ENVIRONMENTAL NOISE AND IMPACT ASSESSMENT

77 Avenue Road

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EXECUTIVE SUMMARY

An assessment has been undertaken to assess the potential noise impact of existing environmental noise sources on the proposed new dwelling at 77 Avenue Road, St John's Wood, NW8 6JD. The results of an environmental noise survey have been used to provide outline acoustic specifications for the building envelope, including glazing and ventilation, that is capable of providing internal noise levels that meet the requirements in the Camden Local Plan and, where appropriate, guidance in BS 8233: 2014 'Guidance on sound insulation and noise reduction for buildings'.

In addition, plant noise limits have been proposed such that any new plant at the premises will meet the Local Authority's requirements.

ENVIRONMENTAL NOISE ASSESSMENT

Based upon the findings of on-site noise levels, exterior design noise levels have been determined for the various occupied spaces within the new house.

Accounting for the effects of both open and closed windows, internal sound levels have been calculated. Generally, internal noise levels with open windows meet the "amber" category (or better) in the Camden Local Plan. However, internal noise levels in bedrooms on the front (Avenue Road) façade are within the "red" category. For these bedrooms, closed windows with trickle vents should be considered for primary ventilation purposes.

The results of the noise survey show that typical thermal double-glazed windows with non-acoustic trickle ventilators will result in internal noise levels in front bedrooms that are, at worst, in the Camden "amber" category.

Using the same glazing and ventilation would result in all other bedrooms having internal noise levels in the "green" category.

Any manufacturer of glazing could be specified provided that they have tested their products to ascertain whether they achieve the above targets, final choice should be made based on incorporation of all environmental and aesthetic factors. The assessment has indicated that with the appropriate mitigation in the form of the specified glazing, internal noise levels within the proposed dwelling will be acceptable.

NOISE IMPACT ASSESSMENT

New services plant at the dwelling is likely to be installed and will include equipment serving heating and cooling to the dwelling, equipment for the swimming pool and car lift. These are likely to be located at roof level (condensers for heating and cooling) and basement for the swimming pool and car lift. Since plant has not yet been selected, the highest permissible plant noise level has been calculated, such that noise from the new plant at the nearest neighbouring houses will meet London Borough of Camden's requirements.

The Local Authority's criteria will be met as long as the total plant noise level – including attenuation if necessary – is equivalent to no higher than 42dBA at 1m during the day and 34dBA at 1m at night.

INTRODUCTION

The proposed development comprises the construction of a new house at 77 Avenue Road, St John's Wood, NW8 6JD. The proposed accommodation includes five bedrooms and a master suite. Additional facilities include a games room/bar, cinema and car parking in the sub-basement and a pool, gym and staff accommodation in the basement.

The master suite and one bedroom overlook the rear of the site; all other bedrooms have windows to the front (Avenue Road) façade.

SITE LOCATION

The site is located at 77 Avenue Road, St John's Wood, within the London Borough of Camden (See Figure 1 below).

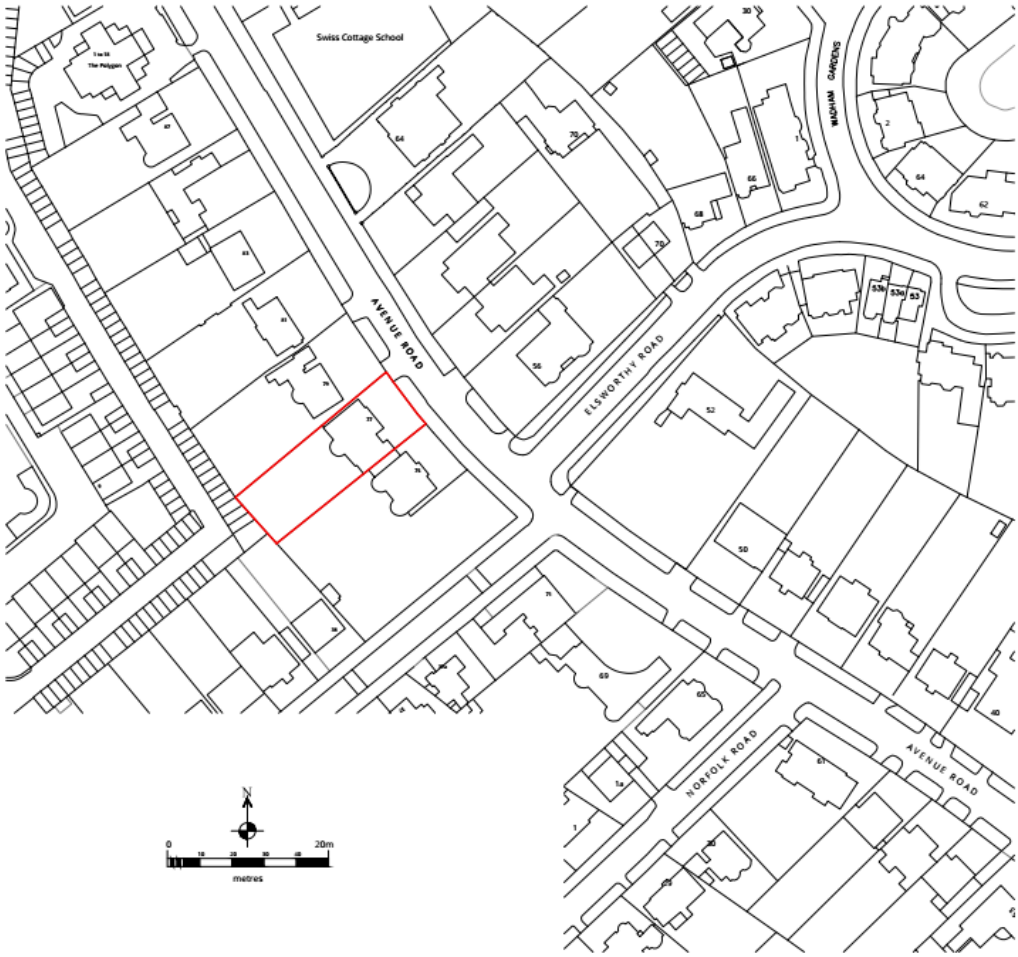


Figure 1: Site location map

PLANNING POLICIES

A great deal of change has occurred in recent years in the assessment of noise impacts and their relationship with planning decisions. The following sections introduce the applicable policies, either national or local, which ought to be considered to support the planning application. It should be highlighted that the assessment is mainly addressed to the local planning authority.

NOISE POLICY STATEMENT FOR ENGLAND

The Noise Policy Statement for England (NPSE[1]), published in March 2010, sets out the long-term vision of Government noise policy. The Noise Policy aims, as presented in this document, are: " *Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:*

- *avoid significant adverse effects on health and quality of life;*
- *mitigate and minimise adverse effects on health and quality of life; and*
- *where possible, contribute to the improvement of health and quality of life."*

The NPSE makes reference to the concepts of NOEL (No Observed Effect Level) and LOAEL (Lowest Observed Adverse Effect Level) as used in toxicology but applied to noise impacts. It also introduces the concept of SOAEL (Significant Observed Adverse Effect Level) which is described as the level above which significant adverse effects on health and quality of life occur.

The first aim of the NPSE is to avoid significant adverse effects, taking into account the guiding principles of sustainable development (as referenced in Section 1.8 of the NPSE). The second aim seeks to provide guidance on the situation that exists when the potential noise impact falls between the LOAEL and the SOAEL, in which case: *"...all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development."*

Importantly, the NPSE goes on to state that: " *This does not mean that such adverse effects cannot occur."*

The NPSE does not provide a noise-based measure to define SOAEL, acknowledging that the SOAEL is likely to vary depending on the noise source, the receptor and the time in question. NPSE advises that: *"Not having specific SOAEL values in the NPSE provides the necessary policy flexibility until further evidence and suitable guidance is available."*

It is therefore likely that other guidance will need to be referenced when applying objective standards for the assessment of noise, particularly in reference to the SOAEL, whilst also taking into account the specific circumstances of a proposed development.

[1] Noise Policy Statement for England, Defra, March 2010

NATIONAL PLANNING POLICY FRAMEWORK

The National Planning Policy Framework (NPPF[2]) was published in March 2012. One of the documents that the NPPF replaces is Planning Policy Guidance Note 24 (PPG 24[3]) "Planning and Noise."

Paragraph 109 of the NPPF states that the planning system should contribute to and enhance the natural and local environment by, (amongst others) *"preventing both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, water or noise pollution or land stability."*

The NPPF goes on to state in Paragraph 123 "*planning policies and decisions should aim to:*

- *Avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;*
- *Mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including thorough use of conditions;*
- *Recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land use since they were established, and*
- *Identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value."*

The NPPF document does not refer to any other documents or British Standards regarding noise other than the NPSE.

Paragraph 11 of the NPPF states that "*planning law requires that applications for planning permission must be determined in accordance with the development plan unless material considerations indicate otherwise."*

Paragraph 12 of the NPPF states that "*This National Planning Policy Framework does not change the statutory status of the development plan as the starting point for decision making. Proposed development that accords with an up-to-date Local Plan should be approved, and proposed development that conflicts should be refused unless other material considerations indicate otherwise. It is highly desirable that local planning authorities should have an up-to-date plan in place."*

Paragraph 13 of the NPPF states that *"the National Planning Policy Framework constitutes guidance for local planning authorities and decision-takers both in drawing up plans and as a material consideration in determining applications."*

Therefore, if a development/local plan does not align closely with the NPPF, planning decisions should be based on assessments which align with the NPPF. So for instance if a development is refused permission due to conflicts with the local plan, this decision can be overturned (i.e. via the appeal process) if the local plan did not closely align with the aims in the NPPF.

[2] National Planning Policy Framework, DCLG, March 2012
[3] Planning Policy Guidance 24: Planning and Noise, DCLG, September 1994

Paragraph 17 of the NPPF states that one of the 12 principles of planning is that it should "*not simply be about scrutiny, but instead be a creative exercise in finding ways to enhance and improve the places in which people live their lives.*"

Paragraph 111 states that *"Planning policies and decisions should encourage the effective use of land by re-using land that has been previously developed (brownfield land), provided that it is not of high environmental value. To prevent unacceptable risks from pollution and land instability, planning policies and decisions should ensure that new development is appropriate for its location. The effects (including cumulative effects) of pollution on health, the natural environment or general amenity, and the potential sensitivity of the area or proposed development to adverse effects from pollution, should be taken into account."*

PLANNING PRACTICE GUIDANCE – NOISE

As of March 2014, a Planning Practice Guidance (PPG[4]) for noise was issued which provides additional guidance and elaboration on the NPPF. It advises that when plan-making and decision-taking, the Local Planning Authority should consider the acoustic environment in relation to:

- Whether or not a significant adverse effect is occurring or likely to occur;
- Whether or not an adverse effect is occurring or likely to occur; and
- Whether or not a good standard of amenity can be achieved.

This guidance introduced the concepts of NOAEL (No Observed Adverse Effect Level), and UAEL (Unacceptable Adverse Effect Level). NOAEL differs from NOEL in that it represents a situation where the acoustic character of an area can be slightly affected (but not such that there is a perceived change in the quality of life). UAEL represents a situation where noise is 'noticeable', 'very disruptive' and should be 'prevented' (as opposed to SOAEL, which represents a situation where noise is 'noticeable' and 'disruptive', and should be 'avoided').

As exposure increases above the LOAEL, the noise begins to have an adverse effect and consideration needs to be given to mitigating and minimising those effects, taking account of the economic and social benefits being derived from the activity causing the noise. As the noise exposure increases, it will then at some point cross the SOAEL boundary.

The LOAEL is described in PPG[5] as the level above which *"noise starts to cause small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life."*

PPG identifies the SOAEL[5] as the level above which *"noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area."*

In line with the Explanatory Note of the NPSE, the PPG goes on to reference the LOAEL and SOAEL in relation to noise impact. It also provides examples of outcomes that could be expected for a given perception level of noise, plus actions that may be required to bring about a desired outcome. However, in line with the NPSE, no objective

[4] Planning Practice Guidance – Noise, http://planningguidance.planningportal.gov.uk/blog/guidance/noise/, 06 March 2014
[5] Paragraph: 005 Reference ID: 30-005-20140306

noise levels are provided for LOAEL or SOAEL although the PPG[6] acknowledges that *"...the subjective nature of noise means that there is not a simple relationship between noise levels and the impact on those affected. This will depend on how various factors combine in any particular situation."*

The relevant guidance in the PPG in relation to the adverse effect levels is summarized in Table 1.

Table 1: PPG guidance on adverse effect levels

Perception	Examples of Outcomes	Increasing Effect Level	Action
Not Noticeable	No Effect	No Observed Effect	No specific measures required
Noticeable and not Intrusive	Noise can be heard, but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life.	No Observed Adverse Effect	No specific measures required
Lowest Observed Adverse Effect Level			
Noticeable and Intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum
Significant Observed Adverse Effect Level			
Noticeable and Disruptive	The noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid
Noticeable and very Disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory	Unacceptable Adverse Effect	Prevent

The Planning Practice Guidance[7] states the following in relation to mitigation measures:

> *"For noise sensitive developments mitigation measures can include avoiding noisy locations; designing the development to reduce the impact of noise from the local environment; including noise barriers; and, optimising the sound insulation provided by the building envelope. Care should be taken when considering mitigation to ensure the envisaged measures do not make for an unsatisfactory development."*

[6] Paragraph: 006 Reference ID: 30-006-20141224
[7] Paragraph: 008 Reference ID: 30-008-20140306

In addition[8]:

"consideration should also be given to whether adverse internal effects can be completely removed by closing windows and, in the case of new residential development, if the proposed mitigation relies on windows being kept closed most of the time. In both cases a suitable alternative means of ventilation is likely to be necessary. Further information on ventilation can be found in the Building Regulations".

THE LONDON PLAN 2016

The London Plan 2016 is the overall strategic plan for London, setting out an integrated economic, environmental, transport and social framework for the development of London over the next 20–25 years. London Plan's Policy 7.15 states the following:

STRATEGIC

The transport, spatial and design policies of this plan will be implemented in order to reduce and manage noise to improve health and quality of life and support the objectives of the Mayor's Ambient Noise Strategy.

PLANNING DECISIONS

Development proposals should seek to manage noise by:

- *a. avoiding significant adverse noise impacts on health and quality of life as a result of new development;*
- *b. mitigating and minimising the existing and potential adverse impacts of noise on, from, within, as a result of, or in the vicinity of new development without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens on existing businesses;*
- *c. improving and enhancing the acoustic environment and promoting appropriate soundscapes (including Quiet Areas and spaces of relative tranquillity);*
- *d. separating new noise sensitive development from major noise sources (such as road, rail, air transport and some types of industrial development) through the use of distance, screening or internal layout – in preference to sole reliance on sound insulation;*
- *e. where it is not possible to achieve separation of noise sensitive development and noise sources, without undue impact on other sustainable development objectives, then any potential adverse effects should be controlled and mitigated through the application of good acoustic design principles;*
- *f. having particular regard to the impact of aviation noise on noise sensitive development;*
- *g. promoting new technologies and improved practices to reduce noise at source, and on the transmission path from source to receiver.*

LDF PREPARATION

Boroughs and others with relevant responsibilities should have policies to:

- *a. manage the impact of noise through the spatial distribution of noise making and noise sensitive uses;*
- *b. identify and nominate new Quiet Areas and protect existing Quiet Areas in line with the procedure in Defra's Noise Action Plan for Agglomerations*[1].

[8] Paragraph: 006 Reference ID: 30-006-20141224

BRITISH STANDARD 4142: 2014

The method employed for assessing the likelihood of noise impact from new plant at the property, at the nearest neighbouring houses, is a standard method laid out in BS 4142: 2014: "Methods for rating and assessing industrial and commercial sound".

This British Standard describes a methodology to be exercised on the outside of a building for determining:

(a) Sound levels from factories, industrial premises or fixed installations and sources of an industrial nature in commercial premises; and
(b) Background sound level.

This standard also describes a method for assessing the impact of the sound referred to within (a) on the nearby residents. The likelihood of sound provoking complaints depends on its level relative to the background sound level and whether or not it has certain tonal or impulsive audible characteristics, such as a distinctive whine, bangs, thumps or clatters. Such sounds are assumed to increase the sound depending how perceptible these sounds are. BS 4142 states that Reference to paragraph 11 "Assessment of the impacts" gives the following conclusion:

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

The standard states that a sound 10 dB or greater than background sound would be likely to be an indication of a significant adverse impact. Around 5 dB would be an adverse impact, whereas a sound equal to background would be a low impact.

Section 8 of BS 4142: 2014 states,

8.1 In using the background sound level in the method for rating and assessing industrial and commercial sound it is important to ensure that values are reliable and suitably represent both the particular circumstances and periods of interest. For this purposes, the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods ...
Since the intention is to determine a background sound level in the absence of the specific sound that is under consideration, it is necessary to understand that the background sound level can in some circumstances legitimately include industrial and/or commercial sounds that are present as separate to the specific sound...
8.1.4 The monitoring duration should reflect the range of background sound levels for the period being assessed. In practice, there is no "single" background sound level as this is a fluctuating parameter. However, the background sound level used for the assessment should be representative of the period being assessed.
... A representative level ought to account for the range of background sound levels and ought not automatically to be assumed to be either the minimum or modal value."

BRITISH STANDARD 8233: 2014

This report has been commissioned to recommend measures to be taken so as to ensure that reasonable standards of peace and quiet are achieved within the dwellings when constructed.

This has been achieved by measuring the existing sound levels on the site and then considering the amount of sound insulation required of the building envelope so as to ensure that target noise levels within the residential flats are achieved. This is based on the guidance set out within BS 8233: 2014 "British Standard Code of practice for Sound insulation and noise reduction for buildings", which states that:

This British Standard provides guidance for the control of noise in and around buildings. It is applicable to the design of new buildings, or refurbished buildings undergoing a change of use, but does not provide guidance on assessing the effects of changes in the external noise levels to occupants of an existing building.
This British Standard does not cover:
a) Specialist applications, such as auditoria and cinemas (for cinemas, see BS ISO 9568);
b) Vibration control, except where it is evident in the form of radiate sound; or
c) Noise that breaks out from the building that might affect external receptors.

LOCAL PLAN POLICY

LONDON BOROUGH OF CAMDEN

The Camden Local Policy document dated 2016 states in Policy A1 'Managing the impact of development' that for noise and vibration:

Noise and vibration can have a major effect on amenity. The World Health Organisation (WHO) for example states that excessive noise can seriously harm human health, disturb sleep and have cardiovascular and behavioural effects. Camden's high density and mixed-use nature means that disturbance from noise and vibration is a particularly important issue in the borough.

Where uses sensitive to noise are proposed close to an existing source of noise or when development that is likely to generate noise is proposed, the Council will require an acoustic report to accompany the application. Further detail can be found in Policy A4 - Noise and Vibration and our supplementary planning document Camden Planning Guidance 6: Amenity.

The proposed development is not likely to result in abnormal levels of noise generation, but it is itself noise-sensitive.

Policy A4 *'Noise and Vibration'* states:

The Council will seek to ensure that noise and vibration is controlled and managed. Development should have regard to Camden's Noise and Vibration Thresholds (Appendix 2). We will not grant planning permission for:

a. development likely to generate unacceptable noise and vibration impacts; or
b. development sensitive to noise in locations which experience high levels of noise, unless appropriate attenuation measures can be provided and will not harm the continued operation of existing uses.

We will only grant permission for noise generating development, including any plant and machinery, if it can be operated without causing harm to amenity. We will also seek to minimise the impact on local amenity from deliveries and from the demolition and construction phases of development.

Further details of the Noise Thresholds are given in the section on Design Noise Levels in the following section.

DESIGN NOISE LEVELS

Noise control in and around buildings is discussed in the British Standard guides on an objective and quantifiable basis. The guides suggest criteria, such as suitable sleeping/resting conditions, and propose noise levels that normally satisfy these criteria for most people.

BS 8233:2014 GUIDANCE ON SOUND INSULATION AND NOISE REDUCTION FOR BUILDINGS.

This Standard provides recommended guideline values for internal noise levels within dwellings which are similar in scope to guideline values contained within the World Health Organisation (WHO) document, Guidelines for Community Noise (1999[9]). These guideline noise levels are shown in Table 2, below:

Table 2: BS 8233 Desirable Internal Ambient Noise Levels for Dwellings

Activity	Location	07:00 to 23:00 hours	23:00 to 07:00 hours
Resting	Living room	35 dB $L_{Aeq,16h}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16h}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16h}$	30 dB $L_{Aeq,8h}$

BS 8233:2014 advises that: "*regular individual noise events… can cause sleep disturbance. A guideline value may be set in terms of SEL or $L_{Amax,F}$ depending on the character and number of events per night. Sporadic noise events could require separate values.*" The assessment of individual noise events during the night-time may only be considered necessary for intermittent environmental sources such as aircraft of train pass-bys for which there is research available to assist with the quantification of the impact. Individual noise events associated with night-time typical road traffic are not considered to be associated with the rise of significant adverse effects on health and quality of life, and this is indeed the case even if the site is located near a motorway. Therefore, an assessment of individual noise events during the night-time for this site is not deemed appropriate or necessary.

LONDON BOROUGH OF CAMDEN

Noise Thresholds are given in Appendix 2 of the document for "proposed developments likely to be sensitive to noise" and for "industrial and commercial noise sources". The former represents noise affecting the proposed development from existing noise sources in the area. Although the services plant at the proposed development is not "industrial or commercial" it is appropriate to use the latter set of thresholds to assess likely noise impacts on nearby dwellings.

In each case, the thresholds are categorised as "red", "amber" and "green". As described in the notes in Appendix 2:

[9] World Health Organisation Guidelines for Community Noise, 1999

The values will vary depending on the context, type of noise and sensitivity of the receptor:

- *Green – where noise is considered to be at an acceptable level.*
- *Amber – where noise is observed to have an adverse effect level, but which may be considered acceptable when assessed in the context of other merits of the development.*
- *Red – where noise is observed to have a significant adverse effect.*

The thresholds for "proposed developments likely to be sensitive to noise" are given in Table 3.

Table 3: London Borough of Camden Noise Thresholds for noise-sensitive properties

Dominant noise source	Assessment location	Design period	LOAEL (Green)	LOAEL to SOAEL (Amber)	SOAEL (Red)
Anonymous noise such as general environmental noise, road traffic and rail traffic[10]	Noise at 1 metre from noise sensitive façade / free field	Day	<50dB $L_{Aeq,16hr}$*	50dB to 72 dB $L_{Aeq,16hr}$*	>72 dB $L_{Aeq,16hr}$*
		Night	<45dB $L_{Aeq,8hr}$*	45dB to 62 dB $L_{Aeq,8hr}$*	>62 dB $L_{Aeq,8hr}$*
			<40dB L_{night}**	>40dB L_{night}**	
	Inside a bedroom	Day	<35dB $L_{Aeq,16hr}$	35dB to 45 dB $L_{Aeq,16hr}$	>45 dB $L_{Aeq,16hr}$
		Night	<30dB $L_{Aeq,8hr}$	30dB to 40 dB $L_{Aeq,8hr}$	>40 dB $L_{Aeq,8hr}$
			<42dB $L_{Amax,fast}$	40dB to 73dB $L_{Amax,fast}$	>73dB $L_{Amax,fast}$
	Outdoor living space (free field)	Day	<50dB $L_{Aeq,16hr}$	50dB to 55dB $L_{Aeq,16hr}$	>55dB $L_{Aeq,16hr}$

*$L_{Aeq,T}$ external values specified are façade levels

**L_{night} external levels are free-field levels

Noise thresholds for plant noise are given in Table 4.

[10] Thresholds are also given for non-anonymous noise, but these are not relevant for the proposed development

Table 4: London Borough of Camden Noise Thresholds for new noise sources

Existing noise sensitive receptor	Assessment location	Design period	LOAEL (Green)	LOAEL to SOAEL (Amber)	SOAEL (Red)
Dwellings**	Garden used for main amenity (free field) and outside living or dining or bedroom window (façade)	Day	'Rating level' 10dB* below background	'Rating level' between 9dB below and 5dB above background	'Rating level' greater than 5dB above background
Dwellings**	Outside bedroom window (façade)	Night	'Rating level' 10dB* below background and no events exceeding 57dBL_{Amax}	'Rating level' between 9dB below and 5dB above background or noise events between 57dB and 88dBL_{Amax}	'Rating level' greater than 5dB above background and/or events exceeding 88dBL_{Amax}

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

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

BUILDING REGULATIONS

Part L of the Building Regulations mandates that buildings become more airtight, and Part F stipulates ventilation requirements. Even though there appears to be a contradiction in this, Part L limits uncontrollable ventilation, while Part F ensures that ventilation requirements are provided in a controlled manner.

VENTILATION REQUIREMENTS FOR HABITABLE ROOMS

Background ventilation

Three types of ventilation are required under Part F. Whole building ventilation provides nominally continuous air exchange which may be reduced or ceased when the building is not occupied. It can be provided via background ventilators operating alone, or together with:

- passive stack ventilators;
- continuous mechanical extract; or
- continuous mechanical supply and extract with heat recovery.

Extract ventilation is applicable to rooms where most water vapour and/or pollutants are released (e.g. kitchens and bathrooms). It can be provided by intermittent fans, passive stack or continuous mechanical extract with or without mechanical supply and heat recovery.

The four systems described in Part F do not present solutions which utilise the use of opening windows for background ventilation. Opening windows do not provide a controllable means of ventilation and also pose security risks. Therefore, it is not possible to offer to the market a residential dwelling which only utilises opening windows for background ventilation.

Purge ventilation

Purge ventilation is required throughout the building to aid the removal of high concentrations of pollutants and water vapour. It is commonly provided simply by opening windows and doors.

Even though purge ventilation is recommended via opening windows, the temporary and intermittent occurrence of this does not normally result in an unacceptable increase of internal noise levels.

Part F goes on to say[11] that "*Purge ventilation provisions may also be used to improve thermal comfort, although this is not controlled under the Building Regulations*."

SUMMARY IN RELATION TO VENTILATION

In summary, background ventilation for new residential dwellings should be provided via one of the four systems in Approved Document F. The composite external building fabric should be designed to ensure that appropriate internal noise levels due to external incident noise are met during background ventilation. This can be secured via a planning condition if deemed necessary.

Purge ventilation for new residential dwellings should be provided via open windows. The slight increase of internal noise levels should be considered acceptable.

[11] Paragraph 4.15 in Approved Document F

MEASUREMENT OF NOISE LEVELS

The following section describes the methodology undertaken in order to establish environmental noise levels around the site.

DETAILS OF ENVIRONMENTAL SOUND SURVEY

Continuous measurements of the incident sound pressure levels (at two locations) at the site were undertaken from Monday 5th March to Tuesday 6th March 2018. The sound level meters were programmed to record the A-weighted L_{eq}, L_{90}, L_{10} and L_{max} noise indices and corresponding octave band frequency information (for L_{eq}) for consecutive sample periods for the duration of the survey.

MEASUREMENT POSITIONS

The measurements of incident sound levels were undertaken at two locations. The approximate location of the sound level meters is indicated in the aerial photograph below, and Table 5**Error! Reference source not found.** describes the two measurement positions.

Figure 2: On site sound pressure level measurement positions

Table 5: Description of measurement positions

Position	Description
1	Front of existing house, on drainpipe
2	Rear balcony of existing house

EQUIPMENT

Details of the equipment used during the survey are provided in Table 6 below. The sound level meters were calibrated before and after the survey; no significant change (+/-0.2 dB) in the calibration level was noted.

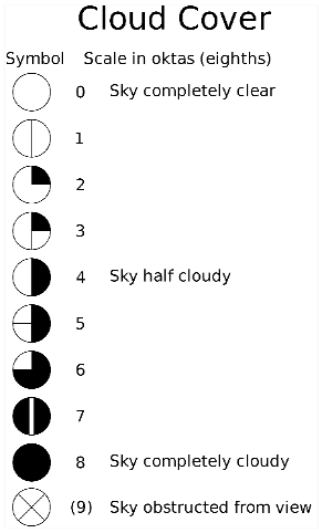
Table 6: On site instrumentation

Position	Description	Model / serial no.	Calibration date	Calibration certificate no.
1	Class 1 Sound level meter	Svantek 977 / 36190	04/08/2016	1608413
	Condenser microphone	ACO Pacific 7052E / 57366		
	Preamplifier	Svantek SV12L / 41504		
	Calibrator	CEL 284/2 /4/03326334	04/08/2016	15050
2	Class 1 Sound level meter	Svantek 949 / 12262	31/05/2017	TCRT17/1312
	Condenser microphone	SV22 / 4012444		
	Preamplifier	Svantek SV12L / 13163		
	Calibrator	Svantek SV 40A / 10847	30/05/2017	TCRT17/1308

WEATHER CONDITIONS

Weather conditions were determined both at the start and on completion of the survey. It is considered that the meteorological conditions were appropriate for environmental noise measurements. Table 7 presents the weather conditions recorded on site at the beginning and end of the survey.

Table 7: Weather Conditions

Date/Time	Description	Beginning of Survey	End of Survey
12.00 5/03/2018 – 12.00 6/03/2018	Temperature (°C)	11	10
	Precipitation:	No	No
	Cloud cover (oktas - see guide)	6	8
	Presence of fog/snow/ice	No	No
	Presence of damp roads/wet ground	Yes*	Yes*
	Wind Speed (m/s)	3	6
	Wind Direction	SW	SW
	Conditions that may cause temperature inversion (i.e. calm nights with no cloud)	No	No

*no influence in the conclusions of the assessment

RESULTS

The main source of noise affecting the front façade of the existing house on the site was observed to be regular traffic on Avenue Road. At the rear of the site, local traffic was also the major source of noise.

EXTERIOR NOISE LEVELS

The single figure free field noise indices recorded are presented in tabular format within Appendix B. The relevant results of the survey have been summarised in Table 8.

Table 8: Summary of survey results (façade levels at front, free field levels at rear)

Position	Measurement period	Range of recorded sound pressure levels (dB)			
		$L_{Amax,T}$	$L_{Aeq,T}$	$L_{A10,T}$	$L_{A90,T}$
1: Front of existing house	Daytime (07.00 – 23.00 hours)	72-94	62-72	65-69	55-60
	Night-time (23.00 – 07.00 hours)	69-84	54-64	58-67	36-59
2: Rear balcony of existing house	Daytime (07.00 – 23.00 hours)	56-75	48-56	50-58	45-49
	Night-time (23.00 – 07.00 hours)	49-69	41-51	43-53	37-47

Table 9 below presents the incident free field noise levels at the measurement positions in terms of daytime and night-time levels measured during the monitoring period at the two locations.

Table 9: Daytime and night-time equivalent levels (façade levels at front, free field levels at rear)

Position	Measurement period	Sound pressure levels (dB)	
		$L_{Aeq\ (16\ hours)*}$	$L_{Aeq\ (8\ hours)}$
1	5-6 March 2018	64.8	59.8
2		51.1	46.2

*not complete 16 hour measurements.

Since the positions of the front and rear façades of the new house are very similar to those of the existing house on the site, the measured noise levels can be used directly to represent the free-field incident sound levels at the front and rear façades of the proposed house.

Incident free-field octave band sound levels at the front and rear façades are shown in **Error! Reference source not found.**Table 10.

Table 10: Summary of free field facade incident environmental noise levels at octave band centre frequencies.

Period	Incident free field sound pressure levels (dB) at Octave Band Centre Frequencies (Hz)								dB(A)
	63	125	250	500	1000	2000	4000	8000	
1: Front of existing house									
Daytime $L_{Aeq,\ 16\ hours}$	67.2	62.0	59.6	57.7	58.5	53.7	46.3	40.8	62
Night-time $L_{Aeq,\ 8\ hours}$	61.1	55.8	53.5	51.9	53.9	48.7	42.7	37.2	57
Spectrum of typical night-time L_{Amax}	80	75	74	74	71	69	63	57	76
2: Rear balcony of existing house									
Daytime $L_{Aeq,\ 16\ hours}$	59.1	55.0	50.8	48.3	46.9	41.2	38.9	33.7	51
Night-time $L_{Aeq,\ 8\ hours}$	52.6	48.2	44.8	41.8	42.1	36.0	37.6	33.3	46
Spectrum of typical night-time L_{Amax}	68	58	51	59	65	48	44	32	66

LONDON BOROUGH OF CAMDEN EXTERNAL NOISE THRESHOLDS

At the front of the site, the façade sound levels are 65 dB $L_{Aeq,16hr}$ during the day and 60 dB $L_{Aeq,8hr}$ at night. At the rear of the site, the façade sound levels are 54 dB $L_{Aeq,16hr}$ during the day and 49 dB $L_{Aeq,8hr}$ at night. The free-field noise level at the rear of the site, representing the noise level within the garden, is 51 dB $L_{Aeq,16hr}$. Therefore, the external noise levels put the site within the “Amber” category, using the methodology in Appendix 2 of the Camden Local Plan, considering all three external noise criteria.

ASSESSMENT OF ENVIRONMENTAL NOISE IMPACTS

The following section presents the assessment of the various noise impacts in line with the methodology outlined in the preceding sections.

INDOOR LEVELS

In order to assess the site in relation to the applicable policy aims, it is important to review the internal noise levels due to incident noise ingress inside the proposed dwelling.

The composite acoustic performance required of any portion of the building envelope will depend upon its location relative to the principal noise sources around the site and the nature of the spaces behind it (noise criteria, size, room finishes etc.).

BS 8233:2014 indicates that typically, with windows partially opened for ventilation, there is a reduction of approximately 15dBA between the incident free-field external sound level and the internal reverberant sound level. Using this approximation gives the internal noise levels in Table 11. For reference, the noise category using the noise thresholds in the Camden Local Plan are also show.

Table 11: Internal noise levels with open windows

Façade	Rooms	Design period	External incident free field noise level	Internal noise level	BS8233:2014 recommended level	LB Camden noise category
Front	Bedroom 1, Bedroom 2, Bedroom 3, Bedroom 5	Day	62dB LAeq,16hr	47dB LAeq,16hr	35 dB LAeq,16hr	RED
		Night	57dB LAeq,8hr	42dB LAeq,8hr	30dB LAeq,8hr	RED
			76dB LAmax (typical)	61dB LAmax (typical)	n/a	Amber
	Staff Bedrooms*	Day	52dB LAeq,16hr	37dB LAeq,16hr	35dB LAeq,16hr	Amber
		Night	47dB LAeq,8hr	32dB LAeq,8hr	30dB LAeq,8hr	Amber
			66dB LAmax (typical)	51dB LAmax (typical)	n/a	Amber
	Study, Formal Dining Room	Day	62dB LAeq,16hr	47dB LAeq,16hr	40dB LAeq,16hr	**
	Staff Living Room*	Day	52dB LAeq,16hr	37dB LAeq,16hr	35dB LAeq,16hr	**

Façade	Rooms	Design period	External incident free field noise level	Internal noise level	BS8233:2014 recommended level	LB Camden noise category
Rear	Master suite, Bedroom 4	Day	51dB $L_{Aeq,16hr}$	36dB $L_{Aeq,16hr}$	35dB $L_{Aeq,16hr}$	Amber
		Night	46dB $L_{Aeq,8hr}$	31dB $L_{Aeq,8hr}$	30dB $L_{Aeq,8hr}$	Amber
			66dB L_{Amax} (typical)	51dB L_{Amax} (typical)	n/a	Amber
	Family Dining, Play Room	Day	51dB $L_{Aeq,16hr}$	36dB $L_{Aeq,16hr}$	40dB $L_{Aeq,16hr}$	**
	Living Room	Day	51dB $L_{Aeq,16hr}$	36dB $L_{Aeq,16hr}$	35dB $L_{Aeq,16hr}$	**

*Staff bedrooms and living room windows open onto lightwells and are therefore screened from traffic on Avenue Road

** There are no recommendations within the Camden local plan for internal noise levels in rooms other than bedrooms

As can be seen, internal noise levels with open windows lead to excessive ("red" category) noise levels in bedrooms on the front façade. Alternative methods of ventilation are therefore required for these rooms to meet the London Borough of Camden's Local Plan guidance. In addition, it is recommended that alternative ventilation is provided to other rooms, particularly on the front façade, to provide internal noise levels that meet the guidance in BS 8233:2014.

The detailed calculation methodology described in BS8233:2014 will be used in the assessment using the following equation[12] as detailed in the British Standard:

$$L_{eq,2} = L_{eq,ff} + 10log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{w1}}{S}10^{\frac{-R_{w,i}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_0}{10}}\right) + 10log_{10}(\frac{S}{A}) + 3$$

Calculations are based on room layouts and dimensions shown in plan drawings 1716-PL-301-0, 1716-PL-302-0, 1716-PL-303-0 and 1716-PL-304-0, elevations 1716-PL-310-0, 1716-PL-311-0, 1716-PL-312-0 and 1716-PL-313-0 and sections 1716-PL-330-0, 1716-PL-331-0, 1716-PL-332-0, 1716-PL-333-0 and 1716-PL-334-0 provided by Wolff Architects.

The starting point in all similar assessments is to review whether an external building fabric comprising elements with the lowest possible sound reduction properties required to meet the Building Regulations (in relation to thermal and ventilation provisions) will be acceptable.

Table 12 below presents the sound reduction indices used in the assessment for these low performing (in terms of sound reduction) elements.

[12] See page 65 and 66 of BS8233:2014 for an explanation of the various terms used in the equation.

Table 12: Elements of external building fabric

External building fabric element	Construction element	Sound reduction indices (dB) at Octave band Centre Frequencies (Hz)				
		125	250	500	1000	2000
Glazing configuration, glass mm/airgap mm/glass mm	4mm glass, 16 mm airgap, 4 mm glass	24	23	30	33	33
Background ventilation system as per System 1 in Approved Document F	Non-acoustic trickle ventilator	32	32	31	33	31
Non vision wall	Cavity masonry	41	45	45	54	58

Table 13 shows predicted internal noise levels in bedrooms on the front façade, with typical thermal double-glazing and non-acoustic trickle ventilators (as shown in

Table 12).

Table 13. Predicted noise levels inside bedrooms to front façade with recommended glazing and ventilators

Façade	Rooms	Design period	Internal noise level	BS8233:2014 recommended level	LB Camden noise category
Front	Bedroom 1, Bedroom 2, Bedroom 3, Bedroom 5	Day	31dB $L_{Aeq,16hr}$	35dB $L_{Aeq,16hr}$	Green
		Night	26dB $L_{Aeq,8hr}$	30dB $L_{Aeq,8hr}$	Green
			46dB L_{Amax} (typical)	n/a	Amber

In all cases, internal equivalent continuous ($L_{Aeq,T}$) noise levels are in the "green" category, with typical night-time L_{AMax} noise levels at the lower end of the "amber" category range (40dB to 73dB L_{Amax}).

The assessment has shown that the resultant night-time ambient noise level in all bedrooms would, at worst, fall within the "amber" category for internal noise as detailed in Camden's Local Plan and therefore should be acceptable to the local authority. In addition, internal noise levels in the bedrooms would also meet the recommendations in BS 8233:2014.

For information, Table 14 shows the predicted internal noise levels for the other bedrooms and living areas when the same glazing and ventilation strategy is employed for those rooms.

Table 14. Predicted internal noise levels with glazing and ventilators recommended for front bedrooms

Façade	Rooms	Design period	Internal noise level	BS8233:2014 recommended level	LB Camden noise category
Front	Staff Bedrooms*	Day	22dB $L_{Aeq,16hr}$	35dB $L_{Aeq,16hr}$	Green
		Night	17dB $L_{Aeq,8hr}$	30dB $L_{Aeq,8hr}$	Green
			36dB L_{Amax} (typical)	n/a	Green
	Study, Formal Dining Room	Day	37dB $L_{Aeq,16hr}$	40dB $L_{Aeq,16hr}$	**
	Staff Living Room*	Day	22dB $L_{Aeq,16hr}$	35dB $L_{Aeq,16hr}$	**
Rear	Master Suite, Bedroom 4	Day	20dB $L_{Aeq,16hr}$	35dB $L_{Aeq,16hr}$	Green
		Night	15dB $L_{Aeq,8hr}$	30dB $L_{Aeq,8hr}$	Green
			35dB L_{Amax} (typical)	n/a	Green
	Family Dining	Day	26dB $L_{Aeq,16hr}$	40dB $L_{Aeq,16hr}$	**
	Living Room	Day	21dB $L_{Aeq,16hr}$	35dB $L_{Aeq,16hr}$	**
	Play Room	Day	20dB $L_{Aeq,16hr}$	40dB $L_{Aeq,16hr}$	**

OUTDOOR LEVELS

As noted previously, the free-field noise level at the rear of the site, representing the noise level within the garden, is 51 dB $L_{Aeq,16hr}$. Therefore, the external noise levels put the site within the “Amber” category, using the methodology in Appendix 2 of the Camden Local Plan.

ASSESSMENT OF MECHANICAL PLANT

Most plant is proposed to be within internal plant rooms, with the exception of condensers. Plant rooms are proposed for the sub-basement at the rear of the house and for the basement at the front and rear. Each plant space is likely to require air inlet and discharge louvres.

The plant will be selected at the developed design stage, and therefore limiting plant noise levels are given in this report to assist the selection of plant and any acoustic treatment required.

CALCULATION OF SPECIFIC SOUND LEVELS

The total maximum permissible noise level emitted by the new services plant may be calculated by considering the highest plant sound level that would be acceptable at the nearest noise-sensitive receptor and correcting for distance, screening and any other acoustic effects.

Assuming propagation as a point source, the reduction in sound due to distance is given by:

$$20 \log r_a/r_m \ dB$$

where

r_a *is the distance from the sound source to the assessment location (m)*

r_m *is the distance from the sound source to the measurement location (10 m)*

Reference to the BS 5228-1:2009 paragraph F.2.2.2.1 (page 129) states that 'in the absence of spectral data, as a working approximation, if there is a barrier or other topographic feature between the source and the receiving position, assume an approximate attenuation of 5dB when the top of the plant is just visible to the receiver over the noise barrier, and 10dB when the noise screen completely hides the source from the receiver.'

ASSESSMENT AGAINST LONDON BOROUGH OF CAMDEN'S REQUIREMENTS

As noted previously, London Borough of Camden's Local Plan includes noise thresholds relating to noise from new plant affecting dwellings. The "green" (LOAEL) threshold requires that rating noise levels outside the nearest neighbouring windows, assessed using the method in BS 4142:2014, are at least 10dB below the pre-existing background sound levels.

Since plant is to be selected, a notional 3dB acoustic feature correction has been allowed for in the calculation of limiting plant sound levels.

For initial design purposes, plantroom louvres in each case will be at ground level. At the closest point of the envelope of the new house to the site boundary the distance is equal to 3m. The proposed louvres will be located further away from the nearest dwelling, but as a worst case scenario, it is assumed that each louvre is at least 3m from any noise-sensitive window of the nearest neighbouring house.

The calculation of the highest permissible plant noise level meeting the London Borough of Camden's "green" criterion is shown in Table 15.

Table 15: Calculation of permissible plant noise level

Item	Measurement	
	Day	Night
Lowest background sound level	45 dB $L_{A90,15min}$	37 dB $L_{A90,15min}$
London Borough of Camden plant rating noise criterion	35 dB $L_{Ar,Tr}$	27 dB $L_{Ar,Tr}$
BS 4142:2014 feature correction	3 dB	3 dB
Permissible plant noise level at nearest noise-sensitive window	32 dB L_{Aeq}	24 dB L_{Aeq}
Distance from source to assessment location r_a	3 metres	3 metres
Hence correction due to distance (to 1m from source)	10 dB	10 dB
Permissible total plant louvre noise level at 1 metre	42 dB L_{Aeq}	34 dB L_{Aeq}

This demonstrates that a plant louvre noise level equivalent to 42 dBA at 1m during the day and 34 dBA at 1m at night will meet the London Borough of Camden's typical requirement, being 10 dB below the lowest background sound level measured at the nearest noise-sensitive window of a neighbouring dwelling. Since no part of any neighbouring property can be subject to noise from all three proposed plantrooms, due to distance and screening provided by the building layout, the above limits are the cumulative for all louvres serving each plantroom.

In the event that the cumulative noise level of the plant louvre due to selected plant is higher than the limits shown, attenuation will be required such that the limit is not exceeded.

ADDITIONAL CONSIDERATIONS

All plant should be fitted with suitable vibration isolators, to prevent vibration from entering the structure and re-radiating in the bedrooms. Mounts should be specified and designed to provide at least 95% isolation efficiency.

Airborne noise transmission from the plant into the property must also be considered as part of the acoustic design of the plant room floor slab. Acoustic floating floors and/or suspended ceilings may be required to control plant noise to acceptable levels.

CONCLUSION

ENVIRONMENTAL NOISE ASSESSMENT

Based upon the findings of on-site noise levels, exterior design noise levels have been determined for the various occupied spaces within the new house.

Accounting for the effects of both open and closed windows, internal sound levels have been calculated. Generally, internal noise levels with open windows meet the “amber” category (or better) in the Camden Local Plan. However, internal noise levels in bedrooms on the front (Avenue Road) façade are within the “red” category. For these bedrooms, closed windows with trickle vents should be considered for primary ventilation purposes.

The results of the noise survey show that typical thermal double-glazed windows, with non-acoustic trickle ventilators, will result in internal noise levels in front bedrooms that are, at worst, within Camden’s Local Plan “amber” category.

Using the same glazing and ventilation would result in all other bedrooms having internal noise levels in the “green” category.

Any manufacturer of glazing could be specified provided that they have tested their products to ascertain whether they achieve the above targets, final choice should be made based on incorporation of all environmental and aesthetic factors. The assessment has indicated that with the appropriate mitigation in the form of the specified glazing, internal noise levels within the proposed dwellings will be acceptable.

NOISE IMPACT ASSESSMENT

New services plant at the dwelling is likely to be installed in the basement and sub-basement and will include equipment serving the swimming pool and the car lift. Since plant has not yet been selected, the highest permissible plant noise level has been calculated, such that noise from the new plant at the nearest neighbouring houses will meet London Borough of Camden’s typical requirements.

The Local Authority’s normal criteria will be met as long as the total plant noise level – including attenuation if necessary – is equivalent to no higher than 42dBA at 1m during the day and 34dBA at 1m at night.

APPENDIX A

Table 16: Acoustic Terminology

Parameter	Description
Ambient Noise Level	The totally encompassing sound in a given situation at a given time, usually composed of a sound from many sources both distant and near ($L_{Aeq,T}$).
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s1 and s2 is given by 20 log10 (s1/s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20μPa. The threshold of normal hearing is in the region of 0 dB and 140 dB is the threshold of pain. A change of 1 dB is only perceptible under controlled conditions.
dB(A), L_{Ax}	Decibels measured on a sound level meter incorporating a frequency weighting (A weighting) which differentiates between sounds of different frequency (pitch) in a similar way to the human ear. Measurements in dB(A) broadly agree with people's assessment of loudness. A change of 3 dB(A) is the minimum perceptible under normal conditions, and a change of 10 dB(A) corresponds roughly to halving or doubling the loudness of a sound. The background noise in a living room may be about 30 dB(A); normal conversation about 60 dB(A) at 1 metre; heavy road traffic about 80 dB(A) at 10 metres; the level near a pneumatic drill about 100 dB(A).
Fast Time Weighting	Setting on sound level meter, denoted by a subscript F, that determines the speed at which the instrument responds to changes in the amplitude of any measured signal. The fast time weighting can lead to higher values than the slow time weighting when rapidly changing signals are measured. The average time constant for the fast response setting is 0.125 (1/8) seconds.
Free-field	Sound pressure level measured outside, far away from reflecting surfaces (except the ground), usually taken to mean at least 3.5 metres
Façade	Sound pressure level measured at a distance of 1 metre in front of a large sound reflecting object such as a building façade.
$L_{Aeq,T}$	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
$L_{max,T}$	A noise level index defined as the maximum noise level recorded during a noise event with a period T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
$L_{10,T}$	A noise level index. The noise level exceeded for 10% of the time over the period T. L_{10} can be considered to be the "average maximum" noise level. Generally used to describe road traffic noise. $L_{A10,18h}$ is the A –weighted arithmetic average of the 18 hourly $L_{A10,1h}$ values from 06:00-24:00.

APPENDIX B

Table 17: Results of environmental noise measurements at Position 1

Date & time	L_{Aeq} [dB]	L_{AFmax} [dB]	L_{A10} [dB]	L_{A90} [dB]
05/03/2018 11:59	65.1	84.1	67.4	57.9
05/03/2018 12:14	64.8	88.5	67.0	57.8
05/03/2018 12:29	64.2	83.8	66.8	57.6
05/03/2018 12:44	63.9	81.3	66.9	57.2
05/03/2018 12:59	64.7	78.8	67.6	58.0
05/03/2018 13:14	64.3	82.3	67.2	57.8
05/03/2018 13:29	64.7	85.3	67.2	57.6
05/03/2018 13:44	64.5	76.4	66.9	57.9
05/03/2018 13:59	65.2	86.3	67.2	57.9
05/03/2018 14:14	64.5	79.4	67.5	57.1
05/03/2018 14:29	63.8	79.7	66.2	58.6
05/03/2018 14:44	64.4	75.9	67.2	58.9
05/03/2018 14:59	63.3	77.9	66.1	57.3
05/03/2018 15:14	62.3	72.0	64.9	57.9
05/03/2018 15:29	65.7	75.7	68.6	60.2
05/03/2018 15:44	65.2	81.9	68.0	58.7
05/03/2018 15:59	63.6	74.5	66.4	58.4
05/03/2018 16:14	63.0	75.8	65.7	57.8
05/03/2018 16:29	63.5	73.9	66.3	58.4
05/03/2018 16:44	63.2	74.3	66.3	57.7
05/03/2018 16:59	64.3	80.7	67.1	57.6
05/03/2018 17:14	64.3	78.5	66.7	57.5
05/03/2018 17:29	64.1	76.2	67.2	57.5
05/03/2018 17:44	63.9	75.5	66.6	58.8
05/03/2018 17:59	65.3	82.8	67.5	59.3
05/03/2018 18:14	64.8	82.3	67.4	57.5
05/03/2018 18:29	66.1	86.8	67.7	58.4
05/03/2018 18:44	63.8	73.8	66.8	58.1
05/03/2018 18:59	64.7	75.4	67.6	58.7
05/03/2018 19:14	65.4	87.9	66.9	58.1
05/03/2018 19:29	64.4	85.4	66.7	58.6
05/03/2018 19:44	64.4	84.3	66.8	57.9

Date & time	L_{Aeq} [dB]	L_{AFmax} [dB]	L_{A10} [dB]	L_{A90} [dB]
05/03/2018 19:59	63.6	74.8	66.5	56.8
05/03/2018 20:14	63.6	76.1	66.5	56.3
05/03/2018 20:29	63.3	78.0	66.6	55.3
05/03/2018 20:44	64.3	75.4	67.3	57.6
05/03/2018 20:59	64.2	74.3	67.1	57.7
05/03/2018 21:14	63.5	77.2	66.5	56.3
05/03/2018 21:29	67.1	90.8	67.4	57.1
05/03/2018 21:44	62.8	73.2	65.9	54.5
05/03/2018 21:59	63.5	72.5	66.5	56.8
05/03/2018 22:14	64.4	80.4	67.2	56.1
05/03/2018 22:29	64.3	74.6	67.6	56.3
05/03/2018 22:44	64.6	80.9	67.8	56.5
05/03/2018 22:59	63.3	75.9	67.0	50.6
05/03/2018 23:14	62.9	76.8	66.8	50.1
05/03/2018 23:29	61.5	76.2	65.4	49.3
05/03/2018 23:44	61.0	75.4	65.1	48.5
05/03/2018 23:59	60.8	75.7	64.8	44.4
06/03/2018 00:14	59.0	70.5	63.9	43.9
06/03/2018 00:29	59.2	71.3	63.9	41.1
06/03/2018 00:44	58.4	72.6	63.2	41.4
06/03/2018 00:59	56.3	69.6	61.5	38.2
06/03/2018 01:14	57.1	69.9	62.0	38.3
06/03/2018 01:29	56.4	71.6	60.3	37.9
06/03/2018 01:44	54.6	70.2	59.0	37.4
06/03/2018 01:59	59.8	81.7	60.4	38.0
06/03/2018 02:14	54.0	71.2	58.1	36.5
06/03/2018 02:29	56.4	71.4	60.7	36.1
06/03/2018 02:44	55.6	73.9	59.9	36.8
06/03/2018 02:59	54.8	74.7	58.5	35.5
06/03/2018 03:14	55.7	72.3	60.3	38.2
06/03/2018 03:29	54.8	71.6	58.8	38.0
06/03/2018 03:44	54.8	69.4	58.4	38.0
06/03/2018 03:59	55.5	71.3	59.7	37.4
06/03/2018 04:14	56.0	71.3	60.7	38.8
06/03/2018 04:29	55.6	75.7	59.2	38.8
06/03/2018 04:44	56.2	69.5	61.0	39.5

Date & time	L_{Aeq} [dB]	L_{AFmax} [dB]	L_{A10} [dB]	L_{A90} [dB]
06/03/2018 04:59	55.6	70.0	60.5	40.2
06/03/2018 05:14	59.0	73.7	63.5	43.2
06/03/2018 05:29	60.1	83.1	63.9	44.4
06/03/2018 05:44	60.0	74.2	64.1	45.1
06/03/2018 05:59	62.4	75.8	65.9	50.4
06/03/2018 06:14	63.0	76.2	66.2	51.5
06/03/2018 06:29	64.4	81.4	66.8	55.5
06/03/2018 06:44	64.4	83.6	66.9	59.4
06/03/2018 06:59	63.7	78.0	66.4	58.7
06/03/2018 07:14	64.6	81.5	67.3	58.8
06/03/2018 07:29	64.7	83.1	67.0	59.2
06/03/2018 07:44	65.5	86.0	67.4	58.0
06/03/2018 07:59	64.8	80.4	66.9	58.7
06/03/2018 08:14	65.2	83.5	67.5	59.2
06/03/2018 08:29	65.1	84.1	67.7	59.8
06/03/2018 08:44	64.7	81.2	67.4	58.9
06/03/2018 08:59	64.2	79.9	66.8	57.1
06/03/2018 09:14	66.1	87.3	67.3	57.2
06/03/2018 09:29	67.8	91.9	67.3	58.2
06/03/2018 09:44	63.3	82.3	65.9	58.0
06/03/2018 09:59	63.8	79.8	66.4	58.4
06/03/2018 10:14	63.9	78.4	66.7	57.5
06/03/2018 10:29	65.7	87.4	67.2	58.4
06/03/2018 10:44	65.7	85.1	67.1	59.0
06/03/2018 10:59	71.5	93.9	67.5	59.0
06/03/2018 11:14	64.0	80.5	66.4	58.7
06/03/2018 11:29	64.5	82.2	66.7	57.6
06/03/2018 11:44	63.7	80.5	66.4	58.3
06/03/2018 11:59	63.7	81.0	66.3	57.1

Table 18: Results of environmental noise measurements at Position 2

Date & time	L_{Amax} [dB]	L_{Aeq} [dB]	L_{A10} [dB]	L_{A90} [dB]
05/03/2018 12:30	50.2	65.9	51.8	46.6
05/03/2018 12:45	50.2	63.4	52.2	46.5
05/03/2018 13:00	50.2	62.2	53.1	46.3
05/03/2018 13:15	49.6	62.1	52.0	46.0
05/03/2018 13:30	50.2	63.7	52.2	45.9
05/03/2018 13:45	50.9	63.9	53.2	46.4
05/03/2018 14:00	50.4	66.7	51.5	46.4
05/03/2018 14:15	50.7	70.7	51.8	45.2
05/03/2018 14:30	50.7	68.5	52.7	47.0
05/03/2018 14:45	52.3	71.9	53.7	46.7
05/03/2018 15:00	50.1	61.3	52.6	46.4
05/03/2018 15:15	49.5	60.7	51.5	47.0
05/03/2018 15:30	54.0	71.8	53.7	47.8
05/03/2018 15:45	51.1	64.8	53.4	47.2
05/03/2018 16:00	52.5	69.7	52.9	47.3
05/03/2018 16:15	52.0	67.8	54.0	48.0
05/03/2018 16:30	50.4	65.6	52.1	47.3
05/03/2018 16:45	50.7	64.5	53.1	46.8
05/03/2018 17:00	51.3	67.2	52.4	46.6
05/03/2018 17:15	51.3	64.6	53.6	46.9
05/03/2018 17:30	50.2	62.1	52.5	46.8
05/03/2018 17:45	51.1	65.2	53.1	47.6
05/03/2018 18:00	52.4	74.8	53.9	48.1
05/03/2018 18:15	52.6	67.9	55.9	46.8
05/03/2018 18:30	51.5	67.9	53.5	47.9
05/03/2018 18:45	50.3	64.8	51.9	47.7
05/03/2018 19:00	56.2	74.8	57.9	48.1
05/03/2018 19:15	52.7	68.4	55.3	47.9
05/03/2018 19:30	51.9	66.1	54.3	47.5
05/03/2018 19:45	49.2	63.3	50.8	46.8
05/03/2018 20:00	49.9	67.9	51.6	46.3
05/03/2018 20:15	49.5	60.8	51.1	46.4
05/03/2018 20:30	51.4	69.1	51.7	46.2

Date & time	L_{Amax} [dB]	L_{Aeq} [dB]	L_{A10} [dB]	L_{A90} [dB]
05/03/2018 20:45	51.2	66.7	52.7	46.9
05/03/2018 21:00	49.0	55.9	50.5	47.0
05/03/2018 21:15	49.2	58.4	51.2	46.7
05/03/2018 21:30	50.8	71.2	51.4	47.1
05/03/2018 21:45	48.3	57.4	50.0	45.9
05/03/2018 22:00	49.2	59.7	50.8	46.8
05/03/2018 22:15	48.7	60.7	50.0	46.3
05/03/2018 22:30	49.4	63.9	51.1	47.0
05/03/2018 22:45	49.6	64.8	51.4	46.5
05/03/2018 23:00	50.6	67.0	51.0	45.5
05/03/2018 23:15	47.3	56.1	49.5	44.3
05/03/2018 23:30	46.3	56.6	48.4	43.5
05/03/2018 23:45	47.5	68.1	48.4	42.8
06/03/2018 00:00	45.6	58.7	47.8	42.4
06/03/2018 00:15	44.5	56.2	46.8	41.5
06/03/2018 00:30	44.4	57.8	46.6	41.1
06/03/2018 00:45	43.9	53.9	46.3	41.0
06/03/2018 01:00	42.7	52.3	45.1	40.2
06/03/2018 01:15	42.8	51.9	45.0	40.1
06/03/2018 01:30	42.3	49.8	44.8	39.2
06/03/2018 01:45	41.1	48.7	43.2	38.5
06/03/2018 02:00	43.9	61.7	44.3	38.8
06/03/2018 02:15	47.5	69.1	44.5	38.4
06/03/2018 02:30	41.8	55.7	44.8	37.4
06/03/2018 02:45	42.9	64.1	44.0	38.1
06/03/2018 03:00	40.9	63.9	43.2	37.3
06/03/2018 03:15	42.3	52.9	44.9	38.6
06/03/2018 03:30	42.1	60.3	44.6	38.3
06/03/2018 03:45	41.7	58.9	43.8	38.8
06/03/2018 04:00	42.5	53.4	45.5	38.7
06/03/2018 04:15	43.1	51.7	45.9	39.2
06/03/2018 04:30	42.7	51.8	44.9	39.5
06/03/2018 04:45	44.3	57.9	46.5	40.0
06/03/2018 05:00	45.9	64.1	48.0	40.7

Date & time	L_{Amax} [dB]	L_{Aeq} [dB]	L_{A10} [dB]	L_{A90} [dB]
06/03/2018 05:15	47.7	62.9	50.1	42.0
06/03/2018 05:30	46.5	57.7	48.9	42.4
06/03/2018 05:45	50.1	67.4	51.1	42.6
06/03/2018 06:00	50.2	66.6	52.9	44.3
06/03/2018 06:15	50.0	67.3	51.8	45.0
06/03/2018 06:30	49.6	60.5	51.9	46.2
06/03/2018 06:45	49.8	63.4	51.8	46.7
06/03/2018 07:00	51.1	69.8	53.1	46.7
06/03/2018 07:15	50.5	62.7	53.0	46.5
06/03/2018 07:30	50.5	62.2	52.4	47.4
06/03/2018 07:45	51.2	63.6	53.3	47.5
06/03/2018 08:00	51.5	72.0	52.5	47.4
06/03/2018 08:15	52.1	67.5	54.0	48.2
06/03/2018 08:30	52.4	69.2	54.1	48.7
06/03/2018 08:45	50.9	64.5	52.9	47.2
06/03/2018 09:00	51.5	67.1	53.9	47.2
06/03/2018 09:15	51.9	69.2	54.2	47.3
06/03/2018 09:30	52.4	73.4	54.1	46.8
06/03/2018 09:45	50.3	64.5	52.6	46.5
06/03/2018 10:00	49.6	63.0	51.5	46.5
06/03/2018 10:15	50.8	65.5	53.0	46.3
06/03/2018 10:30	50.6	67.4	52.0	46.5
06/03/2018 10:45	51.0	65.3	52.0	46.5

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