Kneller Hall

Acoustics Planning Report

Dukes Education

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Executive Summary

The purpose of this acoustics report is to provide clear and relevant information, assessments, and recommendations of acoustic upgrades, in compliance with national, local and heritage protection regulations, for the proposed 'change of use' of the existing Kneller Hall into a senior school. The proposed development also entails the construction of new teaching, auxiliary buildings, and outdoor sports facilities.

The report has focused on three main items relevant for planning purposes:

- Noise impact assessment and recommendations for proposed new outdoor noise generating plant units
- Noise impact assessment for proposed new outdoor sports fields and playgrounds
- Acoustic upgrade recommendations of the existing Listed Buildings for compliance with Building Regulations whilst preserving the character of their historic heritage

With a view to address the first item, an environmental noise survey has been undertaken on site to derive noise limits for the proposed outdoor noise generating equipment based on the requirements of Richmond Upon Thames Borough Council.

A noise propagation model of the proposed plant unit scenario has been designed and rendered using SoundPLAN 8.2. The resultant noise emission levels at 1 m from the surrounding noise-sensitive receptors' façades have proven the suitability of the outdoor plant unit installation in accordance with the noise planning requirements of the Richmond Upon Thames Borough Council provided that the noise control measures described in Section 5.4 are implemented.

The assessment of the second item of the list above have followed a similar methodology by means of rendering a noise propagation model with the outdoor areas and surrounding environment designed using SoundPlan 8.2. The facilities will be in use only during daytime.

The results have shown that generated noise levels will be compliant with England Sports recommended noise limit in 96% of the surrounding and closest noise sensitive receptors. Calculated noise exceedances would only occur in rare occasions when all the large sports facilities (rugby, football and hockey) are used at the same time for at least one hour. Since the calculated exceedances would be no more than 3 dB at six specific points (out of 154 assessed points) during rare occasions, these have been considered negligeable. Therefore, the assessed activity noise at the proposed outdoor sports fields has been deemed compliant with the Local Authority's noise planning requirements.

The last item of the bullet list above has been addressed with an architectural acoustic strategy tailored to achieve the following three main goals:

- Adequate internal noise levels for speech, teaching and learning environments. The assessment has shown that internal noise levels will be achieved considering external noise ingress even with windows open for natural ventilation
- Suitable sound insulation between rooms. The proposed sound insulation strategy has considered the acoustic performance of retained partitions together with recommendations for upgrades and new construction of party elements
- Appropriate reverberation times for speech intelligibility and teaching environments. A comprehensive and flexible acoustic absorption scheme has been proposed for all rooms of the listed buildings.

It should be noted that, as outlined by Building Regulations, the recommendation shall be applied as practically possible under the consideration of the historic character of the listed buildings.

Contents

1.0 Introduction

Cundall has been commissioned by Dukes Education to carry out a review of the architectural and design proposals for the proposed conversion of the existing Kneller Hall in Twickenham, London into a senior school for compliance with the Local Planning Authority acoustic requirements and Building Regulations. The proposed school development will also entail the construction of new teaching and auxiliary buildings.

Figure 1.1 - Masterplan, Source: ADP architecture

The purpose of this report is to advise on the planning acoustic requirements for the proposed development and on potential strategies that could be adopted, based on current architectural proposals. The main items herein covered for planning purposes are:

- Outdoor noise assessment for proposed plant units
- Noise impact assessment for proposed outdoor sports pitches and courts
- Adequate internal noise levels, sound insulation, and reverberation times for 'change of use' of the site Listed Buildings (Kneller Hall, Guard's House and Band Practice Hall).

At this stage, this report refers mainly to generic specifications of material (e.g. plasterboard types, absorptive panels etc.). Where specific manufacturer's data or products are mentioned, alternative products and manufacturers could be used, providing an equal specification is given and approved.

This report should be read in conjunction with the Acoustics Strategy Drawings issued:

- KNH-CDL-ZA-00-DR-AS-45001 - Rev. P04 - Acoustics Strategy - Kneller Hall - GF;
- KNH-CDL-ZA-01-DR-AS-45011 - Rev. P04 - Acoustics Strategy - Kneller Hall - 1F;
- KNH-CDL-ZA-M1-DR-AS-45011 - Rev. P04 - Acoustics Strategy - Kneller Hall - 1M;
- KNH-CDL-ZA-02-DR-AS-45021 - Rev. P04 - Acoustics Strategy - Kneller Hall - 2F;
- KNH-CDL-ZB-00-DR-AS-45001 - Rev. P04 - Acoustics Strategy – Guard’s House - GF;
- KNH-CDL-ZB-01-DR-AS-45011 - Rev. P04 - Acoustics Strategy – Guard’s House - 1F;
- KNH-CDL-ZC-00-DR-AS-45001 - Rev. P04 - Acoustics Strategy - Band Practice Hall - GF;
- KNH-CDL-ZC-01-DR-AS-45011 - Rev. P04 - Acoustics Strategy - Band Practice Hall - 1F;

Environmental noise surveys have been undertaken at the site, with a view to informing attenuation requirements of the building envelope , suitability of proposed natural ventilation strategy and to determine limiting levels for external plant noise emissions.

2.0 Design standards

The acoustics strategy for the proposed development is to provide solutions that fully meet the criteria set out within:

- Building Bulletin 93 'Acoustic Design of Schools: Performance Standards' (v17 February 2015);
- Approved Document E, and
- Local Planning Authority requirements.

2.1 Noise Policy Statement for England

The Noise Policy Statement for England (NPSE) was published by Defra in March 2010. The NPSE sets out the long-term vision of Government noise policy:

"Promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development."

The NPSE long term vision is supported by the following aims:

"Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- *Avoid significant adverse impacts on health and quality of life;*
- *Mitigate and minimise adverse impacts on health and quality of life; and*
- *Where possible, contribute to the improvement of health and quality of life."*

2.2 National Planning Policy Framework

The revised National Planning Policy Framework was updated on 20 July 2021 and sets out the Government's planning policies for England and how these are expected to be applied.

The NPPF states:

"134. Development that is not well designed should be refused, especially where it fails to reflect local design policies and government guidance on design, taking into account any local design guidance and supplementary planning documents such as design guides and codes. Conversely, significant weight should be given to:

a) development which reflects local design policies and government guidance on design, taking into account any local design guidance and supplementary planning documents such as design guides and codes; and/or

b) outstanding or innovative designs which promote high levels of sustainability or help raise the standard of design more generally in an area, so long as they fit in with overall form and layout of their surroundings.

174. Planning policies and decisions should contribute to and enhance the natural and local environment by;

[…]

e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans;

185. Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:

a) mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life;

b) identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason; […]

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

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

2.3 BB93 outlined requirements

The requirements of BB93 are mandatory to all new teaching and learning spaces. Whilst administration and ancillary areas are Building Regulations exempt, the School Premises Regulations (2012) and Independent Schools Standards (2013) are applicable.

Local Authority planning requirements generally relate to the potential noise impact the development will have on nearby noise sensitive premises, as part of the planning process.

This document considers the following elements of school design:

- Internal noise levels to be achieved;
- Sound insulation performance between adjacent noise-sensitive spaces;
- Internal acoustic performance, such as reverberation control and speech transmission index, to allow clear communication of speech between teacher and student to be achieved; and
- Control of plant noise emissions.

The acoustics strategy has been developed based on the assumption that rooms do not need to be specifically designed for students with special hearing and communication needs unless specifically noted.

BB93 requirements are described in more depth in section 3.0.

2.4 Approved Document E on historic buildings

According to approved Document E, in the case of some historic buildings undergoing a material change of use, it may not be practical to improve the sound insulation to the set standards in the document. It is recognised that the special characteristics of historic buildings are to be conserved. Therefore, *"the aim should be to improve sound insulation to the extent that it is practically possible, provided that the work does not prejudice the character of the historic building or increase the risk of long-term deterioration to the building fabric or fittings."*

2.5 Local Authority requirements

Policy LP10 of the Local Plan of the London Borough of Richmond Upon Thames adopted in July 2018 outlines the requirements regarding noise pollution and good acoustic design:

"[…] The Council will seek to ensure that local environmental impacts of all development proposals do not lead to detrimental effects on the health, safety and the amenity of existing and new users or occupiers of the development site, or the surrounding land. These potential impacts can include, but are not limited to, air pollution, noise and vibration, light pollution, odours and fumes, solar glare and solar dazzle as well as land contamination. Developers should follow any guidance provided by the Council on local environmental impacts and pollution as well as on noise generating and noise sensitive development. Where necessary, the Council will set planning conditions to reduce local environmental impacts on adjacent land uses to acceptable levels.

The Supplementary Planning Document (SPD) 'Development Control for Noise Generating and Noise Sensitive Development' of Richmond upon Thames London Borough Council adopted September 2018 provides planning advice related to noise for new proposed developments.[…]

"[…] The Council encourages good acoustic design to ensure occupiers of new and existing noise sensitive buildings are protected. The following will be required, where necessary:

1. *a noise assessment of any new plant and equipment and its impact upon both receptors and the general background noise levels;*
2. *mitigation measures where noise needs to be controlled and managed;*
3. *time limits and restrictions for activities where noise cannot be sufficiently mitigated;*
4. *promotion of good acoustic design and use of new technologies;*
5. *measures to protect the occupiers of new developments from existing sources. […]"*

Noise requirements and necessary assessments for outdoor noise generating equipment, and outdoor multi use games areas (MUGA) & sport pitches are detailed in the Supplementary Planning Document *Development control for Noise Generating and Noise Sensitive Development* adopted September 2018. These are outlined in the following sections 2.5.1 and 2.5.2.

2.5.1 Requirements for outdoor noise generating equipment

Richmond upon Thames London Borough Council will seek to achieve the external noise standards detailed in Figure 2.1 for new industrial and commercial development assessed according to BS 4142:2014 standard. These external noise standards will apply to outdoor noise generating equipment serving different buildings at the proposed Kneller Hall school development.

Noise Significance Risk	BS4142 Outcome	Planning Advice
Minimal	$L_{A,Tr} - L_{A90,T} \le -5$	Where the rating level of noise is below the background noise level by at least 5dB, this indicates that the proposed NGD is likely to be acceptable from a noise perspective. The Borough will seek this level of compliance in most noise sensitive areas and/or where there is a requirement to mitigate creeping background effects.
Low	$L_{A,Tr} - L_{A90,T}$ is > -5 & ≤ 0	Where the rating level of noise is equal to, or below the background noise level by up to 5dB, this indicates that the proposed NGD may be acceptable from a noise perspective but will be more context dependent, i.e. extent and effect on noise sensitive receivers (externally and internally). Compliance within this range is more applicable to less sensitive sites or where there is no requirement to mitigate creeping background effects.
Medium	$L_{A,Tr} - L_{A90,T}$ is > 0 & $\le +5$	Where the rating level of noise is equal to, or above the background noise level by up to 5dB, this indicates that the proposed NGD is less likely to be acceptable from a noise perspective and will be context dependent, i.e. extent and effect on noise sensitive receivers (externally and internally). Compliance within this range is typically only applicable to non-sensitive sites or where there are overriding other reasons why development should be considered. It will typically be necessary for the applicant to confirm how adverse impacts from the NGD will be mitigated and minimised. It is less likely that planning consent will be granted.
High	$L_{A,Tr} - L_{A90,T} > +5$	Where the rating level of noise is above the background noise level by more than 5dB, this indicates that the proposed NGD is unlikely to be acceptable from a noise perspective and planning consent is likely to be refused on noise grounds.

Figure 2.1 - Planning requirements for outdoor noise generating equipment. Source: Richmond upon Thames London Borough Council [1]

[1] Supplementary Planning Document *'Development Control for Noise Generating and Noise Sensitive Development'* adopted September 2018

2.5.2 Requirements for MUGA and sport pitches

It is understood that the Borough would expect that in most cases for any new or modified MUGAs or sport pitch the Sports England guidance is applied, and the application should demonstrate that the level shown in Figure 2.1 can be complied with.

Noise Impact from outdoor MUGA or sport pitch	Location
50 dB(A) $L_{eq,1\ hour}$	Outside a residential property during the daytime about 1 metre from façades of living spaces

Table 2.1 – Noise limit for outdoor MUGA and sport pitches

2.6 Limitations

Details within this specification are believed to be accurate at the time of writing. It is strongly recommended however, and considered good practice, that confirmation be sought from specific manufacturers to see that the minimum performance requirements, as stated within this document, will be achieved by the chosen system / product / installation method.

3.0 BB93 Performance requirements

The objective of BB93 is to provide suitable acoustic conditions within schools that:

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

The acoustics strategy drawings show the key acoustics design criteria for each space within the school. The following sub-sections provide a summary of the applicable criteria.

3.1 Indoor ambient noise levels (IANL)

The IANLs include contributions from:

- External noise sources (outside of the school premises), such as transportation, industrial/commercial premises;
- Building services noise; and
- Actuator and damper noise.

The IANL criteria are specified in terms of the $L_{Aeq,30mins}$ during normal teaching hours. This is the average noise level over a 30-minute period. In addition, BB93 also states that regular discrete events, e.g. aircraft or trains, should not exceed 60 dB $L_{A1,30mins}$, although this criterion only applies for rooms with an IANL of 45 dB $L_{Aeq,30mins}$ or greater.

The IANLs *exclude* noise contributions from:

- Teaching activities within the school premises, including noise from staff or students and teaching equipment within the building or in the playground;
- Equipment used in the space; and
- Rain noise.

The following table summarises the internal ambient noise level criteria given in BB93 for noise break-in and mechanical services noise:

Condition	Ventilation system	Noise level limit
Normal [1] – ventilation for normal teaching activities	Mechanical	Values marked on acoustic strategy drawings
	Natural	Values marked on acoustic strategy drawings + 5 dB [2]
	Hybrid	Mechanical system noise: values marked on acoustic strategy drawings
		Total noise level: values marked on acoustic strategy drawings + 5 dB
Summertime [3] – ventilation under local control of teacher to prevent overheating, allowable during the hottest 200 hours of the year	Mechanical	Values marked on acoustic strategy drawings + 5 dB [2]
	Natural or Hybrid	≤ 55 dB $L_{Aeq,30mins}$

Notes:

[1] Normal condition for ventilation in natural or hybrid mode is defined as when the system is operating to limit the daily average carbon dioxide concentration to no more than 1,500 ppm with the maximum concentration not exceeding 2,000 ppm for more than 20 consecutive minutes on any day. This would normally equate to a minimum ventilation rate of approximately 5 l/s per person. For hybrid systems, the mechanical noise excluding external noise break in should meet the values marked on the acoustic strategy drawings.

[2] The +5 dB does not apply to teaching and learning spaces where the IANL marked on the acoustic strategy drawings is greater than or equal to 45 dB.

[3] The 'normal' ventilation IANL can be exceeded during the hottest 200 hours in peak summertime conditions and the design should show that the 'summertime' IANLs can be met under these conditions as well as under normal operation. The ventilation must be under the local control of the teacher.

Table 3.1 – Summary of internal ambient noise requirements

3.2 Airborne sound insulation between teaching spaces

The minimum airborne sound insulation performance of internal partitions and floors is dictated by the *activity noise level* in the source room and the *noise tolerance* of the receiving room.

The performance standards for airborne sound insulation between spaces is given the notation dB $D_{nT,w}$, which is the weighted standardised level difference.

Whilst performance criteria above are given in terms of $D_{nT,w}$ (site performance), manufacturers typically specify their systems in terms of R_w (a laboratory test rating). Because of the inevitable depreciation between quoted laboratory ratings and the required in-situ performance (due to site constraints, quality of installation and flanking), an allowance needs to be made between these two values.

At this stage of design, an allowance of +5 dB is recommended between the required in-situ performance ($D_{nT,w}$) and the manufacturer's performance data (R_w).

3.2.1 Internal partitions

The following table summarises the in-situ and preliminary laboratory ratings (colours to match acoustics strategy drawings) for each partition type.

Performance criteria for partitions between adjacent teaching spaces (i.e. no doors)		Equivalent laboratory rating
35 dB $D_{nT,w}$	(yellow)	≥ 40 dB R_w
40 dB $D_{nT,w}$	(magenta)	≥ 45 dB R_w
45 dB $D_{nT,w}$	(blue)	≥ 50 dB R_w
50 dB $D_{nT,w}$	(green)	≥ 55 dB R_w
55 dB $D_{nT,w}$	(red)	≥ 60 dB R_w

Table 3.2 – Comparisons of in-situ and laboratory rating for partitions

3.2.2 Internal floors

The intermediate floor construction should provide a minimum sound insulation of 40 dB $D_{nT,w}$ for existing buildings.

Localised enhancement to provide 50 dB $D_{nT,w}$ may be required in some instances in the existing Guard House, such as to the music classrooms, music practice rooms, recording studio and control room.

3.3 Internal airborne sound insulation between teaching spaces and circulation

The performance requirements for partitions and doors between teaching and learning spaces to circulation are given in terms of dB R_w, which is measured in a laboratory.

The following table summarises the ratings (colours to match the acoustics strategy drawings) for each partition type, including the ratings for walls (including any glazing) and doors. It is understood that there will not be openings for ventilation in the partitions.

Type of space used by students	Minimum composite R_w of wall including any glazing	Minimum R_w of doorset
Music classroom, music practice room Control room, Recording studio, Auditorium	40 dB	35 dB
All other spaces in existing buildings	35 dB	30 dB
All other spaces in new buildings	40 dB	30 dB

Type of space used by students	Minimum composite R_w of wall including any glazing	Minimum R_w of doorset
Notes: The above performance values are applicable to partitions separating teaching spaces and circulation where there is a door. It does not include flanking partitions of classrooms that do not give direct access to circulation spaces. Some general class base partitions to circulation have been upgraded, i.e. where they are in close proximity to other teaching spaces that are located within general circulation areas. Where a partition separating a teaching space and a corridor does not contain a door, the assessment and sound insulation requirements have been determined using Section 3.2.1 above.		

Table 3.3 – Sound insulation requirements for partitions and doors between teaching and circulations. No ventilators on partitions

3.4 Impact sound transmission

BB93 sets the maximum impact sound transmission performance of floors. Values are specified in terms of $L'_{nT,w}$, which is the weighted standardised impact sound pressure level, with lower values being more stringent.

The maximum limit of impact sound transmission, from above, for each space is marked on the acoustics strategy drawings. For most general teaching spaces in the listed buildings, a maximum impact sound pressure level of 65 dB $L'_{nT,w}$ is required, reducing to 60 dB $L'_{nT,w}$ for more sensitive spaces. Ancillary spaces in existing buildings are generally rated at ≤ 65 dB $L'_{nT,w.}$

3.5 Reverberation control

3.5.1 Teaching & learning spaces

The reverberation time criteria for each space are marked up on the acoustics strategy drawings. The reverberation time criteria are for rooms that are finished, furnished for normal use, but unoccupied.

The reverberation time is quoted in terms of the mid-frequency reverberation time, T_{mf}, which is the arithmetic average of the reverberation times in the 500 Hz, 1 kHz and 2 kHz octave bands[2] for standard class bases.

3.5.2 Corridors and entrance halls

The objective is to absorb sound in corridors and entrance halls to reduce the level of transmission into teaching spaces.

The requirement is to provide sufficient sound absorption in these areas, the amount being calculated according to Approved Document E, Section 7. It should be noted that corridors that do not give direct access to teaching and learning spaces are not covered by this requirement.

[2] Alternatively, it is acceptable to average the measured reverberation time in the one-third octave bands from 400 Hz to 2.5 kHz.

4.0 Site acoustic surveys

4.1 Environmental noise survey

Unattended noise monitoring has been undertaken at the development site, with a view to assessing the levels of prevailing environmental noise. The measured sound levels at different locations around the site will allow for:

- Setting maximum noise limits for proposed outdoor noise generating plant units according to the Local Authority's acoustic requirements.
- Assess the suitability and potential upgrades of the external building fabric of the existing and proposed buildings for compliance with BB93 indoor ambient noise level requirements.

Attended noise measurements were also conducted inside the existing Kneller Hall building to support the assessment of the external building fabric of existing buildings.

4.1.1 Measurement times and locations

The environmental noise survey comprised of unattended noise monitoring around the site between

- Friday 21 January and Tuesday 25 January 2022; and
- Friday 28 January and Monday 31 January 2022

Figure 4.1 shows the noise measurement locations. The positions were chosen to be representative of background noise levels at nearby NSR.

The manned internal noise level measurements were undertaken inside a room on the first floor of the west wing of the Kneller Hall building on Wednesday 29 June 2022 between 15:00 and 15:20.

Figure 4.1 - Noise sensitive receptors and measurement locations

The following paragraphs summarise the monitoring conditions and acoustic climate at each of the measurement positions:

- MP1: Microphone placed on 2 m high tripod overlooking the B361 to the south of the site. The acoustic environment was dominated by occasional road traffic on the B361 as well occasional distant air traffic and is considered representative of NSR in group 1.
- MP2: Microphone placed on 3 m high pole overlooking Whitton Drive to the west of the site. The acoustic environment was dominated by road traffic on Whitton Drive as well occasional distant air traffic and is considered representative of NSR in group 2.
- MP3: Microphone placed on 2 m high pole overlooking Amberside Close to the north of the site. The acoustic environment was dominated by distant road traffic as well occasional distant air traffic and is considered representative of NSR in group 3.
- MP4: Microphone placed on 2 m high pole overlooking Duke of Cambridge Close to the east of the site. The acoustic environment was dominated by distant road traffic on the B361 to the south as well occasional distant air traffic and is considered representative of NSR in group 4.
- MP5: Microphone placed inside a first floor room to the west wing of Kneller Hall building. It was placed 1.5 m above floor level and at least 1 m away from any wall or reflective surface. The acoustic environment was dominated by distant road traffic and occasional distant air traffic. Measurements were undertaken with windows closed and also windows half open making sure that aircraft events were captured during a simulated natural ventilation scenario.

All MP1-MP4 outdoor measurements are considered to be free field.

4.1.2 Measurement equipment

Table 4.1 below provides relevant details of the equipment used during the noise survey. The sound level meter used conforms to BS EN 61672-2013 Class 1 accuracy and was field calibrated before and after use with no significant drift in measurements observed between calibrations

Equipment	Manufacturer & model	Serial number
Sound level meter	01dB Fusion	11766
Calibrator	Casella	2652023
Sound level meter	Norsonic type 140	1405754
Calibrator	Casella CEL type 120/1	2652023

Table 4.1 – Noise survey equipment

Copies of external calibration certificates are available upon request.

Measurements were made of various noise descriptors, but the key parameter in this assessment is the $L_{A90,T}$ - the noise level exceeded for 90% of the measurement period *T*, referred to as the ‘background’ noise level.

For reference, the $L_{Aeq,T}$ – the equivalent continuous sound pressure level, has also been detailed.

4.1.3 Weather conditions

Weather conditions during the entirety of the surveys were measured by a weather station set up on site.

Adverse weather was observed for brief periods during the 29th, 30th and 31st of January. Data during adverse weather conditions (i.e. periods of rain and windspeeds above 5 m/s) have been excluded from further assessment.

4.1.4 Survey results

The following Table 4.2 provides a summary of background noise levels measured during the outdoor survey.

Measurement position	Date (2022)	Period*	Measurement start time (hh:mm)	Measurement duration, *T* (hrs)	Ambient sound level $L_{Aeq,t}$ (dB)	Typical** background sound level $L_{A90,15min}$ (dB)
MP1	Sun 23 Jan	Daytime	12:45	10.25	52	47
		Night-time	23:00	8	44	34
	Sat 24 Jan	Daytime	07:00	16	54	46
		Night-time	23:00	8	47	33
	Mon 25 Jan	Daytime	07:00	5.75	54	45
MP2	Fri 21 Jane	Daytime	11:30	11.5	64	50
		Night-time	23:00	8	59	36
	Sat 22 Jan	Daytime	07:00	16	63	47
		Night-time	23:00	8	58	33
	Sun 23 Jan	Daytime	07:00	5.5	62	41
MP3	Fri 28 Jan	Daytime	14:30	8.5	48	44
		Night-time	23:00	8	48	38
	Sat 29 Jan	Daytime	07:00	16	51	45
		Night-time	23:00	8	45	34
	Sun 30 Jan	Daytime	07:00	8	50	42
		Night-time	23:00	16	47	32
	Mon 31 Jan	Daytime	07:00	7.5	51	46
MP4	Fri 28 Jan	Daytime	14:30	8.5	53	51
		Night-time	23:00	8	50	42
	Sat 29 Jan	Daytime	07:00	16	54	51
		Night-time	23:00	8	48	41
	Sun 30 Jan	Daytime	07:00	8	53	50
		Night-time	23:00	16	52	36
	Mon 31 Jan	Daytime	07:00	7.5	56	48
* Daytime (07:00-23:00), Night-time (23:00-07:00) **Typical background levels have been based on the mode value						

Table 4.2 - Measured outdoor ambient and background noise levels

Detailed time history graphs showing measured outdoor background levels as well as ambient noise levels in MP1-MP4 measurement positions are included in *Appendix A – Environmental noise time history* to this report.

Table 4.3 shows the results of the indoor sound levels measured inside a room of the Kneller Hall building.

Measurement position	Date (2022)	Scenario	Measurement start time (hh:mm)	Measurement duration, *T* (min)	Ambient sound level $L_{Aeq,t}$ (dB)	Single events $L_{A1,5min}$ (dB)
MP5	Wed 29 Jun	Windows closed	15:06	5	31	39
		Windows 1/3 open	15:13	5	39	44

Table 4.3 - Measured indoor ambient noise level

Data from the noise survey is available upon request.

4.1.5 Uncertainty

There is some inherent uncertainty associated with the results of any noise survey. However, the measurement locations chosen were representative of the conditions at the nearest noise sensitive receptors and current Kneller Hall indoor environment, and weather conditions during the survey period were conducive with noise monitoring.

It is therefore considered that the potential risk associated with such uncertainties is minimal and that the measured noise levels are appropriate to inform the noise impact assessment detailed in this report.

4.2 Sound insulation surveys

Sound insulation surveys of existing internal walls and floors were undertaken inside the Kneller Hall building and the Guard House. The purposes of these tests are:

- assessing the current sound insulation performance of representative existing partitions that will be retained
- understanding the extension of the acoustic upgrades to be applied to the retained existing partitions

The sound insulation tests were undertaken based on BS EN ISO 12354 Parts 1, 2, and 3 guidelines

The sound insulation test results of relevant existing partitions are shown in the following table:

Construction element	Description	Sound insulation performance	
		Airborne ($D_{nT,w}$)	Impact ($L'_{nT,w}$
Kneller Hall - Wall 1	250-300 mm internal masonry wall	54	N/A
Kneller Hall – Façade Wall 1	Façade 300-400 mm brickwork and 3 no. 3-5mm single pane windows with muntins	34	N/A
Kneller Hall - Floor 1	Construction unknown	58	46
Guard House - Floor 1	Construction unknown	40	71
Guard House - Floor 2	Unknown. Same as Guard House Floor 1 + thin carpet	40	66

Table 4.4 - Sound insulation performance of existing construction elements

5.0 Plant outdoor noise emission assessment

Part of the proposed development will entail the installation of mechanical equipment that could potentially contribute to the current ambient noise levels at the nearby residential areas and other noise sensitive receptors. The purpose of this assessment is to evaluate this potential impact and, if deemed necessary, propose mitigation measures with a view of complying with the Local Authority noise requirement and protect the nearby noise sensitive receivers.

The plant unit installation layout and location is based on the following MEP design team (WB Shiels) drawings:

- P2389_57_LR_40_1
- P2389_50_SE_20
- P2389_50_L1_20
- P289_50_SE_20
- P2389_50_L0_20
- P2389_00_X_4
- P2389_00_LR_50
- P2389_00_LR_40

5.1 Proposed plant units

The proposed plant units for the school development that may relevantly contribute to the current ambient noise levels in the area are:

- 3 no. air source heat pumps (ASHP 01-03) located at the proposed new Energy Centre to the north
- 3 no. air handling units (AHU 50-52) on the roof of the proposed new Sports Centre
- 2 no. heat pumps (HP01-02) on the roof of the proposed new Sports Centre
- One air handling unit (AHU 02) to the west of the Band Practice Hall
- One air handling unit (AHU 01) on the roof of the proposed new Teaching Building
- One air supply (SP 01) and one extract fan (EF 01) on the roof of the Teaching Building serving the kitchen area
- 3 no. mechanical ventilation with heat recovery (MVHR 01-03) on the roof of the Teaching Building
- 4 no. condenser units (CU.TB.01 – CU.TB.04) on the roof of the Teaching Building

The proposed location of the plant units is shown in Figure 5.1 below.

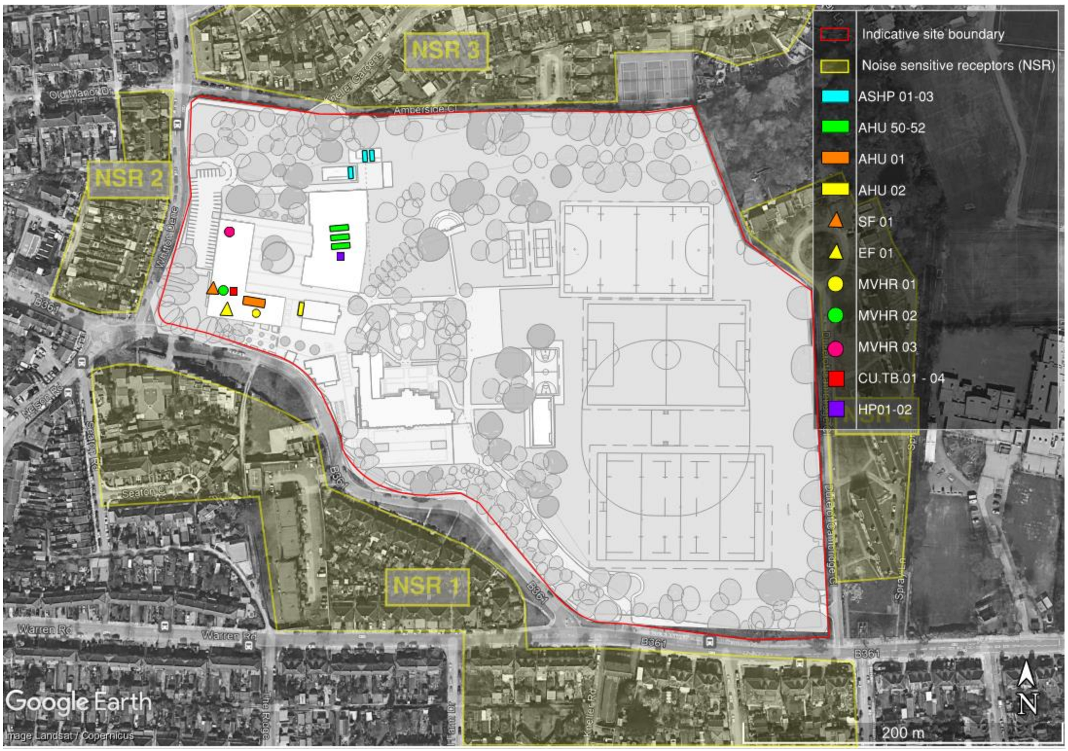


Figure 5.1 - Locations of proposed plant units

The overall noise emission levels of the proposed plant units are shown in Table 5.1 below for reference. Spectral noise emission levels provided by the MEP design team and input into the noise propagation model are detailed in *Appendix B – Spectral noise levels of proposed plant units*

Plant ref	Unit part	Overall L_w (dBA)
AHU 50	Intake (fresh air)	84
	Exhaust	84
	Breakout	63
AHU 51	Intake (fresh air)	83
	Exhaust	82
	Breakout	58
AHU 52	Intake (fresh air)	84
	Exhaust	84
	Breakout	60
AHU 01	Intake (fresh air)	83
	Exhaust	87
	Breakout	62
AHU 02	Intake (fresh air)	86
	Exhaust	90
	Breakout	63
ASHP 01-03	Overall unit	85*
SF 01	Supply Fan	80
	Breakout	54
EF 01	Overall unit	89
MVHR 01	Intake (fresh air)	74
	Exhaust	74
	Breakout	53
MVHR 02	Intake (fresh air)	79
	Exhaust	79
	Breakout	56
MVHR 03	Intake (fresh air)	74
	Exhaust	74
	Breakout	47
HP 01	Entire unit	89
HP 02	Entire unit	89
CU.TB.01	Entire unit	73
CU.TB.02	Entire unit	73
CU.TB.03	Entire unit	63
CU.TB.04	Entire unit	63

Table 5.1 - Overall sound power level (L_w) of proposed plant units

* Sound power level derived from sound pressure level as in line with Daikin Technical datasheet.

5.2 Plant outdoor noise emission limits

Noise emission limits for new plant and equipment have been set at the façades of the nearest noise sensitive receptors based on Local Authority noise policy and guidance from BS 4142:2014 +2019.

Noise limits shown in Table 5.2 have been set to not exceed 5 dB below the measured background level (L_{A90}), in line with Richmond upon Thames London Borough Council's requirements.

Noise sensitive receiver zone	Time Period	Typical background noise level, $L_{A90,15min}$ (dB)	Maximum plant noise rating level, $L_{Ar,Tr}$ (dB)
NSR 1	Daytime (07:00 - 23:00)	46	41
	Night-time (23:00 - 07:00)	33	35*
NSR 2	Daytime (07:00 - 23:00)	47	42
	Night-time (23:00 - 07:00)	33	35*
NSR 3	Daytime (07:00 - 23:00)	42	37
	Night-time (23:00 - 07:00)	32	35*
NSR 4	Daytime (07:00 - 23:00)	50	45
	Night-time (23:00 - 07:00)	36	35*

*In situations where external background noise levels are low, BS 4142: 2014 +A1: 2019 states that "BS 8233 indicates that 35 dBA sound level from the plant, equating to an internal noise level of around 25 dBA or lower [with an open window], with no significant acoustically distinguishing characteristics, is suitable for a bedroom." Therefore, it is considered that noise limits below 35 dB $L_{Aeq,T}$ are not necessary. However, this should be confirmed with the Local Authority.

Table 5.2 - Proposed plant noise limits

Plant noise emission limits apply to the cumulative noise levels from all new items of plant operating at their standard duty and are applicable at 1 metre from the window of the nearest noise sensitive receptors.

It is important to note that the plant noise limits are in terms of 'rating level' as defined in BS 4142:2014. Therefore, if acoustic features, such as tones, impulsivity or intermittence are present a correction will be applied and the actual 'specific noise level' produced by any plant / equipment will need to be lower than the values above. The required level will depend on the type of sound in question.

It is understood that operation times of plant units the units will be as follows:

- All units except AHU 02 could operate before 07:00 hours or 24/7
- The Band Practice Hall AHU 02 unit will not be operating during the night

Therefore, and with a view of ensuring that all noise sensitive receptors are protected at all times, the most stringent limit of the night-time period according for each of the NSR will be adopted. In this instance, all NSR night-time limits are the same 35 dB $L_{Ar,Tr}$.

5.3 Noise propagation model

Architectural drawings, plant location layouts and the noise emission shown in *Appendix B – Spectral noise levels of proposed plant units* have been used to render a noise propagation model using the proprietary software SoundPlan 8.2.

The designed noise propagation model has been based in the following assumptions and parameters:

- Only the closest NSR buildings to the site of each NSR areas shown in Figure 5.1 have been modelled as they will represent the worst-case scenario of noise sensitive receptors.

- NSR 04 zone receptors have not been included in the model as NSR 01-03 already represent the worst-case scenario of potentially affected receivers due to proximity to the proposed mechanical plant.
- Noise emission levels have been calculated at ground and first floor of each individual receptor
- All plant units are assumed to operate 24/7
- Sound attenuation due to noise propagation inside ductwork have been considered where relevant
- The noise control measures (silencers and enclosures) shown in the following section 5.4 have been considered
- No penalty corrections for intermittency, impulsivity or tonality sounds from plant units have been applied as these sound features are not expected to be present at the NSRs due to the applied noise control measures.
- Noise emission levels of plant units have been also considered at the façades of the proposed school development with a view of ensuring that BB93 internal noise levels inside the school rooms are not exceeded.
- Existing constructions to be retained (including the site perimeter walls) and new buildings (including parapet walls on the roof of the Teaching Building) of the proposed Kneller Hall school development have been included in the model.
- Weather louver fences around ASHP units in the Energy Center shown in architectural drawings have not been modelled since they are deemed acoustically transparent

5.4 Noise control measures

The transmission loss figures of the noise reduction elements described in Table 5.3 have been carefully selected so that noise emission levels from the proposed plant units are compliant with the set noise limits.

Unit ref.	Noise control element	Minimum insertion loss (dB) in each octave frequency band (Hz)							
		63	125	250	500	1k	2k	4k	8k
AHU 02	Intake silencer	0	12	16	23	24	25	19	12
	Exhaust silencer	2	13	21	26	29	30	25	18
AHU 01	Intake silencer	0	8	10	15	14	13	10	8
	Exhaust silencer	0	7	15	17	17	13	13	10
AHUs 50 - 52	Intake silencer	0	7	11	12	14	10	7	6
	Exhaust silencer	0	9	10	12	13	10	7	6
EF 01	Exhaust silencer	0	4	12	15	14	11	7	0
ASHP 01-03	Acoustic enclosure	2	5	8	13	16	16	14	12
HP 01-02	Acoustic enclosure	0	5	12	20	19	17	5	2

Table 5.3 - Minimum attenuation required to be provided by the proposed noise control elements

5.5 Results and discussion of noise emission level calculations

The resultant $L_{Ar,Tr.}$ at 1 m from each of the individual NSR façades are shown in form of noise coloured façade map. Worst-case results of noise emission levels at individual NSR are presented in Table 5.4.

NSR Area	Individual receiver	Worst-case $L_{Ar,Tr}$ (dB) of an individual receiver	Night-time noise emission Limit, $L_{Ar,Tr}$ (dB)
NSR 01	99-111 Kneller Road. First Floor	35	35
NSR 02	241-247 Whitton Dene. First Floor	34	35
NSR 03	1 Amberside Close. First Floor	34	35

Table 5.4 - Worst-case scenario results of the noise propagation model renders

As shown in Table 5.4, the worst-case scenario of noise emission levels from the proposed units calculated at 1m from NSRs do not exceed the according set limit. Therefore, providing that the noise control measures recommended in Section 5.4 are applied, the Local Authority's noise requirements for new mechanical units will be met.

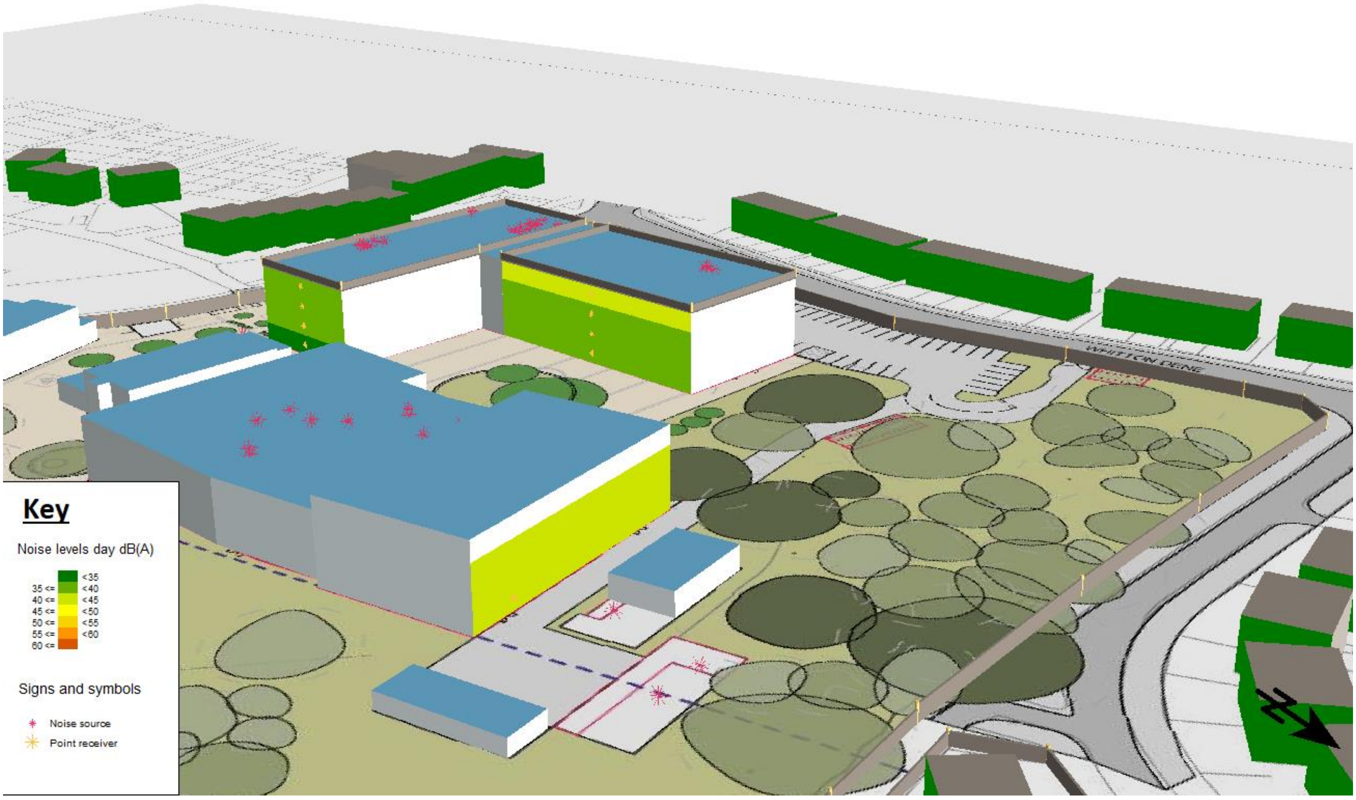


Figure 5.2 - Façade noise map results. View from North-West

Figure 5.3 - Façade noise map results. View from South

6.0 MUGAs and sports pitches noise assessment

According to Sports England guidelines noise levels of activities at MUGAs and AGPs should not exceed 50 dB(A) $L_{eq,1hour}$ outside a residential property during the daytime, about 1 metre from façades of living spaces.

According to Richmond Upon Thames SPD adopted in September 2018:

"The Borough would expect that in most cases for any new or modified MUGAs or AGPs the Sports England guidance is applied, and the application should demonstrate that these levels can be complied with."

The proposed Kneller Hall school development includes several outdoor sports pitches that will fall into the MUGAs or AGPs category:

- Two tennis courts
- A basketball court
- One hockey pitch
- One rugby pitch
- One football field

It is noted that the football and rugby field combined can also be used a a cricket pitch.

All these areas will be used during school break/lunchtime periods, some afternoons after typical school hours or during daytime at some weekends for community sports events.

The proposed locations of the sports fields and relevant NSR zones around the site are indicated in Figure 6.1.

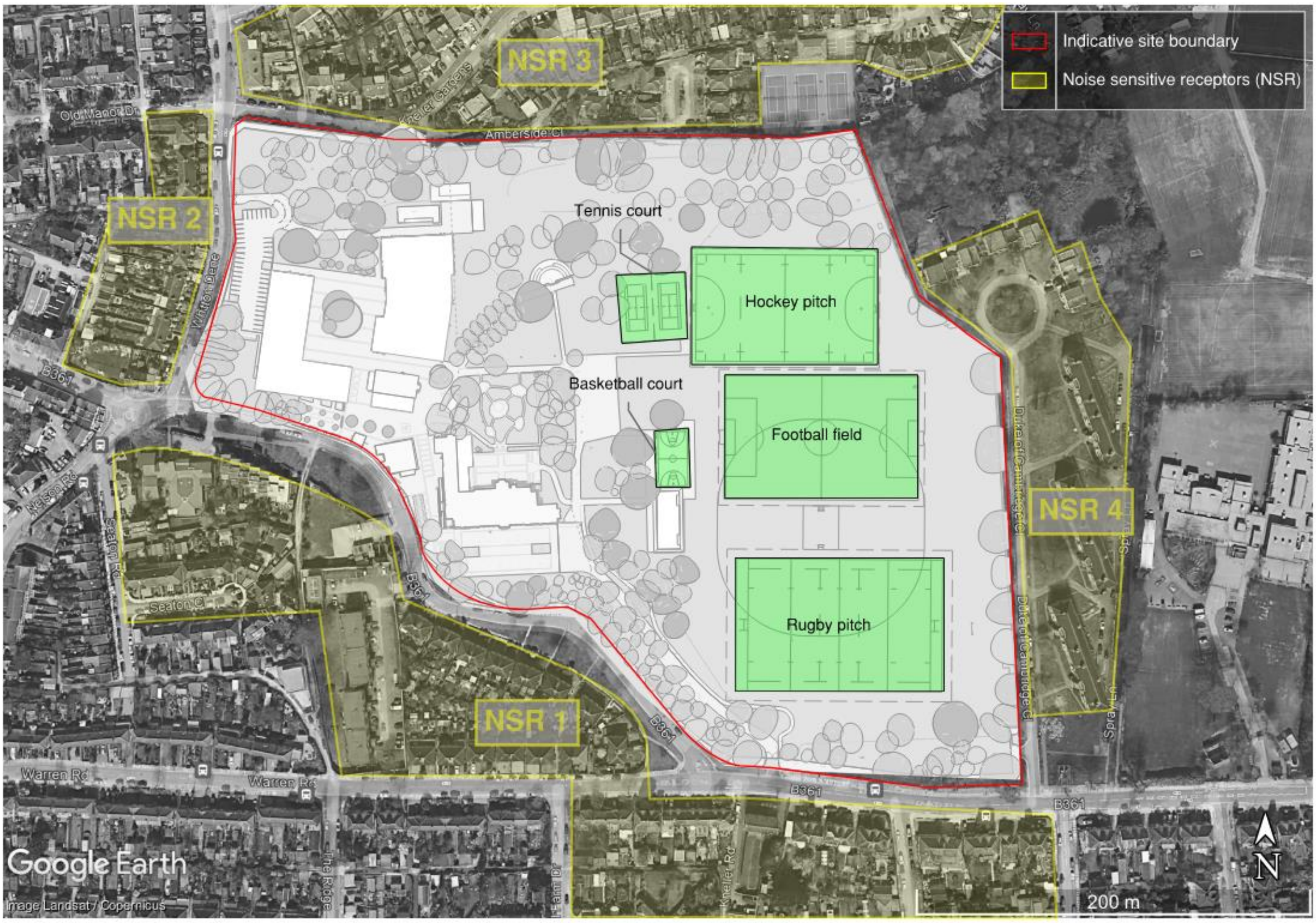


Figure 6.1 - Outdoor sports facilities

An assessment of noise emission levels of activities at the sports pitches have been carried out in line with Sports England Design Guidance Note “Artificial Grass Pitch (AGP) Acoustics Planning Implications” for compliance with the Local Authority’s requirements.

The methodology, results, recommended noise control measures and conclusions are described herein.

6.1 Noise propagation model

Similar to the plant noise assessment, the proprietary software SoundPlan 8.2 have been used to model and render a noise propagation model of activity noise generated at the proposed sports fields.

The relevant assumptions and parameters considered for the modelling are as follows:

- The outdoor sports pitches and courts have been modelled as noise source areas at 1.5m above ground level;
- The noise source areas have been calibrated individually to a typical free-field 58 dB $L_{Aeq,1hr}$ noise level at 10 m from the side line halfway marking in line with Sports England guidelines;
- NSR 02 has not been included in the model as NSR 01, 03 and 04 already represent the worst-case scenario of potentially affected receivers due to proximity to outdoor sports pitches;
- Noise emission levels have been calculated at ground and first floor of each individual receptor;
- Noise control measures described in Section 6.2 have been considered.
- A worst-case scenario of all pitches being in use at the same time has been modelled. However, although this worst-case could happened on occasions, in most cases only a limited number of pitches will be used at any one time.

6.2 Noise control measures

Renders of different design scenarios of the noise propagation model have been run to optimise the design of the sports pitches and courts regarding noise emissions at the closest noise sensitive receptors. The noise control measures outcome of the reiterative modelling process is:

- Hockey, rugby, and football pitches have been located as far as possible towards West to increase the distance to the NSR 04 zone
- A reflective sound barrier is proposed to be installed to the east and north-east of the hockey pitch to attenuate sound levels at the nearby residential units at Duke of Cambridge Close (NSR 04)

  The barrier should be at least 3 m high, without junction gaps, imperforate and should have a minimum 15 Kg/m^2 surface weight. It should also be weather resistant, durable and easy to maintain.

  Dimensions and location of the proposed barrier are shown in Figure 6.2 below.

It is acknowledged that the project architects adopted these noise control measures to respond to the acoustic advice.

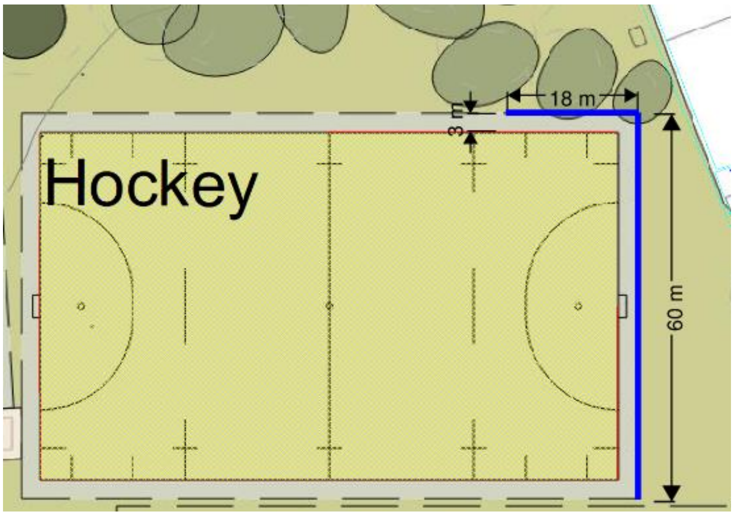


Figure 6.2 - Proposed reflective noise barrier location and dimensions

6.3 Results and discussion of noise emission level calculations

The calculated $L_{Aeq,1h}$ noise level results at 1 m from the receptor's façade are presented in form of noise façade coloured map in Figure 6.3 and Figure 6.4.

Figure 6.3 - Façade noise map results. View from South

Figure 6.4 - Façade noise map results. View from North

As shown in the summary of the façade map results in Table 6.1, the noise emission levels at the NSR are compliant with the criteria except for a reduced number of façade points (light orange façade points in Figure 6.3). Furthermore, the set noise limit is exceeded at this façade point by no more than 3 dB, which is considered non-significant or negligeable.

Total NSR Façade points	Facades points exceeding criteria (> 50 dB $L_{Aeq,1h}$)	Façade points exceeding +3 dB over criteria (> 53 dB $L_{Aeq,1h}$)
154	6 points. 4% of total points	0 points. 0% of total points

Table 6.1 - Summary of facade noise map results

It should be noted that the results shown the results for the worst-case scenario of all pitches being in use at the same time. As previously mentioned in section 6.1, whilst this worst-case may occur in few occasions, in most cases only some of the pitches will be used at any one time, thereby reducing the overall noise emissions.

Therefore, it is considered that provided that the sports pitches are located as indicated in Figure 6.1 and the recommended noise barrier is installed, the noise emission levels of activities at these areas will not entail an adverse impact on the surrounding noise sensitive receptors.

6.4 Other outdoor areas

Noise from pedestrians in transition/access areas will be minimal compared to other sources of noise assessed in this report (i.e. external plant, MUGA sports fields).

Noise from outdoor areas between and around buildings (which a number of pupils may occupy during breakout / lunchtime periods) will be present however this is restricted to set times during school days only, and will not be present during evenings, nights or weekends. These sources are unlikely to be intrusive and are not considered to affect the quality of life or produce adverse health impacts on nearby receptors, and as such have not been further assessed.

7.0 Internal ambient noise level assessment

Adequate internal ambient noise levels in teaching and study rooms are important for focusing and learning conditions. BB93 recommend maximum internal ambient noise levels for different type of rooms. These limits have been indicated in the acoustic strategy mark-ups accompanying this document.

7.1 Influence of natural ventilation on internal ambient noise levels

The following MEP ventilation strategy drawings have been reviewed:

- P2389_50_L0_21 School Hall mechanical services strategy
- P2389_50_L0_31 Guard's House mechanical services strategy ground floor
- P2389_50_L1_31 Guard's House mechanical services strategy first floor
- P2389_50_L0_11 Kneller Hall mechanical services strategy ground floor
- P2389_50_L1_11 Kneller Hall mechanical services strategy first floor
- P2389_50_LM_11 Kneller Hall mechanical services strategy mezz
- P2389_50_L2_11 Kneller Hall mechanical services strategy second floor

The acoustic strategy can be summarised as follows:

- Some spaces in the Guard's House and Band Practice Hall will be ventilated via an AHU system in addition to fan coil units for cooling. Other rooms will entail natural ventilation.
- All rooms in Kneller Hall will be naturally ventilated.

It is considered that a natural ventilation strategy would be acceptable for most spaces, with opening windows used where necessary (i.e. for the control of overheating).

As noted above, where natural or hybrid ventilation is provided to a space, the overall internal ambient noise level (mechanical plus break-in noise) can be relaxed by 5 dB for most spaces. For example, if the acoustics strategy drawing notes that the internal ambient noise level should be 35 dB $L_{Aeq,30mins}$ (e.g. for a standard classroom), this could be relaxed to 40 dB $L_{Aeq,30mins}$. (It should be noted that this relaxation does not apply to teaching and learning spaces where the IANL criterion is greater than or equal to 45 dB $L_{Aeq,30mins}$.)

However, where mechanical ventilation is used (even as part of a hybrid system), noise levels attributable to the mechanical ventilation system should not exceed the internal ambient noise level criterion marked on the acoustic strategy drawings. It is recommended that NR levels inside the Kneller Hall, Guard's house and Band Practice Hall do not exceed NR32. Recording and control room may require lower NR limits depending on specific client's requirements.

Mechanical ventilation will be required for internal spaces that have no external façades and for rooms with increased ventilation requirements.

7.2 Internal ambient noise levels

As a representative scenario of teaching and study rooms, internal ambient noise levels were measured in a room at First floor in the West Wing of the Kneller Hall building with closed and 1/3 opened windows (5 no. of windows in the room). The surveyed room is referenced as *F03 6th Form Classroom* at first floor of the Kneller Hall building acoustic strategy mark-up drawing (ref. KNH-CDL-ZA-01-DR-AS-45011).

The results of the internal noise survey are compared in Table 7.1 to the BB93 recommended maximum internal ambient noise level for teaching spaces in refurbished buildings. It should be noted that the 5-minute measurement was considered representative due to the steady outdoor ambient noise levels in the area.

A +5 dB relaxation is applied to the recommended internal noise levels when windows are open according to BB93 standards.

Measured Internal ambient noise level $L_{Aeq,5min}$ with windows closed (dB)	Internal ambient noise level $L_{Aeq,30min}$ in teaching spaces for refurbished buildings recommended by BB93 guidelines (dB)	Measured Internal noise level $L_{Aeq,5min}$ with 1/3 opened windows (dB)	Internal ambient noise level $L_{Aeq,30min}$ in teaching spaces for refurbished buildings recommended by BB93 guidelines (dB) + 5dB relaxation
31	35	39	40

Table 7.1 - Internal ambient noise levels measure vs. criteria

As shown in Table 7.1 above, the current internal ambient noise levels inside the surveyed room are already compliant with BB93 standards.

The $L_{A1,\ 5\ min}$ was also measured during aircraft events in the vicinity to assess their noise impact within the room. Noise levels were measured with windows closed and also windows 1/3 open. The results, shown in Table 4.3, demonstrate that the measured noise levels of a single aircraft event are comfortably compliant with the upper limit of 60 dB $L_{A1,30mins}$. It is noted however, that this criterion only applies for rooms with an IANL of 45 dB $L_{Aeq,30mins}$ or greater.

During the environmental noise survey, it was noted that variations in ambient noise level across the site were non-significant, so similar compliant internal ambient noise levels are expected in the Guard house and Band Practice Curtilage listed buildings.

However, it should be noted that, for the recording and control room spaces in the Guard House, internal ambient noise levels are recommended to be below 30 dBA $L_{Aeq,30min}$. Therefore, an upgrade of the window systems or enhanced acoustic absorption in these rooms is recommended to minimise the impact of external noise.

8.0 Internal partitions

The acoustics strategy drawings show the minimum airborne sound insulation requirements for all partitions and doors and are based on partitions being full height from structural floor to soffit with no penetrations for glazing or ventilation within the dividing element, except where stated.

A more detailed assessment should be carried out with design progression, with a view to determining any specific room adjacencies that require an increased acoustic partition rating (due to relative sizes of rooms / common area of dividing wall, etc).

8.1 Retained wall constructions

Most of the existing internal masonry wall constructions will be retained at both Kneller Hall and the Guard House. These partitions range in width from 200 to 300 mm and are currently lined with plasterboard.

As shown in Table 4.4, a 54 dB $D_{nT,w}$ was measured on-site as a representative airborne sound insulation performance for this type of partition. The measured performance demonstrates that the existing masonry partitions will meet the sound insulation requirements indicated in the acoustic strategy mark-up drawings.

It is understood that the masonry walls will be lined with a new plasterboard layer.

8.2 Proposed new lightweight wall constructions

It is understood that the existing stud walls will be either removed or replaced by new lightweight wall constructions. New partitions will also be erected in some area to create new rooms.

The following table summarises the proposed partition types and which in-situ ratings they are suitable for (the in-situ requirements are coloured as per the acoustics strategy drawings).

Ref	Laboratory rated performance (thickness)	Example construction	> 35 dB R_w	> 45 dB R_w	> 50 dB R_w	> 35 dB $D_{nT,w}$ [>40 dB R_w]	> 40 dB $D_{nT,w}$ [>45 dB R_w]	> 45 dB $D_{nT,w}$ [>50 dB R_w]	> 50 dB $D_{nT,w}$ [>55 dB R_w]	> 55 dB $D_{nT,w}$ [>60 dB R_w]
01	42 dB R_w [102 mm] Q606043	▪ 15 mm Duraline ▪ 70 mm C stud ▪ 15 mm Duraline	✓	×	×	✓	×	×	×	×
02	47 dB R_w [102 mm] Q606044	▪ 15 mm Duraline ▪ 70 mm C stud ▪ 25 mm APR 1200 ▪ 15 mm Duraline	✓	✓	×	✓	✓	×	×	×
03	50 dB R_w [102 mm] Q606A0465	▪ 15 mm Duraline ▪ 70 mm Acoustud ▪ 50 mm APR 1200 ▪ 15 mm Duraline	✓	✓	✓	✓	✓	✓	×	×
04	52 dB R_w [124 mm] Q6060575	▪ 15 mm Duraline ▪ 92 mm C stud ▪ 3x 25 mm APR 1200 ▪ 15 mm Duraline	✓	✓	✓	✓	✓	✓	×	×

Ref	Laboratory rated performance (thickness)	Example construction	> 35 dB R_w	> 45 dB R_w	> 50 dB R_w	> 35 dB $D_{nT,w}$ [>40 dB R_w]	> 40 dB $D_{nT,w}$ [>45 dB R_w]	> 45 dB $D_{nT,w}$ [>50 dB R_w]	> 50 dB $D_{nT,w}$ [>55 dB R_w]	> 55 dB $D_{nT,w}$ [>60 dB R_w]
05	62 dB R_w [147 mm] A316009	▪ 2 layers 15 mm SoundBloc ▪ RB1 resilient bar ▪ 70 mm C stud ▪ 50 mm APR 1200 ▪ 2 layers 12.5 mm SoundBloc	✓	✓	✓	✓	✓	✓	✓	✓
06	Estimated 52-54 dB R_w [200 mm]	▪ 15 mm Duraline ▪ Twin 70 mm I stud ▪ 50 mm APR 1200 ▪ 15 mm Duraline	✓	✓	✓	✓	✓	✓	×	×
07	Estimated 36 dB R_w [117 mm]	▪ 2 layers 12.5 mm Fireline ▪ 92 mm I stud ▪ 25 mm APR 1200 ▪ *Exposed*	Boxing of services only							
08	62 dB R_w [200 mm] A216009	▪ 2 layers 15 mm SoundBloc ▪ Twin 48 mm C stud ▪ 50 mm APR 1200 ▪ 2 layers 15 mm SoundBloc	✓	✓	✓	✓	✓	✓	✓	✓
09	Estimated 50 dB R_w [313 mm]	▪ 2 layers 15 mm SoundBloc ▪ 250 mm SFS ▪ 50 mm APR 1200 ▪ 15 mm Duraline ▪ 18 mm laminate face board	✓	✓	✓	✓	✓	✓	×	×
10	Estimated 53 dB R_w [mm]	▪ 15 mm Duraline ▪ 215 mm solid blockwork ▪ *Exposed*	✓	✓	✓	✓	✓	✓	×	×
11	Estimated 50 dB R_w [200 mm]	▪ 2 layers 15 mm Wallboard ▪ 146 mm C stud ▪ 50 mm APR 1200 ▪ 2 layers 15 mm Wallboard	✓	✓	✓	✓	✓	✓	×	×

Table 8.1 – Partition types

The laboratory ratings provided by manufacturers are the maximum sound reductions capable from those partitions, excluding flanking noise. In order for partitions to meet their acoustic ratings in-situ, manufacturers' instructions regarding detailing must be followed.

Additional care should be taken with partitions containing a resilient bar (i.e. Wall Type 05) to ensure that this is not compromised. Quality of installation will need to be high to ensure that the correct length screws are used and the resilient bar is not bridged. The images below illustrate situations where the incorrect screw length has been applied and the benefit of the resilient bar is therefore void, resulting in a partition that will not provide the expected acoustic performance:

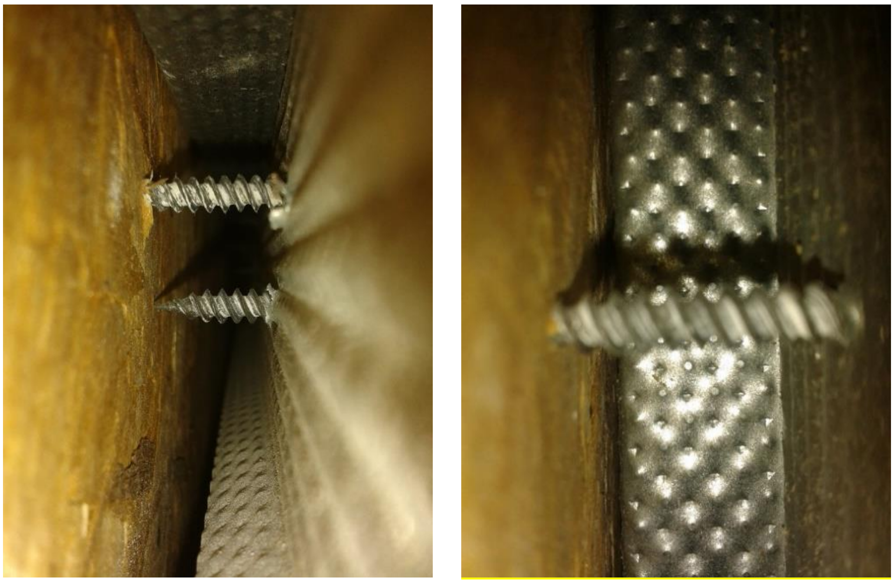


Figure 8.1 – Resilient bar compromised

8.3 General partition guidelines

In order to see that acoustic integrity and performance of partitions is maintained and controlled, the following guidance is recommended.

- Partitions should be full height, from the structural floor to soffit, and well-sealed.
- Suitable deflection head details will be necessary to see no loss of performance.
- Alternative board types could be substituted, acoustically, providing they equal or exceed the minimum mass per unit area (kg/m²) of those specified.
- Penetrations for services should be avoided where possible through partitions separating adjacent teaching / learning spaces. Where there is no alternative, suitable details will be needed to see acoustic performance is maintained. Good practice is for services to be routed through corridors wherever possible and enter each teaching space above the doors.
- Electrical sockets located in partitions having a sound insulation performance requirement of 40 dB $D_{nT,w}$ or greater should not be located back to back and should be pattressed or specified with appropriate proprietary socket box covers/infills. Hilti Putty Pads, Firefly Socket Box Covers, Knauf Putty Pads or similar would be considered suitable products.
- Where double layers of board are used, joints should be staggered. Facing boards should be well sealed with skim finish. Fixing straps should be applied to horizontal joints to the inner lining.
- Partitions surrounding plant rooms have been based on an assumed plant room reverberant noise level no greater than 80 dBA.
- It is strongly recommended that for partitions with an acoustic rating of 50 dB $D_{nT,w}$ or above, metal corner angles should be included in the head detail, e.g. as shown in Figure 8.2.

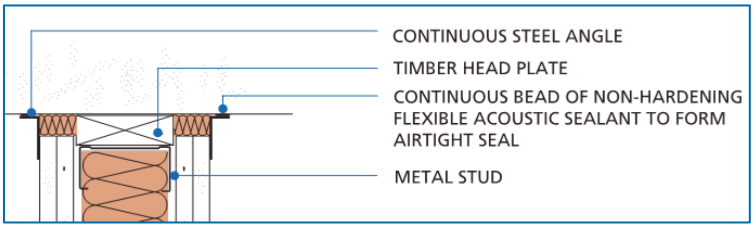


Figure 8.2 - Enhanced partition head junction detail

Based on extensive experience of pre-completion testing within school developments, there are a number of common issues that regularly result in partitions not achieving the required in-situ performance, including, but not limited to the following.

- **Services penetrations** – generally, for partitions up to 45 dB $D_{nT,w}$, suitable detailing around mechanical, electrical or hydraulic services penetrations, including suitable cross talk attenuation, can be provided such that the sound insulation of the partition is not adversely affected. For partitions with an acoustic rating of 50 dB $D_{nT,w}$ or above, mechanical or electrical services penetrations generally have an adverse impact on the partition's rating. Services should be routed to avoid these penetrations or will need to be suitably boxed out.
- **Unsealed gaps** – manufacturer's literature typically provides robust means of sealing partitions to the underside of profiled slabs / roof constructions. Most failed wall tests are attributable to poorly sealed head track details.
- **Flanking noise** – detailing around columns, external walls etc. are common reasons for flanking noise that can adversely affect the sound insulation of partitions.

8.4 Doorsets

The acoustics strategy drawings indicate the minimum recommended laboratory rated sound insulation for new doorsets throughout the school.

New acoustic doorsets should be of proprietary type, by a specialist manufacturer. The acoustic rating of the doorset should include the door, frame, seals, hinges, any furniture, and any required glazing or vision panels.

For other doorsets, i.e. dividing ancillary spaces to common circulation areas, there is no specific requirement for acoustic insulation. However, it is considered good practice that in particularly noise sensitive locations, such as private offices and meeting rooms, proprietary acoustic doorsets capable of achieving a minimum sound reduction of 30 dB R_w be specified. Where this is considered appropriate, it is marked on the acoustic strategy drawings.

Where possible, doors should be located as far apart as possible on either side of a dividing partition, to minimise the risk of flanking sound via the corridor.

It is noted that some existing doors will be retained due to their historic character. In this instance, the recommend sound insulation rating might not be achieved, however, it is not considered significantly detrimental to the overall sound insulation of spaces.

8.5 Music rooms

It is noted that due to the layout of the music teaching and practice spaces, doors are in close proximity to one another, therefore flanking noise is still likely to be an issue and may potentially limit the sound insulation performance achievable. It is recommended that the internal lining of corridor partitions be upgraded with an additional layer of 12.5 mm dense plasterboard to reduce this issue.

It is also recommended that the internal lining of the external wall be upgraded to two layers of plasterboard within music spaces, where necessary.

8.6 Vision panels within dividing partitions

8.6.1 Corridor walls

The acoustic rating of corridor partitions includes any glazed element. Depending on the area of glazing, its sound insulation performance could be relaxed slightly; however, every care must be taken such that the overall rating of the partition is not degraded. The following rule of thumb can be applied to set the minimum performance for glazing.

% of wall area that comprises glazing	Maximum reduction in glazing R_w permitted
< 10 %	-3 dB
10 – 20 %	-2 dB
20 – 45 %	-1 dB
Note: For example, if a corridor partition (7500 mm x 2700 mm) rated at 40 dB R_w includes a glazed vision panel (2200 mm x 1200 mm), i.e. ~13%, the sound reduction index of the glazing could be reduced by up to 2 dB, i.e. 38 dB R_w, with negligible impact on the overall sound insulation of the partition.	

Table 8.2 – Internal glazing to corridors - reductions in sound insulation performance permitted

8.6.2 Control room at Guard House

At the time of writing, it has been not confirmed whether the first floor Control Room requires visual communication only, or visual and audio communication to the recording room

BB93 states that '*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. 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.*'

9.0 Floors

The same principles apply to the airborne sound insulation of floors as to partitions. However, floors generally contain significant mass for structural purposes and their acoustic performance is generally sufficient to meet the typical requirements without further treatment.

However, based on the findings of the sound insulation test undertaken on site, the airborne and impact sound performance of the Guard House first floor construction do not currently with the minimum BB93 sound insulation requirements.

Construction element	Description	$D_{nT,w}$ Airborne sound insulation performance		$L'_{nT,w}$ Impact sound insulation performance	
		Measured (dB)	Criterion (dB)	Measured (dB)	Criterion (dB)
Kneller Hall - Floor 1	Construction unknown	58	≥ 45	46	≤ 60
Guard House - Floor 1	Construction unknown	40	≥ 50	71	≤ 60
Guard House - Floor 1 + thin carpet	Construction unknown.	40	≥ 50	66	≤ 60

Figure 9.1 - Sound insulation performance of existing floors

It is acknowledged that construction upgrade proposals in listed buildings may be limited due to conservation and structural constraints. Therefore, as described in Approved Document E, the aim should be to improve sound insulation to the extent that it is practically possible, provided that the work does not prejudice the character of the historic building or increase the risk of long-term deterioration to the building fabric or fittings.

9.1.1 Acoustic upgrade of Guard's House floor construction

At the time of preparation of this report, the existing first floor build-up of the Guard House is unknown. However, based on the sound insulation test results and observations on site, a timber joist system with plasterboard ceiling directly fixed to the underside of joists and floorboards with carpet tiles is assumed.

Two options of floor acoustic upgrades are recommended:

- Option 1 (if the existing ceiling is to be retained):
  – The installation of an independent ceiling separated at least 150 mm from the original ceiling should be installed with 50 mm mineral wool infill and two layers of 12.5 mm high density plasterboard (note, absorptive finishes will also be required. Refer to Section 11.0 below)
  – 10-15 mm plywood/chipboard layer should be fixed to the existing floorboards
  – 5 mm 7210C Regupol or similar resilient layer should be glued on top of the plywood / chipboard
  – carpet or vinyl adhesively installed on top fo the resilient layer.
  – Use isolation strips on the perimeter of the floor
- Option 2 (if the existing ceiling can be removed):
  – a new ceiling suspended at least 200 mm from the underside of the joists by means of resilient hangers is recommended.
  – 100 mm mineral wool infill should be installed in the ceiling void and two layers of 15 mm high density plasterboard used as the main ceiling soffit (note, absorptive finishes will also be required. Refer to Section 11.0 below)
  – 15 mm plywood/chipboard layer should be fixed to the existing floorboards
  – 5 mm 7210C Regupol or similar resilient layer should be glued on top of the plywood / chipboard

– carpet or vinyl adhesively installed on top of the resilient layer.

– Use isolation strips on the perimeter of the floor

9.1.2 Acoustic upgrade of Kneller Hall floor construction

Based on the sound insulation tests undertaken on site, the current construction of the floors at Kneller Hall would not require further improvement to achieve airborne and impact sound requirements.

10.0 Other details

10.1 Services penetrations

Wherever possible, services (mechanical, electrical, hydraulic) should not pass through partitions dividing adjacent teaching spaces but be routed via an adjoining corridor or non-teaching space.

Where there is no other option but to pass services through sound-resisting partitions, care must be taken to see that the acoustic integrity of the partition is not compromised. *Appendix C – Services penetrations* gives suggested detailing options for each partition type.

10.1.1 Radiator pipework

It is permissible to pass radiator pipework through partitions separating adjacent general classbases.

All pipework penetrations must be acoustically sealed. Penetrations should be no greater than 10 mm larger than required for the pipework, and sealed with a flexible, non-setting acoustic sealant such as mastic. Where larger penetrations occur, they must be reduced to within 10 mm of the pipe using materials of equivalent acoustic performance of the floor, ceiling or wall penetrated, prior to sealing.

10.2 Services / SVP

Any pipework (including SVPs) passing through teaching spaces, or resulting in openings in partitions, should be acoustically sealed. Guidance within Approved Document E states that:

"Pipes and ducts…should be enclosed for their full height. The enclosure should be constructed of material having a mass per unit area of at least 15 kg/m^2. Either line the enclosure, or wrap the duct or pipe within the enclosure, with 25 mm unfaced mineral wool."

Boxing out of services could therefore be achieved with 2 layers of 12.5 mm Wallboard (or alternative boards equivalent or denser). Any boarding option will require 25 mm unfaced mineral wool insulation within. Any access doors or hatches to risers within teaching spaces should provide the same level of acoustic performance and be well sealed when closed.

Boarding should be full height, taken from structural floor up to the soffit, and sealed at top and bottom using a bead of non-hardening sealant.

Doors to service risers that pass through sensitive spaces should have an acoustic rating of at least 30 dB R_w and be well sealed when closed.

Sprinkler pipework should not pass between acoustically adjacent spaces, instead being routed via corridors, entering noise-sensitive spaces (teaching spaces and office type accommodation) over access doors.

10.3 Isolation of steelwork

Steelwork is a very effective medium through which sound can readily travel. It is therefore imperative that rooms that are particularly sensitive to noise, or rooms where high noise levels are likely to be generated, should have their steelwork boxed in completely. For rooms that are less noise-sensitive or less likely to generate as much activity noise, the level of protection to steelwork can be reduced.

The transmission of sound via structural elements between adjacent spaces is only an issue where two adjacent spaces share a common steel member (e.g. where a beam or column is located above/within a partition, or where steel members pass through dividing partitions, i.e. purlins passing above ceilings).

10.3.1 Steelwork passing across partitions rated at ≥ 50 dB $D_{nT,w}$

For noise sensitive rooms (where surrounding partitions include a rating of 50 dB $D_{nT,w}$ or greater), it will be necessary to box the steelwork out completely (even where located above ceilings). This includes steelwork located at the head of a partition or within the noise sensitive/high activity noise space.

The suggested means of boxing out would include using Glasroc F Firecase. The following detail is recommended as a minimum:

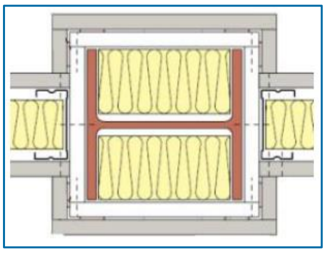


Figure 10.1 – Suggested boxing out detail where steelwork is located within a very noise sensitive space, or where high activity noise levels are anticipated

If the steelwork is located above the ceiling line, the outer layer of plasterboard could be removed i.e. the steel only boxed in using the Glasroc F Firecase.

The following detail (below) shows the likely detail where partitions are taken to the underside of steelwork (i.e. above the ceiling line):

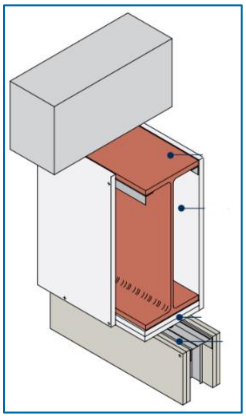


Figure 10.2 – Suggested boxing out detail where steelwork is located at the head of partition, above the ceiling line

11.0 Reverberation control

11.1 Reverberation control in teaching, learning, study and ancillary spaces

The acoustic strategy drawings that accompany this report show the target reverberation time criterion for each space (teaching and ancillary).

Provision of suitable reverberation times enables clear communication of speech between teacher and student, and between students in teaching and study spaces.

The reverberation time (RT) in a relatively reverberate room can be expressed in terms of the room constant or total room absorption *'R'*. This descriptor is a function of the surface area (m^2) of the room and the sound absorption property 'α' (values from 0.0 to 1.0) of the surface finishes:

$$R = \sum (\text{Surface area} * \text{Absorption coefficient } \alpha)$$

The same required room constant R can be achieved with different combinations of absorption class and surface areas (e.g. highly sound absorptive material on small areas or low absorption coefficient materials over large areas).

It should be noted that an even distribution of the sound absorptive material inside the room is essential for a homogenic reverberation time.

Calculations of required acoustic treatment in each room of the listed buildings have been undertaken. The input for these calculations have been based on the proposed floor finishes shown in the project interior design drawings:

- LXA-1629-SH-121
- LXA-1629-SH-120
- LXA-1629-KH-123
- LXA-1629-KH-122
- LXA-1629-KH-121
- LXA-1629-KH-120
- LXA-1629-GH-121
- LXA-1629-GH-120

Primary surface finishes of walls and ceiling partitions in all rooms will entail either a plasterboard lining on existing brickwork, plasterboard on stud walls or, plasterboard with a certain ceiling void behind in the case of ceilings.

The results of the calculations, shown in *Appendix D – Recommended absorption areas*, provide the area (walls and/or ceiling) to be covered according to the type of acoustic absorption class selected (Class A, B or C).

It is understood that the use of wall acoustic treatment is the preferable option over ceiling acoustic finishes. Although this can be implemented in most of the rooms, some spaces will require from the installation of suspended/fixed acoustic ceiling panels, or baffles to achieve the required reverberation time.

Ceiling acoustic panels or baffles are lightweight materials that can be easily installed from the new plasterboard ceilings without intrusive works made in the structural elements. In the same way, wall panels are generally installed with a clipping system fixed to the plasterboard lining.

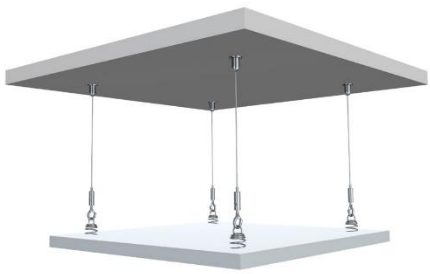


Figure 11.1 - suspended baffle (left) and panel (center) from plasterboard ceiling. Ceiling panel clipped / glued to the soffit (right)

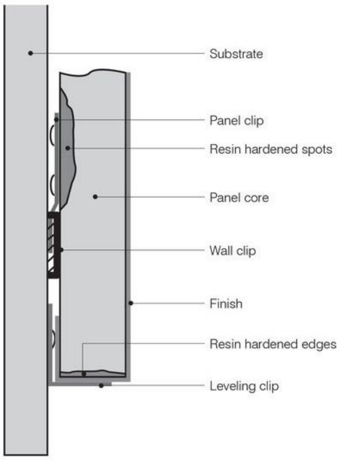


Figure 11.2 - Detail of a wall panel clipping system

The wide range of colours and on-panel printing options in the market will allow for suitable aesthetics according to the main interior design of the room.

Soft furniture such as upholstered seats in the Auditorium and Library will contribute to reduce the reverberation time in those spaces.

11.2 Sound absorption in corridors and entrance halls

Absorption should be provided within corridors and entrance halls, so that unwanted sound is absorbed and does not interfere with teaching areas. Section 7 of the Approved Document E provides a method for calculating the amount of absorptive material required to comply.

The recommended minimum absorptive finishes for entrance halls, corridors and hallways, are for an area equal to or greater than the floor area to be covered in a Class C absorber (as defined in BS EN ISO 11654: 1997), or better.

If corridors are to have an open-cell ceiling where they are used as ventilation voids, this will entail that an acoustic ceiling finish cannot be incorporated. In such case, it is proposed that a continuous 600 mm high band of Class A acoustic wall panels are provided to both sides of the corridor. This strategy will provide an equivalent absorption to a Class C ceiling.

Where teaching/study spaces are accessed directly off the stairwells, provision of absorptive treatment is required within these areas. For other stairwells and corridors with no direct access to teaching/study spaces, although not mandatory, it is considered prudent to provide absorption (spread evenly over all levels) to control the reverberation and thus provide a more comfortable acoustic environment.

11.3 Sound absorption in recording and control room at Guard's House

Reverberation time calculations have shown that the recording studio would not require from additional acoustic treatment to comply with the maximum RT recommended by BB93. However, this spaces are generally acoustically treated to control other acoustical factors rather than RT that could affect musical recordings. Therefore, a specific design would need to be discussed and agreed according to the client's specifications and building constraints.

It is envisaged that other acoustic treatment different from those described in section 11.1 would not be required.

11.4 Sound absorption in the auditorium at the Band Practice Hall

The auditorium of the Band Practice Hall presents a more complex room acoustics design. Therefore, proprietary software Odeon v.17.1 was used to model the noise propagation and distribution inside the room.

Surface finishes shown in 11.1 have been used in the model. These are based on the interior design floor finishes, architectural drawings and discussions with the architect and interior design team.

Areas	Description
Floor	▪ Parquet
Walls	▪ Plaster on brickwork ▪ Window glass
Ceiling	▪ Painted plasterboard
Others	▪ Aluminium ventilation ductwork ▪ Upholstered seats ▪ Wooden hollow stage

Table 11.1 - surface finishes used in the room acoustic model for the auditorium

The aim of the room acoustics simulations was to obtain the sound absorption class and area required with a view to achieving minimum suitable acoustic conditions for speech and/or music activities.

The results of the simulations have allowed for the following proposals of acoustic treatment:

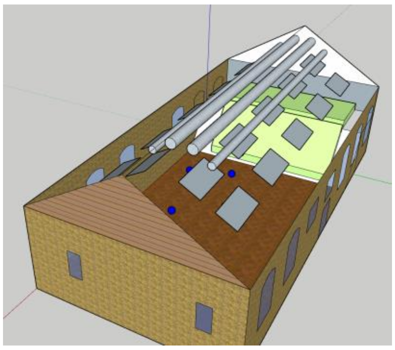
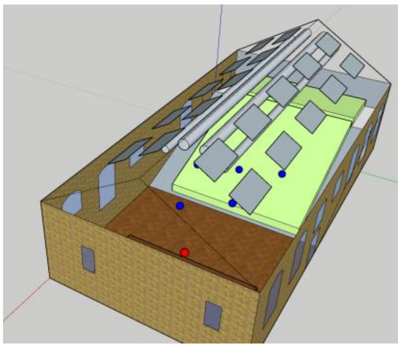
Option 1	Option 2	Option 3
All ceiling soffit sprayed with 10 mm acoustic spray (Sonaspray fcx or similar) Smooth or rough finish Predicted reverberation time with seats platform extended: 0.8 second.	Acoustic panels Class A suspended below the ventilation ducts, parallel to each side of the pitched roof. Minimum total area recommended: 57.6 m^2 Panels can be designed with different shapes and colours. Predicted reverberation time seats platform extended: 1 second.	Acoustic panels Class A suspended or fixed to the ceiling behind ductwork and parallel to each side of the pitched roof. Minimum total area recommended: 57.6 m^2 Panels can be designed with different shapes and colours. Predicted reverberation time seats platform extended: 1.2 second.
		

Table 11.2 - Recommended minimum acoustic absorption treatment for the auditorium

12.0 Conclusion

The main target of this acoustic report is to provide clear and relevant information, assessments, and recommendations of acoustic upgrades, in compliance with national, local and heritage protection regulations, for the proposed 'change of use' the existing Kneller Hall development into a senior school. The development will also entail the construction of new teaching, auxiliary buildings and outdoor sports facilities.

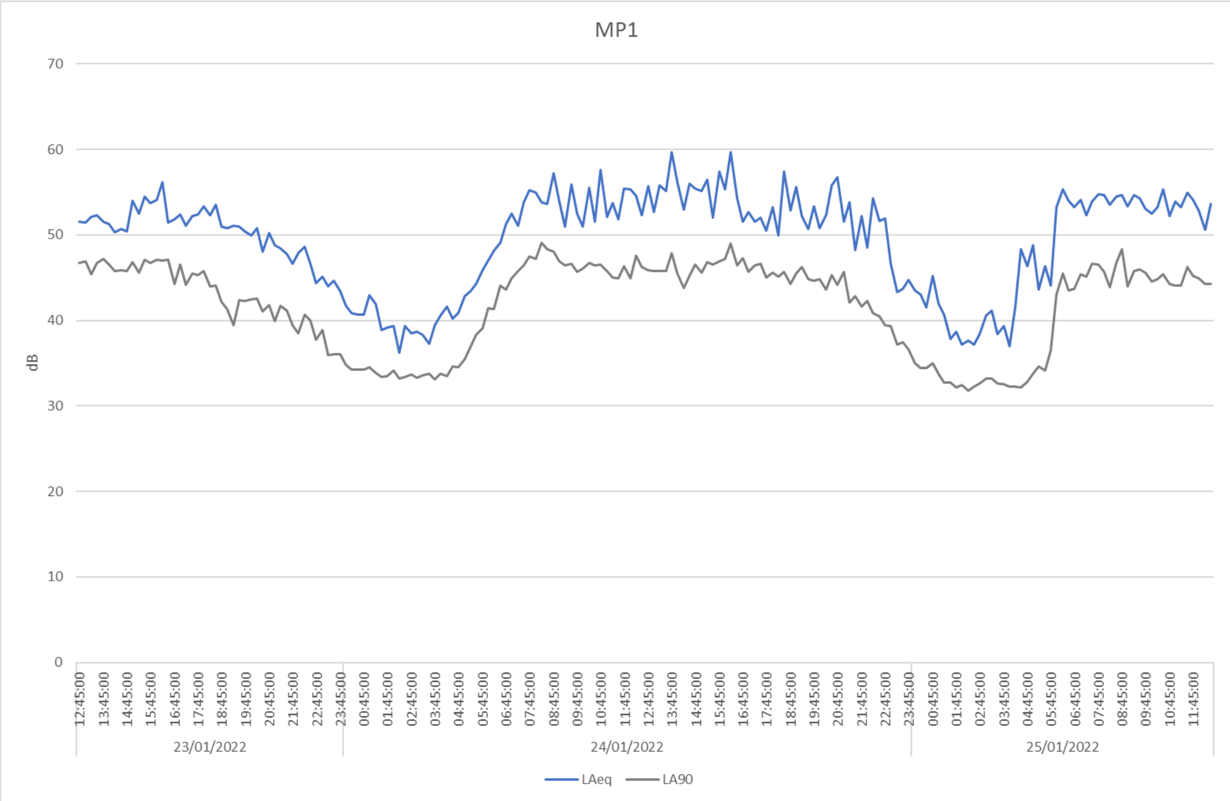
The report has focused on three main items relevant for planning purposes:

- Noise impact assessment and recommendations for proposed new outdoor noise generating plant units
- Noise impact assessment for proposed new outdoor sports fields and playgrounds
- Acoustic upgrade recommendations of the existing Listed Buildings for compliance with Building Regulations whilst preserving the character of their historic heritage

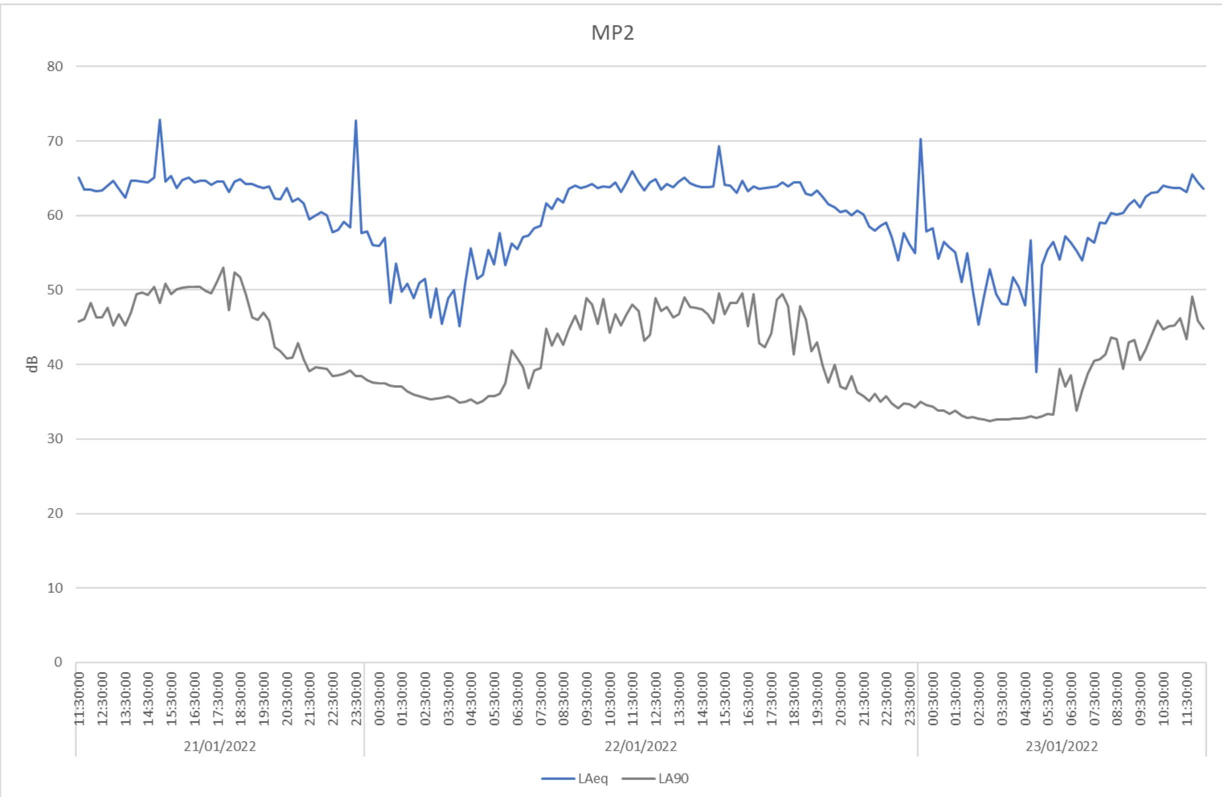
The results of the noise propagation models for outdoor noise generating plant units and activities in the sports fields have shown that, provided the noise control measures described in section 5.4 and 6.2 are applied, the surrounding residential areas will be protected from noise generated by the proposed school development.

In regard to the hereby proposed sound insulation strategy and architectural acoustic upgrades, It is believed these represents the best practical means to achieved Building Regulation standards for schools considering the project heritage constraints.

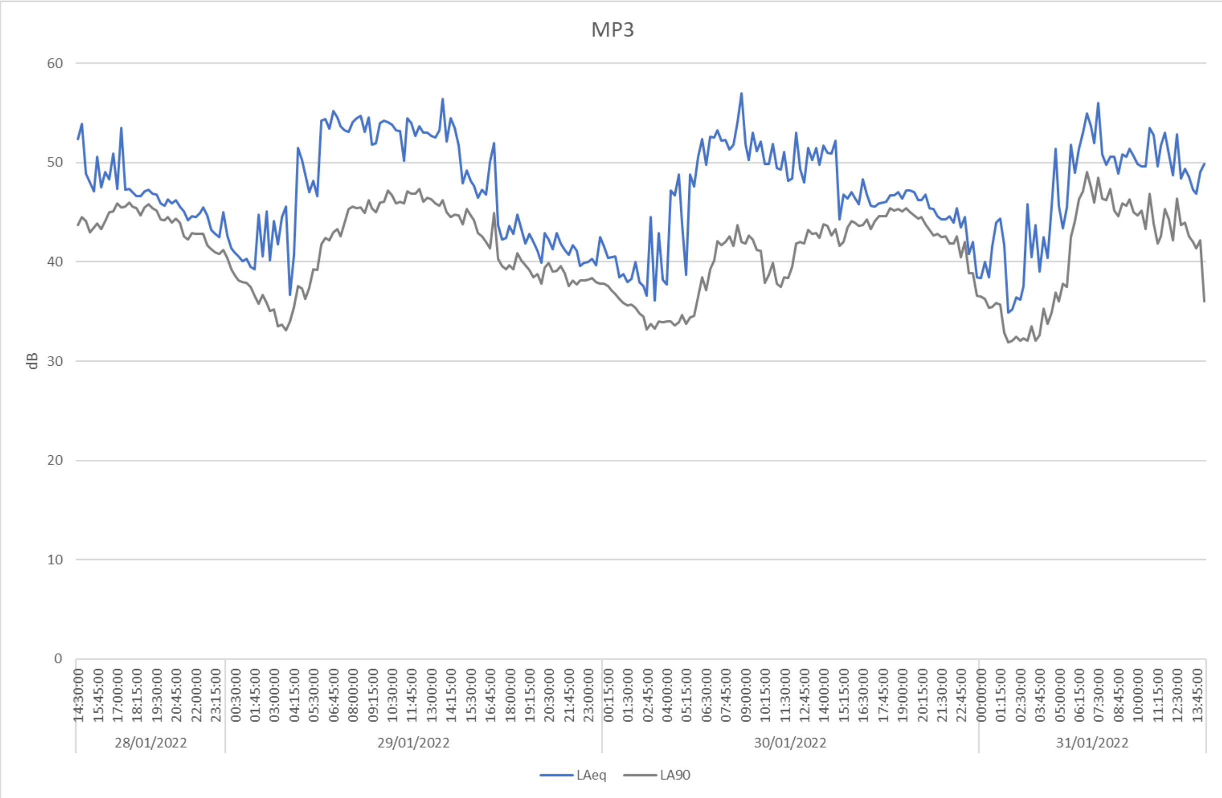
Appendix A – Environmental noise time history



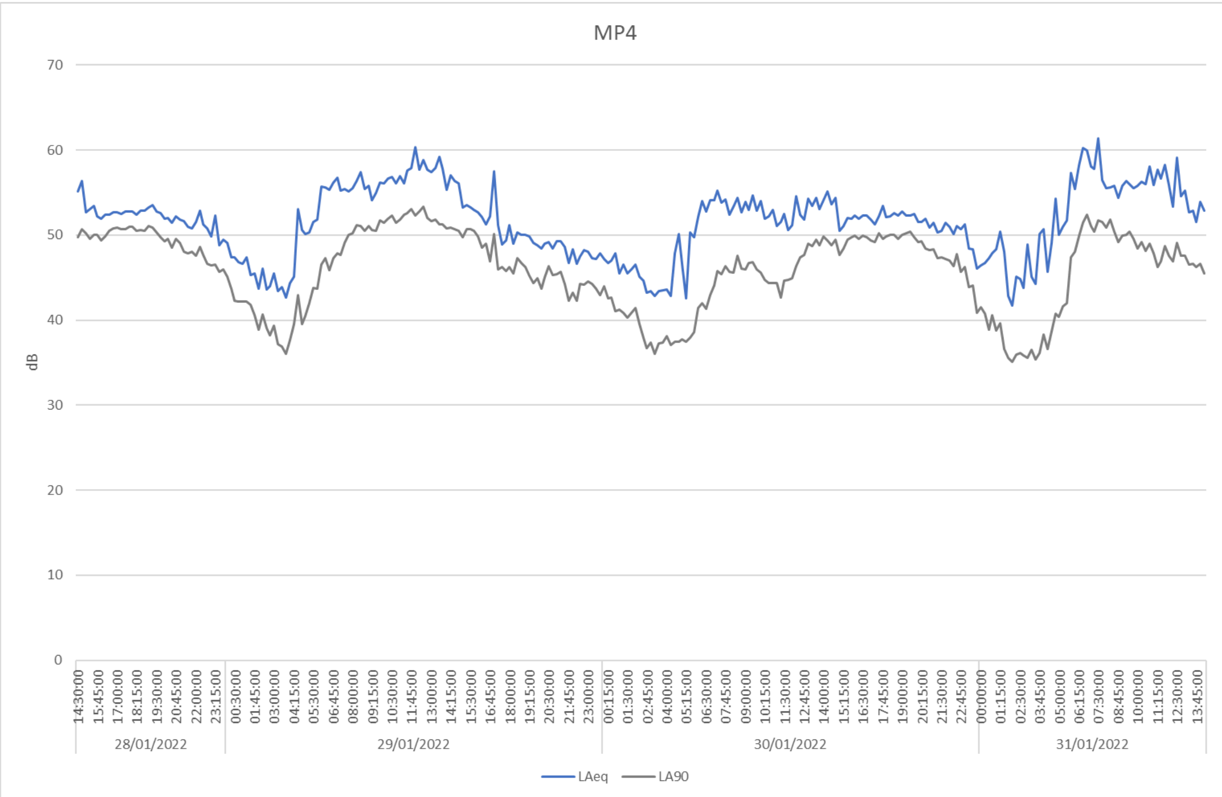
Appendix A0.1 - Time history graph of ambient and background sound levels at MP1



Appendix A0.2 - Time history graph of ambient and background sound levels at MP2



Appendix A0.3 - Time history graph of ambient and background sound levels at MP3



Appendix A0.4 - Time history graph of ambient and background sound levels at MP4

Appendix B – Spectral noise levels of proposed plant units

Plant ref	Manufacturer	Location	Noise emision descriptor	Unit part	Comment	Overall (dBA)	Sound Level (dB) in each octave frequency band 63	125	250	500	1000	2000	4000	8000
ASHP 01-03	Daikin	Energy centre	Lp	Overall unit	-	65	73	64	63	60	60	58	54	54
			Lw	Overall unit	Derived from Lp as in line with Daikin Technical datasheet	85	93	84	83	80	80	78	74	74
AHU 50	VES	Sports Hall	Lw	Intake (Fresh air)	-	84	77	85	85	81	80	75	71	72
				Exhaust	-	84	76	87	84	81	79	75	71	72
				Breakout	Total Lw - case inertion loss	63	67	72	70	49	44	39	36	37
AHU 51	VES	Pool Hall	Lw	Intake (Fresh air)	-	83	75	85	79	81	77	74	71	67
				Exhaust	-	82	75	85	79	80	77	74	70	67
				Breakout	Total Lw - case inertion loss	58	65	68	64	49	41	38	36	32
AHU 52	VES	Changing area	Lw	Intake (Fresh air)	-	84	80	85	81	82	79	76	73	69
				Exhaust	-	84	80	85	80	82	78	76	73	69
				Breakout	Total Lw - case inertion loss	60	70	71	66	50	43	40	38	34
AHU 01	VES	Teaching Block	Lw	Intake (Fresh air)	-	83	79	83	80	81	77	74	70	68
				Exhaust	-	87	75	83	87	85	82	76	75	73
				Breakout	Total Lw - case inertion loss	62	67	69	70	51	44	39	38	36
AHU 02	VES	Practice Hall	Lw	Intake (Fresh air)	-	86	81	86	82	83	80	78	75	71
				Exhaust	-	90	84	87	87	86	84	84	80	80
				Breakout	Total Lw - case inertion loss	63	73	73	70	53	46	46	43	43
SF 01	VES	Teaching Block	Lw	Supply Fan	-	80	73	83	77	78	75	72	69	65
				Breakout	Total Lw - case inertion loss	54	60	66	59	43	36	33	31	27
EF 01	VES	Teaching Block	Lw	Fan	-	89	81	85	89	88	84	80	76	71
MVHR 01	VES	Teaching Block	Lw	Intake (Fresh air)	-	74	74	81	72	70	69	66	59	54
				Exhaust	-	74	74	81	72	70	69	66	59	54
				Breakout	Total Lw - case inertion loss	53	64	67	57	38	33	30	24	19
MVHR 02	VES	Teaching Block	Lw	Intake (Fresh air)	-	79	69	81	78	76	74	70	66	63
				Exhaust	-	79	69	81	78	76	74	70	66	63
				Breakout	Total Lw - case inertion loss	56	59	67	63	45	38	34	31	28
MVHR 03	VES	Teaching Block	Lw	Intake (Fresh air)	-	74	62	75	67	68	70	67	63	59
				Exhaust	-	74	62	75	67	68	70	67	63	59
				Breakout	Total Lw - case inertion loss	47	51	59	53	37	34	32	28	24
HP 01-02	Daikin	Sports Hall	Lp	Overall unit	-	79	65	69	74	79	74	71	59	56
			Lw	Overall unit	Derived from Lp as in line with Daikin Technical datasheet	89	75	79	84	89	84	81	69	66
CU.TB.01-02	Mitsubishi	Teaching Block	Lw	Overall Unit	-	73	60	55	64	62	67	68	66	57
CU.TB.03-04	Mitsubishi	Teaching Block	Lw	Overall Unit	-	63	67	68	65	61	58	52	45	38

Appendix C – Services penetrations

The following details assume that the size of penetration is only slightly larger than the service passing through the partition. In the case where larger holes have been made to allow services to pass, they will require additional treatments.

Partition Type:	R_w 40 / 45 dB or $D_{nT,w}$ 35 dB	$D_{nT,w}$ 40 dB	$D_{nT,w}$ 45 dB	$D_{nT,w}$ 50 dB	$D_{nT,w}$ 55 dB
Mechanical Services	See Table below				
Single metal/plastic pipe 15 – 110 mm		A	A	A1	A1*
Ventilation ducting – circular/rectangular		B	B	C	C*
Tray with refrigerant lines and cables		D	D	E	E*
Electrical Services					
Conduit		A	A	A	A*
Single cable (fire alarm)		A	A	A	A*
Tray/basket with cables 50 – 300 mm		D	D	E	E*
Trunking with lid and cables 50 – 100 mm		D	D	E	E*
Dado trunking		D	D	E	E*

Detail #A

- Penetration should be packed with mineral wool and well-sealed with non-hardening mastic

Detail #A1

- Penetration should be packed with mineral wool and well-sealed with non-hardening mastic
- For shared radiator piping, there should be an acoustic break, e.g. a section of flexible piping, a change in medium such as a small section of plastic pipework, or a rubber grommet

Detail #B

- Penetration should be packed with mineral wool and well-sealed with non-hardening mastic
- Crosstalk attenuator should be fitted where a common duct serves vents in multiple rooms

Detail #C

- Penetration should be packed with mineral wool and well-sealed with non-hardening mastic
- Crosstalk attenuator should be fitted across partition

Detail #D

- Penetration should be packed with mineral wool and well-sealed with non-hardening mastic
- Tray/trunking/basket can pass through partition

Detail #E

- Tray/trunking/basket should be cut either side of partition with no hard contact through penetration.
- Services should be passed via a sleeve through penetration
- Sleeve/partition junction should be well sealed with non-hardening mastic
- Any internal void within the sleeve should be filled with mineral wool

✸ Services passing through this partition type should be avoided where possible

Where pipework services are to be passed through partitions in sleeves, it is recommended that sleeves should be chosen so that pipework fits snugly once installed. Larger diameter sleeves will need to be densely packed with mineral wool once the pipe has been passed through.

Should a penetration be significantly larger than the services passing through the partition (for example, where whole blocks have been removed), additional treatments will be necessary.

Partitions with an R_w rating (principally to corridors) are not required to have their performance tested on site; however it is considered that service penetrations through such partitions should be sealed as followed in order to maintain acoustic integrity:

<table>
<tr><th>Room 1</th><th>Room 2</th><th>Treatment to R_w rated partitions</th></tr>
<tr><td>Classroom</td><td>Classroom</td><td rowspan="2">2x 50 mm mineral fibre batt, sealed with non-hardening mastic</td></tr>
<tr><td>Classroom</td><td>WC</td></tr>
<tr><td>Classroom</td><td>Corridor</td><td rowspan="4">1x 50 mm mineral fibre batt, sealed with non-hardening mastic</td></tr>
<tr><td>Office</td><td>Corridor</td></tr>
<tr><td>Office</td><td>WC</td></tr>
<tr><td>WC</td><td>WC</td></tr>
<tr><td>WC</td><td>Corridor</td><td>No acoustic requirement</td></tr>
</table>

Appendix D – Recommended absorption areas

Predicted reverberation times shown below are before any acoustic treatment is applied.

Rooms highlighted in red will required the surface area to be covered by the according acoustic absorption Class (option 1, 2 and 3) to not exceed the RT Target.

Guard's House Rooms	Volume	Predicted RT (s)	Target (s) RT	Option 1: Class A Absorption		Option 2: Class B Absorption		Option 3: Class C Absorption	
				m2	% floor area	m2	% floor area	m2	% floor area
Guards House - Music Classroom	196	0.9	1.0	2.3	3%	2.6	3%	3.4	4%
Guards House - Recording Studio	27	0.8	0.8	0.1	1%	0.1	1%	0.1	1%
Guards House - Control Room	36	0.8	0.6	3.4	24%	3.9	27%	5.1	36%
Guards House - Music Practice Room 6	27	0.8	0.8	0.2	2%	0.2	2%	0.2	2%
Guards House - Music Practice Room 5	38	0.8	0.8	0.6	4%	0.7	5%	1.0	6%
Guards House - Music Practice Room 4	27	0.8	0.8	0.2	1%	0.2	2%	0.2	2%
Guards House - Music Practice Room 3	22	0.7	0.8	-0.1	-2%	-0.2	-2%	-0.2	-2%
Guards House - Music Practice Room 2	28	0.8	0.8	0.5	4%	0.5	5%	0.7	6%
Guards House - Music Practice Room 1	20	0.8	0.8	0.4	6%	0.5	7%	0.6	9%
Guards House - Music & Creative Tech Classroom	122	1.1	1.0	3.1	8%	3.5	9%	4.7	12%
Guards House - Staff Office	45	2.0	1.2	3.3	22%	3.7	25%	4.9	33%
Guards House - Music Classroom	107	1.0	1.0	2.8	8%	3.2	9%	4.3	12%
Guards House - Sick Bay	22	1.6	1.2	1.1	15%	1.2	17%	1.6	22%
Guards House - School Nurse	44	2.1	1.2	3.3	23%	3.8	26%	5.0	35%
Guards House - Security Office	60	2.2	1.2	4.8	25%	5.4	28%	7.2	37%
Guards House - Security Mess Office	34	1.9	1.2	2.2	20%	2.5	23%	3.3	30%

Kneller Hall Rooms	Volume	Predicted RT (s)	Target (s) RT	Option 1: Class A Absorption		Option 2: Class B Absorption		Option 3: Class C Absorption	
				m2	% floor area	m2	% floor area	m2	% floor area
Kneller Hall - G01 - Library large area	518	1.2	1.2	10.8	7%	12.2	8%	16.3	11%
Kneller Hall - G01 - Library small study area	139	1.1	1.0	5.5	14%	6.2	16%	8.2	21%
Kneller Hall - G02 - Form Classroom	187	1.2	1.0	10.0	20%	11.3	23%	15.1	31%
Kneller Hall - G03 - Librarian Office	49	1.0	1.0	1.1	8%	1.2	9%	1.6	12%
Kneller Hall - G04 - Form Classroom	161	1.2	1.0	8.6	20%	9.7	23%	12.9	31%
Kneller Hall - G06 - Form Classroom	158	1.2	1.0	9.0	22%	10.1	24%	13.5	33%
Kneller Hall - G10 - General Classroom	484	1.7	1.0	46.3	49%	52.1	55%	69.5	74%
Kneller Hall - G11 - General Classroom	187	1.3	1.0	10.1	22%	11.4	24%	15.1	32%
Kneller Hall - G12 - Cafe	233	2.9	1.5	17.1	29%	19.2	33%	25.7	44%
Kneller Hall - G13 - Meeting Room	120	2.0	0.8	20.4	68%	23.0	76%	30.6	102%
Kneller Hall - G14 - Hall	277	2.5	2.0	10.0	14%	11.3	16%	15.1	22%
Kneller Hall - G15 - Headteacher	146	2.3	0.8	25.8	70%	29.0	79%	38.6	106%
Kneller Hall - G16 - Staff Office	175	1.3	1.2	4.2	10%	4.7	11%	6.3	14%
Kneller Hall - G17 - Video conferencing	12	0.7	0.8	-0.2	-7%	-0.2	-8%	-0.3	-10%
Kneller Hall - G18 - Lecture Space	496	3.7	1.0	75.3	76%	84.7	85%	113.0	114%
Kneller Hall - F01 - Form Seminar Room	61	1.0	1.0	1.1	6%	1.2	7%	1.6	9%
Kneller Hall - F02 - Form Classroom	45	0.8	1.0	-1.4	-7%	-1.6	-8%	-2.1	-11%
Kneller Hall - F03 - Form Classroom	67	0.8	1.0	-1.6	-6%	-1.8	-6%	-2.3	-8%
Kneller Hall - F04 - Form Classroom	77	0.8	1.0	-1.3	-4%	-1.5	-5%	-2.0	-6%
Kneller Hall - F06 - General Classroom	330	1.3	1.0	20.9	25%	23.5	29%	31.4	38%
Kneller Hall - F07 - General Classroom	250	1.3	1.0	16.3	26%	18.4	29%	24.5	39%
Kneller Hall - F08 - Form Classroom	173	1.2	1.0	9.8	23%	11.1	26%	14.7	34%
Kneller Hall - F09 - Seminar/Learning	120	1.2	1.0	6.6	22%	7.4	25%	9.9	33%
Kneller Hall - F10 - Staff Office	154	1.3	1.2	4.2	11%	4.7	12%	6.2	16%
Kneller Hall - F11 - Staff Work Room	187	1.3	1.2	4.9	10%	5.5	12%	7.3	16%
Kneller Hall - F12 - Art Classroom	369	3.1	1.0	52.3	50%	58.8	56%	78.4	74%
Kneller Hall - G19 - Video conferencing copy	12	0.7	0.8	-0.2	-8%	-0.3	-9%	-0.4	-12%
Kneller Hall - M01 - From Classroom	62	0.8	1.0	-0.8	-3%	-0.9	-3%	-1.2	-5%
Kneller Hall - M02 - From Classroom	65	0.8	1.0	-0.7	-3%	-0.8	-3%	-1.1	-4%
Kneller Hall - M03 - From Classroom	69	0.8	1.0	-1.0	-4%	-1.1	-4%	-1.5	-5%
Kneller Hall - M04 - From Classroom	67	0.8	1.0	-0.9	-3%	-1.0	-4%	-1.3	-5%
Kneller Hall - S01 - Form Study	56	0.8	1.0	-0.9	-4%	-1.0	-4%	-1.3	-6%
Kneller Hall - S02 - Form Common Room	173	1.0	1.0	5.3	8%	5.9	9%	7.9	11%
Kneller Hall - S03 - Form Study room	74	0.9	1.0	-0.8	-3%	-0.9	-3%	-1.2	-4%
Kneller Hall - S06 - Art Classroom	242	2.5	1.0	30.8	32%	34.7	36%	46.2	48%
Kneller Hall - S07 - General Classroom	146	1.0	1.0	4.5	10%	5.0	11%	6.7	15%
Kneller Hall - S08 - General Classroom	218	1.2	1.0	11.4	18%	12.9	21%	17.1	27%
Kneller Hall - S09 - Pupil/Learning support	60	0.9	1.0	0.0	0%	0.0	0%	0.0	0%
Kneller Hall - S10 - General Classroom	119	1.1	1.0	4.3	12%	4.8	13%	6.4	18%
Kneller Hall - S11 - General Classroom	162	1.2	1.0	7.8	18%	8.8	20%	11.7	27%
Kneller Hall - S12 - Art Classroom	369	3.0	1.0	52.2	50%	58.7	56%	78.3	74%

School Hall Rooms	Volume	Predicted RT (s)	Target (s) RT	Option 1: Class A Absorption		Option 2: Class B Absorption		Option 3: Class C Absorption	
				m2	% floor area	m2	% floor area	m2	% floor area
Breakout space/Foyer	172.6	0.81	1.2	-21.0	-35%	-23.6	-40%	-31.4	-53%
Dressing Room 1	26.1	0.57	1.5	-6.4	-71%	-7.2	-80%	-9.6	-106%
Dressing Room 2	26.1	0.76	1.5	-4.9	-55%	-5.5	-61%	-7.4	-82%
Auditorium	-	depending on optio	0.8-1.5	See section 11.4					

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