Hamilton Architects

Bird College

Noise Impact Assessment

MLM.

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Contents

1 Executive Summary

MLM Consulting Engineers Limited has been appointed to advise on the acoustic design issues associated with the proposed development at Bird College, Alma Rd, Sidcup DA14 4ED. This report provides a noise impact assessment at RIBA Stage 2.

The key acoustic issues are summarised below:

Baseline Sound Conditions

The site is exposed to low to moderate levels of noise, not untypical for this type of setting. Environmental sound conditions at the site are mainly affected by road traffic, remote road traffic, occasional air traffic, and plant noise.

Control of Internal Ambient Noise Levels

Recommendations for building envelope mitigation measures are provided to demonstrate how appropriate internal ambient noise levels can be achieved across the Proposed Development.

For the residential accommodation, standard thermal double glazing with enhanced acoustic performance, a brickwork external wall and acoustic trickle ventilators is expected to be sufficient to achieve the BS8233 indoor ambient noise criteria.

For the teaching spaces including activities comprising amplified music, thermal double glazing with enhanced acoustic performances will be required to avoid significant adverse impact at the nearest noise sensitive receptors. These rooms are also required to be mechanically ventilated.

Where mechanically ventilated, systems should be designed to achieve appropriate internal ambient noise levels as detailed in this report.

Sound Insulation between the Student Accommodation and the Studios

This report presents appropriate acoustic design criteria for the walls and floors between the proposed teaching studios and the student accommodation and, based upon current architectural proposals, provides an assessment of the ability of the scheme to satisfy these requirements. A minimum sound reduction of 80dB R_w is expected to satisfy the sound insulation criteria detailed in this report. A masonry wall with linings to each side of the partitions and a concrete floor with suspended ceiling are expected to achieve the minimum sound insulation requirements.

Control of Building Services Noise

Plant noise limits are provided in accordance with the BS4142:2014. Plant specifications are to be chosen and designed to meet these requirements as the design progresses.

Construction Noise and Vibration Impact

The noise and vibration impact from the proposed construction works have been assessed. Mitigation measures have been recommended where necessary. A scheme of noise and vibration monitoring for the duration of the construction has been recommended to ensure that the noise and vibration levels do not exceed the limits set out in this report.

2 Introduction

MLM Consulting Engineers Limited has been commissioned by Hamilton Architects, to provide a noise impact assessment for the proposed development at Bird College, Alma Rd, Sidcup DA14 4ED.

The proposed development is understood to comprise the demolition of three existing blocks and the construction of a new three storey building providing a theatre, teaching studios and student accommodation rooms. The construction of a further block comprising a gym, a dance studio and a physio/medical room is proposed to the rear of the site. An external amphitheatre and alterations to the existing parking are also proposed.

This report records the provisions made at the Planning Stage (RIBA Stage 2) for the acoustic design of the proposed new build blocks and the proposed alterations to the existing facilities at Bird College.

The suitability of the site for development of the proposed usage types has been based on the current development proposals and the measured noise levels. Where predicted levels indicate that noise may be a determining factor in the granting of planning permission, mitigation measures have been considered to ensure satisfactory conditions are met.

An assessment of the noise levels affecting the proposed development has been made in relation to any relevant internal ambient noise level criteria. The results of the survey have been used to outline the sound insulation requirement of the building envelope and the ventilation strategy. The survey data has also been used to outline suitable building orientation and layout for acoustics.

Sound rating level limits have been recommended for building services plant associated with the proposed new development at the site in accordance with BS 4142:2014.

The report firstly defines appropriate acoustic design standards. It goes on to set out the measured acoustic data and presents the assessment of potential noise impacts in relation to the development. Whilst every effort has been made to ensure that this Report is easily understood, it is technical in nature; a glossary of terms is included in Appendix A to assist the reader.

3 Relevant Standards and Guidance Documents

A summary of the Standards and guidance documents used to inform the acoustic design of the scheme is provided below. Further details are provided in Appendix B.

- Building Bulletin 93 'Acoustic Design of Schools: Performance Standards;
- The School Premises (England) Regulations 2012;
- Independent School Standards;
- Equality Act 2010;
- BS 4142:2014 "Method for Rating and Assessing Industrial and Commercial Sound";
- Local Authority Acoustic Requirements– London Borough of Bexley;
- British Standard 8233:2014
- Building Regulations - Approved Document E;
- IOA Good Practice Guide on the Control of Noise from Pubs and Clubs;
- BS5228:2009 – Code Of Practice for Noise and Vibration Control on Construction and Open Sites; and
- BS 6472:2008 Guide to evaluation of human exposure to vibration in buildings, Part 1.

4 Design Information

Our assessment has been based on the drawings provided by Hamilton Architects, as detailed below:

- 19055 (00)01 Site Location Plan;
- 19055 (00)03 Proposed Site Plan;
- 19055 (01)01 GF Proposed Main Accomodation Studio Block Plan;
- 19055 (01)02 1F Proposed Main Accomodation Studio Block Plan;
- 19055 (01)03 2F Proposed Main Accomodation Studio Block Plan;
- 19055 (01)07 GF Proposed Theatre Block Plan;
- 19055 (01)08 1F Proposed Theatre Block Plan.

5 Site Description

5.1 Existing Site

The site location falls within the jurisdiction of the London Borough of Bexley. The site is surrounded by residential areas to the north and to the south. To the east of the proposed development site is Warring Park and immediately to the west is the Birkbeck Primary School. Lansdown Road and Faraday Avenue are the main road noise sources affecting the site.

The location of the proposed development site is identified in Figure 1.

Figure 1: Site Location (Approximate Site Boundary - Red Line), Nearest Noise Sensitive Receptors and Measurement Positions (MP)

The nearest/worst-affected existing noise-sensitive receptors (NNSR) are expected to be the residential properties along the northern and southern site perimeter and the school receptor to the west of the proposed development site. Potentially affected receptors are shown in Figure 1 above.

The site is subject to road traffic noise and air traffic noise which are the dominant noise sources impacting the site.

5.2 Proposed Development

The proposed development is understood to comprise the demolition of three existing blocks and the construction of a three storey building providing a theatre, studio blocks and student accommodation units. It is understood that the development will also comprise the construction of a classroom block to the rear of the site and an external amphitheatre. Alterations to the parking are also proposed.

It should be noted that the student accommodation is proposed at first floor level, directly above the dance studios. There is also one student accommodation room proposed adjacent to one of the dance studios at ground floor level.

The proposed new build areas are shown in Figure 2 below.

Figure 2: Proposed Site Plan

6 Baseline Sound Conditions

6.1 Survey Overview

The prevailing sound conditions in the area have been determined by an Environmental Sound Survey, over a number of suitable measurement locations around the development site, so as to inform the specification and design as shown in Figure 1, within Section 5.1 of this Report.

The Environmental Sound Survey has been undertaken by MLM Consulting Engineers Limited over a period of five days, between Thursday 24 and Monday 28 September 2020. The measurement results are presented in detail in Appendix B, and are summarised below, together with the main site observations.

The results of the environmental noise survey inform three aspects of the acoustic design for the development:

- Determination of the sound insulation performance of the building envelope and ventilation strategy, based on the acoustic criteria, Local Authority and any Client specific requirements; and
- Establish acceptable building services plant noise emission limits in accordance with the proposed acoustic criteria, Local Authority and any Client specific requirements.
- Establish acceptable noise emission limits for the noise due to any external and internal college activity.

6.2 Local Sound Conditions

Environmental sound conditions at the site are mainly affected by road traffic, remote road traffic, occasional air traffic, and plant noise. The site is exposed to low to moderate levels of noise, not untypical for this type of setting.

6.3 Measurement Results Summary

The levels of environmental sound measured at each position are summarised in Table 1 below. Full survey details and results, including time history graphs and typical spectral noise levels are provided in Appendix C.

Table 1: Summary of Measured Noise Levels Used in the Assessment

Measurement Position	Survey Period	Period (T)	Highest $L_{Aeq,30\ mins}$ (dB)	Average $L_{Aeq,T}$ (dB)	Typical Maximum Noise Event L_{Amax}* (dB)	Highest $L_{A01,30min}$ (dB)	Typical LA90,10mins** (dB)
MP4	24/09/2020 to 28/09/2020	School (15:00 – 19:00)	60	56	-	66	47
		Daytime (15:00 – 23:00)	-	56	-	-	47
		Night time (23:00 – 07:00)	-	53	73	-	37
MP1	24/09/20 12:00 - 14:10	-	-	64		-	48

Table 1: Summary of Measured Noise Levels Used in the Assessment							
Measurement Position	Survey Period	Period (T)	Highest $L_{Aeq,30\ mins}$ (dB)	Average $L_{Aeq,T}$ (dB)	Typical Maximum Noise Event L_{Amax}*(dB)	Highest $L_{A01,30min}$ (dB)	Typical LA90,10mins** (dB)
MP2	24/09/20 14:20 -14:35	-	-	66	-	-	48
MP3	24/09/20 14:45 – 14:50	-	-	63	-	-	-
MP5	28/09/20 11:15 – 13:30	-	-	49	-	63	40

* Typical L_{Amax} values are determined by undertaking a detailed review and statistical analysis of the measured noise levels. In this case the 90th percentile value is used to represent the typical L_{Amax} during the night time period. This level is expected to be exceeded less than 10 times per night.

** The L_{A90} is shown for periods (T) of 1 hour during the daytime and 15 minutes during the night-time periods. The 1 hour daytime L_{A90} and the 15 minutes nigh time L_{A90} are an estimation base on the arithmetic average of 5 minute sample periods.

Measurements that were affected by adverse weather conditions have been excluded from the above summary.

7 Noise Modelling

7.1 Modelling Overview

To establish the variation in environmental noise levels around the site and to determine the façade sound insulation performance required to meet the specified internal noise targets and external noise limits, predictions have been carried out using the Cadna/A suite of noise modelling software.

7.2 Road Traffic Noise Predictions

The predictions of road traffic noise have been carried out in accordance with the CRTN, and ISO 9613 prediction methodologies for road traffic noise which allow consideration of the effects of the acoustic screening provided by existing buildings in the vicinity, as well as the as-built structures of the proposed development. The noise model was calibrated with the noise levels measured during our noise survey.

The predictions are based on the results of the environmental noise survey as summarized in Section 6 and detailed in Appendix C of this report.

The following parameters have been predicted:

- $L_{Aeq,day(16h)}$ dB;
- $L_{Aeq,night(8h)}$ dB.

7.3 College Activity Noise Predictions

The noise levels for the proposed activities have been estimated based on assumed internal and external noise activity noise levels. The noise levels used for the assessment are detailed in Section 11.3 of this report. The noise sources used are considered representative of the expected operational noise levels. The sound insulation performances detailed in Section 8 have also been considered for the modelling exercise.

The following parameters have been predicted:

- $L_{Aeq,T}$ (dB).
  *T corresponds to the duration of the event.

7.4 Noise Model Output

In addition to the derived source/activity noise levels used in the predictions detailed in Sections 7.2 and 7.3 above, the model also considers the effects of the topographical conditions throughout the area, ground absorption, atmospheric absorption, acoustic reflections, acoustic screening as well as applying a light downwind propagation correction to represent worst case.

The model has been used to determine typical environmental $L_{Aeq,\ T\ mins}$ noise levels incident on the various facades of the proposed development during daytime and night-time (road traffic only) periods and to inform the design of the external building fabric. The predicted noise levels for the college activities model have also been used to assess on the impact of these activities at the nearest noise sensitive receptors.

8 Building Envelope - Minimum Sound Insulation Performance Requirements

8.1 Overview

This section sets out the minimum sound insulation performance requirements for the proposed development. The façade and roof constructions detailed in this section are expected to be sufficient to achieve all the noise criteria related to the proposed development. It should be noted that the minimum sound insulation performances for both the student accommodation and the proposed new spaces for the college will be dictated by the noise impact due to the college activities comprising amplified music.

Please note that all the assessments presented in this report are based on the external building fabric performances detailed in this section.

8.2 Minimum External Glazing and Door Sound Reduction Requirements

Tables 2 and 3 below sets out the glazing sound reduction index requirements for the student accommodation rooms and the proposed new rooms for the college.

Table 2: Minimum Sound Reduction Performance Requirements - External Glazing – Student Accommodation

Room	Octave Band Centre Frequency, Hz							R_w (C_{tr})	Comment
	63	125	250	500	1000	2000	4000		
	Sound Reduction Performance, R_w (dB)							(dB)*	
Bedroom**	22	27	26	33	39	39	47	36(-3)	Representative of thermal glazing with enhanced acoustic performance.
Living Room**	22	27	29	31	32	38	47	34(-2)	Representative of thermal glazing with slightly enhanced acoustic performance.

*Please note that the performance specifications for the glazed sections apply to the system as a whole - inclusive of glazing, framing, opening lights, balcony doors, etc. The performance of the glazing system will depend on many factors, such as the configuration, size, frame quality, quality of sealing, etc.

**The minimum sound insulation requirements for the glazing is dictated by the noise from the college activities. In order to achieve the BS8233 indoor criteria, room to room noise flanking has also been considered for this assessment.

Table 3: Minimum Sound Reduction Performance Requirements - External Glazing – College

Room	Octave Band Centre Frequency, Hz							R_w (C_{tr})	Comment
	63	125	250	500	1000	2000	4000		
	Sound Reduction Performance, R_w (dB)							(dB)*	
All Studios and Gym	25	30	30	39	44	48	51	42(-5)	Representative of thermal glazing with enhanced acoustic performance.
Physio and Interview Room/Counselling	22	27	29	31	32	38	47	34(-2)	Representative of thermal glazing with slightly enhanced acoustic performance. ***

*Please note that the performance specifications for the glazed sections apply to the system as a whole - inclusive of glazing, framing, opening lights, balcony doors, etc. The performance of the glazing system will depend on many factors, such as the configuration, size, frame quality, quality of sealing, etc.

**It is recommended that the internal sound insulation between this room and any studio/gym is designed in such way that the cumulative noise levels do not exceed the BB93 indoor ambient noise levels detailed in Table 16 in Section 12.3 of this report. Please note that the BB93 internal sound insulation assessment is not included in this report. This assessment should be carried out during the design stage.

8.3 Minimum Wall Sound Reduction Requirements

The Table below sets out the minimum performance requirement for the external wall (non-glazed elements).

Table 4: Minimum Sound Reduction Performance Requirements - External Wall – Student Accommodation									
Room	Octave Band Centre Frequency, Hz							R_w (C_{tr}) (dB)	Comment
	63	125	250	500	1000	2000	4000		
	Sound Reduction Performance, R_w (dB)								
Bedroom and Living Room	31	36	40	41	45	52	52	46(-3)	Representative of a brick wall (260Kg/m²)

Table 5: Minimum Sound Reduction Performance Requirements - External Wall – College									
Room	Octave Band Centre Frequency, Hz							R_w (C_{tr}) (dB)	Comment
	63	125	250	500	1000	2000	4000		
	Sound Reduction Performance, R_w (dB)								
All Studios and Gym	36	41	45	45	54	58	58	52(-4)	Representative of a brick wall (480Kg/m²)
Black Box	40	47	53	58	68	75	75	63(-5)	Representative of: Brickwork (240Kg/m²) with a linin of 2 layers of 12.5mm Fireline boards on independent studs. Cavity filled with 50mm of Gypglas. The internal performance space walls, in combination with the adjacent external walls will need to be designed to achieve this minimum sound reduction performance
Physio and Interview Room/Counselling	31	36	40	41	45	52	52	46(-3)	Representative of a brick wall (260Kg/m²)

8.4 Minimum Roof Sound Reduction Requirements

The tables below set out the minimum performance requirements for the roof of the student accommodation and college.

Table 6: Minimum Sound Reduction Performance Requirements - Roof – Student Accommodation									
Room	Octave Band Centre Frequency, Hz							R_w (C_{tr}) (dB)	Comment
	63	125	250	500	1000	2000	4000		
	Sound Reduction Performance, R_w (dB)								
All Bedrooms and Living Rooms	22	27	37	43	48	52	52	46(-7)	Representative of a tiled roof with a suspended ceiling and sound insulation in its cavity

Table 7: Minimum Sound Reduction Performance Requirements - Roof – College									
Room	Octave Band Centre Frequency, Hz							R_w (C_{tr}) (dB)	Comment
	63	125	250	500	1000	2000	4000		
	Sound Reduction Performance, R_w (dB)								
All Studios/Gym, Physio room and Interview Room /Counselling	34	39	40	49	53	57	57	52(-5)	Representative of 100mm reinforced concrete slab (260Kg/m^2)
Black Box	48	48	50	61	66	73	77	63(-6)	Representative of 200mm reinforced concrete slab (260Kg/m^2) with a suspended plasterboard ceiling. Absorber layer in the cavity.

8.5 Ventilation Strategy Acoustic Requirements

8.5.1 Student Accommodation

Whole Room Ventilation Condition

Suitable internal ambient noise levels are not expected to be achieved with partially open windows. Therefore, trickle ventilators or a mechanical ventilation strategy would be required to achieve appropriate internal ambient noise levels.

The following ventilator performances are expected to be sufficient to achieve the criteria.

Table 8: Minimum Insertion Loss Performance Requirements – Ventilator – Student Accommodation									
Room	Octave Band Centre Frequency, Hz							D_{new}* (dB)	Comment
	63	125	250	500	1000	2000	4000		
	Insertion Loss Performance, D_{ne} (dB)								
Bedroom	28	33	39	43	38	33	31	35	Acoustic trickle ventilator
Living Room	26	31	30	30	34	28	30	30	Standard trickle ventilator

*A single trickle ventilator have been assumed for each of the rooms. 3dB should be added to the D_{new} value for each duplication in number of ventilators. I.e.: 1: 35dB D_{new} / 2 Vents: 38dB D_{new} / 4 Vents: 41dB D_{new}…

Where mechanically ventilated, systems should be designed to achieve appropriate internal ambient noise levels as defined in Table 10 in Section 8.5.3 below.

Overheating and Purge Ventilation

Windows may be openable in all rooms to mitigate overheating, and for purge ventilation.

8.5.2 College

All the studios will be required to be mechanically ventilated in order to reduce the noise break out from amplified music.

8.5.3 Appropriate internal ambient noise levels inside the proposed Physio and Counselling rooms cannot be achieved with opening windows. A mechanical ventilation system strategy is recommended for these rooms. Internal Mechanical Services Noise Limits.

Where applicable, mechanical ventilation systems should be designed to achieve appropriate internal ambient noise levels as defined in Table 9.

Table 9: Building Services Internal Noise Limits

Room Type	Noise Rating Limit (dB)
Bedrooms	NR25
Living Rooms	NR30
Dining Rooms	NR35
College	Mechanical services should be designed in order to meet the internal ambient noise level limits detailed in Table 16 in Section 12.3 of this report.

9 Amplified Music Noise Limitations

The assessments presented in this report are based on the activity noise levels detailed in Section 11.3. The noise levels for any activity including amplified music/speech should be controlled so the levels assumed for this assessment are not exceeded at any time.

If the activity noise levels are expected to operate above the assumed levels, noise limiters should be installed to ensure that levels do not exceed those shown in Table 13 and Section 11.3.2. This should be confirmed to MLM and in such case, a further assessment would be required.

10 Sound Insulation between the Student Accommodation and the Studios

10.1 Overview

The sound insulation requirements between the student accommodation and the studios are based on achieving the minimum Building Regulation Approved Document E requirements and on achieving internal ambient noise levels in the receiving room 10dB below the BS8233:2014 indoor ambient noise levels criteria detailed in Table 15 in Section 12.2 of this report. Achieving the BB93 internal ambient noise levels detailed in Table 16 in Section 12.3 of this report has also been considered for this assessment.

This assessment has been based on the proposed room dimensions. The activity noise levels detailed in Section 11.3 of this report have been assumed for this assessment.

It is essential to note that this assessment methodology does not ensure that the activity noise is inaudible within the student accommodation, only that it is controlled to a level at which the noise would not be overly intrusive. This is done on the basis that the student accommodation forms part of the same development as the college, meaning the majority of students will be using the facilities during the hours of usage, which is during the daytime period only.

10.2 Airborne Sound Insulation Requirements

The following numerical performance requirements are considered suitable for the proposed development.

Table 10: Partition Airborne Sound Reduction Requirements and Guidelines

Location	Partition Type	Airborne Standard (dB)
Studio to Student Accommodation - Bedroom	Party Walls / Floors	70 $D_{nT,w}$* and 45 $D_{nT,w} + C_{tr}$
Studio to Student Accommodation – Living Room		70 $D_{nT,w}$ *and 45 $D_{nT,w} + C_{tr}$

*It is understood that the college will be in operation from 8am to 7pm. This sound reduction requirement is therefore specified to achieve the BS8233 daytime criteria only.

A minimum laboratory sound reduction performance of 80dB R_w for a lightweight construction and 76 dB R_w for a heavyweight construction is expected to be sufficient to satisfy all the criteria presented in Table 15 above. It is understood that the same party wall will be separating the studios from both the bedrooms and living rooms. It is also assumed that the same construction will be used for both floors, studio to bedroom and studio to living room.

The following wall and floor constructions are expected to be sufficient to achieve the minimum laboratory sound reduction requirements.

Wall Constructions

The following heavy wall construction is expected to achieve the required minimum sound reduction.

- Solid block wall of a minimum mass of 240kg/m^2 with 13mm plaster each side.
- Lining to each side of the solid block:
  - 85mm Cavity filled with 50mm Isover Acoustic Partition Roll or similar.
  - 2 x 12.5mm Plasterboard (Density: 710kg/m^3) (On independent studs: no connection points between the solid block and the plasterboard lining)

This wall construction is an enhanced version for the British Gypsum wall with reference: B226007.

The following lightweight construction is also expected to achieve the required minimum sound reduction:

- Two frames of Gypframe 92 S 10 'C' Studs spaced at 600mm centres with Gypframe 99 FC 50 Fixing Channel at 3600mm centres or Gypframe GAB3 Acoustic Braces at 3300mm centres. Cavity filled with 3 layers of 100mm Isover Acoustic Partition Roll or similar and 2 layers of 100mm of mineral wool with a minimum density of 62kg/m^3.
- 3x 15mm Soundbloc to each side of the partition

British Gypsum reference: A326019

Floor Constructions

The following floor construction is expected to achieve the required minimum sound reduction.

- 250mm Concrete slab (Minimum density 2000Kg/m^3);
- Suspended ceiling: 3 x 15 Soundbloc on specialist acoustic hangers. 300mm Cavity filled with 100mm Isover Acoustic Partition Roll or similar.

11 Noise Impact from the College Activities on the Nearest Noise Sensitive Receptors

11.1 Assessment Overview

It is understood that the following activities will take place in the proposed development:

- Daytime outdoor and indoor performances including amplified speech and amplified music at the proposed outdoor amphitheatre and the proposed internal performance space, "Black Box";
- Daytime indoor amplified music in the proposed studios and gym;

11.2 Limiting Criteria

The following criteria have been used for the assessment.

The Institute of Acoustics Good Practice Guide on the Control of Noise from Pubs and Clubs (March 2003) states the following with regards to the noise impact from Pubs and Clubs:

"Music, singing and speech, both amplified and non-amplified, are common sources of noise disturbance arising from the [public and private use of public houses, clubs, hotels, discotheques, restaurants, cafes, community or village halls and other similar premises]. As far as these sources are concerned, the purpose of developing the objective criteria [for the proposals], should attempt to ensure that:

- *For premises where entertainment takes place on a regular basis, music and associated sources should not be audible inside noise-sensitive property at any time. In the absence of [objective criteria in the guidance document], what is 'regular' should be determined on a local basis to reflect local expectations and should be incorporated by local authorities in their planning and enforcement policies; and*
- *For premises where entertainment takes place less frequency, music and associated sources should not be audible inside noise sensitive property between 23:00 and 07:00 hours. For other times, appropriate criteria need to be developed which balance the rights of those seeking and providing entertainment, with those who may be disturbed by the noise.*

For the purposes of this document, noise may be considered not audible or inaudible when it is at a low enough level such that it is not recognisable as emanating from the source in question and it does not alter the perception of the ambient noise environment that would prevail in the absence of the source in question."

It is understood that noisy activities including amplified music will take place on a daily basis within the college premises. Accordingly, the acoustics Good Practice Guide on the Control of Noise from Pubs and Clubs (March 2003) have been considered suitable in order to assess the noise impact from the amplified music arising from the college. The guidance does not define quantifiable levels at which noise becomes inaudible inside a premises. For the purposes of this assessment, an appropriate limit is considered to be ensuring that noise from the amplified music does not exceed the measured typical background noise levels on site, outside the nearest noise sensitive receptors.

Following the criteria detailed above, the noise limits for the college activity at the nearest noise sensitive receptors are summarized in Table 11 below.

The worst affected receptors are identified in Figure 3 below.

Table 11: College Activity - Noise Limit at the Worst Affected Receptors		
Receptor	Period	Limit for Activities Including Amplified Music/Speech $L_{Aeq,T}$ (dB)*
All receptors	School (08:00 - 19:00)	40

*It is understood that amplified music activities will only occur during the daytime between 8:00 and 19:00.

Figure 3: Worst Affected Noise Sensitive Receptors

11.3 Assumed Noise Sources

A noise modelling exercise have been undertaken to predict the noise levels due to the proposed indoor and outdoor activities for the proposed development. The details for each of the cases studied for the assessment are presented below.

It should be noted that each case has been assessed individually. The use of the proposed performance spaces and the studios have been assumed not to be simultaneous (unless specifically detailed in the assessment).

11.3.1 Indoor Amplified Music

The assumed noise levels for the indoor activities including amplified music are detailed in Table 12 below. The noise spectrum for the proposed performance space is taken from previous measurements by MLM Consulting Engineers Ltd in a small club. This spectrum and broadband noise values have been selected as being representative of the reverberant levels in this type of space. For the proposed studios, the same noise spectrum is used, but adjusted to broadband levels typically used in this type of teaching space.

Table 12: Assumed Activity Noise Levels										
Room	Quantity	Octave Band Centre Frequency, Hz								dBA
		63	125	250	500	1000	2000	4000	8000	
		Noise Levels (dB)								
Black Box	$L_{p,rev}$	100	100	100	97	94	91	90	90	100
Studio / Gym	$L_{p,rev}$	95	95	95	92	89	86	85	85	95

If the internal activity noise levels are expected to operate above the assumed levels, noise limiters should be installed to ensure that levels do not exceed those shown. This should be confirmed to MLM and in such case, a further assessment would be required.

For this assessment it has been assumed that, as a worst case, all the studios and gyms will be in operation simultaneously.

It is understood that the proposed indoor performance space ("Black Box"), will not include any windows. The area of external wall and roof in the performance space are limited to those shown in the figure below.

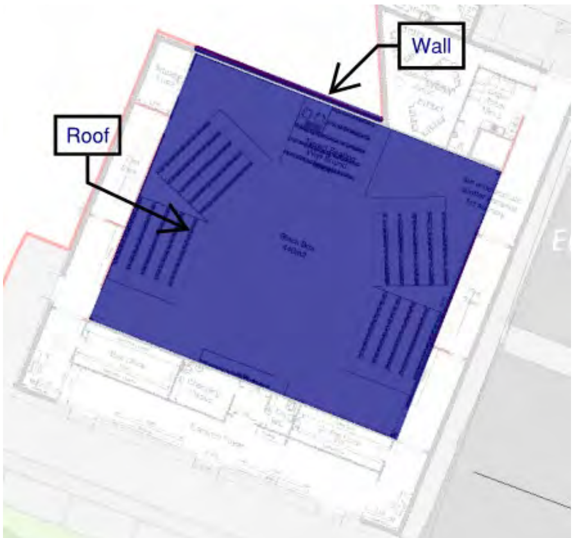


Figure 4: Black Box – Area Sources used in the Assessment

11.3.2 Outdoor Performance

The following noise emitting activities have been assumed for the outdoor performance space:

Amplified Speech and Music - two loudspeakers with a maximum sound pressure level of 89dBA at 1m per loudspeaker have been assumed. The assumed noise levels for the loud speakers are considered to be sufficient to provide a good sound coverage to the audience area (17 - 22dB above the existing noise levels).

The noise map below shows the noise levels coverage for the assumed loud speakers.

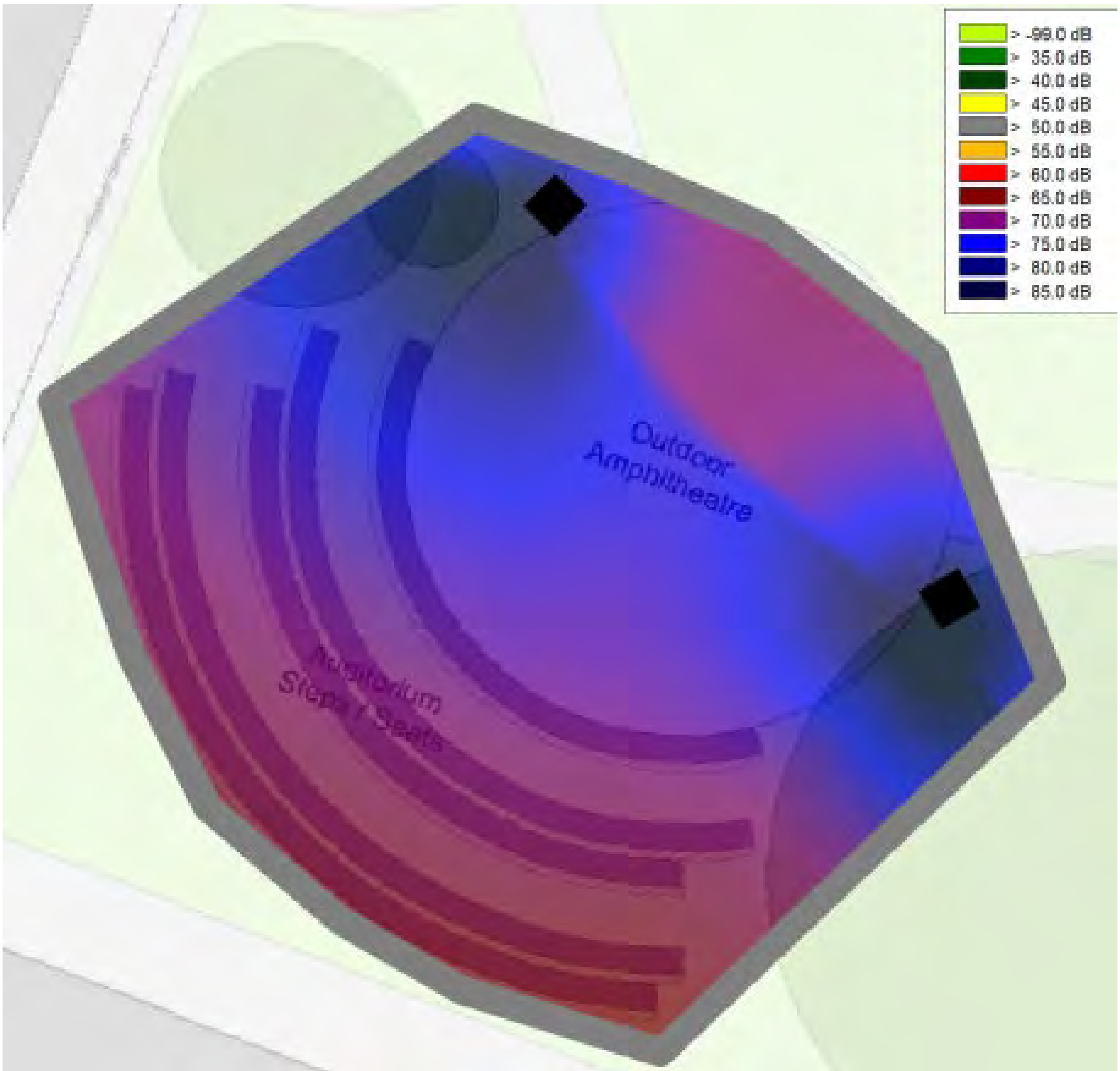


Figure 5: Loud Speakers Coverage – Outdoor Amphitheatre

It should be noted that significant changes to the assumed locations and directivity for the speakers could significantly alter the predicted noise impact.

11.4 Predictions and Assessment

A noise modelling exercise has been undertaken to predict the noise impact at the NNSRs due to activity within the college. The assessment is based on the assumed noise levels detailed in Section 11.3 above and the minimum external building fabric performances detailed in Section 8 earlier in this report.

The table below summarizes the predicted noise levels at each of the receptors. A comparison for these predictions against the limiting criteria is also shown.

Table 13: Predicted Noise Levels at the NNSRs due to the Proposed Activities

Case	R1 (Residential)		R2 (Residential)		R3 (School)	
	Predicted Noise Levels (dB)	Noise Limit (dB)	Predicted Noise Levels (dB)	Noise Limit (dB)	Predicted Noise Levels (dB)	Noise Limit (dB)
Indoor Amplified Music - Studios & Gym (Daytime)	37	40	35	40	37	40
Indoor Amplified Music - Black Box (Daytime)	15	40	28	40	40	40
Outdoor Performance – Outdoor Amphitheatre (Daytime)	20	40	40	40	36	40

As shown in the table above the proposed noise limits at the nearest noise sensitive receptors are expected to be met provided that the amplified music limitations detailed in Section 9 and the minimum external building fabric performances detailed in Section 8 earlier in this report.

12 Control of Internal Ambient Noise Levels

12.1 Overview

There are generally two sources of noise to address in order to provide suitable internal ambient sound conditions for both the proposed residential rooms and the teaching spaces.

- External noise (aircraft, traffic, plant);
- Building services noise (mechanical ventilation, cooling).

This assessment is based on the measured noise levels on site along with the predicted noise levels impacting on the façades of the proposed block, and the latest general arrangement drawings provided by Hamilton Architects (Please note that significant changes to the room's geometry are likely to result in changes to the sound reduction requirements.). The output of our noise model has also been considered in order to assess the noise levels incident on the façades of the proposed new rooms.

It should be noted that the predicted noise levels impacting on the facades of the proposed development include the noise contributions from the road traffic, air traffic and plant noise sources measured on site as well as the noise contributions from the noisy activities comprising amplified music assumed for this assessment. The details for these activities are presented in Section 11 earlier in this report.

The minimum sound insulation performance requirements detailed in Section 8 and Section 10 have been used for this assessment.

12.2 Student Accommodation

12.2.1 Internal Ambient Noise Level Guidance and Assessment Methodology

The external building fabric for the student accommodation has been assessed based on the predicted external noise break-in to the proposed rooms.

BS 8233:2014 "Guidance on sound insulation and noise reduction for buildings" provides the design guidance used for the external building fabric assessment, this is shown in Table 14 below. The maximum noise level criterion is taken from ProPG Planning and Noise (2017).

Table 14: BS 8233:2014 - Internal Ambient Noise Level Guidance

Activity	Location	Daytime	Night Time
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16hour}$	30 dB $L_{Aeq,16hour}$ & 45 dB $L_{Amax,F}$ 10-15 events, no single event greater the 55 dB $L_{Amax,F}$.
Resting	Living room	35 dB $L_{Aeq,16hour}$	-

It is essential to note that this assessment methodology does not ensure that the amplified music activity noise is inaudible within the student accommodation, only that it is controlled to a level at which the noise would not be overly intrusive. This is done on the basis that the student accommodation forms part of the same development as the college, meaning the majority of students will be using the facilities during the hours of usage, which is during the daytime period only.

12.2.2 Predicted Internal Ambient in the Student Accommodation

The criteria set out in Table 15 above are expected to be met provided that all the sound insulation requirements for the building envelope, the amplified music limitations and the minimum sound insulation requirements between the studios/gym and the student accommodation detailed in Sections 8, 9 and 10 earlier in this report are included in the design.

As detailed above in Section 12.2.1, it is essential to note that this assessment methodology does not ensure that the activity noise is inaudible within the student accommodation, only that it is controlled to a level at which the noise would not be overly intrusive.

12.3 College (BB93 assessment)

12.3.1 Indoor Ambient Noise Levels Criteria

BB93 stipulates the maximum indoor ambient noise levels, $L_{Aeq,30min}$, in unoccupied, critical spaces should not exceed certain values, in order to provide clear communication of speech between teacher and student and suitable study conditions. The building envelope must provide sufficient sound insulation from external noise sources in order to achieve suitable internal ambient noise levels. BB93 sets out indoor ambient noise level (IANL) criteria for the various spaces. The maximum IANLs related to the proposed scheme are summarised in Table 15 below.

Table 15: Internal Ambient Noise Level Criteria

Room Type	Upper Limit For Indoor Ambient Noise Level dB $L_{Aeq,30min}$
Dance Studio	40
Scenery Studio	35
Gym	40
Physio	35
Interview Room/Counselling	35
Black Box (Performance Space)	30
Lighting / Control room	35
Teaching Room (Academy Room)	35
WCs	50
Circulation	45

In addition to the above, in order to protect students from regular discrete noise events, e.g., aircraft or trains, BB93 recommends that indoor ambient noise levels should not exceed 60 dB $L_{A1,\ 30mins}$. This is achieved by default in rooms having limits of 40dB or less for indoor ambient noise level $L_{Aeq,30min}$ but requires assessment in spaces with higher IANL limits, e.g. 45 and 50 dB.

Indoor ambient noise limits (IANL) include noise contributions from external noise sources, building services and internal drainage, but exclude noise contributions from teaching activities or from students or equipment within the building or outdoor area. For example, equipment such as TVs and overhead projectors are not considered.

12.3.2 Building Envelope Sound Reduction Requirements

The building envelope and ventilation strategy requirements set out in Sections 8 and 9 earlier in this report are expected to be sufficient to achieve the BB93 target internal ambient noise criteria set out in Table 16 above.

12.3.3 Predicted Internal Ambient Noise Levels in the College

The indoor ambient noise limits set out in Table 16 above are expected to be met provided that all the sound insulation requirements and amplified music limitations detailed in Sections 8 and 9 earlier in this report are included in the design.

The internal sound insulation between the teaching spaces should be designed in such way that the total cumulative noise levels do not exceed the BB93 indoor ambient noise levels detailed in Table 16 above. Please note that this report does not include any assessment for the sound insulation between teaching spaces. The sound insulation between the proposed teaching spaces should be assessed during the design stage.

As detailed earlier in this report, it is essential to note that this assessment methodology does not ensure that the activity noise is inaudible within the student accommodation, only that it is controlled to a level at which the noise would not be overly intrusive.

13 Control of Building Services Noise

13.1 Assessment Criteria

Noise emissions from building services plant associated with the proposed new development will need to be controlled, in order to achieve acceptable levels of environmental noise when the development is complete and is in operation. The assessment of external plant noise is typically undertaken in accordance with the following standard:

- BS 4142:2014+A1 "Method for Rating and Assessing Industrial and Commercial Sound".

13.2 Noise Sensitive Locations

Plant noise will need to be limited at the nearest noise-sensitive dwellings. These have been identified as the residential properties along the northern and southern site perimeter and the school receptor to the west of the proposed development site. The worst affected receptors are identified in Figure 3 in Section 11 earlier in this report.

13.3 Noise Control Strategy

Typically, plant noise emissions to the surroundings should be assessed in accordance with guidance presented in BS 4142:2014 - Methods for Rating and Assessing Industrial and Commercial Sound. Accordingly, it is recommended that items of static services plant and machinery associated with the development should be designed to give a cumulative sound rating level ($L_{Ar,Tr}$) of no greater than the current prevailing typical background sound level ($L_{A90,T}$) at any time at the nearest noise-sensitive receptors, which would be an indication of the proposed development having a low impact, depending on the context.

Accordingly, the noise criterion set out below is proposed based on the typical L_{A90} levels measured at MP4 and MP5, which are considered representative of the background noise level at the nearest sensitive properties.

Table 16: Proposed Rating Level Limits for Building Services Plant Equipment

NNSR Location	Operating Period	Typical Measured Background Noise Level $L_{A90,T}$	Proposed "Rating Level" At The Nearest Noise Sensitive Receptor $L_{Ar,T}$
All Receptors	Daytime (07:00-23:00)	40	40
	Night-time (23:00-07:00)	35*	35
	School Period (08:00 – 19:00)	40	40

*Lowest $L_{A90,T}$ measured at MP4. 46dB $L_{pA,10,T}$ and 45dB $L_{Aeq,T}$ were measured for the same period at MP4. The proximity in these values suggests that for this period the measurements were barely affected by any direct road traffic noise. Therefore, the lowest measured $L_{A90,T}$ at MP4 is expected to be representative of the typical background noise at the worst affected receptors where direct traffic noise is not expected to be dominant.

The above limits apply to the total noise emission levels from all static plant and processes within the proposed development. Individual plant items may need to be designed to a lower limit such that the overall total level achieves the stated criteria above. It is anticipated that if the above limits are adhered to, this would result in a low impact at the nearest sensitive receptors.

13.4 Practical Control Measures

Precise plant details are not yet known. However, it should be borne in mind that screening of any external plant (such as the AC condenser units), may be necessary to control the transmission of noise and achieve the above criteria as well as to reduce the noise level produced by the plant to a reasonable extent around the footprint of the building itself. Depending upon the models chosen, it may also be necessary to apply individual noise attenuators to items of external plant. Notwithstanding the above, given the location of the external plant area relative to the proposed residential dwellings, it is considered that the proposed plant screen may need to be acoustically rated to adequately control noise emissions.

Once selections have been made, noise emission data for the proposed external plant and performance data for any mitigation treatment proposals should be provided for review.

Acoustic treatment may also be required to control noise emanating from the air intake and discharge grilles associated with the ventilation and extraction systems. In our experience, toilet extracts and MVHR system termination points may require treatment. Once specific plant details are known, an assessment of atmospheric emissions should be undertaken and the specification of any required mitigation treatments derived.

14 Minimizing Construction Noise and Vibration Impact

14.1 Potential Demolition and Construction Impacts

Noise and vibration levels generated by construction activities have the potential to impact upon nearby noise-sensitive receptors; however the magnitude of the potential impact would depend upon the type of activity; periods of operation; source to receiver distance; ground absorption and reflections.

There is a distance of approximately 5m between the construction site and the nearest school receptor and approximately 30m between the location where the proposed new block will be constructed and the nearest residential receptors. The impacts of construction have been assessed in accordance with BS5228:2009 to assess whether mitigation measures will be required during construction. The worst affected receptors are identified in Figure 3 in Section 11 earlier in this report.

14.2 Noise Assessment

14.2.1 Construction Noise Criteria

The Table below details the BS5228 significance effect threshold values at receptors.

Table 17: Construction Noise Impact Significance Criteria

Assessment category and threshold value period	Threshold value, in decibels - dB(A)		
	Category A	Category B	Category C
Daytime	65	70	75
Evenings and weekends	55	60	65
Night-time	45	50	55

1. A significant effect has been deemed to occur if the total L_{Aeq} noise level, including construction, exceeds the threshold level for the Category appropriate to the ambient noise level.
2. If the ambient noise level exceeds the threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total L_{Aeq} noise level for the period increases by more than 3 dB due to construction activity.
3. Applied to residential receptors only.
   A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.
   B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.
   C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.

14.2.2 Noise Limits

According to the ABC method for assessing the significant effects from construction noise, in BS5228 "Code of practice for noise and vibration control on construction and open sites – Part 1: Noise", states that "a potential significant effect is indicated if the L_{Aeq} noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level."

It is assumed that the construction works will only occur during the daytime during the midweek period. Based on the measured ambient noise levels on site, the worst affected receptors are expected to be impacted by noise levels which are in the order of 49dB $L_{Aeq,day.}$ Based on these levels, the construction noise should be limited to the values below.

Table 18: Proposed Noise Limits During Construction at the Worst Affected Receptors			
Period*	Measured Ambient Noise Level – dB L_{Aeq}	BS5228 Construction Noise Limit for Significant Effect dB L_{Aeq}	BS5228 Construction Noise Limit at which Additional Mitigation Measures should be Provided dB L_{Aeq}
Daytime	49	65	75

*It is assumed that no noise emitting construction works will occur during the weekend (other than Saturday morning) or during the night time periods.

Where site noise levels are expected to exceed 65dBA, BS5228 states that the level at which noise insulation, or the reasonable costs thereof, will be offered to occupiers of the nearest receptors; this is 75dBA $L_{eq,10\ hours}$. This level is also set out as the basic construction noise limit in urban areas near main roads in the 1976 version of Advisory Leaflet 72. The standard states that noise insulation should be provided where the 75dBA level is exceeded for a period of 10 or more days of working in any 15 consecutive days or for a total number of days exceeding 40 in any 6 consecutive months.

Where possible, significant adverse effect should be avoided. Given the close proximity of the Proposed Development to the receptor locations, it is likely to be very difficult to achieve a construction noise level of 65dBA. Where it is not possible to achieve this level, it is recommended that construction noise is limited to below the point at which provision of additional mitigation measures is required; 75dBA.

75dBA $L_{eq,10\ hours}$ is therefore deemed to be the highest acceptable limit at the nearest receptors above which additional mitigation measures would be required in the form of noise insulation provided to the receptors, or temporary rehousing of residents/school users. Noise insulation generally consists of secondary glazing with alternative means of ventilation where required.

14.2.3 Construction Plant

Hamilton Architects has confirmed that the plant schedule presented in Tables 19 to 20 below may be assumed for this assessment as being representative of the machinery and operation times expected for the construction works.

Table 19: Schedule of Construction Plant – Site Preparation			
Noise Sources	L_{WA} dB	Quantity of Site	% on Time
Large Excavator Mounted Breaker	110	2	20
Tracked Excavator	107	2	80
Spreading Fill	109	2	25
Vibratory Roller	102	2	30
Lorry (Unloading)	108	3	40
Concrete Truck Mixer	103	1	5
Road Sweeper	104	1	5

Table 20 Schedule of Construction Plant – Substructure			
Noise Sources	L_{WA} dB	Quantity of Site	% on Time
Concrete Truck Mixer	103	3	25
Piling Rig	111	1	90
Small Breaker	110	2	20

Table 20 Schedule of Construction Plant – Substructure			
Noise Sources	L_{WA} dB	Quantity of Site	% on Time
Compressor	106	2	50
Poker Vibrator	97	3	15
Lorry Mounted Concrete Pump	109	1	80
Lorry (Unloading)	108	2	40
Petrol Sawy	109	3	20
Tracked Excavator	107	2	80
Hand Held Circular Saw	109	2	35
Dumper Trucks	106	2	25
Diesel Jet Washer	108	1	25
Mobile Crane	103	1	90
Vibratory Roller	102	2	30

Table 21: Schedule of Construction Plant – Superstructure			
Noise Sources	L_{WA} dB	Quantity of Site	% on Time
Concrete Truck Mixer	103	2	25
Lorry (Unloading)	108	3	20
Petrol Saw	109	2	40
Tracked Excavator (rubber tracks)	107	2	70
Dumper Trucks	106	2	25
Mobile Crane Operation	103	2	90
Telescopic Forklift (17m) JCB 540	107	1	80
Hand Tools (hammers)	98	8	40
Concrete Pump (pumping)	112	2	70

14.2.4 Predicted Construction Noise Levels

Noise predictions have been undertaken to provide an estimate of the plant noise emissions from the site during the construction works at the nearest receptors. The predictions have been based on the plant schedule presented in the section above. From these predictions it has been possible to determine whether the adopted target noise criterion of 75 dBA $L_{eq,day}$ is likely to be met during the works. The magnitude of any impact has then been determined and the requirement for further mitigation measures considered.

Calculations have been undertaken for the cumulative sound power levels of the plant included for each of the construction phases. The cumulative noise levels for each of the phases have been evenly distributed along the areas where the construction works are expected to take place. The construction working-areas assumed for this assessment are shown in the figure below Predicted construction noise levels are summarised in Table 22 below.

Figure 6: Assumed Construction- Areas (Blue)

Table 22: Predicted Construction Noise Levels at the Nearest Noise Sensitive Receiver and Limits

Receptor	Predicted Construction Noise Level – dB L_{Aeq}*			BS5228 Construction Noise Limit for Significant Effect dB L_{Aeq}	BS5228 Construction Noise Limit at which Additional Mitigation Measures should be Provided dB L_{Aeq}
	SP	Sub**	Sup		
R1	55	63 - 72	60	65	75
R2	49	57 - 66	54		
R3 (School)	66	74 – 83	71		

*SP: Site Preparation; Sub: Substructure; Sup: Superstructure
**The predicted noise levels for the substructure phase may vary significantly depending on the type of piling and the distance between any machinery and the receiver. The values presented are estimations based on the cumulative sound power levels for the plant assumed for this assessment and historical measured data for different type of pilings.

The predicted construction noise levels for the site preparation and the superstructure phases are within the BS5228 construction noise limits. Depending on the piling type and the distance to the receivers, the noise limits may be exceeded during the substructure phase at the school receptor. Therefore, it is recommended that the mitigation measures detailed in the following section are considered for the substructure phase.

14.2.5 Mitigation Measures

General

The following general mitigation measures are recommendations from BS5228 and should be employed on this site.

- Avoid unnecessary revving of engines and switch off equipment when not required;
- Keep internal haul routes well maintained and avoid steep gradients;
- Use rubber linings in, for example, chutes and dumpers to reduce impact noise;
- Minimize drop height of materials;
- Start plant and vehicles sequentially rather than all together;
- Use alternative plant and equipment: alternative silenced plant may be available. This should be confirmed with the manufacturer. (As detailed in the paragraphs below)

Specification and Substitution

All plant specifications must be reviewed to ensure they are the quietest available for the required purpose; this is in accordance with best practicable means.

Modification of Plant and Equipment

The following extract from BS5228 sets out how plant noise may be reduced by modification.

"Noise from existing plant and equipment can often be reduced by modification or by the application of improved sound reduction methods, but this should only be carried out after consultation with the manufacturer. Suppliers of plant will often have ready-made kits available and will often have experience of reducing noise from their plant. For steady continuous noise, such as that caused by diesel engines, it might be possible to reduce the noise emitted by fitting a more effective exhaust silencer system or by designing an acoustic canopy to replace the normal engine cover. Any such project should be carried out in consultation with the original equipment manufacturer and with a specialist in noise reduction techniques. The replacement canopy should not cause the engine to overheat nor interfere excessively with routine maintenance operations.

It might be possible in certain circumstances to substitute electric motors for diesel engines, with consequent reduction in noise. On-site generators supplying electricity for electric motors should be suitably enclosed and appropriately located. Noise caused by resonance of body panels and cover plates can be reduced by stiffening with additional ribs or by increasing the damping effect with a surface coating of special resonance damping material. Rattling noises can be controlled by tightening loose parts and by fixing resilient materials between the surfaces in contact; this is generally a maintenance issue."

The following table contains suggested methods for reducing noise levels from construction plant specific to this site. These measures should be implemented wherever possible.

Table 23: Recommended Mitigation Measures

Plant Type	Source of Noise	Proposed Mitigation	Potential Sound Reduction dBA
Piling Rigs	Power Units or Base Machine	Fix more efficient sound reduction equipment or exhaust. Acoustically dampen panels and covers. When intended by the manufacturer, engine panels need to be	5 - 10

Table 23: Recommended Mitigation Measures			
Plant Type	Source of Noise	Proposed Mitigation	Potential Sound Reduction dBA
		kept closed. Use acoustic screens when possible	
Crane and Excavators	Engine	Fit more efficient exhaust sound reduction equipment Manufacturers' enclosure panels need to be kept closed	5 – 10
Concrete Pump	Engine Pushing	Use machine inside acoustic enclosure with allowance for engine cooling and exhaust	Up to 20
Concrete Mixers	Cleaning	Do not hammer the drum	n/a
Materials Handling	Impact of Material	Do not drop materials from excessive heights. Screen dropping zones, especially on conveyor systems. Line chutes and dump trucks with a resilient material	Up to 15

Enclosures

The significant sources of plant noise should be enclosed where possible. The close proximity of the nearest sensitive receptors means that all practicable means to reduce noise must be employed wherever possible.

The concrete pump is a significant noise source which could potentially be enclosed. Covers should enclose the plant as fully as possible, should be of sufficient mass (17kg/m^2 minimum), and should be lined inside with an acoustically absorbent material with minimum 25mm thickness. An example of the enclosure design is shown below.

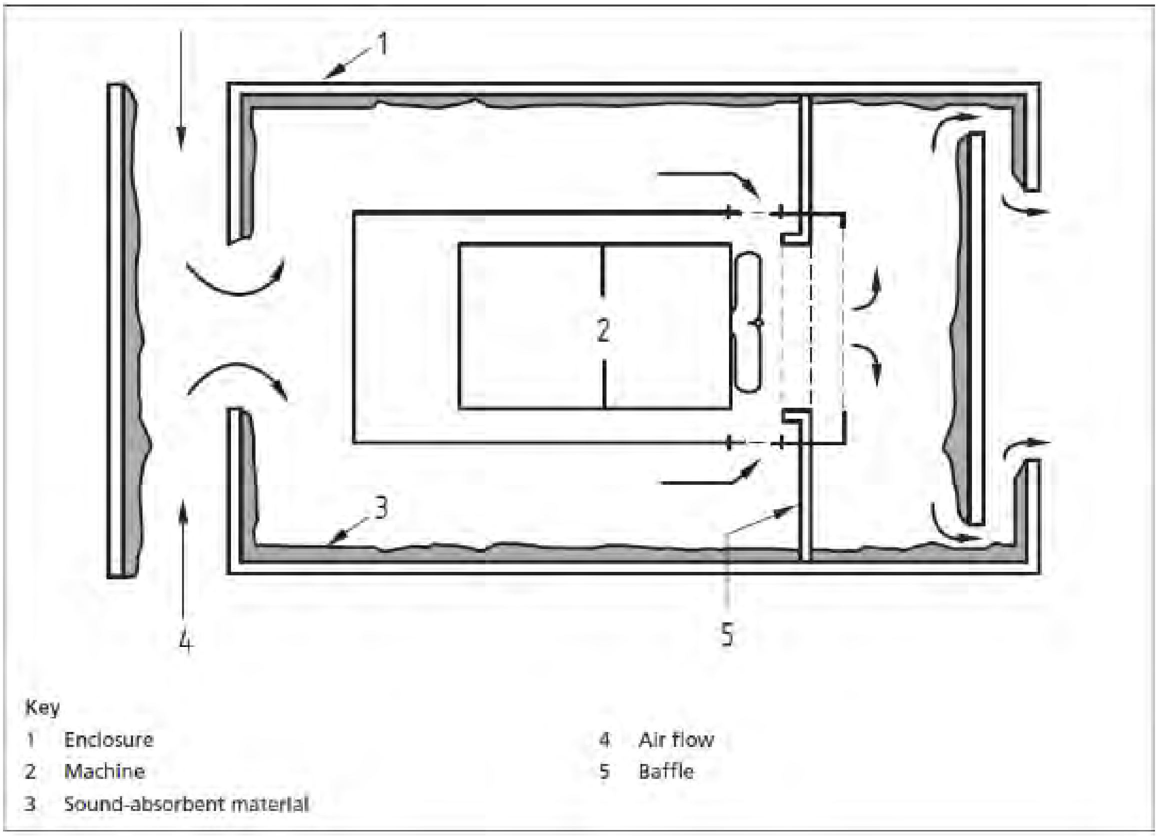


Figure 7: Example Plant Enclosure

A maximum of 20dBA sound reduction can be expected from a suitably designed enclosure with openings.

Use and Siting of Equipment

All plant should be used in accordance with manufacturers' instructions.

Plant should be located away from noise-sensitive areas where possible; loading and unloading should not be carried out next to the sensitive receptors. The concrete pump and drum should be located at least 25m from the nearest sensitive receptors wherever possible.

The crane, and other plant use intermittently, should be shut down or throttled down to a minimum between work periods.

Acoustic convers to engines must be kept closed when the plant is in use or idling; compressors should have effective enclosures and should not be operated with access panels open.

The following advice is taken from BS5228:

"Materials should be lowered whenever practicable and should not be dropped. The surfaces on to which the materials are being moved should be covered by resilient material.

When a site is in a residential environment, lorries should not arrive at or depart from the site at a time inconvenient to residents."

Maintenance

"Regular and effective maintenance by trained personnel is essential and will do much to reduce noise from plant and machinery. Increases in plant noise are often indicative of future mechanical failure.

Sound-reducing equipment can lose its effectiveness before failure is indicated by visual inspection.

Noise caused by vibrating machinery having rotating parts can be reduced by attention to proper balancing. Frictional noise from the cutting action of tools and saws can be reduced if the tools are kept sharp. Noises caused by friction in conveyor rollers, trolleys and other machines can be reduced by proper lubrication."

Screening

Due to the proximity and elevation of the nearest sensitive receptors, screening will only be effective if located in close proximity to the plant. It is recommended that screening is employed for all quasi-stationary plant such as the piling rigs, crane and concrete drum. Where possible, the moveable screening should prevent line-of-sight from plant to the sensitive receptors.

It is also recommended that a high mass site hoarding is used along the western site boundary to protect the school receptor from the worst-case noise level impact. This barrier should be as tall as is reasonably practical.

Piling

It is not currently known which piling technique will be used. It is recommended that, where practicable, piling works are carried out using a contiguous flight auger piling technique. This is known to generally cause the least impact in terms of noise and vibration and is therefore considered as the most appropriate piling method.

Approximately 6 hours of piling rig usage per day has been assumed for our calculations. It is recommended that the hours of use are considered so that piling does not begin first thing in the morning, or continue to the very end of the working day, therefore avoiding period when the majority of people are at home. It is also recommended that any pilling works schedule is agreed with the school receptor and where practicable avoid these works to be carried out when the closest classrooms are being used.

14.2.6 Predicted Construction Noise Levels with Mitigation Measures

The predicted construction noise levels further to the implementation of the mitigation measures outlined above are shown in Table 24 below.

Table 24: Predicted Construction Noise Levels at the Nearest Noise Sensitive Receiver – Mitigated Plant – Substructure Phase at R3 (School receptor)

Receptor	Predicted Construction Noise Level – dB L_{Aeq}	BS5228 Daytime Construction Noise Limit dB L_{Aeq}
R3 (School)	64 – 73	75

Piling works are expected as close as 5m from the school receptor. During these periods, the mitigated site noise levels are expected to be 73dBA as a maximum at the nearest receptor. It should be ensured that the school are pre-warned about the expected noise levels, and that they are managed so as not to coincide with sensitive activities in the school.

14.2.7 Construction Noise Monitoring

A scheme of noise monitoring is recommended for the duration of the construction to ensure that construction noise levels do not exceed the proposed limit of 75dBA.

A minimum of one monitoring location representative of construction noise levels at the school receptor would be beneficial in managing the noise impact at this location.

It is recommended that a construction noise limit of 75dBA $L_{eq,10\ hours}$ is used at 1m from the façade of the nearest sensitive receptors. Alerts should also be set to a level of 65dBA and 70dBA $L_{eq,10\ hours}$.

Text message and/or email alerts should be set up at the guidance values to be received by the site manager, the monitoring personnel and any other relevant party. The noise data should be accessible via a web-based portal.

In the instance that the noise limits are exceeded, works should be halted and the reason for exceedance determined and remedied before works commence again.

14.3 Vibration Assessment

14.3.1 Community Relations

BS5228 suggests the following with respect to community relations:

"Good relations with people living and working in the vicinity of site operations are of paramount importance. Early establishment and maintenance of these relations throughout the carrying out of site operations will go some way towards allaying people's fears.

It is suggested that good relations can be developed by keeping people informed of progress and by treating complaints fairly and expeditiously. The person, company or organization carrying out work on site should appoint a responsible person to liaise with the public. The formation of liaison committees with members of the public can be considered for longer term projects when relatively large numbers of people are involved."

With vibration, the fear of building damage can be exacerbated where people are unsure of the levels of vibration it would take to impact upon their property, and therefore good communication can help to alleviate fears beforehand.

14.3.2 Significance of Vibration Effects

Of the proposed construction plant, the piling rigs and vibratory rollers are the only items likely to cause significant levels of vibration.

As detailed earlier in this report, it is unknown the piling technique that will be used. It is recommended that, where practicable, piling works are carried out using a contiguous flight auger piling technique. This is known to generally cause the least impact in terms of noise and vibration and is therefore considered as the most appropriate piling method.

BS5228 provides some historical measurements of various piling techniques. The Auger piling measurements are summarised below.

Table 25: BS5228 Augering Vibration Measurements

Soil Conditions	Pile Dimensions (m)	Piling Mode	Plan Distance (m)	PPV (mm/s)
Fill/dense ballast/London clay	1.05	Augering	20	0.05
Fill/dense ballast/London clay	1.05	Auger hitting base of hole	20	0.23
Fill/wet sand/lias clay	0.9	Augering	9	0.2

Table 25: BS5228 Augering Vibration Measurements				
Soil Conditions	Pile Dimensions (m)	Piling Mode	Plan Distance (m)	PPV (mm/s)
Fill clay	0.35	Augering	10	0.38
Fill clay	0.35	Dollying Casing	10	1.1
Fill clay	0.35	Auger hitting base of hole	10	0.96
Fill/sand/clay	0.5	Augering	10	0.4
6m of soft ground over rock	0.6	Augering	5	0.54

The level at which vibration might just be perceptible in residential environments is 0.3mm/s. 1.0mm/s PPV is likely to cause complaint, but can normally be tolerated if prior warning and explanation has been given. 10mm/s is likely to be intolerable. The levels at which vibration is likely to cause building damage are much higher than those that are generally tolerable in terms of human response.

Based on the historical Auger Piling measurements set out in Table 26 above, it can be seen that the expected levels of vibration are generally expected to be below the level at which complaint becomes likely at the school receptor; however there are likely to be occasions when this level is exceeded due to an impact with the base of the hole for example.

Similarly, use of vibratory rollers within 30m of the school has the potential to exceed the levels at which complaint is likely. Assuming a roller with two drums, 0.5mm drum vibration amplitude, and 1m drum width, the predicted vibration level is likely to be approximately 5mm/s PPV at the nearest distance of 5m.

To manage the impact, the school should be given prior warning for when piling and vibratory rolling will occur within 30m of the building. The correspondence should assure occupiers that building damage is very unlikely, even though it will be perceptible.

14.3.3 Construction Vibration Monitoring

A scheme of vibration monitoring is recommended for the duration of the piling works to ensure that construction vibration levels do not exceed a proposed limit of 10 mm/s.

A minimum of one monitoring location should be used, representative of the vibration levels at the school.

It is recommended that a construction noise limit of 10mm/s is used at 1m from the façade of the nearest sensitive receptors. Alerts should also be set to a level 7mm/s to provide advance warning of any exceedances that may occur.

Text message and/or email alerts should be set up at the guidance values to be received by the site manager, the monitoring personnel and any other relevant party. The noise data should be accessible via a web-based portal.

In the instance that the vibration limits are exceeded, works should be halted and the reason for exceedance determined and remedied before works commence again.

15 Conclusion

MLM Consulting Engineers Limited has been commissioned by Hamilton Architects, to advise on acoustic design issues associated with the proposed development at Bird College, Alma Rd, Sidcup DA14 4ED.

The suitability of the site for school and residential development has been assessed based on the results of an environmental noise survey undertaken at the proposed development site. Recommendations have been made on the sound insulation requirement of the building envelope and the ventilation strategy to achieve BS8233 and BB93 indoor ambient noise level criteria and to mitigate the noise impact from the proposed college activities at the nearest receptors. The survey data has also been used to outline suitable building orientation and layout for acoustics.

The noise impact at the nearest receptors due to the proposed college activities have been assessed. Mitigation measures have been recommended where necessary.

This report presents appropriate acoustic design criteria for the walls and floors between the proposed teaching studios and the student accommodation and, based upon current architectural proposals, provides an assessment of the ability of the scheme to satisfy these requirements.

Sound rating level limits have been recommended for building services plant associated with the Proposed Development in accordance with BS 4142:2014.

The noise and vibration impact from the proposed construction works have been assessed. Mitigation measures have been recommended where necessary. A scheme of noise and vibration monitoring for the duration of the construction has been recommended to ensure that the noise and vibration levels do not exceed the limits set out in this report.

Where the analysis indicates the proposed scheme is unlikely to achieve compliance with the required performance levels, or where details have yet to be provided, appropriate solutions are proposed such that the numeric performance standards can be achieved.

Appendix A - Glossary of Acoustic Terminology

Wording	Description
Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (Sound Level)	The sound level is the sound pressure relative to a standard reference pressure of 20μPa (20x10-6 Pascals) on a decibel scale.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s1 and s2 is given by 20 log10 (s1/s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20μPa.
A-weighting, dB(A)	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Noise Level Indices	Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.
$L_{eq,T}$	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
$L_{max,T}$	A noise level index defined as the maximum noise level during the period T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall Leq noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
$L_{90,T}$	A noise level index. The noise level exceeded for 90% of the time over the period T. L_{90} can be considered to be the "average minimum" noise level and is often used to describe the background noise.
$L_{10,T}$	A noise level index. The noise level exceeded for 10% of the time over the period T. L_{10} can be considered to be the "average maximum" noise level. Generally used to describe road traffic noise.
Free-Field	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5m
Facade	At a distance of 1m in front of a large sound reflecting object such as a building façade.
Fast Time Weighting	An averaging time used in sound level meters. Defined in BS 5969.

In order to assist the understanding of acoustic terminology and the relative change in sound, the following background information is provided.

The human ear can detect a very wide range of pressure fluctuations, which are perceived as sound. In order to express these fluctuations in a manageable way, a logarithmic scale called the decibel, or dB scale is used. The decibel scale typically ranges from 0 dB (the threshold of hearing) to over 120 dB. An indication of the range of sound levels commonly found in the environment is given in the following table.

Table A1: Typical Sound Levels Found in the Environment

Sound Level	Location
0dB(A)	Threshold of hearing
20 to 30dB(A)	Quiet bedroom at night
30 to 40dB(A)	Living room during the day
40 to 50dB(A)	Typical office
50 to 60dB(A)	Inside a car
60 to 70dB(A)	Typical high street
70 to 90dB(A)	Inside factory
100 to 110dB(A)	Burglar alarm at 1m away
110 to 130dB(A)	Jet aircraft on take off
140dB(A)	Threshold of Pain

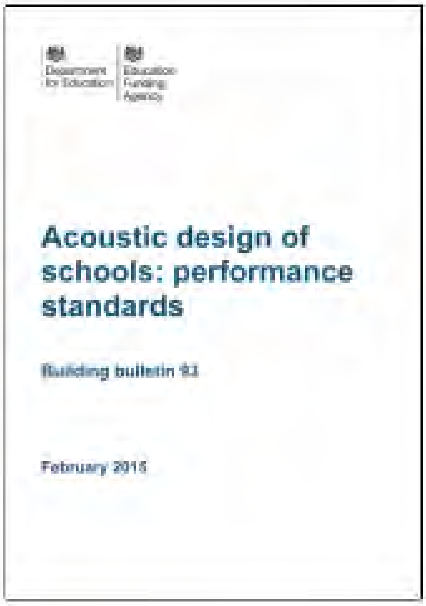
Appendix B - Basis of the Acoustic Specification - Acoustic Criteria Summary

Building Bulletin 93 'Acoustic Design of Schools: Performance Standards'

The acoustic conditions in schools are enforced by Part E of the Building Regulations, School Premises Regulations and the Independent School Standards, which apply to new and existing schools. School premises are also subject to the Equality Act.

Requirement E4 from Part E of Schedule 1 of the Building Regulations 2010 (as amended by Statutory Instrument, SI 2002/2871) states:

"Each room or other space in a school building shall be designed and constructed in such a way that it has the acoustic conditions and the insulation against disturbance by noise appropriate to its intended use."


Acoustic design of schools: performance standards

Building bulletin 93

February 2015

The normal means of satisfying the regulatory Requirement E4 of the Building Regulations, the School Premises Regulations and the Independent School Standards, is to adopt the appropriate performance standards as set out in Section 1 of Building Bulletin 93.

The objective of Building Bulletin 93 is to provide acoustic conditions in schools that:

- Facilitate clear communication of speech between teacher and student, and between students; and
- Do not interfere with study activities.

BB93 provides mandatory comprehensive acoustic guidance for primary and secondary education spaces. Performance standards for schools are detailed therein and give guidance on appropriate internal ambient noise levels, outdoor ambient noise levels, levels of airborne and impact sound insulation for internal partitions and suitable reverberant conditions for each area.

Acoustics of Schools: A Design Guide

This document, produced jointly by IOA and ANC is designed to accompany the revised performance standards for the acoustic design of schools published by the Department for Education in November 2015 (BB93). It provides provide supporting guidance and recommendations on the acoustic design of new and refurbished schools. It replaces the guidance previously published in the 2003 edition of Building Bulletin 93: Acoustic Design of Schools

Indoor Ambient Noise Level Requirements

The internal ambient noise level includes noise contributions from:

- External sources outside the school premises (including, but not limited to, noise from road, rail and air traffic, industrial and commercial premises);
- Building services (e.g. ventilation system, plant, etc.). If a room is naturally ventilated, the IANL is calculated and measured with ventilators or windows open as required to provide ventilation as described in section 1.1.3. If a room is mechanically ventilated or cooled, the plant should be assumed to be running at its normal operating duty;
- Actuator and damper noise.

The indoor ambient noise level excludes noise contributions from:

- Teaching activities within the school premises, including noise from staff, students and equipment within the building or in the playground. Noise transmitted from adjacent spaces is addressed by the airborne and impact sound insulation requirements;
- Equipment used in the space (e.g. machine tools, dust and fume extract equipment, compressors, computers, fume cupboards) as these noise sources are considered as operational noise; and
- Rain noise – however Building Regulation submissions should demonstrate that lightweight roofs have been designed so that the IANL requirements are not exceeded by 25dB under 'heavy' rain.

The objective is to provide suitable indoor ambient noise levels (IANL) for

- Clear communication of speech between teacher and student;
- Clear communication between students;
- Learning and study activities.

The internal ambient noise level requirements of BB93 are shown in Table B1 below for information.

Table B1: Internal Noise Criteria (External Noise and Building Services Noise) from BB93 Table 1

Room Type	Upper Limit For Indoor Ambient Noise Level (dB) $L_{Aeq,30min}$	
	New build	Refurbishment
Nursery school rooms Primary – Classroom, class base, general teaching, small group Secondary – classroom, general teaching, seminar, tutorial, language lab	35	40
Open plan – teaching area, resource/breakout	40	45
Primary Music Room	35	40
Secondary music classroom, practice/group room	35	40
Performance/recital room, ensemble room, recording studio	30	35
Control room for recording	35	40
Control room not for recording	35	40
Lecture room	35	40
Teaching space for students with special hearing and communication needs	30	35
SEN calming room	35	35
Study Room (individual study. Withdrawal, remedial work, teacher preparation	40	45
Libraries – Quiet study area, resource area	40	45
Science laboratory	40	45
Design and technology – Resistant materials, CadCam, electronics/control, textiles, food, graphics, design/resource area, ICT room, Art	40	45
Drama studio, assembly hall, multi-purpose hall (drama, PE, audio/visual presentations, assembly, occasional music	35	40

Table B1: Internal Noise Criteria (External Noise and Building Services Noise) from BB93 Table 1		
Room Type	Upper Limit For Indoor Ambient Noise Level (dB) $L_{Aeq,30min}$	
	New build	Refurbishment
Atrium, circulation space not intended for teaching and learning	45	50
Sports hall, dance studio, gymnasium/activity studio	40	45
Swimming pool	50	55
Meeting room, interviewing/counselling room, video conference room	40	45
Dining room	45	50
Administration and Ancillary Spaces		
Kitchen, changing area, toilet, changing area	50	55
Office, medical room, staff room	40	45
Corridors, stairwell, coats and locker area	50	55

In addition to the above requirements, the IANLs should not exceed 60dB $L_{A1,30mins}$.

The ventilation strategy must be designed to ensure that internal noise level limits are achieved when systems are operating during normal conditions; intermittent boost and when systems are running in order to prevent summertime overheating. BB93 acknowledges that a ventilation strategy may include a combination of various ventilation systems to deal with different operating conditions and it recommends tolerances on the proposed IANL limits for different types of ventilation system under different operating conditions.

A summary of the ventilation condition, system type and associated IANL tolerance is presented in Table B2 below.

Table B2: Summary Of Ventilation Condition, System Type And Associated (IANL) Tolerance		
Condition	Ventilation System	Noise Level Limit
Normal – ventilation for normal teaching and learning activities	Mechanical	Table 1 value
	Natural	Table 1 value + 5 dB
	Hybrid (Mechanical & Natural)	Mechanical system noise: Table 1 value
		Total noise level: Table 1 value + 5 dB
Summertime Ventilation under local control of teacher to prevent overheating – allowable during the hottest 200 hrs of the year	Mechanical	Table 1 value + 5 dB
	Natural or Hybrid	≤55 dB
Intermittent boost Ventilation under local control of teacher for dilution of fumes during practical activities as in	Mechanical	Table 1 value + 5 dB
	Natural	≤55 dB

Table B2: Summary Of Ventilation Condition, System Type And Associated (IANL) Tolerance		
Condition	Ventilation System	Noise Level Limit
practical spaces for science, art, food technology and design and technology.		
Process – extract can be automatic ventilation for safety and/or under local control of teacher, as required for fume and dust extract in design and technology, odour and steam from cookers in food technology, fume cupboard extract and similar process extract systems.	Mechanical and/or natural	For new fume cupboards the maximum noise level should not exceed 50 dB(A), measured at a height of 1,500 mm above the floor and 1,500 mm from the face of the fume cupboard, with the sash set at a height of 200 mm.

Airborne Sound Insulation Requirements

Separating Walls and Floors

The 'in-situ' acoustic performance requirement of any partition, as defined in BB93, is defined by the nature of the rooms that the partition separates. This is based on the level of activity noise within the source room and the noise tolerance of the receiving room. For reference, the BB93 designations for activity noise and noise tolerances teaching and ancillary spaces are detailed in Table B3 below.

Table B3: Room Classifications for the Purposes of Airborne Sound Insulation from BB93 Table 1		
Room Type	Activity Noise (Source Room)	Noise Tolerance (Receiving Room)
Nursery school rooms Primary – Classroom, class base, general teaching, small group Secondary – classroom, general teaching, seminar, tutorial, language lab	Average	Medium
Open plan – teaching area, resource/breakout	Average	Medium
Primary Music Room	High	Medium
Secondary music classroom, practice/group room	Very High	Low
Performance/recital room, ensemble room, recording studio	Very High	Low
Control room for recording	High	Low
Control room not for recording	Average	Medium
Lecture room	Average	Medium
Teaching space for students with special hearing and communication needs	Average	Low

Table B3: Room Classifications for the Purposes of Airborne Sound Insulation from BB93 Table 1		
Room Type	Activity Noise (Source Room)	Noise Tolerance (Receiving Room)
SEN calming room	High	Low
Study Room (individual study. Withdrawal, remedial work, teacher preparation	Low	Medium
Libraries – Quiet study area	Low	Medium
Libraries –Resource area	Average	Medium
Science laboratory	Average	Medium
Design and technology – Resistant materials, CadCam	High	High
Design and technology – Electronics/control, textiles, food, graphics, design/resource area, ICT room, Art	Average	Medium
Drama studio, assembly hall, multi-purpose hall (drama, PE, audio/visual presentations, assembly, occasional music	High	Low
Atrium, circulation space not intended for teaching and learning	Average	Medium
Sports hall, dance studio, gymnasium/activity studio	High	Medium
Swimming pool	High	High
Meeting room, interviewing/counselling room, video conference room	Low	Medium
Dining room	High	High
Administration and Ancillary Spaces		
Kitchen	High	High
Office, medical room, staff room	Low	Medium
Corridors, stairwell, coats and locker area	Average	High
Changing area, toilet	Average	High

From the tables above, the following matrices taken from BB93 are used to derive the in-situ acoustic performance required between the adjoining spaces.

Table B4: New Build Performance Standards for Airborne Sound Insulation between Spaces from BB93 Table 3a					
Minimum $D_{nT,w}$ dB		Activity Noise in Source Room			
		Low	Average	High	Very High
Noise Tolerance in Receiving Room	High	N/A	35	45	50
	Medium	40	45	50	55
	Low	45	50	55	55

Table B5: Refurbished Performance Standards for Airborne Sound Insulation between Spaces from BB93 Table 3b					
Minimum $D_{nT,w}$ dB		Activity Noise in Source Room			
		Low	Average	High	Very High
Noise Tolerance in Receiving Room	High	N/A	30	35	45
	Medium	30	40	45	45
	Low	35	40	50	50

The sound insulation performance criteria for separating walls and floors are given in terms of a level difference $D_{nT,w}$. It should be noted that $D_{nT,w}$ is the 'in-situ' sound insulation performance between two rooms. The acoustic performance of building fabric elements is usually specified in terms of R_w, the 'Weighted Sound Reduction Index' parameter. This represents the inherent acoustic performance of the element itself, free of any flanking transmission and is determined under idealised laboratory conditions. However, since laboratory performances are not normally achievable on-site, allowances must be made for on-site factors, such as flanking transmission and other acoustic weaknesses.

Accordingly, based upon the required $D_{nT,w}$ performance standards and the proposed layout of rooms within the new build areas of the development, an assessment has to be undertaken to determine the required laboratory (R_w) ratings of the separating partitions. The calculations are undertaken in accordance with BB93 methodology.

The minimum airborne sound insulation requirement between circulation spaces and other spaces used by pupils is given in Table 4a of BB93. Criteria for the separating wall construction and any doorset in the wall are quoted in terms of the weighted sound reduction index, R_w.

Table B6: Corridor Wall Sound Insulation Sound Reduction Requirements from BB93 Table 4a (no ventilators)

Type of space used by students	Minimum R_w		
	Composite R_w of wall and glazing with no ventilator		Doorset
	New build	Refurbishment	
Secondary school music room Control room for recording Drama Multi-purpose hall Teaching spaces for students with special hearing or communication needs	45	40	35
Primary music classroom All other teaching areas	40	35	30

There are a separate set of requirements for corridor walls which include ventilators; it is assumed that these are not applicable to this development.

Reverberation

BB93 sets out suitable reverberation times (RT) for different areas of schools in terms Tmf, which is the arithmetic average RT in the 500 Hz, 1000 Hz and 2000 Hz octave frequency bands. These values can be calculated and the effectiveness of various treatments assessed. Generally for classrooms in primary/secondary schools it is a requirement to control reverberation times to less than 0.6/0.8 seconds respectively, although the precise requirement will vary according to the room use.

BB93 Exceptions

BB93 provides a number of exceptions to the airborne sound insulation requirements for areas of non-compliance (derogations) that regularly occur in school designs. These are as follows:

- Serving hatches between kitchens and multipurpose halls used for dining should be avoided where practicable, and serveries placed between kitchens and dining areas wherever possible to avoid noise transfer during meal preparation. Where this is not possible, serving hatches should be designed to have as high a level of sound insulation as practicable (not less than 18 dB Rw) and, if necessary, use of the dining hall space timetabled so that noise sensitive activities, e.g., exams, do not take place in the hall when the kitchen is in use. Where the space is used solely for dining purposes, a sound insulation serving hatch is not necessary;
- Where it is essential to link a teaching space with another occupied room via an interconnecting door for operational or safety purposes, a doorset should be used with a rating of at least 35 dB R_w. The surrounding wall containing the doorset should have a sound insulation rating of at least 45 dB R_w;
- Where there is an operable wall or folding partition between a teaching area and a hall, the minimum $D_{nT,w}$ between the spaces should be 45 dB. The end user should be made aware that the sound insulation performance of the operable wall may not facilitate simultaneous use of the spaces on either side.

Vision panels between multi-purpose halls, music rooms and control rooms require careful consideration. If visual communication only is required then the vision panel should provide at least 45 dB R_w, set within a wall rated at 55 dB R_w. This degree of sound insulation from a vision panel will require specialist design input. Where visual and audio communication is required between the spaces then a sliding vision panel of only nominal acoustic performance may be appropriate, set in a wall rated at 45 dB R_w.

Impact Sound Insulation Requirements

In addition to the airborne sound insulation for floors, BB93 advises that the levels of impact sound insulation provided must also be considered.

BB93 presents in-situ performance standards for impact sound insulation of floors. Whilst Part E of the Building Regulations states that the impact criteria should be achieved without finishes, BB93 (2015) has clarified that in schools the final floor finishes can be taken into account, since they are usually fixed.

The maximum impact sound pressure level ($L'_{nT,w}$) for the different room types is given in Table B7.

Table B7: Impact Sound Insulation Requirements from BB93 Table 5

Type Of Room (Receiving Room)	Maximum Impact Sound Pressure Level $L'_{nT,W}$ dB	
	New Build	Refurbishment
Teaching space for students with special hearing and communication needs	55	60
Secondary music classroom Practice/group room Performance/recital room Ensemble room Control room for recording Control room not for recording	55	60
Nursery school rooms Primary – Classroom, class base, general teaching, small group Secondary – classroom, general teaching, seminar, tutorial, language lab Open plan – teaching area, resource/breakout Primary Music Room Lecture room Library	60	65

Table B7: Impact Sound Insulation Requirements from BB93 Table 5		
Type Of Room (Receiving Room)	Maximum Impact Sound Pressure Level $L'_{nT,W}$ dB	
	New Build	Refurbishment
Science laboratory Design and technology – Resistant materials, CadCam Design and technology – Electronics/control, textiles, food, graphics, design/resource area, ICT room, Art Drama studio, assembly hall, multi-purpose hall (drama, PE, audio/visual presentations, assembly, occasional music Sports hall, dance studio, gymnasium/activity studio Meeting room, interviewing/counselling room, video conference room		
Dining room, swimming pool Kitchen Office, medical room, staff room Corridors, stairwell, coats and locker area Changing area, toilet	65	65

Reverberation Time Requirements

The control of reverberation in rooms for teaching is important to provide an acoustic environment that is conducive to good speech communication.

Hard surface finishes will result in acoustical reflections which take time to decay and can lead to increased noise in spaces. The rate of sound decay in a space is considered in technical terms as the Reverberation Time (RT). To control reverberation it is necessary to provide acoustically 'absorptive' finishes.

BB93 sets out suitable reverberation times for different areas of schools in terms of T_{mf}, which is the arithmetic average RT in the 500 Hz, 1000 Hz and 2000 Hz octave frequency bands. These values can be calculated and the effectiveness of various treatment solutions assessed.

Table B8: Reverberation Time Requirements from BB93 Table 6		
Room Type	Reverberation Time Criteria T_{mf} (seconds)	
	New Build	Refurbishment
Teaching space for students with special hearing and communication needs	T ≤ 0.4 averaged from 125Hz – 4kHz T ≤ 0.6 in every octave band from 125Hz – 4kHz	≤ 0.4
Primary and Secondary music classroom Practice/group room ≤ 30m³ Practice/group room > 30m³ Performance/recital room Ensemble room, Live Room Control room	≤ 1.0 ≤ 0.6 ≤ 0.8 1.0 – 1.5 0.6 – 1.2 ≤ 0.5	≤ 1.0 ≤ 0.8 ≤ 1.0 1.0 – 1.5 0.6 – 1.2 ≤ 0.6
Nursery and Primary school rooms – Classroom, class base, general teaching, small group	≤ 0.6	≤ 0.8
Secondary – classroom, general teaching, seminar, tutorial, language lab, study room, science laboratory Design and technology – Resistant materials, CadCam Design and technology – Electronics/control, textiles, food, graphics, design/resource area, ICT room, Art	≤ 0.8	≤ 1.0
Open plan – teaching area Open plan - resource/breakout	≤ 0.5 ≤ 1.2	≤ 0.5 ≤ 1.2
Lecture room (fewer than 50 people) Lecture room (more than 50 people)	≤ 0.8 ≤ 1.0	≤ 1.0 ≤ 1.0
Library	≤ 1.0	≤ 1.2
Drama studio	≤ 1.0	≤ 1.5
Atrium, foyer, entrance hall, circulation	≤ 1.5	≤ 2.0
Assembly hall, multi-purpose hall (drama, PE, audio/visual presentations, assembly, occasional music	0.8 – 1.2	0.8 – 1.5
Sports hall, swimming pool	≤ 1.5 – 2.0 (dependant on size)	≤ 2.0
Gymnasium/activity studio	≤ 1.5	≤ 2.0
Dance studio	≤ 1.2	≤ 1.5
Meeting room, interviewing/counselling room, video conference room	≤ 0.8	≤ 0.8

Table B8: Reverberation Time Requirements from BB93 Table 6		
Room Type	Reverberation Time Criteria T_{mf} (seconds)	
	New Build	Refurbishment
Dining room	≤ 1.0	≤ 1.5
Kitchen	≤ 1.5	≤ 2.0
Office, medical room, staff room	≤ 1.0	≤ 1.2
Corridors, stairwell	Method A/B from ADE*	Method A/B from ADE*
Coats and locker area, changing areas, toilet	≤ 1.5	≤ 2.0

The Equality Act 2010

The Equality Act 2010 replaces all previous equality legislation such as Race Relations Act, Disability Discrimination Act and Sex Discrimination Act and provides a single, consolidated source of discrimination law, covering all the types of discrimination that are unlawful. It simplifies the law and extends the protection from discrimination in certain areas. The aspects that are relevant to acoustic in school are principally those relating to disabilities and where English is not the first language and clarity of speech is particularly important to assist comprehension.

The equality act places a duty on all schools and local authorities to prepare and implement accessibility strategies and plans to increase over time the accessibility of schools for disabled pupils and staff. Schools and local authorities are required to provide strategies for:

a) increasing the extent to which disabled pupils can participate in a school's curriculum

b) improving the physical environment of schools for the purpose of increasing the extent to which disabled pupils are able to take advantage of education and the benefits, facilities and services provided

c) improving the delivery to disabled pupils of information that is readily accessible to pupils who are not disabled

This could mean provision of physical aids and acoustic improvements which would benefit hearing impaired and other pupils.

When alterations affect the acoustics of a space then improvement of the acoustics to promote better access for children with special needs, including hearing impairments, must be considered. Approved Document M: 2004 – 'Access to and Use of Buildings', in support of the Building Regulations includes requirements for access for children with special needs.

Other guidance includes BS 8300:2009 'Design of Buildings and their Approaches to Meet the Needs of Disabled People, Code of Practice' and 'Acoustics of Schools: a Design Guide'.

In order to fulfil their duties under the Equality Act 2010, school client bodies should anticipate the needs of deaf and other disabled children as current and potential future users of the school. Pupils with special educational needs are generally even more sensitive to the acoustic environment than others. Consequently, required reverberation times are shorter, sound insulation between adjacent spaces is higher and indoor ambient noise levels (and the capacity for distraction) lower than in environments for other pupils. This is reflected in requirements of BB93.

Pupils with hearing impairment, autism and other special needs are often very sensitive to specific types of noise, particularly those with strong tonal, impulsive or intermittent characteristics. This should be taken into consideration in the design of areas which may be used by such children.

The acoustic design of all special school accommodation, and of alternative provision and special units attached to mainstream schools for pupils with special hearing and communication needs, should always involve an acoustician and in the case of pupils with hearing impairment an audiologist, as well as the school client body. The type of accommodation and approach to inclusion varies and must inform the design process.

The required acoustic conditions will depend on a pupil's individual special needs and may be accommodated by a specialist provision (e.g. a quiet room for private study and communication, or an assisted listening device for participation in general teaching), or by improving the general acoustic conditions of teaching and learning spaces. Advice from a specialist acoustic consultant should be sought to allow the school client body to make an informed decision on the appropriate provision for the school's intended use.

The acoustic criteria for these types of accommodation should be signed off by the school client body in the same way as alternative performance standards (APS) as the particular needs of the pupils and the activities they take part in may vary widely from one school to another and within the same school.

The figures for rooms intended specifically for pupils with special hearing or communication needs in mainstream accommodation given in the tables in BB93 are a starting point and may not be suitable for the particular needs of the children in some types of accommodation.

BS 4142:2014+A1 'Methods for rating and assessing industrial and commercial sound'

BS 4142:2014+A1 describes the method for assessing the likely impact of noise sources of an industrial, commercial or fixed nature on people residing in the area.

New commercial development can often incorporate plant and processes that have the potential to generate noise, especially if operated at night-time when background noise levels are at their lowest.

Good practice dictates that new developments should be designed to give a cumulative noise rating level ($L_{Ar,Tr}$) of no more than the current prevailing background noise level (L_{A90}) at a distance of 1m from the nearest residential facades, when assessed in accordance with BS 4142:2014+A1 as this is defined as a low impact.

BS 4142:2014 sets out a method to assess the likely impact of noise from factories, industrial premises or fixed installations and sources of an industrial nature in commercial premises on noise-sensitive receptors in the vicinity.

The procedure contained in BS 4142:2014+A1 for assessing the likely impact is to compare the measured or predicted noise level from the source in question, the $L_{Aeq,T}$ 'specific noise level', immediately outside the dwelling with the $L_{A90,T}$ background noise level.

Where the noise contains a tonality, impulsivity, intermittency and other sound characteristics, then a correction depending on the grade of the aforementioned characteristics of the sound is added to the specific noise level to obtain the $L_{Ar,Tr}$ 'rating noise level'.

A correction to include the consideration of a level of uncertainty in noise measurements, data and calculations can also be applied, when considered necessary.

BS 4142:2014+A1 states: *"The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs". An estimation of the impact of the specific noise can be obtained by the difference of the rating noise level and the background noise level and considering the following:*

- *Typically, the greater this difference, the greater the magnitude of the impact;*
- *A difference of around +10dB or more is likely to be an indication of a significant adverse impact;*
- *depending on the context;*
- *A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context;*
- *The lower the rating level is relative to the measured background level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background level, this is an indication of the specific sound source having a low impact, depending on the context."*

The periods associated with day or night, for the purposes of the Standard, are considered to be 07.00 to 23.00 and 23.00 to 07.00, respectively.

Local Authority Requirements - London Borough of Bexley

The London Borough of Bexley was contacted by telephone call in relation to the noise criteria to be adopted for the proposed development at Bird College, Alma Rd, Sidcup DA14 4ED.

It was confirmed to MLM Consulting Engineers that there are no specific requirements and that the best practice design should be applied in order to mitigate any adverse effect at the nearest receptors.

British Standard 8233:2014

BS 8233:2014 *Guidance on sound insulation and noise reduction for buildings* draws on the results of research and experience to provide information on achieving internal acoustic environments appropriate to their functions. The guideline values provided are in terms of an average (L_{Aeq}) level.

The standard advises that, for steady external noise sources, it is desirable for residential internal ambient noise levels to not exceed the guidance values, as detailed below in Table B.1.

Table B.1: BS8233:2014 Indoor Ambient Noise Level Guidance

Activity	Location	Daytime	Night Time
Resting	Living room	35 dB $L_{Aeq,16hour}$	-
Dining	Dining room	40 dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16hour}$	30 dB $L_{Aeq,16hour}$

Table B.2: BS8233:2014 Indoor Ambient Noise Levels

Location	Design Range $L_{Aeq,T}$ dB
Open Plan Office	45 – 50
Executive Office	35 – 40
Meeting Rooms/Training Rooms	35 – 45
Circulation	45 – 55
Department store	50 – 55

BS 8233:2014 goes on to suggest that where a Development is considered necessary or desirable, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions will still be achieved.

With regards to maximum noise levels, the Standard identifies that regular individual noise events (such as passing trains or scheduled aircraft etc.) can cause sleep disturbance. The standard does not provide a guideline design target, but simply goes on to suggest that a guideline value may be set in terms of SEL or L_{AFmax}, depending upon the character and number of events per night. It goes on to suggest that more sporadic noise events could require separate values.

In respect of external noise levels, the guidance in BS 8233:2014 suggests that "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."

BS 8233:2014 provides a much more detailed narrative on noise levels in external amenity areas and acknowledges that it may not always be necessary or feasible to ensure that noise levels remain within these guideline values.

In respect of gardens and patios, BS 8233:2014 states; "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."

It is clear from the narrative of BS 8233:2014, that proposed development within noisy environments should be designed to ensure that the recommended internal design standards are achieved, and that noise levels in external amenity areas are designed to effectively control and reduce noise levels, although it acknowledges that in certain circumstances meeting the external design recommendations may not be feasible, or necessary, especially where the provision of such spaces is desirable for other technical, planning or policy reasons.

Acoustic Criteria: Building Regulations - Approved Document E

The requirements under the 2003 Part E of the Building Regulations are as follows:

E1. Dwelling-houses, flats and rooms for residential purposes shall be designed and constructed in such a way that they provide reasonable resistance to sound from other parts of the same building and from adjoining buildings.

E2. Dwelling-houses, flats and rooms for residential purposes shall be designed and constructed in such a way that (a) internal walls between a bedroom or a room containing a water closet and other rooms and (b) internal floors, provide reasonable resistance to sound. This requirement does not apply to internal walls containing doors, to internal walls separating ensuite toilets from the associated bedrooms or existing walls and floors in a building subject to a material change of use.

E3. The common parts of buildings which contain flats and rooms for residential purposes shall be designed and constructed in such a way as to prevent more reverberation around the common parts than is reasonable.

The performance standards defining "reasonable resistance to sound" are quantified in Approved Document E. These numerical standards are listed in Table 1 below. For this project Requirements E1, E2 and E3 apply.

The following numerical performance standards apply to the residential element of the proposed development:

Table B.5: Numeric Performance Standards

Dwelling-Flats		Airborne standard $D_{nT,w}$ + C_{tr} dB	Impact standard $L'_{nT,w}$ dB
Purpose built dwelling-houses and flats	Walls	≥ 45	-
	Floors and stairs	≥ 45	≤ 62

Internal Floors and Walls within Residences

Approved Document E also sets a minimum performance requirement of 40 dB R_w for internal walls surrounding bedrooms and internal partitions surrounding WCs. It should be noted that the 40 dB R_w criterion is a laboratory rating only and cannot be measured on-site. It should also be noted that this criterion specifically does not apply to any walls containing doors or to walls between en-suite bathrooms and the associated bedroom.

Reverberation in Common Parts

This requirement only applies to corridors, stairwells, hallways and entrance halls which give access to the flats. Absorption is required to all corridors, stairwells and hallways which provide direct access to residential dwellings.

Requirement E3 of the Building Regulations requires common areas within buildings be treated acoustically to reduce the build-up of reverberant sound. The extent of this requirement has subsequently been clarified as follows (ref. Planning Portal):

"The purpose of this requirement is to protect residents from noise produced in reverberant common areas. The requirement only applies to "corridors, stairwells, hallways, and entrance halls which give access to the flat or room for residential purposes". To comply with this, it is recommended that absorbent treatment should normally be applied only to common areas onto which dwellings open directly. Where separating walls, without doors or windows, are adjacent to common areas it would not normally be necessary to treat the common areas, assuming normal usage. Other situations are dealt with in paragraph 0.8 of Approved Document E (2003)."

These will comprise the use of absorbent finishes such as carpets and acoustic ceiling finishes in common areas.

The amount of absorption required depends on whether the particular common area is an entrance hall, defined as a space for which the ratio of the longest to the shortest floor dimension is three or less, or a corridor and hallway defined as a space for which the ratio of the longest to the shortest floor dimension is greater than three. To demonstrate that this has been complied with, two methods are given as described below.

Method A

Cover a specified area with an absorber of an appropriate class that has been rated according to BS EN ISO 11654:1997 *Acoustics – Sound absorbers for use in buildings – Rating of sound absorption*.

Entrance Halls, Corridors or Hallways

Cover an area equal to or greater than the floor area with a Class C absorber or better.

Stairwells or a Stair Enclosure

Calculate the combined area of the stair treads, the upper surface of the intermediate landings, the upper surface of the landing and the ceiling area on the top floor. Either, cover at least an area equal to this calculated area with a Class D absorber, or cover an area equal to 50% of this calculated area with a Class C absorber or better.

The absorptive material should be distributed equally between all floor levels.

Method B

Determine the minimum amount of absorptive material using a calculation procedure in octave bands. In comparison to Method A, this method takes into account the existing absorption provided by all surfaces. This method is intended only for corridors, hallways and entrance halls.

Entrance Halls

A minimum of 0.2 m^2 total absorption area per cubic metre of the volume should be provided.

Corridors and Hallways

A minimum of 0.25 m^2 total absorption area per cubic metre of the volume should be provided.

We would typically advise that Method A is adopted for circulation areas, as it means that there is greater freedom with floor finishes.

Non-Domestic Uses

The sound insulation requirements presented in Approved Document E are designed to provide a "reasonable resistance" to the passage of sound from normal domestic activities from other parts of the same building or adjoining buildings. A higher standard of sound insulation may be required between spaces used for domestic purposes and communal or non-domestic purposes.

In these situations the appropriate level of sound insulation will depend on the noise generated in the communal or non-domestic space.

In this particular case, non-domestic use areas are considered to be the proposed plantrooms and commercial units located at the ground floor level of the proposed building. Good practice dictates that in order to ensure the effects of the activity noise within the plantrooms and the commercial units do not unduly affect the occupants of the residences above, the separating partitions should be capable of reducing the noise levels to such an extent that they are indiscernible within the adjacent residence. To ensure a specific sound is indiscernible to the occupants of the receiving room, it is generally considered appropriate that a resultant level of at least 10 dB(A) below the otherwise prevailing L_{Aeq} noise climate is targeted within in the receiving room.

In accordance with the requirements of BS8233:2014, maximum internal noise levels of 30 dB L_{Aeq} and 35 dB L_{Aeq} have been proposed for the bedrooms and kitchen/living room areas respectively. As such, as a worst case, the separating partitions between the plantroom and the residential areas of the development should be capable of reducing noise levels emanating from within the non-residential areas to a maximum level of 20 dB L_{Aeq} (NR15) within the adjacent residential receiving rooms.

IOA Good Practice Guide on the Control of Noise from Pubs and Clubs

The Institute of Acoustics Good Practice Guide on the Control of Noise from Pubs and Clubs (March 2003) states the following with regards to the noise impact from Pubs and Clubs:

"Music, singing and speech, both amplified and non-amplified, are common sources of noise disturbance arising from the [public and private use of public houses, clubs, hotels, discotheques, restaurants, cafes, community or village halls and other similar premises]. As far as these sources are concerned, the purpose of developing the objective criteria [for the proposals], should attempt to ensure that:

- *For premises where entertainment takes place on a regular basis, music and associated sources should not be audible inside noise-sensitive property at any time. In the absence of [objective criteria in the guidance document], what is 'regular' should be determined on a local basis to reflect local expectations and should be incorporated by local authorities in their planning and enforcement policies; and*
- *For premises where entertainment takes place less frequency, music and associated sources should not be audible inside noise sensitive property between 23:00 and 07:00 hours. For other times, appropriate criteria need to be developed which balance the rights of those seeking and providing entertainment, with those who may be disturbed by the noise.*

For the purposes of this document, noise may be considered not audible or inaudible when it is at a low enough level such that it is not recognisable as emanating from the source in question and it does not alter the perception of the ambient noise environment that would prevail in the absence of the source in question."

IEMA – Guideline for Environmental Noise Impact Assessment

The guidelines provide a number of commonly used approaches to the assessment of noise impact by numerical methods. Whilst these all generally pertain to traffic noise, these are useful when looking to determine the impact of other noise sources.

- High Impact – greater than 10dBA change in sound level;
- Medium Impact – between 5 and 9.9dBA change in sound level;
- Low Impact – between 3 and 4.9dBA change in sound level; and
- Very Low Impact – Less than 3dBA change in sound level.

The Equality Act 2010

The Equality Act 2010 replaces all previous equality legislation such as Race Relations Act, Disability Discrimination Act and Sex Discrimination Act and provides a single, consolidated source of discrimination law, covering all the types of discrimination that are unlawful. It simplifies the law and extends the protection from discrimination in certain areas. The aspects that are relevant to acoustic in school are principally those relating to disabilities and where English is not the first language and clarity of speech is particularly important to assist comprehension.

The equality act places a duty on all schools and local authorities to prepare and implement accessibility strategies and plans to increase over time the accessibility of schools for disabled pupils and staff. Schools and local authorities are required to provide strategies for:

d) increasing the extent to which disabled pupils can participate in a school's curriculum

e) improving the physical environment of schools for the purpose of increasing the extent to which disabled pupils are able to take advantage of education and the benefits, facilities and services provided

f) improving the delivery to disabled pupils of information that is readily accessible to pupils who are not disabled

This could mean provision of physical aids and acoustic improvements which would benefit hearing impaired and other pupils.

When alterations affect the acoustics of a space then improvement of the acoustics to promote better access for children with special needs, including hearing impairments, must be considered. Approved Document M: 2004 – 'Access to and Use of Buildings', in support of the Building Regulations includes requirements for access for children with special needs.

Other guidance includes BS 8300:2009 'Design of Buildings and their Approaches to Meet the Needs of Disabled People, Code of Practice' and 'Acoustics of Schools: a Design Guide'.

In order to fulfil their duties under the Equality Act 2010, school client bodies should anticipate the needs of deaf and other disabled children as current and potential future users of the school. Pupils with special educational needs are generally even more sensitive to the acoustic environment than others. Consequently, required reverberation times are shorter, sound insulation between adjacent spaces is higher and indoor ambient noise levels (and the capacity for distraction) lower than in environments for other pupils. This is reflected in requirements of BB93.

Pupils with hearing impairment, autism and other special needs are often very sensitive to specific types of noise, particularly those with strong tonal, impulsive or intermittent characteristics. This should be taken into consideration in the design of areas which may be used by such children.

The acoustic design of all special school accommodation, and of alternative provision and special units attached to mainstream schools for pupils with special hearing and communication needs, should always involve an acoustician and in the case of pupils with hearing impairment an audiologist, as well as the school client body. The type of accommodation and approach to inclusion varies and must inform the design process.

The required acoustic conditions will depend on a pupil's individual special needs and may be accommodated by a specialist provision (e.g. a quiet room for private study and communication, or an assisted listening device for participation in general teaching), or by improving the general acoustic conditions of teaching and learning spaces. Advice from a specialist acoustic consultant should be sought to allow the school client body to make an informed decision on the appropriate provision for the school's intended use.

The acoustic criteria for these types of accommodation should be signed off by the school client body in the same way as alternative performance standards (APS) as the particular needs of the pupils and the activities they take part in may vary widely from one school to another and within the same school.

The figures for rooms intended specifically for pupils with special hearing or communication needs in mainstream accommodation given in the tables in BB93 are a starting point and may not be suitable for the particular needs of the children in some types of accommodation.

BS5228:2009 – Code Of Practice for Noise and Vibration Control on Construction and Open Sites

Part 1 - Construction Noise

Noise levels generated by construction activities have the potential to impact upon nearby noise-sensitive receptors; however, the magnitude of the potential impact will depend upon a number of variables. In the UK, BS5228 presents the appropriate methodology to predict and assess noise emission levels from a construction site.

BS5228 sets out a methodology for predicting, assessing and controlling noise levels arising from a wide variety of construction and related activities. As such, it can be used to predict noise levels arising from the operations at proposed construction sites. BS5228 also sets out tables of sound power levels generated by a wide variety of construction plant to facilitate such predictions.

Noise levels generated by the proposed site operations and experienced at local receptors will depend upon a number of variables, the most important of which are the:

- Amount of noise generated by plant and equipment being used at the site, generally expressed as a sound power level;
- Periods of operation of the plant at the site, known as the 'on-time';
- Distance between the noise source and the receptor, known as the 'stand-off';
- Attenuation due to ground absorption or barrier screening effects; and
- Reflection of noise due to the presence of hard vertical faces such as walls.

In order to determine the likely effect of noise during demolition and construction of the proposed development, noise predictions have been carried out in accordance with the procedures presented in BS5228, taking full account of Best Practicable Means (BPM). The prediction method described in BS5228 comprised taking the source noise level of each item of plant and correcting it for:

- Distance effects between source and receiver;
- Percentage operating time of the plant;
- Barrier attenuation effects;
- Ground absorption; and
- Facade corrections.

BS5228 gives several examples of acceptable limits for construction or demolition noise. The most simplistic is based upon the exceedance of fixed noise limits and paragraph E.2 states that: "Noise from construction and demolition sites should not exceed the level at which conversation in the nearest building would be difficult with the windows shut."

Paragraph E.2 goes on to state: "Noise levels, between say 07.00 and 19.00 hours, outside the nearest window of the occupied room closest to the Site boundary should not exceed: 70 decibels (dBA) in rural, suburban areas away from main road traffic and industrial noise or 75 decibels (dBA) in urban areas near main roads in heavy industrial areas. These limits are for daytime working outside living rooms and offices."

This assessment considers the criteria set out in Section E.3 of BS5228, which considers impact significance based upon the change in ambient noise associated with construction activities. It is stated that this can be considered as "an alternative and/or additional method to determine the significance of construction noise levels". Example Method 1 (The ABC Method) considers the existing ambient noise environment (the L_{Aeq} noise level environment) at the neighbouring sensitive receptors and proposes levels which are not to be exceeded.

Table E.1 of BS5228 sets out significance effect threshold values at receptors. The process for determining this requires the determination of the ambient noise level at the relevant receptor (rounded to the nearest 5dB), which is then compared to the total noise level, including the predicted construction noise level. If the combined noise level exceeds the appropriate category value, then the impact is deemed to be significant. The relevant statistics from Table E.1 are set out in Table 1 below. Compliance with these guidance levels should ensure a minor impact.

Table B6: Construction Noise Impact Significance Criteria

Assessment category and threshold value period	Threshold value, in decibels - dB(A)		
	Category A	Category B	Category C
Daytime	65	70	75
Evenings and weekends	55	60	65
Night-time	45	50	55

NOTE 1 A significant effect has been deemed to occur if the total L_{Aeq} noise level, including construction, exceeds the threshold level for the Category appropriate to the ambient noise level.

NOTE 2 If the ambient noise level exceeds the threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total L_{Aeq} noise level for the period increases by more than 3 dB due to construction activity.

NOTE 3 Applied to residential receptors only.

A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.

B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.

C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.

The Example method 2 (5 dB(A) change) states that if the total noise of the pre-construction ambient noise and the site noise exceeds the pre-construction ambient noise level by 5 dB, subject to lower cut-off values of 65 dB, 55 dB and 45 dB $L_{Aeq,T}$ from site noise alone for daytime, evening and night-time periods respectively, the noise level generated by the site activities are considered to be potentially significant.

Part 2 - Construction Vibration

BS 5228:2009 Part 2 provides recommendations for vibration control in relation to construction and open sites where work activities generate significant vibration levels. This Standard provides recommendations for procedures to establish effective liaison between developers, site operators and local authorities.

Vibration may be impulsive such as that due to hammer-driven piling; transient such as that due to vehicle movements along a railway; or continuous such as that due to vibratory driven piling.

The primary cause of community concern in relation to vibration generally relates to building damage from both construction and operational sources of vibration, although, the human body can perceive vibration at levels which are substantially lower than those required to cause building damage.

Damage to buildings associated solely with ground-borne vibration is not common and although vibration may be noticeable, there is little evidence to suggest that they produce cosmetic damage such as a cracks in plaster unless the magnitude of the vibration is excessively high. The most likely impact, where elevated levels of vibration do occur during the demolition and construction phases, is associated with perceptibility.

There are currently no British Standards that provide a methodology to predict levels of vibration from construction activities, other than that contained within BS5228: Part 2, which relates to vibratory piling and compaction.

Annex C from BS 5228 states current measured vibration levels for piling. Annex D of BS5228 Part 2 provides a number of additional measured vibration levels for piling. The data given in this annex is largely historical and comes from various forms of piling and kindred operations at various distances from the operation location.

Annex E, of the same document presents empirical formulae to predict levels of vibration from construction activities. These formula enable a prediction of resultant peak particle velocities (PPV) for a variety of activities, scaling factors and parameters, and provide indicators of the probability of these figures to be exceeded.

To control the impact of vibration during site preparation and construction of a development, limits relating to the perceptibility of vibration are typically set.

BS5228 indicates that the threshold of human perception to vibration is around 0.14 mm/s, although it is generally accepted that for the majority of people vibration levels in excess of between 0.15 and 0.3 mm/s peak particle velocity (PPV) are just perceptible, which forms the basis of the recommend maximum permitted vibration levels of 1 mm/s PPV within occupied residential dwellings. Table 2 below summarizes vibrations significance criteria. The limits are presented in terms of PPV as it is the simplest indicator for both perceptibility and building damage.

Annex B from BS 5228 'Significance of vibration effects' describes methods to identify the likely significance of vibration levels from construction and demolition activities. The table below B.7 Guidance on effects of vibration levels from BS 5228.

Table B7: Guidance On Effects Of Vibration Levels	
Vibration level A), B), C)	Effect
0.14 $mm \cdot s^{-1}$	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 $mm \cdot s^{-1}$	Vibration might be just perceptible in residential environments
1.0 $mm \cdot s^{-1}$	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 $mm \cdot s^{-1}$	Vibration is likely to be intolerable for any more than a very brief exposure to this level in most building environments.

A) The magnitudes of the values presented apply to a measurement position that is representative of the point of entry into the recipient.

B) A transfer function (which relates an external level to an internal level) needs to be applied if only external measurements are available.

C) Single or infrequent occurrences of these levels do not necessarily correspond to the stated effect in every case. The values are provided to give an initial indication of potential effects, and where these values are routinely measured or expected then an assessment in accordance with BS 6472-1 or -2, and/or other available guidance, might be appropriate to determine whether the time varying exposure is likely to give rise to any degree of adverse comment.

It is again worth noting that the purpose of the target construction vibration criteria is to control the impact of construction vibration insofar as is reasonably practicable and is entirely based on the likelihood of the vibration being perceptible, rather than causing damage to properties. Hence, although vibration levels in excess of 1 mms-1 PPV would be considered major adverse in respect of the likelihood of perceptibility, they would not be considered significant in terms of the potential for building damage, which would require levels of at least 15 mms-1 PPV to result in minor cosmetic damage in light / unreinforced buildings.

British Standard 6472

BS 6472:2008 *Guide to evaluation of human exposure to vibration in buildings, Part 1, Vibration sources other than blasting* describes how to determine the vibration dose value, VDV, from frequency-weighted vibration measurements. The vibration dose value is used to estimate the probability of adverse comment which might be expected from human beings experiencing vibration in buildings. Consideration is given to the time of day and use made of occupied space in buildings, whether residential, office or workshop. BS 6472 states that in homes, adverse comment about building vibrations is likely when the vibration levels to which occupants are exposed are only slightly above thresholds of perception.

BS 6472 contains a methodology for assessing the human response to vibration in terms of either the vibration dose value, or in terms of the acceleration or the peak velocity of the vibration, which is also referred to as peak particle velocity. The advice contained in BS 6472 states that when the vibration is intermittent, as is the case at this site with the only significant potential source of vibration being the railway lines to the north, the vibration dose value, or VDV, may be used to assess the potential for impacts.

Appropriately-weighted vibration measurements can be aggregated to derive the vibration dose values. The vibration dose value is a single figure descriptor that represents the cumulative dose of transient vibrations, taking into account the frequency spectrum and duration of each event. The vibration dose value is determined over a 16 hour daytime period or eight hour night-time period, and the guidance in BS 6472 is set out as follows:

Table B8: Vibration Dose Values ($ms^{-1.75}$) Above Which Various Degrees Of Adverse Comment May Be Expected In Residential Buildings			
Period	Low Probability of Adverse Comment	Adverse Comment Possible	Adverse Comment Probable
Residential Buildings - 16 hour day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential Buildings - 8 hour night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

There are two key aspects to the effect that the building structure will have on the measured vibration levels: the first is generally a reduction as the vibration passes into the foundations of a building; there is typically then amplification as the vibration propagates up the building to the upper storeys and across potentially suspended floors. Each of these factors is considered below.

To consider the transfer of vibration through the foundations of the proposed residential dwellings, guidance has been sought from the Handbook of Urban Rail Noise and Vibration Control (HURNVC), published by the Federal Transit Administration, USA, written by H J Saurenam, J T Nelson and G P Wilson.

The HURNVC sets out attenuation factors that can be applied to calculate the transfer function between vibrations measured on unloaded ground and vibration at a foundation. The type of foundations has yet to be decided yet, but we have been advised that it could either be piled or strip foundations. For the purpose of this assessment, the assumption of a strip foundation has been used as the worst case assumption.

To extrapolate the measured unloaded ground vibration levels up the building to a suspended upper storey, an amplification factor is required. Based on figures presented in Transmission of Ground-borne Vibration in Buildings by Jorgen Jakobsen, Journal of Low Frequency Noise and Vibration, Vol. 8 No. 3, 1989, both low and a high amplification factors have been considered appropriate for this assessment. The "high" and "low" amplification correspond to the upper and lower bounds of potential resonance for a slab on columns.

Appendix C - Noise Survey Information

Introduction

The prevailing sound conditions in the area have been determined by an environmental sound survey over a number of suitable measurement locations around the development site so as to inform the specification and design. The Environmental Sound Survey has been undertaken by MLM Consulting Engineers Ltd over a period of five days, between Thursday 24 and Monday 28 September 2020.

Noise Survey Methodology

The noise survey comprised unattended measurements, undertaken at one fixed measurement position and attended measurements, undertaken at four fixed measurement positions as shown in Figure C.1 below. Noise monitoring was undertaken over sequential 5 minute periods at each measurement position for the duration of the survey.

Sound Indices

The sound indices measured during the sound survey are shown below:

- $L_{Aeq,T}$ - The A-weighted equivalent continuous sound pressure level over a period of time; and
- $L_{A90,T}$ - The A-weighted sound pressure level exceeded for 90% of the measurement period. Indicative of the background sound level;
- $L_{A10,T}$ - The $A\text{-}_{weighted}$ sound pressure level exceeded for 10% of the measurement period. Indicative of the road traffic sound level.
- $L_{A1,T}$ - The $A\text{-}_{weighted}$ sound pressure level exceeded for 1% of the measurement period. Indicative of the maximum sound level.

All noise measurements were undertaken by a consultant certified as competent in environmental noise monitoring, and, in accordance with the principles of BS 7445[1].

Measurement Equipment

All acoustic measurement equipment used during the noise survey conformed to Type 1 specification of British Standard 61672[2]. A full inventory of this equipment is shown in Table C1 below:

Table C1: Inventory of Acoustic Measurement Equipment

Equipment	Manufacturer-Model Type	Serial Number	Calibration	
			Certificate Number	Expiry Date
Sound Level Meter	01dB - FUSION	12089	CV-DTE-19-PVE-68072	24 May 2021
Preamplifier	PRE22	1805176		
Microphone	GRAS 40CE	331995		
Calibrator	01dB - Cal31	87808	TCRT20/1198	2 April 2021

The microphones were fitted with protective windshields for the measurements.

The noise measurement equipment used during the survey was calibrated at the start and end of each measurement. The calibrator used had itself been calibrated by a UKAS accredited calibration laboratory within the twelve months preceding the measurements. No significant drift in calibration was found to have occurred.

[1] British Standard 7445: 2003: *Description and measurement of environmental noise*. BSI
[2] British Standard 61672: 2003: *Electroacoustics. Sound level meters*. Part 1 *Specifications.* BSI.

Weather Conditions

Weather conditions were dry for the majority of the monitoring period. There were high wind speed gust periods during the weekend.

Local Sound Conditions

Environmental sound conditions at the site are mainly affected by road traffic, remote road traffic, occasional air traffic, and plant noise. The site is exposed to low to moderate levels of noise, not untypical for this type of urban setting.

It is not possible to comment on the precise nature of the noise climate throughout the full duration of the unattended survey period.

Noise Measurement Positions

The noise measurement positions were selected to monitor worst-case noise levels incident on the various façades of the development, as well as consider variations in the surrounding noise climate; this, together with the extended duration of the environmental survey, would ensure a more robust and accurate assessment of the external building fabric elements around the proposed development. The selected locations are described in detail below and shown in Figure C.1.

Noise Measurement Position 1 (MP1) – Attended measurement position

The microphone was located approximately 1.7 metres above local ground level. Measurements undertaken at this position were free-field.

Attended measurements of the traffic noise arising from Lansdown Road.

Noise Measurement Position 2 (MP2) – Attended measurement position

The microphone was located approximately 1.7 metres above local ground level. Measurements undertaken at this position were free-field.

Attended measurements of the traffic noise arising from Faraday Avenue.

Noise Measurement Position 3 (MP3) – Attended measurement position

The microphone was located approximately 1.7 metres above local ground level. Measurements undertaken at this position were free-field.

Attended measurements of kids using the playing field at the North site boundary.

Noise Measurement Position 4 (MP4) – Unattended measurement position

The microphone was located approximately 3 metres above local ground level. Measurements undertaken at this position were free-field.

Unattended measurements at North site boundary (Worst case noise levels at the development site). This measurement position is also representative of the background noise environment at the noise sensitive receptors to the south which are not screened from the main roads.

Noise Measurement Position 4 (MP4) – Unattended measurement position

The microphone was located approximately 1.7 metres above local ground level. Measurements undertaken at this position were free-field.

Unattended measurements towards the centre of the site. This measurement position is representative of the background noise environment at the worst affected noise sensitive receptors.

Noise Climate

During the time on-site, it was noted that the background noise climate was affected by road traffic and air traffic movements which are the dominant noise sources impacting the site.

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Figure C.1: Measurement Locations

Noise Measurement Results

The results of environmental noise survey are summarised in Tables C2 to C4 below. A graphical illustration of the unattended noise measurement data during the full measurement period can be found at the end of this Appendix.

Table C2: Summary of Measured Noise Levels at MP4

Survey Date	Period (T)	Highest $L_{Aeq,30\ mins}$ (dB)	Average $L_{Aeq,T}$(dB)	Typical Maximum Noise Event L_{Amax}*(dB)	Highest $L_{A01,30min}$(dB)	Typical $L_{A90,10\ mins}$**(dB)
24/09/2020	School (15:00 – 19:00)	59	55	-	64	47
	Daytime (15:00 – 23:00)	-	53	-	-	47
	Night time (23:00 – 07:00)	-	53	73	-	38
28/09/2020	School (07:00 – 11:00)	60	56	-	66	49
	Daytime (07:00 – 11:00)	-	56	-	-	49
	Night time (23:00 – 07:00)	-	51	71	-	37

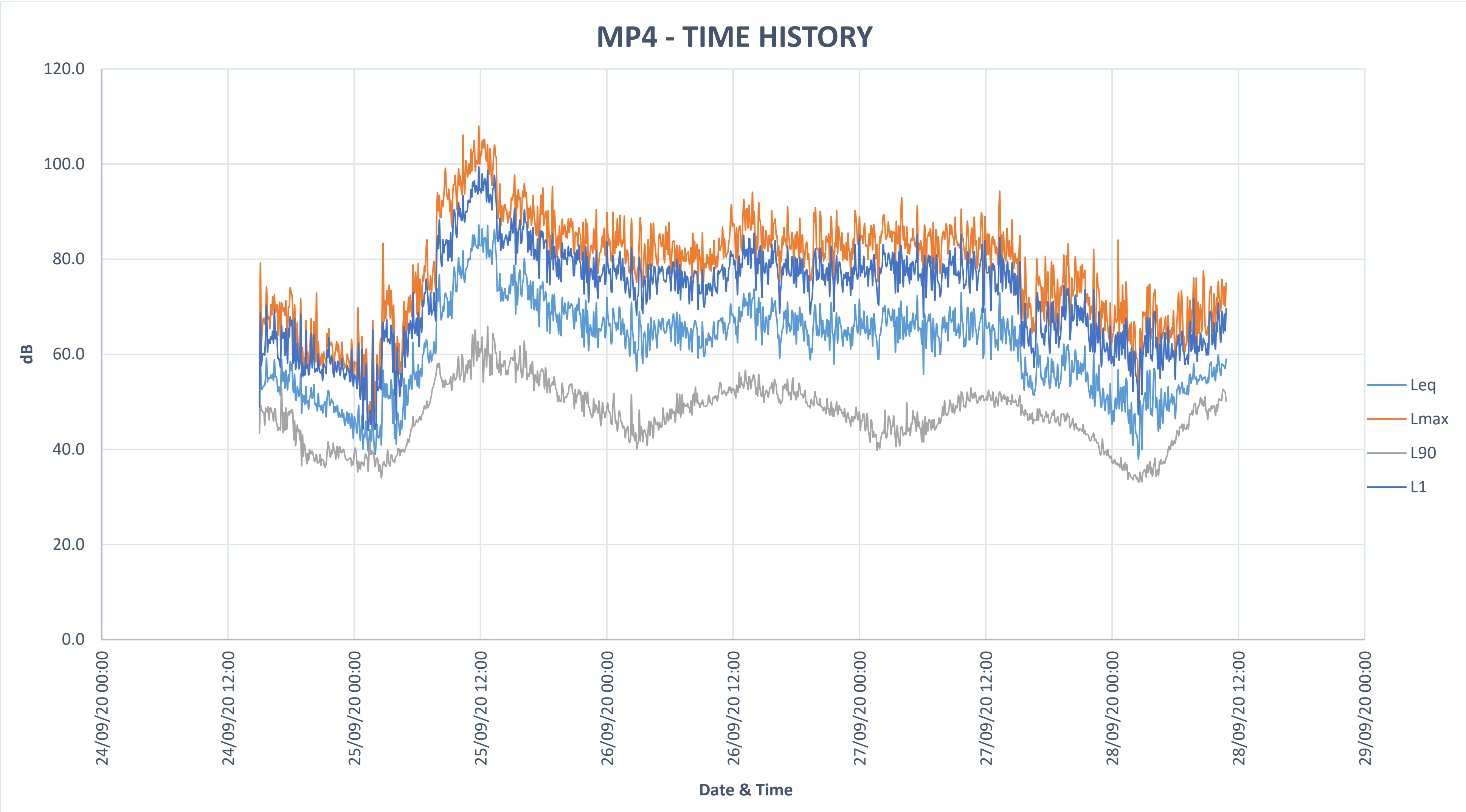
* Typical L_{Amax} values are determined by undertaking a detailed review and statistical analysis of the measured noise levels. In this case the 90th percentile value is used to represent the typical L_{Amax} during the night time period. This level is expected to be exceeded less than 10 times per night.

** The L_{A90} is shown for periods (T) of 1 hour during the daytime and 15 minutes during the night-time periods. The 1 hour daytime L_{A90} and the 15 minutes nigh time L_{A90} are an estimation base on the arithmetic average of 5 minute sample periods.

*** Measurements affected by adverse weather conditions have been excluded.

Table C3: Summary of Attended Measurements

Location	Date and Time	Duration(min)	$L_{Aeq,T}$ (dB)	$L_{A90,T}$ (dB)	Highest $L_{A01,T}$(dB)	Comment
MP1	24/09/20 12:00	130	64	48	-	Road traffic noise measurements. -
MP2	24/09/20 14:20	15	66	48	-	Road traffic noise measurements.
MP3	24/09/20 14:45	5	63	-	-	Sample measurement of kids using the playing field.
MP5	28/09/20 11:15	135	49	40	63	Some of the periods include airplane events. Air traffic noise has been considered for this assessment.


MP4 - TIME HISTORY
120.0
100.0
80.0
60.0
40.0
20.0
0.0
dB
24/09/20 00:00
24/09/20 12:00
25/09/20 00:00
25/09/20 12:00
26/09/20 00:00
26/09/20 12:00
27/09/20 00:00
27/09/20 12:00
28/09/20 00:00
28/09/20 12:00
29/09/20 00:00
Date & Time
Leq
Lmax
L90
L1

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