proceed
Rating level (L _{Ar,Tr}) is more than 5 dB above the background level LA ₉₀	Normally unacceptable

As such, for this development, the maximum emission level (dB L_{Ar,Tr}) should not exceed 5 dB below the typical external background noise (LA_{90,15min}) at the nearest noise sensitive premises.

3.4 Vibration levels.

The Local Authority will normally require a vibration assessment where railways, either surface or underground, are within 30 m of a proposed development.

The SPD sets out guidance on acceptable levels of vibration within residential developments, in line with British Standard BS 6472-1, expressed in terms of vibration dose values (VDVs) and presented in Table 3.

Table 3 Local Authority guidance on vibration in residential areas

Location	Day-time 07:00 – 23:00 hrs	Night-time 23:00 – 07:00 hrs
Residential	< 0.2 ms ^{-1.75}	< 0.1 ms ^{-1.75}

These values are in line with the BS 6472-1 threshold of ‘low probability of adverse comment’.

The SPD also states that re-radiated noise, as a result of vibration from adjacent railways and other sources, shall not exceed 35 dB LA_{Smax} within habitable residential rooms.

4. Environmental sound survey.

An acoustic survey has been carried out at the proposed site as part of works undertaken for the Original Proposed Development to establish the prevailing local environmental sound conditions. The results of the survey remain valid for the Amended Proposed Development.

4.1 Methodology.

The survey was undertaken between the 20th July and 25th July 2018 and comprised six days of unattended sound measurements by a single sound level meter with additional attended short-term sound measurements taken at various locations across the site. The measurement positions are illustrated in Figure 3.

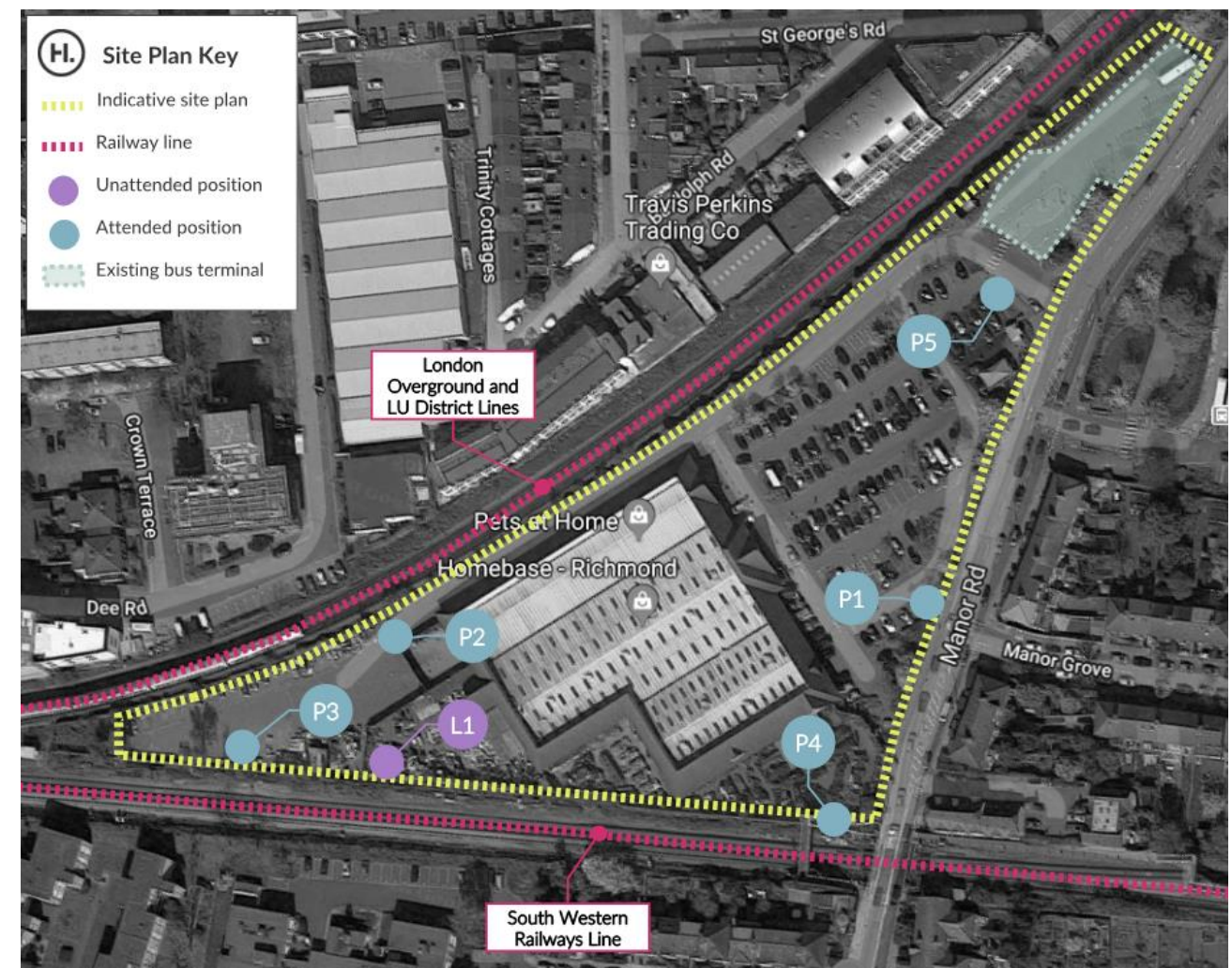


Figure 3 Measurement positions

A summary of the survey details and results are set out in the Sections below. Full details of the survey, measurement conditions and equipment details are provided in Appendix C.

4.1.1 Unattended measurements

The unattended measurement position L1 was located within the rear service yard of the Homebase on the existing site. The measurement location was deemed representative of the nearest residential receivers, the rear of the properties to the south of the site on Manor Park.

There are few train passes during night-time period. It is expected that background noise levels measured at position L1 during the night-time periods are representative of the nearby residential properties both to the north and the south of the site.

Measurements recorded consisted of contiguous fifteen-minute samples of ambient noise levels ($L_{Aeq,15min}$ in dB), maximum noise levels ($L_{Amax,15min}$ in dB) and background noise levels ($L_{A90,15min}$ in dB) between Friday 20th July 2018 and Wednesday 25th July 2018. The measurement position was at a height of approximately 1.2 metres above ground level and considered free-field.

4.1.2 Attended measurements

Short-term attended measurements were taken on Friday 20th July and Wednesday 25th July 2018 to acquire representative sound data from nearby transportation sources.

The measurement positions, as presented in Figure 3, were selected to capture the following sources:

- P1 - Continuous measurements of road traffic sound emissions over four hours.
- P2 - Measurements of sound from operational trains along the north boundary of the site, approximately 1.5 m above ground floor level.
- P3 - Measurements of sound from operational trains along the south boundary of the site, approximately 1.5 m above ground floor level.
- P4 - Measurements of sound from operational trains along the south boundary of the site, on the pedestrian bridge over the train line approximately 4 m above ground level.
- P5 - Measurements of sound from bus movements from the bus terminal towards the northeast corner of the site, approximately 1.5 m above ground floor level.

All attended measurement positions were considered free-field.

4.2 Results.

4.2.1 Unattended measurements

A summary of the unattended measurements recorded at position L1 is provided in Table 4. Full detailed results and a time history are shown in Appendix C.

Table 4: Summary of long-term noise monitoring at position L1

Period,T	Typical average ambient sound level, dB $L_{Aeq,T}$	Typical maximum event level*, dB $L_{Amax,15min}$	Typical background noise level, dB $L_{A90,15min}$
Day (07:00-23:00)	62	87	41
Night (23:00-07:00)	59	83	39

* Typical maximum is based on the highest 90th percentile of the measured data

4.2.2 Attended measurements

The results of the short-term measurements are summarised in Figure 4.

The sound levels presented for the railway sources were undertaken for the duration of a train pass-by. Each event varied in duration from approximately 10 – 30 seconds. A sample of at least ten events were measured at each location.

The different types of trains measured at the various measurement locations were as follows:

- P2 (along the north boundary of the site) - London Overground and London Underground District Line trains
- P3 (along the south boundary of the site) - South Western Railways and Freight trains
- P4 (on the pedestrian bridge over the southern train line) - South Western Railways

The average sound pressure levels presented for the road traffic sources at position P1 are based on measurements taken over a three-hour period, in line with the guidance provided in the *Calculation of Road Traffic Noise* document dated 1988 (CRTN).

The sound levels presented for bus sources at position P5 were undertaken for the duration of a bus pass-by. Each event varied in duration from approximately 6 – 13 seconds.

For each measurement position both average levels in terms of $L_{Aeq,T}$, and maximum levels in terms of L_{Amax} , are given.

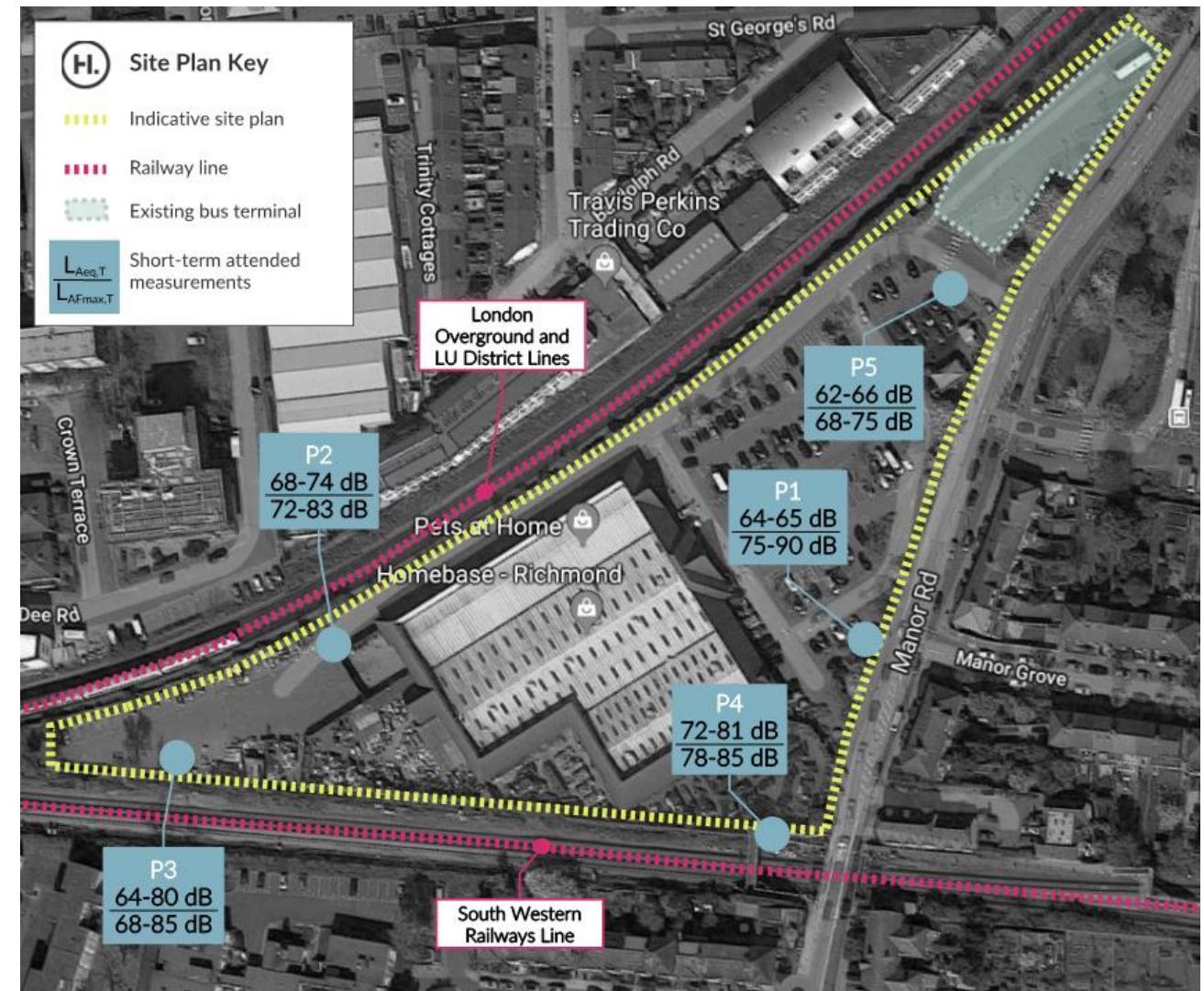


Figure 4 Summary of short-term attended measurement results

The dominant sources of sound local to the site are from road traffic on Manor Road and railway traffic on the London Overground and South Western Rail lines. Some aircraft activity was noted while on site, however the associated sound levels did not impact noticeably on the measured levels, when compared to the road and railway traffic sources.

The results of the above measurements were used to calculate the average sound levels over a full day (07:00 – 23:00) and night (23:00 – 07:00) at the site from both railway lines and road traffic.

The average sound levels from trains and rail traffic were calculated using the methodology set out in the *Calculation of Railway Noise* document dated 1995 (CRN), while the road traffic sound levels were predicted following the methodology set out in the *Calculation of Road Traffic Noise* document dated 1988 (CRTN).

The predicted average daytime and night time sound levels from railway and road traffic sources at the various measurement positions are presented in Table 5.

A correction factor, accounting for differences in height and relative distance from the railway line has been applied to all measurements at 1.5 m above ground level, in accordance with CRTN methodology. This is equivalent to an increase of 3.5 dB to all results at positions P2 and P3.

Table 5 Predicted average daytime and night time sound levels from railway and road traffic sources

Measurement location	Sound source	Calculated average sound levels from road traffic and railway sources (dB)	
		Daytime (07:00 – 23:00), $L_{Aeq,16hr}$	Night time (23:00 – 07:00), $L_{Aeq,8hr}$
P1	Road	67	57
P2	Railway	65	60
P3		62	56
P4		66	61

5. Implications of environmental sound.

The existing sound levels in the vicinity of the site have implications on the design of the façades and the ventilation strategy of the Amended Proposed Development. These are discussed in the following sections.

5.1 Specialist acoustic modelling.

The results of the environmental sound survey were used to validate a specialist acoustic computer model of the existing site developed using Cadna-A software. The model methodology is in accordance with CRN and CRTN. The model was then used to predict the variation in sound levels that would affect different parts of the Original Proposed Development. The modelling has been updated to include the changes to the scheme as part of the Amended Proposed Development. An image of the updated model results for the average daytime $L_{Aeq,T}$ are shown in Figure 5 below.

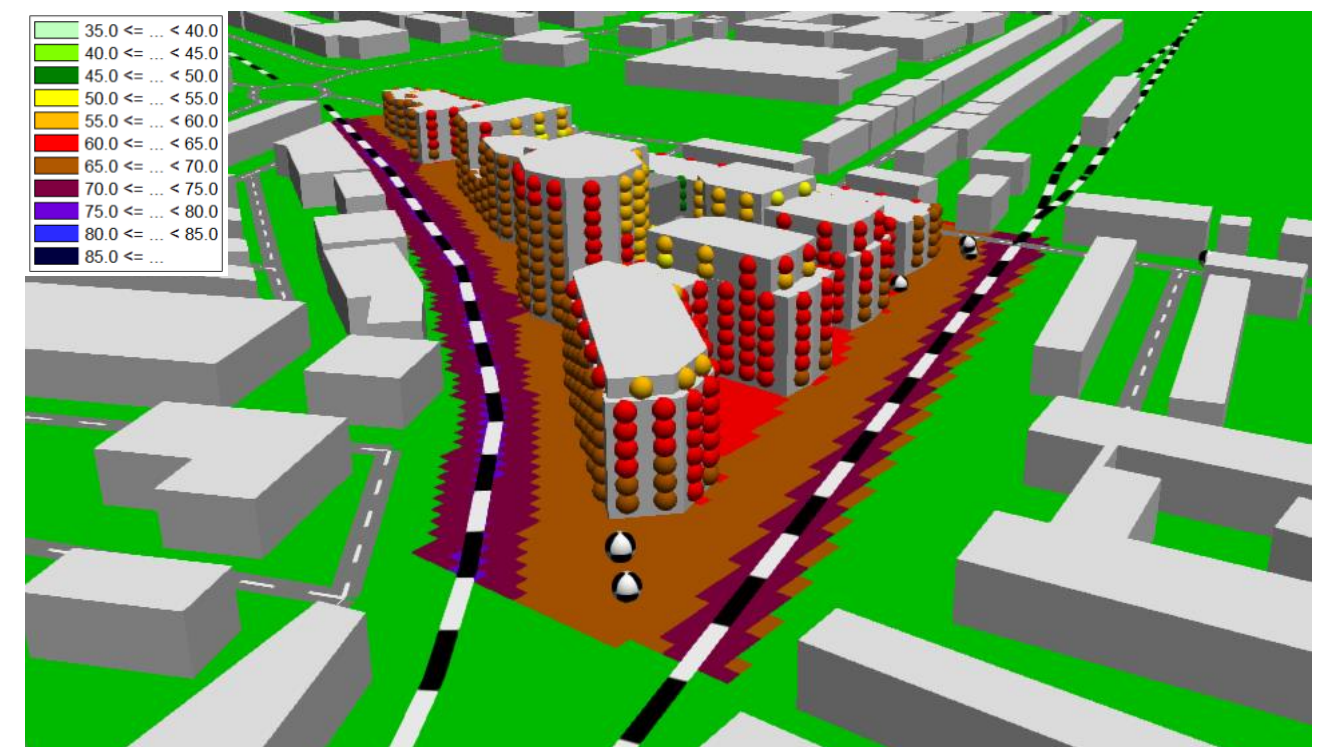


Figure 5 Image from specialist acoustic model, looking northwest – Predicted daytime levels L_{Aeq} .

By defining the sound level at the façades of the new buildings, the sound insulation requirements of the façades and the ventilation strategy can be established. These are discussed in the sections below.

Results of the updated predicted façade levels across the development are presented in more depth in Appendix D.

5.2 Design of façade.

5.2.1 Blocks A, B C and D

At the planning application stage, allowance should be made for high performance double glazed window systems of circa 45 dB R_w on those elevations of Blocks A, B C and D most exposed to rail and road traffic noise.

It is expected that windows on other façades of these blocks, more screened from the rail and road noise, are likely to require a lower performance. The window specification will be refined as the design develops through the RIBA stages post planning.

Solid elements of the façade and the roofs should achieve a performance of at least 55 dB R_w. This is achievable with both traditional and suitably built-up light-weight systems.

5.2.2 Block E

As the bus layover will be located directly below the residential apartments in Block E, careful consideration is required for the design of the façade of this block to help control noise from bus movements and limit potential disturbance to the occupants.

5.2.2.1 Glazing and façade

In order to help limit noise break in to bedrooms of apartments overlooking the entrance and exits of the bus layover, on the south and east façades of Block E, very high-performance window systems will be required in these areas.

It is recommended that allowance should be made for a secondary glazing system for all bedroom windows along the south façade and for the bedroom windows of the ground floor duplex apartments on the east façade. The external window and secondary glazing system will be required to achieve a sound reduction performance of at least 53 dB R_w. The window and glazing specification across the whole of Block E will be refined as the design develops through the RIBA stages post planning.

Solid elements of these façades should achieve a sound reduction performance of at least 60 dB R_w. This is a high-performance façade but should be achievable with both traditional and carefully detailed and suitably built-up light-weight systems.

Due to the character of the noise generated by buses it will be important to ensure the low frequency sound reduction performance of both the glazing and the solid elements of the façade in these areas is suitable to control the low frequency content of the bus noise.

5.2.2.2 Bus layover soffit

The proposed bus layover area is located directly below residential apartments and as such it is recommended that the separating floor construction between the bus layover area and the apartments above should achieve a sound insulation performance in the region of 65 dB D_{nT,w} + C_r.

Currently proposals for the separating construction here include a 400mm thick solid concrete slab with downstand beams of total thickness 1200mm.

With an appropriate floor build-up above the slab, this construction should be capable of achieving the recommended sound insulation performance. The floor build-up will be developed as the design progresses through the RIBA stages post planning.

5.2.3 Ventilation strategy

Mechanical ventilation is likely to be required for the majority of the development, with openable windows for purge ventilation.

It is considered that appropriate internal noise levels can be achieved with good acoustic design to the façade elements.

5.3 External Transportation Noise Risk Assessment.

The Draft Supplementary Planning Document “Noise Sensitive & Noise Generating Development” drawn up by the three London Boroughs previously indicated, describes the initial site noise risk assessment procedure to be followed and the concept of Noise Risk Categories (NRC). The initial site noise risk assessment table from the draft SPD is reproduced below.

External Transportation Noise Risk Assessment (measured/predicted, empty site, pre-mitigation)

Noise Risk Category*	Potential Effect if unmitigated	Pre-Planning Application Guidance
0 – Negligible L _{Aeq,16hr} < 50dB L _{Aeq,8hr} < 40dB	No adverse effect on health and quality of life	Development proposal is likely to be acceptable from a noise perspective. Noise assessment /report required to demonstrate no adverse impacts. Good acoustic design encouraged to improve existing environment.
1 – Low L _{Aeq,16hr} 50-63dB L _{Aeq,8hr} 40-55dB	Adverse effect on health and quality of life	Noise environment likely to cause adverse impacts. Noise assessment /report required to demonstrate how adverse impacts will be minimised and how good acoustic design will be implemented. Planning conditions and other measures to control noise are likely to be required.
2 – Medium L _{Aeq,16hr} 63-69dB L _{Aeq,8hr} 55-60dB L _{A-Smax} <82dB	Significant adverse effect on health and quality of life	Noise environment likely to cause significant adverse impacts and development may be refused unless Noise assessment /report required to demonstrate how significant adverse impacts will be avoided and other adverse impacts minimised and how good acoustic design will be implemented. Planning conditions and other measures to minimise noise will be necessary.
3 – High L _{Aeq,16hr} > 69dB L _{Aeq,8hr} > 60dB L _{A-Smax} <82dB	Unacceptable adverse effect on health and quality of life	Noise environment likely to cause unacceptable adverse impacts and development likely to be refused even if a good acoustic design process is followed, unless there is an overriding case for development in the context of Government policy on sustainable development.

Figure 6 Reproduction of Initial Site Noise Risk Assessment table from SPD

The predicted daytime and night-time façade levels, as reported in Appendix D, are compared with the Noise Risk Categories in Table 6 and Table 7 below.

Table 6 Comparison of predicted daytime facade levels against Noise Risk Categories

Predicted external daytime noise level, dB(A)	Noise Risk Category (NRC)	Comments
65 – 69	2 - Medium	– This can be dealt with by appropriate façade and ventilation design, as set out in Section 5.2 above, and the setting of appropriate planning conditions.
60 – 64	1 - Low to 2 - Medium	
50 – 59	1 - Low	
< 50	0 – Negligible	– These areas are within the internal courtyard of the proposed buildings to the north of the site.

Table 7 Comparison of predicted night-time façade levels against Noise Risk Categories

Predicted external night-time noise level, dB(A)	Noise Risk Category (NRC)	Comments
60 – 63	2 - Medium to 3 - High	<ul style="list-style-type: none"> There are limited areas, at low level, where predicted façade sound levels are 1-3 dB above the medium NRC. A difference of this magnitude would not normally be a perceptible difference outside of laboratory conditions. This can be dealt with by appropriate façade and ventilation design, as set out in Section 5.2 above, and the setting of appropriate planning conditions.
55 – 59	2 - Medium	<ul style="list-style-type: none"> This can be dealt with by appropriate façade and ventilation design, as set out in Section 5.2 above, and the setting of appropriate planning conditions.
40 – 54	1 - Low	

5.4 External amenity areas

Both the National Planning Policy Framework and the Greater London Authority (under the London Plan, 2019) advise to identify and protect amenity areas from noise.

The World Health Organisation (WHO) provides guidance on noise levels for outdoor areas, advising that to avoid annoyance to most people a level of less than 55 dB and ideally less than 50 dB L_{Aeq} should be targeted.

An image from the model is presented in Figure 7 showing the predicted daytime L_{Aeq} sound levels across some of the proposed ground level external amenity areas. As it can be seen, sound levels within the majority of the main ground level landscaped areas are expected to exceed 55 dB, with the exception of the more screened internal courtyard of the Block A.

It is therefore recommended that screening to noise from the site boundary is incorporated into the landscaping design. Screening would be most effective along the boundaries of the two railway lines and along the boundary of Manor Road. In order to provide sufficient acoustic benefit, the screening along the boundaries should be solid (i.e. close border timber fencing) and be at a height of at least 2.5m.

Balconies would also be exposed to higher levels of noise than the ideal. Where balconies are proposed to offer occupants breakout space, reductions in noise level could be achieved with mitigation measures such as, increased balustrade heights to provide a barrier to noise and the incorporation of acoustic absorption to the soffit of the balcony above.

There are also several rooftop terrace areas proposed across the scheme. Noise levels on roof terrace areas more heavily screened from the railway and road noise sources are not expected to exceed 55 dB.

Roof terrace areas overlooking the railway lines and Manor Road are expected to be exposed to higher levels of noise than ideal. These areas would benefit from additional screening in the form of increased parapets or balustrades heights to provide a barrier to noise.

BS 8233 advises that a level of 50-55 dB L_{Aeq} is desirable within external amenity areas, but recognises that these levels may not be achievable in all circumstances. It further advises that in higher noise areas, such as city centres and urban areas adjoining strategic transport networks, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited.

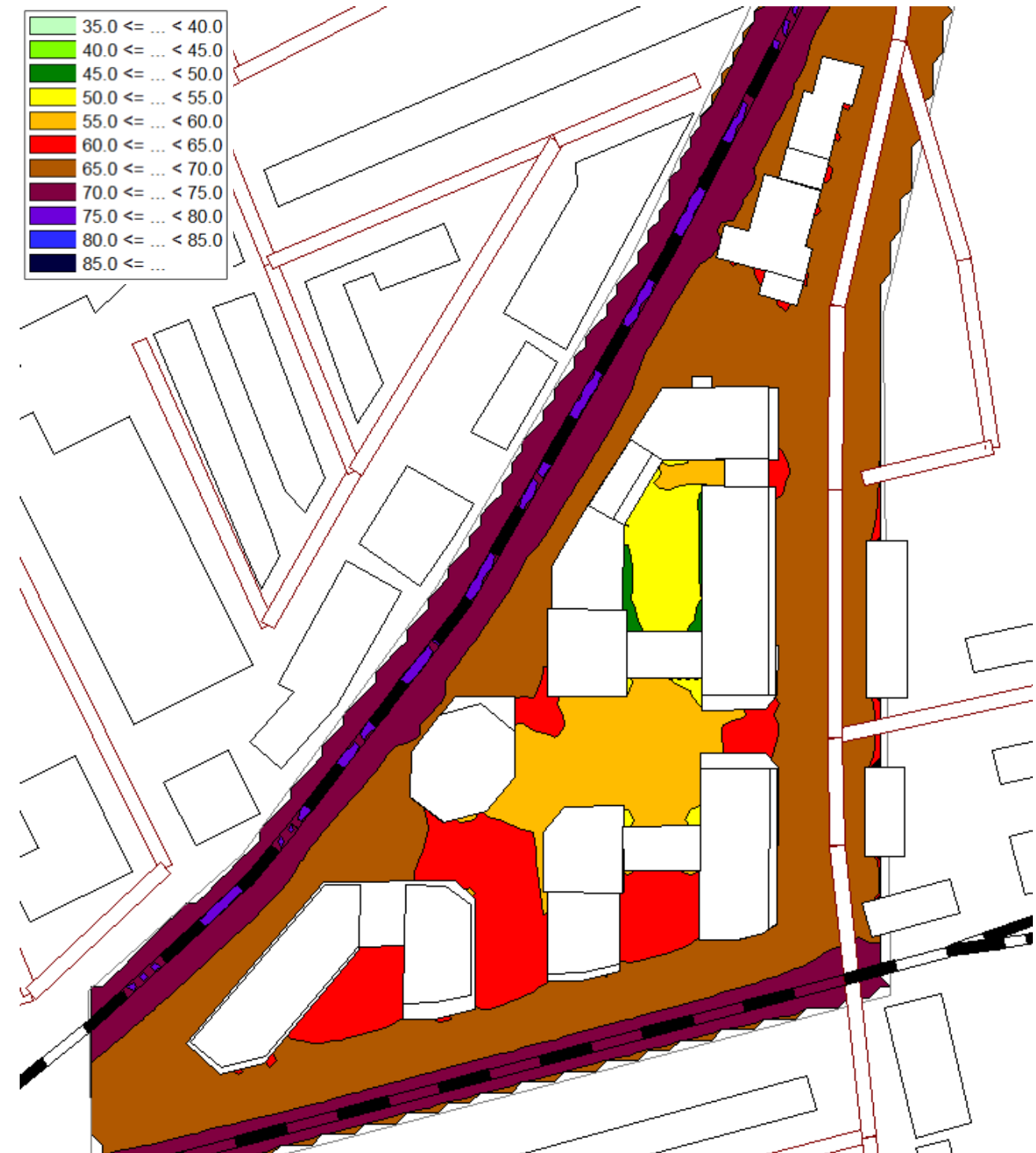


Figure 7 Image from model showing predicted daytime L_{Aeq} sound levels across the proposed ground level external amenity areas

5.5 Noise impact on residential properties to the south of the site.

It is understood that concerns have been raised with regard to the effect of introducing buildings opposite the residential properties to the south of the site, on Manor Park, and the extent to which this may increase noise levels at the properties from the existing railway line due to additional reflected noise.

As part of the specialist acoustic modelling undertaken on the Original Proposed Development, a comparison was made of the predicted noise levels incident on the properties on Manor Park, with the existing buildings on the site and with the proposed buildings associated with the development. As the changes to the development are limited to the south of the site this assessment remains valid for the Amended Proposed Development. Figure 8 shows the predicted noise levels incident on the properties for both scenarios.

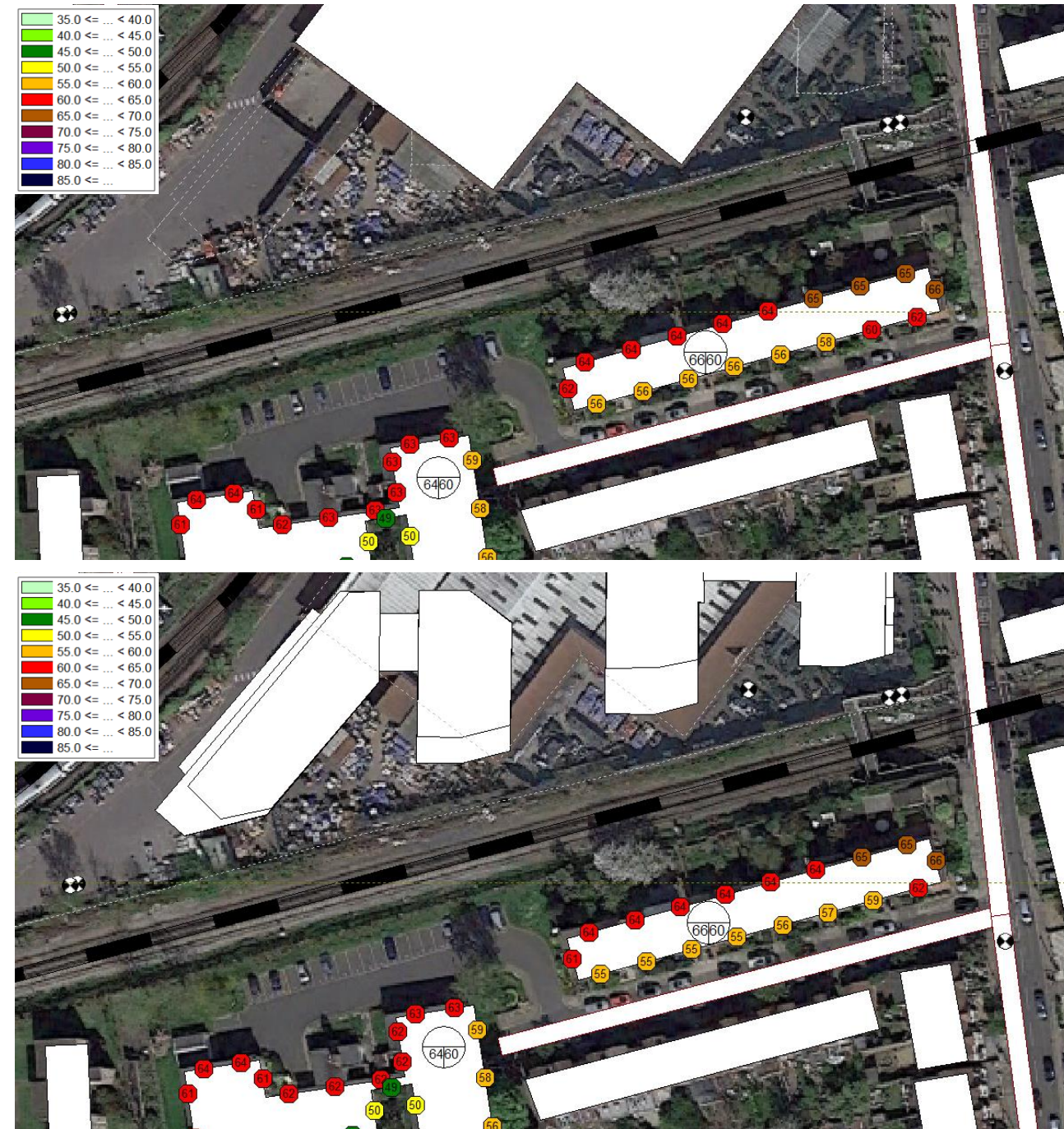


Figure 8 Comparison of L_{Aeq} noise levels incident on properties on Manor Park with existing buildings (top) and proposed buildings (bottom)

It can be seen that, with the proposed buildings, the predicted noise levels incident on the majority of the properties on Manor Park remain the same, even slightly decreasing for some properties. This is due to the fact

that the façades of the proposed buildings are actually set back further from the railway line than the existing Homebase building.

As part of the proposed mitigation strategy, a solid fence along the southern boundary of the site is recommended to help control noise from the railway line. The modelling considered a second scenario where a solid barrier of height 2.5m was introduced at the site boundary. As a result of reflections from this barrier, noise levels incident on the properties on Manor Park would potentially increase by a maximum of 1 dB. A difference of this magnitude would not normally be perceptible outside of laboratory conditions and can be considered a marginal effect.

6. Noise emissions of fixed plant.

Noise emissions from any equipment introduced in the area will need to be controlled to minimise the impact on the local sound environment as required by the local authority.

Noise levels due to building services associated with the proposed development are advised to meet the following noise level criteria (expressed as “free-field”) shown below in Table 8. These noise limits are proposed at one metre from the nearest noise sensitive receptors as indicated in Figure 1.

The limits are based on the typical background noise levels measured at position L1, which are deemed representative of the closest façade of the nearest noise sensitive receptor on Manor Park.

Table 8 Building services noise emission limits to properties on Ashby Street

Period	Typical prevailing background noise level $L_{A90,15min}$ dB	Noise emission limit calculation $L_{A,Tr}$ dB
Daytime (07:00 – 23:00)	41	36
Night-time (07:00 – 23:00)	39	34

It should be noted that these are the combined operational noise levels of plant at the nearest noise sensitive façade. As such, the combined operational noise levels of all plant are required to achieve the noise limits defined within Table 8.

For plant noise that is tonal, contains a specific character or is intermittent, the limits of Table 8 above need to include a character correction as defined within BS 4142: 2014.

The plant emission limits proposed are not considered particularly onerous and should be achievable with appropriate mitigation measures.

7. Ground-borne vibration survey.

The site is bounded to the north by the London Overground and London Underground District lines and to the south by the South Western Railways line, which also carries freight trains. Due to this, the risk of ground-borne vibration to the site needs to be assessed.

7.1 Methodology.

A vibration survey was undertaken on the 20th July 2018 as part of the Original Proposed Development with measurements of ground-borne vibration taken concurrently with the airborne sound measurements at locations P2 and P3 indicated in Figure 9. The results of the survey remain valid for the Amended Proposed Development.

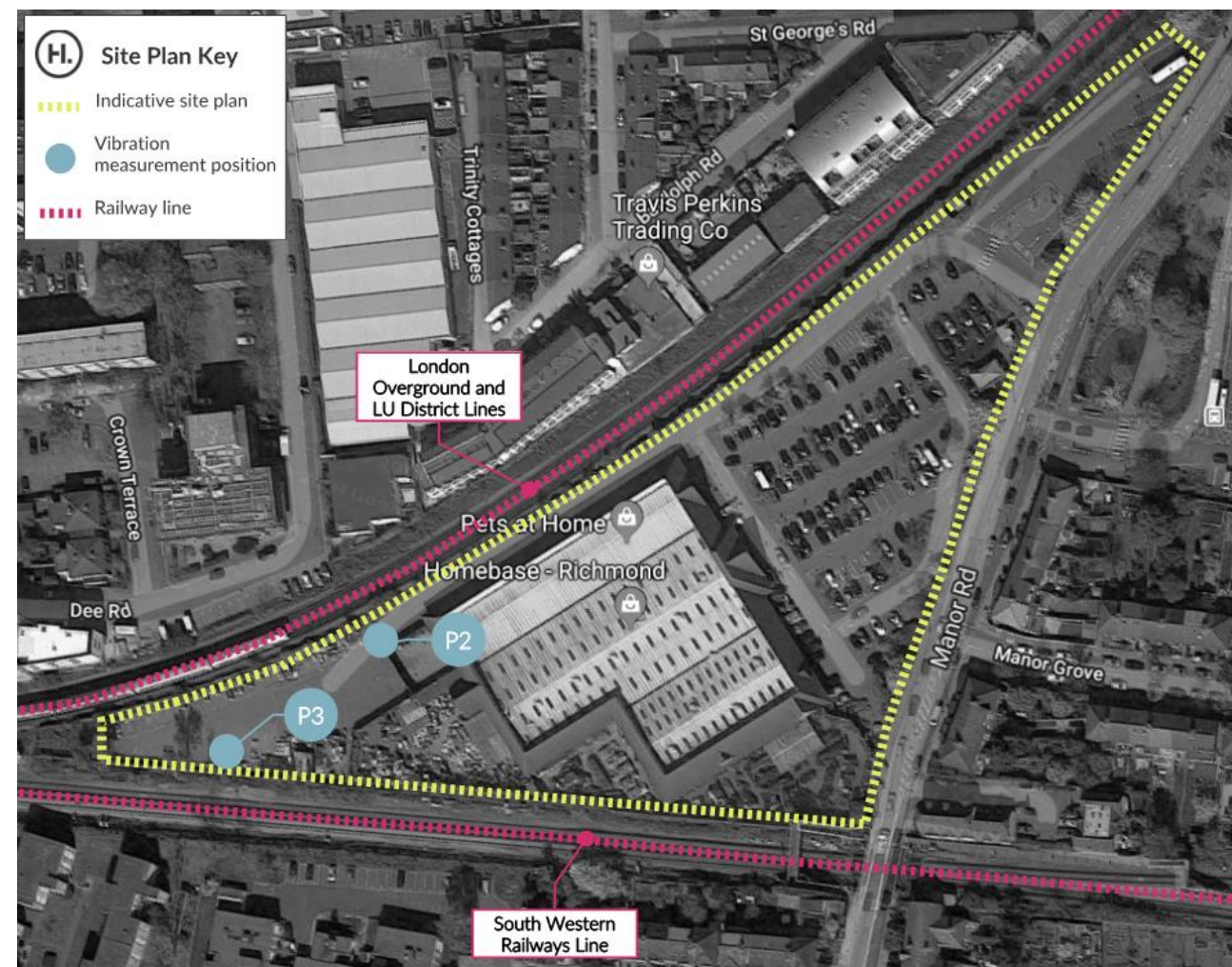


Figure 9 Vibration measurement positions

The survey was undertaken with the intent of quantifying the vibration levels generated from the various train movements. Vibration dose values (VDV) and rms-acceleration values were recorded at 30 seconds intervals, in the vertical direction only (Z-axis).

During the survey, the meter confirmed distinct 'vibration events', occurring at both positions. The vibration events were not perceptible to touch.

A more detailed description of the survey, including measurement times and instrumentation has been included in Appendix E. The measurement data has not been included in its entirety but is available on request.

7.2 Results.

The results of the vibration measurements are summarised in Table 9.

The VDV's presented are the range of values measured from train pass events at each measurement position. Each train pass event varied in duration from approximately 10 – 30 seconds.

The different types of trains measured at the various measurement locations were as follows:

- P2 (along the north boundary of the site) - London Overground and London Underground District Line trains
- P3 (along the south boundary of the site) - South Western Railways and Freight trains

Table 9 Summary of vibration measurement results

Measurement Location	Measured vibration dose values, $m/s^{1.75}$ for train pass event
P2	0.004 – 0.008
P3	0.003 – 0.026

7.3 Vibration impact assessment.

The average VDV's for day and night time periods have been calculated based on the London Overground, London Underground District Line, South Western Railways and Freight train timetables available online, and on the guidance provided in BS 6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings, Part 1: vibration sources other than blasting*.

The rms-acceleration values measured have been used to calculate the regenerated noise levels due to ground-borne vibration transmission from the rail tracks that will likely be experienced by the proposed residences. The assessment assumes that residences will start on the ground floor of the building. The regenerated noise levels from train pass-bys were calculated in accordance with the methodology given in the Association of Noise Consultants' *Measurement and Assessment of Groundborne Noise & Vibration* dated 2012.

As the proposals for the building substructure are in their early stages of development, no corrections have been applied for the losses associated with the building foundations and can therefore be considered worst case. The predicted day time and night time VDV's and regenerated noise levels at positions P2 and P3 are reported in Table 10.

Table 10 Predicted vibration dose values and regenerated noise levels in the future level 1 residences

Measurement Location	Predicted vibration dose values, $m/s^{1.75}$		Predicted re-radiated noise level, $L_{A_{max}}$ (dB) Low amplification factor (such as expected for concrete framed buildings)
	Daytime (07:00 – 23:00)	Night time (07:00 – 23:00)	
P2	0.04	0.03	< 31
P3	0.10	0.09	< 34

The predicted VDV's at both measurement locations given in Table 10 fall well below the BS 6472:2008 threshold of *low probability of adverse comment* and specialist mitigation measures would not normally be considered necessary.

There is potential for individual train events, particularly South Western Railway and Freight train passes on the nearside track of the southern railway line, to be perceptible by some people

The predicted levels of re-radiated noise at both measurement positions are below the Local Authorities required limit of 35 dB $L_{A_{max}}$ and as such are unlikely to cause disturbance. As such, specialist mitigation measures would not normally be considered necessary. Impact of vibration and re-radiated noise on the development from trains would not therefore be considered significant.

8. Summary and conclusion.

Environmental sound and vibration surveys have been undertaken to establish the existing conditions. The results have been used to assess the impact of sound and vibration on the Amended Proposed Development. Comparisons have also been made with LBRuT policy to identify any limits or specialist measures that may be required.

The environmental sound survey indicates that the site is exposed to relatively high levels of environmental sound, primarily governed by road and railway traffic activity in the local area. The results indicate that the background sound levels do not vary significantly between day to night periods.

The results of the environmental sound survey were used to validate a specialist acoustic model of the existing site. This modelling has been used to predict the sound levels incident on the proposed buildings and across the proposed site.

The modelling has also been used to assess the impact of the proposed buildings on the neighbouring properties; particularly the residential properties to the south of the site on Manor Park. The modelling indicates that with the proposed buildings the noise levels incident on the properties on Manor Park will remain the same as existing for the majority of the properties, even slightly decreasing for some properties.

An assessment has been undertaken to understand the implications of the existing sound environment on the design of the facade and ventilation design. This has been summarised as follows:

- The sound reduction performance of the external façade will be controlled by the performance of the glazing. Preliminary calculations have been undertaken and these indicate that, for Block A, B, C and D, facades overlooking the road and railway lines will require high-performance double-glazed window systems in the region of 45 dB R_w.
- Mechanical ventilation is likely to be required for the majority of the development, with openable windows for purge ventilation.

The proposed bus layover area is located directly below residential apartments in Block E, with several facades directly overlooking the entrance and exit to the bus layover.

In order to help limit noise break in to bedrooms of apartments overlooking the entrance and exits of the bus layover, very high-performance window systems will be required in areas of the south and east façades of Block E. It is recommended that allowance should be made for a secondary glazing system in these areas

The proposed bus layover area is located directly below residential apartments and as such it is recommended that the separating floor construction between the bus layover area and the apartments above should achieve a very high sound insulation performance.

With the currently proposed slab depth, and an appropriate floor build-up above the slab, the recommended sound insulation performance should be achievable.

Exact selections for the building services plant equipment are not available at this early stage. Guideline plant noise emission limits have been derived in line with local authority requirements. The plant emission limits proposed are not considered particularly onerous and should be readily achieved with appropriate mitigation measures. The need to control noise to these limiting levels can be enforced by a suitably worded condition.

Vibration measurements were undertaken several ground floor locations, in-line with the proposed facades of building across the development. The results indicated that the levels of vibration measured on site from railway sources were below the threshold required by the Local Authority and the BS 6472:2008 threshold of *low probability of adverse comment*. As such, perceptible vibration and re-radiated sound from ground-borne vibration is not expected to require mitigation.

It is considered that any potentially significant environmental effects associated with the proposed development can be adequately controlled during the design stages, such that no significant effects would be likely.

Appendix A – Acoustic terminology.

Sound

Sound is produced by mechanical vibration of a surface, which sets up rapid pressure fluctuations in the surrounding air.

The Sound Pressure

The Sound Pressure is the force (N) of sound on a surface area (m²) perpendicular to the direction of the sound. The SI-units for the Sound Pressure are Nm⁻² or Pa (Pascal).

Sound is measured with microphones responding proportionally to the sound pressure – p . The power is proportional to the square of the sound pressure.

The Sound Pressure Level

The human ear has an approximately logarithmic response to sound pressure over a very large dynamic range. The lowest audible sound pressure approximately 2×10^{-5} Pa (2 ten billionths of an atmosphere) and the highest is approximately 100 Pa.

It is therefore convenient to express the sound pressure as a logarithmic decibel scale related to this lowest human audible sound, where:

$$L_p = 10 \log \left(\frac{p^2}{p_{ref}^2} \right) = 10 \log \left(\frac{p}{p_{ref}} \right)^2 = 20 \log \left(\frac{p}{p_{ref}} \right)$$

Where:

L_p = sound pressure level (dB)

p = sound pressure (Pa)

$p_{ref} = 2 \times 10^{-5}$ – reference sound pressure (Pa)

In accordance with the logarithmic scale, doubling the sound pressure level gives an increase of 6 dB.

Decibel (dB)

The decibel is the unit used to quantify sound pressure levels as well as sound intensity and power levels.

In accordance with the logarithmic scale, an increase of 10 dB in sound pressure level is equivalent to an increase by a factor of 10 in the sound pressure level (measured in Pa). Subjectively, this increase would correspond to a doubling of the perceived loudness of the sound.

Frequency

The rate at which the pressure fluctuations occur determines the pitch or frequency of the sound. The frequency is expressed in Hertz (Hz) or cycles per second.

Octave and Third Octave Bands

An octave is the interval between two points where the frequency at the second point is twice the frequency of the first.

There are many methods of describing the frequency content of a noise. The most common methods split the frequency range into defined bands, in which the mid-frequency is used as the band descriptor and in the case of octave bands is double that of the band lower. For example, two adjacent octave bands are 250 Hz and 500 Hz.

Third octave bands provided a fine resolution by dividing each octave band into three bands. For examples, third octave bands would be 160 Hz, 250 Hz and 315 Hz for the same 250 Hz octave band.

The human ear is sensitive to sound over a range of frequencies between approximately 20 Hz to 20 kHz and is generally more sensitive to medium and high frequency than to low frequencies within the range. This is the basis of the A-weighting.

A-Weighting

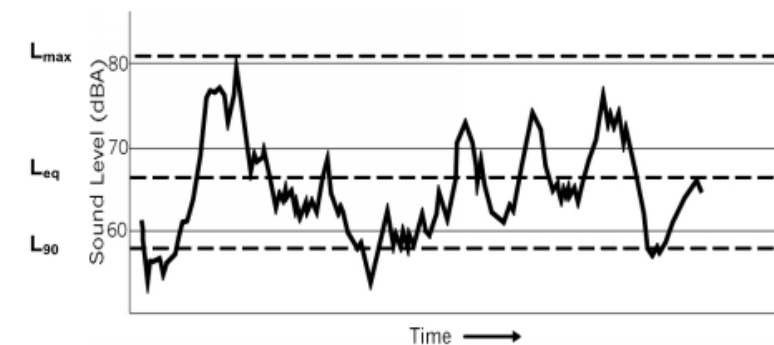
The A-weighting is a correction term applied to the frequency range in order to mimic the sensitivity of the human ear to noise. It is generally used to obtain an overall noise level from octave or third octave band frequencies.

An A weighted value would be written as dB(A), or including A within the parameter term.

Noise Units

In order to assess environmental noise, measurements are carried out by sampling over specific periods of time, such as five minutes, the statistically determined results being used to quantify various aspects of the noise.

The figure below shows an example of sound level varying with time. Because of this time variation the same period of noise can be described by several different levels. The most common of these are described below.



$L_{eq,T}$

The $L_{eq,T}$ is a parameter defined as the equivalent continuous sound pressure level over a defined time period 'T'. It is the sound pressure level equivalent to the acoustic energy of the fluctuating sound signal.

The $L_{eq,T}$ can be thought of as an 'average' sound pressure level over a given time period (although it is not an arithmetic average). Typically the $L_{eq,T}$ will be an A-weighted noise level in dB(A) and is commonly used to describe all types of environmental noise sources.

$L_{01,T}$

The $L_{01,T}$ is a parameter defined as the sound pressure level exceeded for 1% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter.

$L_{10,T}$

The $L_{10,T}$ is a parameter defined as the sound pressure level exceeded for 10% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter and is generally used to describe road traffic noise.

$L_{90,T}$

The $L_{90,T}$ is a parameter defined as the sound pressure level exceeded for 90% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter and is generally used to describe the prevailing background noise level.

$L_{max,T}$

The $L_{max,T}$ is a parameter defined as the maximum noise level measured during the specified period 'T'.

Specific Noise Level, $L_{Aeq,T}$

This is the equivalent continuous A-weighted sound pressure level at the assessment position due to a specific noise source operating over a given time interval.

Free Field

A measurement taken in the free field is at least 3.5m from reflecting vertical surfaces and 1.2m from the ground.

Façade

A measurement is influenced by the reflection of sound from the façade of a building within 3.5m. A façade measurement is made 1m in front of the vertical building surface.

R_w

A single-number quantity which characterizes the airborne sound insulation of a material or building element in the laboratory. See BS EN ISO 717-1: 1997.

Appendix B – London Borough of Richmond upon Thames planning policy.

Internal design noise levels

Richmond Upon Thames Draft Supplementary Planning Document (SPD) 'Development Control for Noise Generating & Noise Sensitive Development' sets out the following guidance for internal noise levels:

The Boroughs will normally seek to achieve the design noise levels contained in Table 4 of BS8233:2014 in all noise sensitive rooms. It should be noted that the acoustic integrity of the building envelope will be compromised in the event windows are opened for ventilation purposes, typically reducing the insulation to no more than 10 to 15 dB(A). The use of good acoustic design should aspire to achieve the internal design levels in noise sensitive rooms with windows partially open, although on certain sites the Boroughs may agree to assess the proposal assuming windows are closed. In many sites classified as NRC 0 then it should be possible to achieve the design noise levels with windows open.

Table 1: Internal Ambient Noise Levels for Dwellings

Situation	Location	07:00 – 23:00 hrs.	23:00 – 07:00 hrs.
Resting	Living room	35 dB LAeq,16 hour	-
Dining	Dining room/area	40 dB LAeq, 16 hour	-
Sleeping (daytime resting)	Bedroom	35 dB LAeq,16 hour	30 dB LAeq, 8 hour
Sleeping	Bedroom	-	45 dB LAMax (several times in any one hour)

(Source: BS8233:2014, page 24, Table 4 "Indoor Ambient Noise Levels")

Notes:

- (i) The Table provides recommended levels for overall noise in the design of a building. These are the sum total of structure-borne and airborne noise sources. Groundborne noise is assessed separately and is not included as part of these targets, as human response to groundborne noise varies with many factors such as level, character, timing, occupant expectation and sensitivity.
- (ii) The levels shown in the Table are based on the existing guidelines issued by the WHO and assume normal diurnal fluctuations in external noise. In cases where local conditions do not follow a typical diurnal pattern, for example on a road serving a logistic hub with high levels of traffic at certain times of the night, an appropriate alternative period, e.g. 1 hour, may be used, but the level should be selected to ensure consistency with the levels recommended in the Table.
- (iii) These levels are based on annual average data and do not have to be achieved in all circumstances. For example, it is normal to exclude occasional events, such as fireworks night or New Year's Eve.
- (iv) Regular individual noise events (for example, scheduled aircraft or passing trains) can cause sleep disturbance. A guideline value may be set in terms of SEL or L_{AMax,F}, depending on the character and number of events per night. Sporadic noise events could require separate values.
- (v) If relying on closed windows to meet the guide values, there needs to be appropriate alternative ventilation that does not compromise the façade insulation or the resulting noise level. If applicable, any room should have adequate ventilation (e.g. trickle ventilators should be open) during assessment.
- (vi) Attention is drawn to the Building Regulations.

- (vii) In certain circumstances where external noise levels above WHO guidelines, but development is considered necessary or desirable, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved.
With regard to noise from individual noise events, the Boroughs consider that for a reasonable standard in noise sensitive rooms at night (i.e. bedrooms) individual noise events measured with F time weighting should not normally exceed 45dB L_{AMax} more than 10 times a night. This guideline is supported by advice contained in the WHO community Noise Guidelines (2000).

Design noise levels for external amenity spaces

Richmond Upon Thames Draft Supplementary Planning Document (SPD) 'Development Control for Noise Generating & Noise Sensitive Development' sets out the following guidance for external amenity noise levels:

The acoustic environment of external amenity areas shall always be assessed and noise levels should ideally not be above the range 50 to 55dB LAeq,16hr. It may be necessary to carefully locate and design amenity areas and/or to provide acoustic screening in order to meet this goal.

Developers are encouraged to enter into pre application discussion where noise levels in proposed amenity spaces are likely to be above 55dB LAeq,16hr. In such cases, the availability of reasonable access to an outdoor recreational area away from but close to the development site, that meets the above target external levels will be taken into account in deciding whether the scheme is acceptable in noise terms. Soundscape management techniques, including psychological masking, may also help to provide a suitable outdoor acoustic environment in otherwise noisy locations. It is accepted that, in some circumstances it may be appropriate to vary, or not to apply, these goals in order to meet wider planning objectives. BS8233:2014 (Section 7.7.3.2 Design criteria for external noise) contains the following guidance:

"For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50 dB L_{Aeq,T} with an upper guideline value of 55 dB L_{Aeq,T} which would be acceptable in noisier environments. However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. In higher noise areas, such as city centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited.

Other locations, such as balconies, roof gardens and terraces, are also important in residential buildings where normal external amenity space might be limited or not available, i.e. in flats, apartment blocks, etc. In these locations, specification of noise limits is not necessarily appropriate. Small balconies may be included for uses such as drying washing or growing pot plants, and noise limits should not be necessary for these uses. However, the general guidance on noise in amenity space is still appropriate for larger balconies, roof gardens and terraces, which might be intended to be used for relaxation. In high-noise areas, consideration should be given to protecting these areas by screening or building design to achieve the lowest practicable levels. Achieving levels of 55 dB L_{Aeq,T} or less might not be possible at the outer edge of these areas, but should be achievable in some areas of the space."

Appendix C – Environmental sound survey.

An environmental sound survey was undertaken by Hoare Lea between the 20th July and 25th July 2018. The survey comprised long term unattended monitoring on site and short-term attended measurements.

Weather conditions

The weather conditions on site during both survey periods were dry with approximately 50%-80% cloud cover. The wind speeds were lower than 5 ms⁻¹ as recommended by the guidance.

Equipment details

The measurement equipment was calibrated before and after the survey. No significant drift has been observed. The equipment used for the survey has been summarised in Table C1. The instruments used for the survey were in calibration during the survey and their calibration certificate numbers have been included in the table for reference.

Table C1: Instrumentation details

Survey details	Instrumentation description	Manufacturer	Model	Serial Number	Date of Calibration	Certificate Number
Long term survey Position L1	Sound Level Meter	Rion	NL-52	00832187	10/11/2017	UCRT17/2011
	Microphone	Rion	UC-59	10815	10/11/2017	UCRT17/2011
	Pre-amp	Rion	NH-25	32215	10/11/2017	UCRT17/2011
	Acoustic Calibrator	Rion	NC-74	34557134	12/10/2017	UCRT17/1880
Short term measurements	Sound Level Meter	Rion	NA-28	01260200	29/08/2017	UCRT17/1731
	Microphone	Rion	UC-59	00280	29/08/2017	UCRT17/1731
	Pre-amp	Rion	NH-23	60103	29/08/2017	UCRT17/1731
	Acoustic Calibrator	Rion	NC-74	34172704	29/06/2017	UCRT17/1544

Long term unattended monitoring results

The results of the unattended measurements have been calculated into daytime ($L_{Aeq,16hr}$) and night-time ($L_{Aeq,8hr}$) equivalent levels, and are shown with the associated measured typical minimum background noise level ($L_{A90,15min}$) and maximum instantaneous measured noise level ($L_{Amax,T}$) in Table C2 below.

Table C2 Measured noise levels at Position L1

Measurement Position		Position L1					
Measurement Date	Time	Daytime			Night-time		
		$L_{Aeq,T}$ dB	Max $L_{Amax,T}$ dB	Min $L_{A90,15min}$ dB	$L_{Aeq,8hr}$ dB	Max $L_{Amax,T}$ dB	Min $L_{A90,15min}$ dB
Fri 20 th Jul 2018	16:00 – 23:00	60	87	41	-	-	-
21 st Jul 2018	23:00 – 07:00	-	-	-	60	83	39
Sat 21 st Jul 2018	07:00 – 23:00	63	82	41	-	-	-
22 nd Apr 2018	23:00 – 07:00	-	-	-	59	80	39
Sun 22 nd Jul 2018	07:00 – 23:00	62	83	41	-	-	-
23 rd Apr 2018	23:00 – 07:00	-	-	-	59	80	40
Mon 23 rd Jul 2018	07:00 – 23:00	63	85	41	-	-	-
24 th Apr 2018	23:00 – 07:00	-	-	-	58	79	39
Tues 24 th Jul 2018	07:00 – 23:00	63	83	41	-	-	-
25 th May 2018	23:00 – 07:00	-	-	-	58	80	39
Wed 25 th Jul 2018	07:00 – 15:00	61	86	42	-	-	-

A time history of the L_{Aeq} , L_{A90} and L_{Amax} from the unattended measurements recorded is presented overleaf.

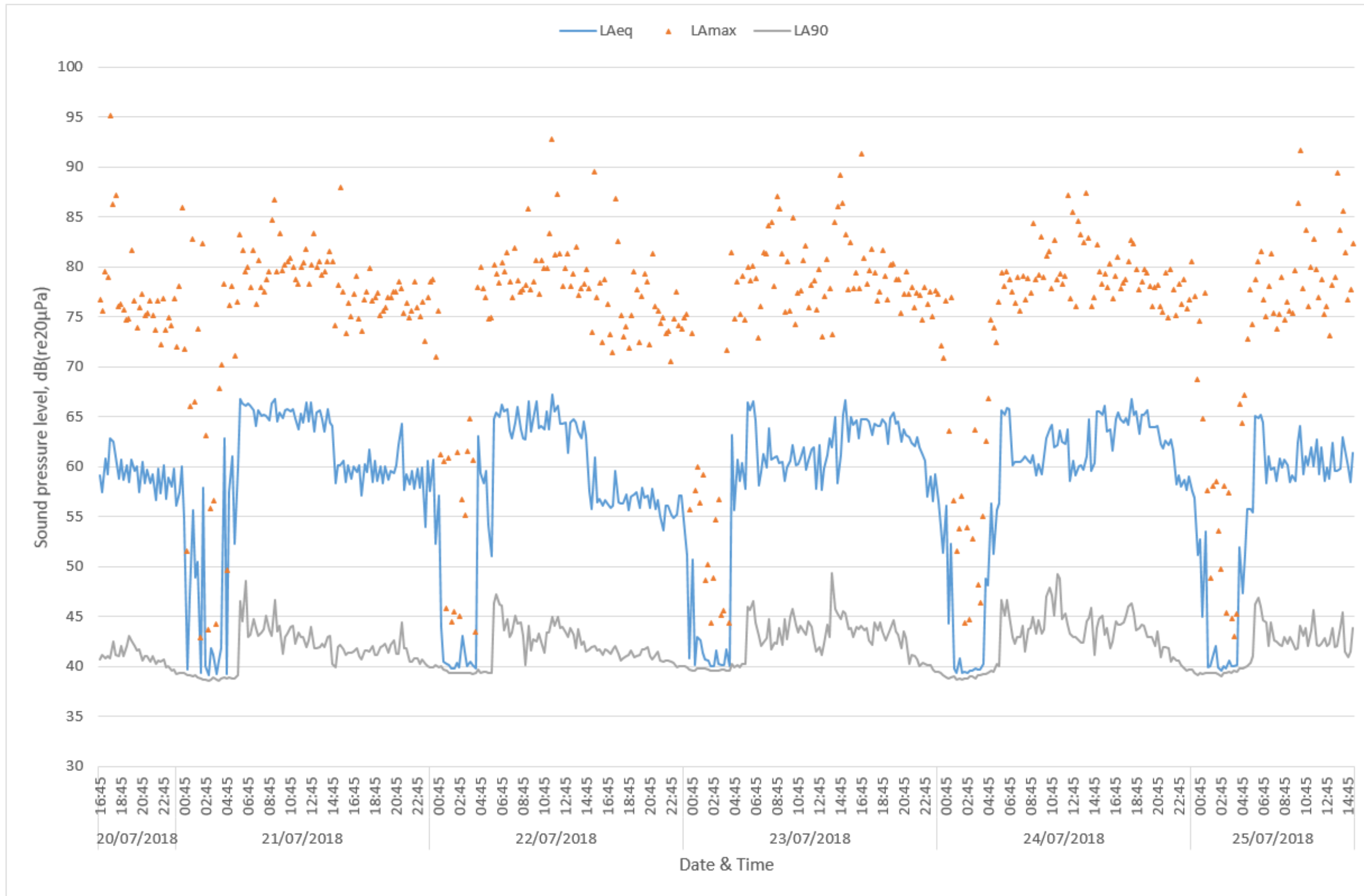


Figure C1 Time history results from unattended monitoring position L1

Short term attended monitoring

The results of the attended road traffic measurements taken at position P1, along Manor Road, are shown in terms of average ($L_{Aeq,T}$) noise levels measured with the associated maximum instantaneous noise level ($L_{Amax,T}$) and noise level exceeded for 10% of the measurement period (L_{A10}) in Table C3 below.

Table C3 Attended measurement results - Position P1 - Road traffic on Manor Road

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Amax}	Level exceeded for 10% of time, dB (L_{A10})	Measurement Description
20/07/2018 11:45:00	01:00:00	64	90	69	Road traffic measurements
20/07/2018 12:45:00	01:00:00	65	87	69	
20/07/2018 13:45:00	01:00:00	65	83	69	
20/07/2018 14:45:00	01:00:00	66	90	69	

The results of the attended railway traffic measurements taken at position P2, P3 and P4 are shown in terms of average ($L_{Aeq,T}$) noise levels measured with the associated maximum instantaneous noise level ($L_{Amax,T}$) and sound exposure level (L_{AE}) in Table C4, C5 and C6 below.

Table C4 Attended measurement results - Position P2 - Railway traffic on London Overground line

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Amax}	Sound exposure level, dB (L_{AE})	Measurement Description
20/07/2018 12:31	00:00:18	72	77	85	Near track, westbound
20/07/2018 12:35	00:00:17	71	76	83	Far track, eastbound
20/07/2018 12:40	00:00:15	72	76	84	Near track, westbound
20/07/2018 12:41	00:00:13	74	79	85	Far track, eastbound
20/07/2018 12:49	00:00:19	72	78	84	Near track, westbound
20/07/2018 12:55	00:00:14	72	76	84	Far track, eastbound
20/07/2018 12:58	00:00:31	70	77	85	2 trains - Both near & far tracks
20/07/2018 13:05	00:00:12	74	78	85	Far track, eastbound
20/07/2018 13:11	00:00:33	74	84	89	2 trains - Both near & far tracks

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Amax}	Sound exposure level, dB (L_{AE})	Measurement Description
20/07/2018 13:23	00:00:21	68	72	81	Near track, westbound
20/07/2018 13:29	00:00:13	74	79	85	Far track, eastbound
20/07/2018 13:31	00:00:29	73	83	88	Near track, westbound

Table C5 Attended measurement results - Position P3 - Railway traffic on South Western Railway line

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB $L_{Aeq,T}$	Maximum event level, dB L_{Amax}	Sound exposure level, dB (L_{AE})	Measurement Description
20/07/2018 13:50	00:00:16	70	74	82	Near track, eastbound
20/07/2018 13:58	00:00:15	76	85	87	Near track, eastbound
20/07/2018 14:00	00:00:17	68	72	80	Far track, westbound
20/07/2018 14:06	00:00:11	71	75	82	Far track, westbound
20/07/2018 14:11	00:00:22	66	71	80	Far track, westbound
20/07/2018 14:16	00:00:18	71	77	83	Far track, westbound
20/07/2018 14:17	00:00:28	66	71	81	Near track, eastbound. Train slowed down to halt just before site then sped up past the site
20/07/2018 14:21	00:00:39	69	75	85	2 trains - 1 overground westbound, 1 south westbound
20/07/2018 14:25	00:00:31	80	85	95	FREIGHT TRAIN - Far track, westbound
20/07/2018 14:28	00:00:15	64	68	76	Far track, westbound
20/07/2018 14:29	00:00:19	67	72	80	Near track, eastbound

Table C6 Attended measurement results - Position P4 - Railway traffic on pedestrian railway bridge

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB LAeq,T	Maximum event level, dB LAfmax	Sound exposure level, dB (LAE)	Measurement Description
20/07/2018 15:16	00:00:20	76	81	89	Near track, eastbound
20/07/2018 15:19	00:00:12	80	84	91	Far track, westbound
20/07/2018 15:20	00:00:18	76	82	89	Near track, eastbound
20/07/2018 15:28	00:00:37	77	84	93	2 trains - 1 Near track, eastbound, 1 Far track, westbound
20/07/2018 15:35	00:00:26	72	79	86	Near track, eastbound
20/07/2018 15:38	00:00:16	78	82	90	Far track, westbound
20/07/2018 15:44	00:00:18	73	80	85	Far track, westbound
20/07/2018 15:45	00:00:19	78	84	91	Near track, eastbound
20/07/2018 15:47	00:00:14	81	85	93	Far track, westbound
20/07/2018 15:52	00:00:25	72	78	86	Near track, eastbound

The results of the attended measurements of bus movements taken at position P5, are shown in terms of average (LAeq,T) noise levels measured with the associated maximum instantaneous noise level (LAmax,T) in Table C7 below.

Table C7 Attended measurement results - Position P1 - Road traffic on Manor Road

Measurement date and time	Measurement period, T (hh:mm:ss)	Average ambient noise levels, dB LAeq,T	Maximum event level, dB LAfmax	Measurement Description
20/07/2018 12:05	00:00:13	80.4	67.6	Bus pulling in
20/07/2018 12:07	00:00:12	80.4	68.6	Bus pulling out
20/07/2018 12:14	00:00:13	79	75.0	Bus pulling out
25/07/2018 15:49	00:00:11	65	68.4	Bus pulling out
25/07/2018 15:50	00:00:05	82.5	69.8	Bus pulling in
25/07/2018 15:55	00:00:14	81.5	72.8	Bus pulling out

Appendix D – Predicted façade levels.