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Technical Report:

Environmental Noise Assessment
For Sparks Farm, Hurdle Drove
West Row, Mildenhall
Suffolk

dBC 10713

Environmental Noise Assessment

Date of Assessment:	16 August 2023
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1. Executive Summary

1.1. This environmental noise assessment has been produced to accompany a planning application for 4 one-bedroom units within an existing barn structure, for David Shipp of Hammetts Farm, for submission to West Suffolk Council.

1.2. The acoustic environment at the proposed development, during the monitoring period, was dominated by agricultural machinery and flying sorties from RAF Mildenhall and RAF Lakenheath.

1.3. The noise affecting the site was measured at location P1 over a six-day period between 28th July and 2nd August 2023. The average daytime noise levels affecting site were $L_{Aeq,16hr}$ 56dB and $L_{Aeq,8hr}$ 49dB at night.

1.4. Using guidance outlined in ProPG Planning and Noise guidance, the measured noise levels place the development into a low to medium risk category meaning the development requires good acoustic design to sufficiently mitigate the potential effects of noise and allow residents comfortable living conditions with regards to external noise.

1.5. To meet the BS 8233:2014 acoustic criteria for indoor noise levels, enhanced double glazing units and increases in the building shell's sound insulation as specified in the 2.0 Recommendations Section below should be installed in bedrooms and living rooms as a minimum. To minimise sleep disturbance the same glazing specification recommended in Section 2 to mitigate against steady external noise sources (BS 8233) should be installed in the bedrooms and trickle ventilation may be installed as specified in Section 2.

1.6. With the recommendations installed, during occasional night flying the internal noise levels may be marginally above the guidance level, however in our considered opinion due to occasion and levels these exceedances would not be excessive and still broadly meet the requirements of NPSE.

1.7. The Noise Policy Statement for England (NSPE) outlines three aims for effective management and control of environmental, neighbourhood and neighbour noise:

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

1.8. The proposed recommendations within this report should address these aims by effectively reducing ambient noise levels from air traffic sources to acceptable levels inside the development.

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2. Recommendations

2.1. The following glazing and background ventilation specifications should be installed in the living rooms and bedrooms of the development. These specifications are the minimum suggested specifications. Any other glazing can be used if the specification used is equivalent.

Element – Glazing	R_w	Sound Reduction Index, R 1/1 octave band centre frequency between 31.5Hz and 8kHz						
		63	125	250	500	1k	2k	4k
8mm Pilkington glass/16mmArgon/ 8.8mm Pilkington Optiphon (living rooms and bedrooms)	42	16	21	30	39	47	50	55
Element – Trickle vent	**D n,e,w (dB)**	1/1 octave band centre frequency between 31.5Hz and 8kHz						
		63	125	250	500	1k	2k	4k
Greenwood 5000EAW.AC2	-	33	42	40	36	48	53	56

Table 1: Sound Reduction Indices, R in dB

2.2. To provide better protection against day and night-time flying noise the sound insulation of all ceilings should be increased. The usual directly fixed 1 layer of 12.5mm plasterboard should be replaced with 2 layers of 15mm 'Soundbloc' plasterboard fixed to the ceiling joists on resilient bars.

2.3. It is recommended that the walls are a brick/block cavity construction.

2.4. The building materials used in the external building façade should not compromise the sound insulation of the building when enhanced glazing specifications are installed. Prior to any construction taking place the materials used in the external building façade and bedroom ceilings is checked by an acoustic consultant.

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3. Introduction

3.1. David Shipp intends to submit a planning application to West Suffolk Council and required a 'Environmental Noise Assessment' and 'Acoustic Design Statement' to accompany the application to protect future residents from the effects of aircraft noise. An acoustic assessment has been undertaken to accompany the planning application for four one-bedroom units within an existing barn structure at Sparks Farm, Hurdle Drove, West Drove.

3.2. Due to the proximity of the development to Mildenhall and Lakenheath Air Bases an environmental noise assessment has been undertaken. This report number dBC/10713/SR/001 will address environmental noise affecting the site.

3.3. dB Consultation Limited has been commissioned to undertake an Environmental Noise Assessment of the proposed new dwellings using methodology and guidance outlined in BS 8233:2014, WHO guidelines and ProPG: Planning and Noise 2017.

3.4. The assessment was based upon the noise measured on site between 28th July and 2nd August 2023 at a representative location to the rear of the proposed barn development.

3.5. The report was written by Samantha Riley of dB Consultation Limited, a practicing acoustician for over 24 years, Full Member of the Institute of Acoustics (MIOA) and experienced in noise assessment in many industrial and commercial sectors.

3.6. The report has been reviewed by Danny Blacklock, Managing Director at dB Consultation Limited, a practicing acoustician for over 25 years, Full Member of the Institute of Acoustics (MIOA) and experienced in noise assessment in many industrial and commercial sectors.

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4. Relevant Standards & References

Noise Policy Statement for England (NPSE)

4.1. The NPSE sets out the long-term vision of the Government's policy on noise, which in essence is to promote good health and a good quality of life through the effective management of noise within the context of Government Policy on sustainable development.

4.2. The NPSE outlines three aims for effective management and control of environmental, neighbourhood and neighbour noise:

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

4.3. In its aims, the NPSE uses key phrases "significant adverse" and "adverse" and these are related to the following terms which are currently being applied to noise impacts.;

- *NOEL – No Observed Effect Level – this is the level below which no effect can be detected or measured,*
- *LOAEL – Lowest Observed Adverse Effect Level – which is the level above which adverse effects on health and quality of life can be detected; and*
- *SOAEL – Significant Observed Adverse Effect Level – which is the level above which significant adverse effects on health and quality of life occur.*

4.4. The NPSE notes that it is not possible to have a single objective noise-based measure that defines SOAEL that would be applicable in all situations, consequently the NOEL, LOAEL and SOAEL are likely to change for the location, noise type and times. It is the acoustician who should identify relevant SOAEL levels taking into account the noise source exposures and receptors.

BS 8233:2014 Sound Insulation and Noise Reduction for Buildings

4.5. This latest revision superseded the previous 1999 version in 2014. It uses the results of research and experience to provide information on the design of buildings to result in suitable internal acoustic environments appropriate for their functions. It includes controlling the noise from outside the building, noise from plant and services within it and room acoustics for non-critical situations.

4.6. The main changes in this latest version of BS8233 were made to include revisions to Building Regulations Approved Doc E, the publication of the National Planning Policy Framework in 2012 removal of documents such as PPG24, and most importantly a reappraisal of the targets for various classes of living spaces following various research findings.

4.7. It must be noted that in the introduction of this document, it raises the point that without due care and attention, certain measures to control noise may have the ability to impinge on fire precautions and other health and safety requirements.

4.8. In section 5.2 BS 8233 states that "when planning permission is sought for a new building or a change of use to an existing building, the local authority may grant permission, with or without conditions regarding noise levels so that local or national policies are met.

4.9. Section 7.7.2 provides a desirable level for the internal ambient noise levels for dwellings which have been included in the table below. These levels have been based on the existing guidance of the WHO and assume normal diurnal fluctuations in external noise, such as rush hour traffic.

Activity	Location	Time Period	
		07:00 to 23:00	23:00 to 07:00
Resting	Living Room	35dB $L_{Aeq,16h}$	-
Dining	Dining Room/Area	40dB $L_{Aeq,16h}$	-
Sleepin	Bedroom	35dB $L_{Aeq,16h}$	30dB $L_{Aeq,8h}$

Table 2: Excerpt of BS8233:2014 Table 4 –Indoor Ambient Noise Levels for Dwellings

4.10. Note 5 of this section states that "If relying on closed windows to meet the guide values, there needs to be an appropriate alternative ventilation that does not compromise the façade insulation or the resulting noise level.

4.11. Section 7.7.3.2 refers to the design criteria for external areas such as gardens and patios. For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50dB $L_{Aeq,T}$ with an upper guideline value of 55dB $L_{Aeq,T}$ which would be acceptable in noisier environments.

4.12. Fig.1 below shows the noise contours from the Report on Military Aviation Noise Contour of Station-Based Aircraft Activity at RAF Lakenheath and RAF Mildenhall (OEM/06/20 report). The location of Sparks Farm is marked with a blue star and is located outside of the 66dB contour.

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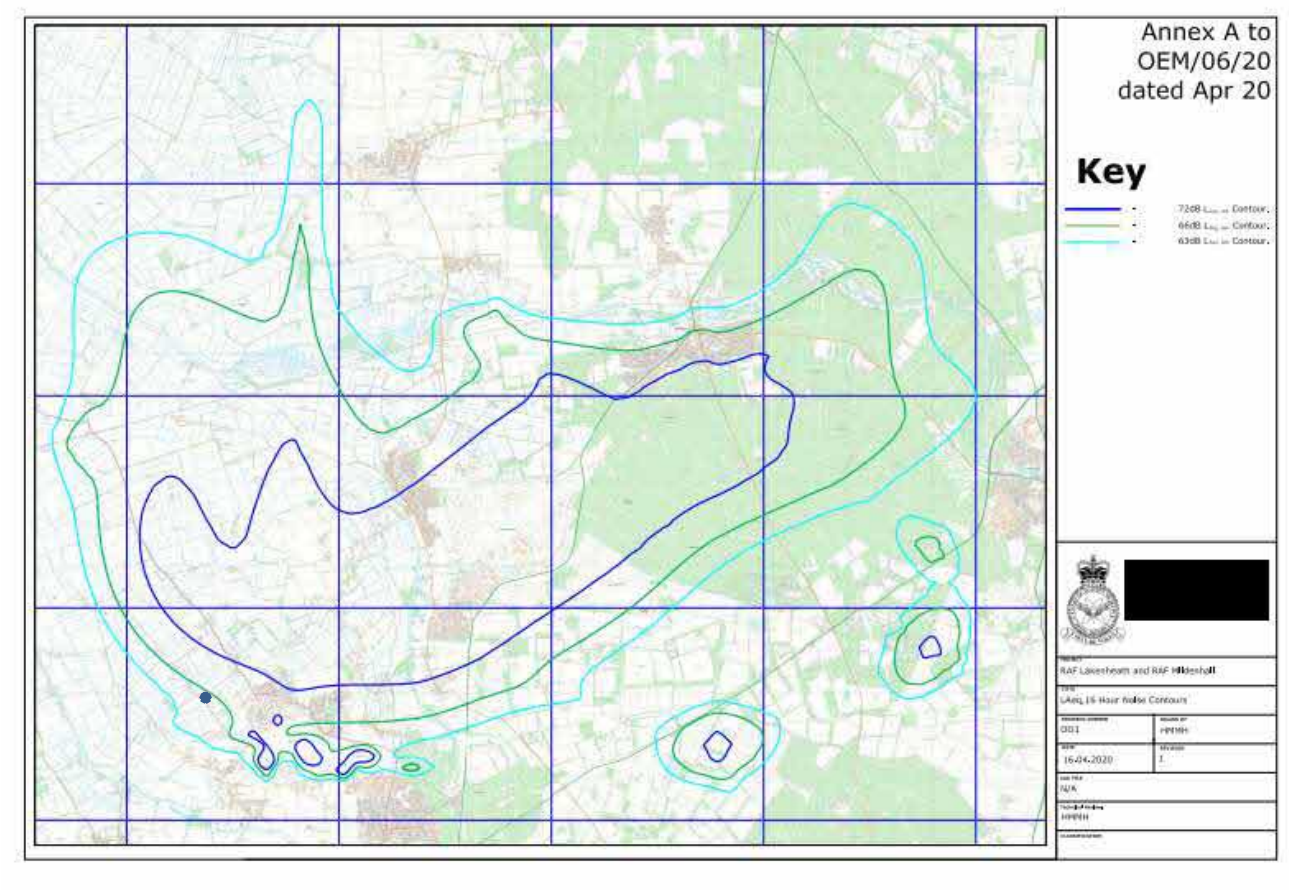

Fig.1: Noise Contour of Station-Based Aircraft Activity at RAF Lakenheath and RAF Mildenhall and location of Sparks Farm marked by a blue star.

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5. Site Description

5.1. The proposed four one-bedroom units are to be located within an existing barn surrounded by a mixture of arable and livestock agricultural land. The site is located on a single lane road with farmhouses and other residential properties in the vicinity. The acoustic environment on site is dominated by aircraft noise emanating from RAF Mildenhall located 1250m to the southeast of the site as indicated in Fig.2 and RAF Lakenheath located over 7000m northeast of the site.

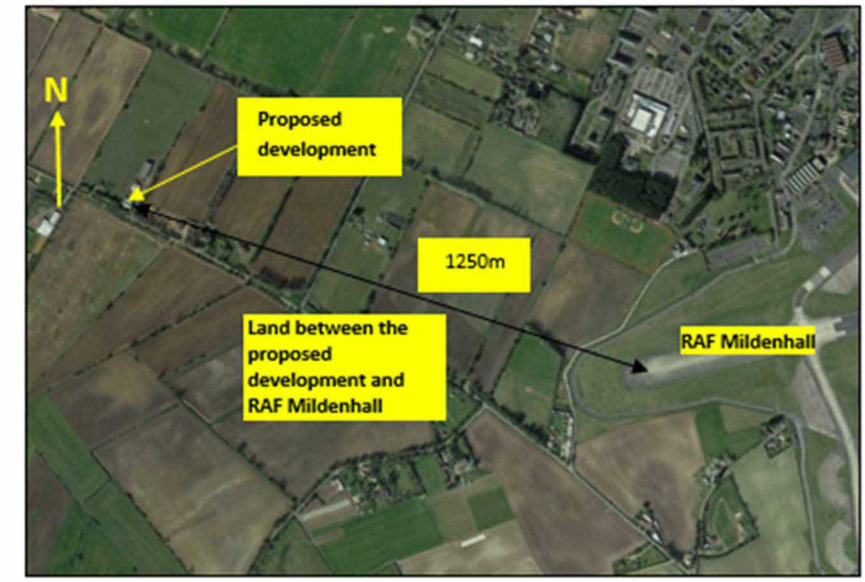

Fig.2: Site Location in relation to RAF Mildenhall.

5.2. Fig.3 shows the location of the proposed development to the north of Hurdle Drove, outlined in white and the monitoring location P1 marked.

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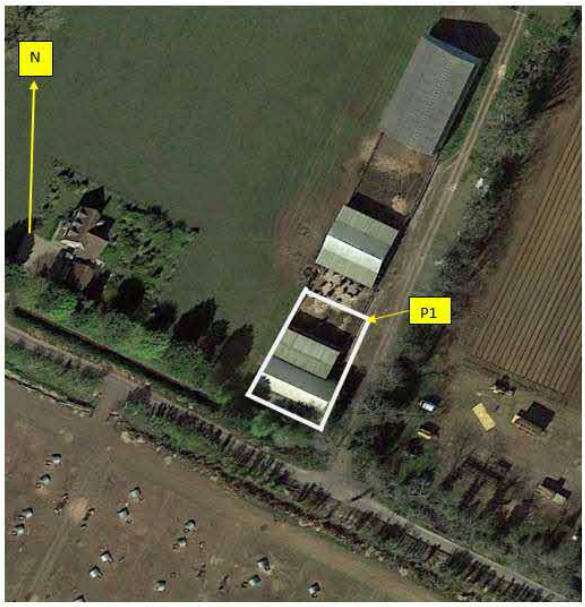

Fig.3: The location of the proposed development outlined in white and monitoring location P1.

5.3. Fig.4 below shows the proposed floor plan for the four units.

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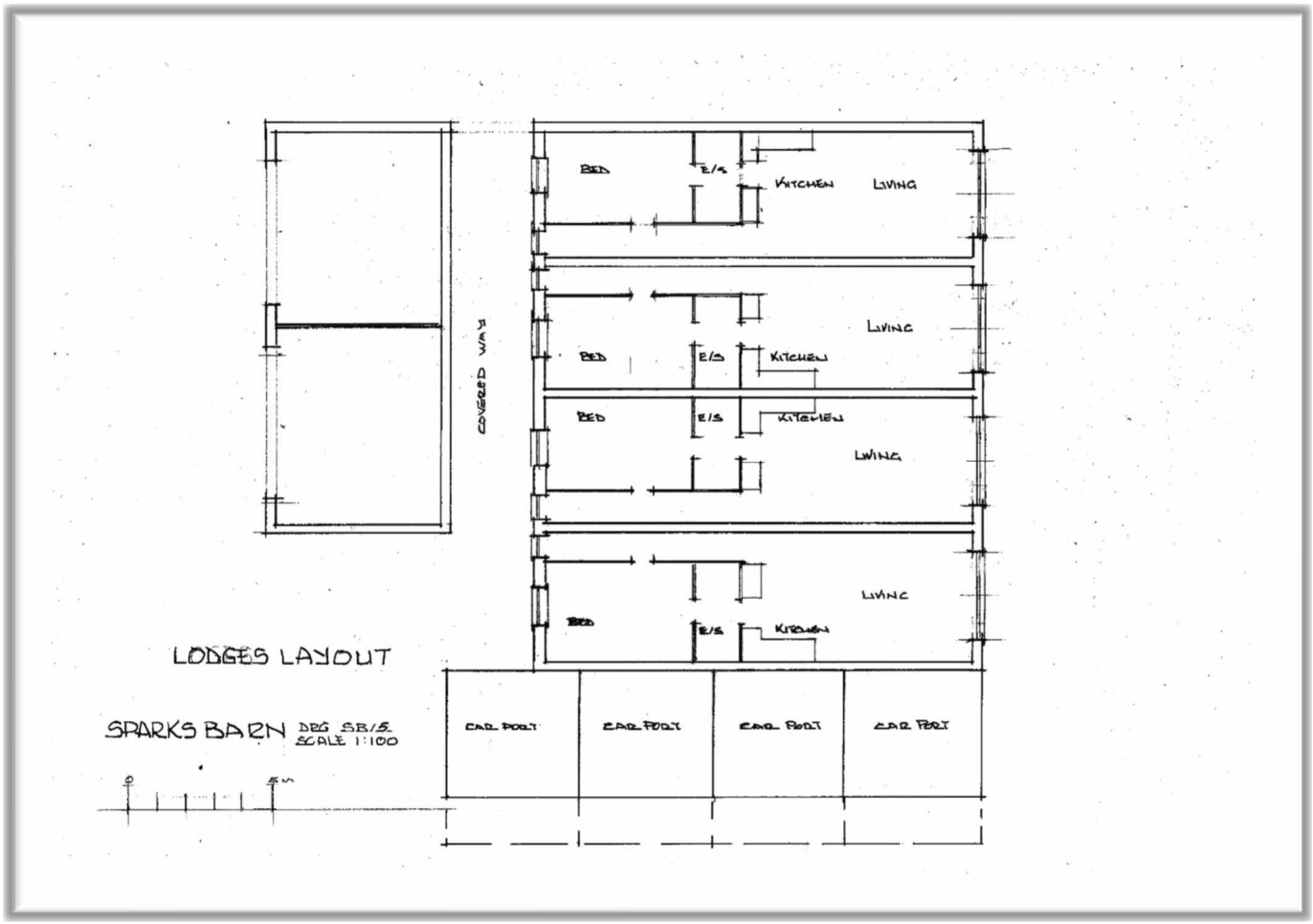

Fig.4: Proposed floor plan.

6. Environmental Noise Measurements

6.1. The noise affecting the site was measured in the proposed rear garden behind the existing barn, monitoring location P1, representative of the noise from aircraft from RAF Mildenhall and RAF Lakenheath affecting the site. The measurement location is described in Table 3 below and indicated with the yellow arrow in the photograph.

Location	Description	Photograph
P1	Situated behind the existing barn at Sparks Farm, Hurdle Drove, Mildenhall, 1.7m off the ground	

Table 3: Noise Monitoring Location

6.2. The monitoring was undertaken using one Norsonic 140 sound level meter serial 1404899 and using a Campbell Associates outdoor microphone system serial number NOR-1211#2.14155 which was field calibrated to 114dB at 1kHz using a Nor-1251 calibrator serial number 34682. Both meter and calibrator have been calibrated at a UKAS accredited laboratory within the last two years. Calibration certificates are available upon request.

6.3. The field calibration readings were within were standard guidance allowance.

6.4. A summary of the weather between 28th July and 2nd August 2023 has been summarised below in Table 4 below.

Date	Time	Details	Temperature °C	Wind Speed m^{-1}	Wind Direction
28tJJuly	23.00-07.00	Light cloud, sunny intervals	15-24	3.6-4.9	W/SW
28th/29th July	07.00-23.00	Light cloud, showers	15-18	3.6-4.0	SW
29thJuly	07:00-23:00	Light showers, sunny intervals	16-21	4.0-7.6	SW/W
29th/30th July	23:00-07:00	Clear Sky, dry	13-15	4.9-5.8	SW
30thJuly	07:00-23:00	Sunny intervals, light showers	14-20	4.9-8.9	W
30th/31st July	23:00-07:00	Overcast, light showers	15-16	4.5-4.9	SW
31s August	07:00-23:00	Showers, heavy rain	16-20	5.4-8.5	SW/W
31st March/1st August	23:00-07:00	Drizzle, showers	14-17	4.5-5.8	W
1st August	07:00-23:00	Light showers, sunny intervals	15-19	4.0-6.7	W
1st/2nd August	23.00-07.00	Patchy cloud	9-10	4.0-4.5	W
2nd August	07.00-23.00	Drizzle, sunny intervals	14-19	2.2-5.4	W

Table 4: Weather

6.5. During the monitoring there were periods where the wind exceeded the recommended level and the data was used with caution, however the noise from sorties was significant and not impacted by elevated wind speeds.

6.6. BS 8233:2014 paragraph 6.3.2 states: '*It should be noted that for a jet aircraft the frequency content of* noise *when landing is generally different from that when departing. Typically, landing jet aircraft produce relatively higher levels of high frequency noise and departing jet aircraft produce relatively higher levels of low frequency noise.*'

6.7. The worst-case scenario for occupants of the development would be during take-off when the noise spectrum would contain a higher level of low frequency noise. Low frequency noise is more difficult to attenuate than higher frequency.

6.8. Table 5 contains the free-field, daytime (07:00-23:00) $L_{Aeq,16hr}$ and night-time (23:00-07:00) $L_{Aeq,8hr}$ ambient noise levels affecting site between 28th July and 2nd August 2023.

Monitoring Location	Date	Daytime $L_{Aeq,16hr}$	Date	Night-time $L_{Aeq,8hr}$
	28tr July	53	28tr/29th July	48
	29th July	56	29th/30th July	46
	30th July	53	30th/31st July	48
	31st July	57	31st July/1st August	46
	1st August	57	1st/2nd August	53
	2nd August	57		
	Log Averag	**56**	**Log Averag**	**49**

Table 5: Environmental Noise Measurements in dB at P1

6.9. At P1 the average daytime noise level was 56dB(A) and 49dB(A) at night. The ambient noise seemed consistent with distant traffic and flying sorties.

6.10. The average 1/1 octave band centre frequencies between 63Hz and 4kHz for daytime, night-time and worst-case scenario flying noise, (marginally below the 66dB contour) affecting the site are shown in Table 6 below. The worst case, when flying occurs, levels will be used in the BS 8233:2014 Assessment.

Time period	L_{Aeq}	1/1 octave band centre frequency (Hz)						
		63	125	250	500	1k	2k	4k
Daytime	56	63	61	59	55	50	47	44
Night-time	49	64	57	52	49	46	44	43
Worst-case scenario Flying (day and night)	64	60	63	67	63	60	53	40

Table 6: 1/1 octave band level affecting site

6.11. Considering the worst case measured ambient noise levels on site, ProPG Guidance places the site in a medium to high risk category, whereby the development should be subject to good acoustic design to ensure the comfort of future occupants.

6.12. There is precedent set with other residential properties in the vicinity, some closer to the airfield.

7. BS 8233:2014 Assessment

Internal Ambient Noise Levels

7.1. Section 4 of this report outlines the desirable indoor ambient noise levels expected for steady external sources within living rooms and bedrooms.

7.2. The indoor ambient noise level within the living room and bedroom at the assessed location has been determined by calculation using the data in Table 6 and using the following room dimensions and the sound reduction indices (R) of the building products in Table 7.

Living Room size 8mL x 4.5mW x 2.4mH windows 6m^2

Bedroom size 5mL x 3.5mW x 2.4mH windows 1m^2

Element	R_w	Sound Reduction Index, R 1/1 octave band centre frequency between 31.5Hz and 8kHz								
		31.5	63	125	250	500	1k	2k	4k	8k
Brick/Block Cavity	50	24	28	34	41	45	54	58	58	58
Roof (enhanced ceiling) living rooms and bedrooms	48	20	26	32	38	44	50	56	62	62
8mm glass/16mmArgon/ 8.8mm Pilkington Optiphon (living and bedrooms)	42	11	16	21	30	39	47	50	55	55

Table 7: Sound Reduction Indices, R in dB

7.3. Despite the noise from flying sorties affecting the proposed new development the overall noise levels were not considered too high, so the use of trickle vents for background ventilation would be acceptable for the development.

7.4. An example trickle vent specification is shown in Table 1 in the Recommendations section above.

7.5. Furthermore, with such a high specification of glazing installed, the overall external façade sound insulation performance of the walls and roof is limited to that of the construction materials used. *It is important that the external wall and roof constructions are checked prior to construction starting to ensure that the external materials do not compromise the use of such high specification glazing.* Full recommendations are given in Section 2 of this report.

7.6. Using the measured ambient noise levels at P1, the calculated indoor ambient noise levels within the living room and bedroom of the assessed house have been shown, with the appropriate assessment criteria, in Table 8.

7.7. It is reasonable, at this location, to consider the instances of flying sorties from RAF Mildenhall and RAF Lakenheath on indoor ambient noise levels. During the monitoring period there were instances where noise levels were distinctly elevated as a result of flying from the air bases. Therefore, in our considered

opinion, to ensure protection against flying sorties, we have used the highest 1 hr daytime ambient noise levels affecting site to determine the daytime internal noise levels. The night-time internal noise levels were determined using the 8hr average night-time noise level and to protect against occasional night-time flying the same 1hr levels used for the daytime assessment of the living room. Using the data during this period only the indoor ambient noise levels were determined by calculation and the levels shown in Table 8.

Living Room		Living Room flying		Bedroom		Bedroom Night-time flying	
$L_{Aeq,16hr}$	Criteria	$L_{Aeq,1hr}$	Criteria	$L_{Aeq,8hr}$	Criteria	$L_{Aeq,1hr}$	Criteria
30	35	35	35	23	30	32	30

Table 8: Indoor Ambient Noise Levels in dB

7.8. In reference to internal noise levels ProPG states '*These internal L_{Aeq} target levels are based on annual average data and do not have to be achieved in all circumstances. For example, it is normal to exclude occasional events, such as fireworks night and New Year's Eve*'. dBC has not received data stating the number of times during a year RAF Mildenhall and RAF Lakenheath undertakes night flying. If night flying was considered an occasional event, then it would be reasonable to assume target guidelines will not be met during these events, but it should be noted that the protection afforded by the glazing and external façade construction should be such that any exceedance of guidance levels is not excessive, in our considered opinion.

7.9. Furthermore, when dealing with reasonably high external noise levels ProPG also states '*Where development is considered necessary or desirable, despite external noise level above the guidelines, the internal L_{Aeq} target levels may be relaxed by up to 5dB and reasonable internal conditions still achieved*.' The internal levels in bedrooms during night flying would only occassionally be marginally above the guideline levels in this case.

External Amenity Areas

7.10. The development has an external amenity space (garden) to the rear of property and is affected by aircraft noise. The average daytime ambient noise level measured during the monitoring period was $L_{Aeq,16hr}$ 56dB which is marginally above the upper guideline value of 55dB(A). During flying sorties short periods of evaluated levels will be experienced. Although, the gardens cannot be screened from air traffic and as the monitoring suggests this is likely to occur every day, the levels are within acceptable limits overall.

7.11. The development is not adjacent to or influence by road traffic, except sporadic local farm activity so no perimeter screening is required.

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7.12. It is our considered opinion that the provision of amenity areas is essential to this development despite being affected by relatively high annual average noise levels during flying sorties. The benefits of the gardens outweigh the fact they will be subject to occasional higher than desirable noise levels at certain times of the day.

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8. Conclusions and Recommendations

8.1. During the monitoring period of 28th July to 2nd August 2023 the acoustic environment surrounding the development at Sparks Farm, Hurdle Drove, Mildenhall was dominated by flying sorties from RAF Mildenhall and RAF Lakenheath. The daytime ambient noise level was $L_{Aeq,16hr}$ 56dB and $L_{Aeq,8hr}$ 49dB at night.

8.2. The site is affected by relatively high noise levels during flying sorties and the worst-case ambient daytime and night-time levels is 64dB(A) which, according to ProPG Guidance place the site in a medium risk category during the day, and on the rare occasions when there is night flying in the high risk category meaning the development requires good acoustic design to sufficiently mitigate the potential effects of noise and allow residents comfortable living conditions with regards to external noise.

8.3. Part of the good acoustic design is the installation of enhanced double-glazing to the living rooms and bedrooms. To ensure reasonable ambient noise levels at the development the following acoustic specification for glazing have been recommended.

Room	Element	R_w	Sound Reduction Index, R 1/1 octave band centre frequency between 31.5Hz and 8kHz						
			63	125	250	500	1k	2k	4k
Living room and Bedrooms	8mm glass/16mmArgon/ 8.8mm Pilkington Optiphon (living and bedrooms)	42	16	21	30	39	47	50	55

Table 9: Acoustic Specifications in dB

8.4. Trickle ventilation using vents with the specification in Section 2 above are acceptable for this development.

8.5. Background ventilation should not be confused with opening windows for rapid ventilation or to prevent overheating. The glazing should remain fully openable, and it should always be the occupant's decision to open a window or not. It is usually understood that when living in a location affected by relatively high noise levels there is likely to be a compromise of higher internal noise levels if the windows are opened.

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9. *Acoustic Design Statement*

Stage 1: Initial Site Noise Risk Assessment

9.1. The daytime ambient noise level affecting the development was $L_{Aeq,16hr}$ 56dB and $L_{Aeq,8hr}$ 49dB at night, there was some influence on these levels by flying activity from RAF Mildenhall and RAF Lakenheath. Therefore, the site is in the low to medium risk category, in this category the risk may be reduced by following a good design process that is demonstrated in a detailed Acoustic Design Statement (ADS).

Stage 2: Element 1 & 2 –Good Acoustic Design process/Internal Noise Level Guidance

9.2. To ensure that good acoustic conditions exist in all living rooms of the development enhanced double-glazing units (R_w 42dB) with good low frequency attenuation properties, as specified in Section 7 above, should be installed. Trickle ventilation can be installed as part of the glazing units at this development.

9.3. To ensure good protection against external noise levels at night, with or without night flying, enhanced double glazing units (R_w42dB) as specified in Section 7 should be installed. The weakness in terms of the living rooms and bedroom façades is the roof/ceiling, to maximise protection from external noise the sound insulation of all the ceilings should be increased. The ceilings should have two layers of 15mm 'Soundbloc' plasterboard installed on a resilient bar system as opposed to the usual direct-fixed finish of 1 layer of 12.5mm wallboard. This action would reduce the internal noise level to comfortably below guideline levels on normal non-flying days and marginally above the guideline level of 30dB(A) at night during occasional flying activity.

9.4. The glazing should remain fully openable and it should always be the occupant's decision to open a window or not. It is usually understood that when living in a location affected by relatively high noise levels there is likely to be a compromise of higher internal noise levels if the windows are opened.

9.5. On the occasion of night flying (worst-case scenario), reasonable internal noise levels (marginally above the guideline levels) can be met with enhancement of the building shell's sound insulation. Any exceedance would not be considered excessive in this case. It should be noted that natural light within habitable rooms is important to most people so there is no reasonable scope at this development to re-arrangement of the building to protect all the living rooms and bedrooms.

Stage 2: Element 3 –External Amenity Area Noise Assessment

9.6. There is an external amenity space (garden) to the rear of the properties and is affected by aircraft noise. The average daytime ambient noise level measured during the monitoring period was $L_{Aeq,16hr}$ 56dB which is marginally above the upper guideline value of 55dB(A). The garden cannot be screened from air traffic and as the monitoring suggests this is likely to occur every day, so there is no reasonable way to reduce the noise levels affecting the garden from aircraft noise in this case.

9.7. However, it is our considered opinion that the provision of amenity areas is essential to this development despite being affected by relatively high annual average noise levels during flying sorties. The benefits of the gardens outweigh the fact they will be subject to occasional higher than desirable noise levels at certain times of the day.

Stage 2: Element 4 –Assessment of Other Relevant Issues

9.8. The noise mitigation measures for this development will ensure internal noise guidelines are always below the NPSE Lowest Observed Adverse Effect Level (LOAEL) during normal activity affecting the acoustic environment around the development.

9.9. During the worst-case scenario, the occasion of night flying, internal noise guideline may rise to levels considered to have an observed adverse effect (OAE) but would be below the NPSE Significant Observed Adverse Effect Level (SOAEL). The glazing specification and enhancement to the bedroom ceiling detail and external building façade for this development would ensure that any exceedance would not be excessive. Please note: dBC has no data regarding night-flying activity to consider currently.

9.10. This Environmental Noise Assessment provides all the appropriate evidence and discussion on the good acoustic design consideration for this development.

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10. Glossary of Acoustic Terminology.

dB(A)

The human ear is less sensitive to low (below 125Hz) and high (above 16kHz) frequency sounds. A sound level meter can be used to duplicate the ear's variable sensitivity to sound across a spectrum of frequencies. This is achieved by building a filter into the instrument with a similar frequency response to that of the average ear. This is called an "A-weighting filter". Measurements of sound made with this filter are called A-weighted sound level measurements and the unit is dB(A).

$L_{eq,T}$

The sound from noise sources often fluctuates widely during a given period of time. An average value can be measured, the equivalent sound pressure level Leq. The Leq is the equivalent sound level which would deliver the same sound energy as the actual fluctuating sound measured in the same time period (T).

$L_{10,T}$

This is the minimum level exceeded for not more than 10% of the time period (T). This parameter is often used as a "not to exceed" criterion for noise.

$L_{90,T}$

This is the minimum level exceeded for not more than 90% of the time period (T). This parameter is often used as a descriptor of "background noise" for environmental impact studies.

L_{fmax}

This is the maximum sound pressure level that has been measured over a period using a fast time constant.

Octave Bands

In order to completely determine the composition of a sound it is necessary to determine the sound level at each frequency individually. Usually, values are stated in octave bands. The audible frequency region is divided into 10 such octave bands whose centre frequencies are defined in accordance with international standards.

Addition of noise from several sources

Noise from different sound sources combine, on a logarithmic scale, to produce a sound level higher than that from any individual source. Two equally intense sound sources operating together produce a sound level which is 3dB higher than one alone and 3 identical sources produce a 5dB higher sound level.

Attenuation by distance

Sound which propagates from a point source in free air attenuates by 6dB for each doubling of distance from the noise source. Sound energy from line sources (e.g. stream of cars) drops off by 3dB for each doubling of distance.

Subjective impression of noise

Sound intensity is not perceived directly at the ear; rather it is transferred by the complex hearing mechanism to the brain where acoustic sensations can be interpreted as loudness. This makes hearing perception highly individualised. Sensitivity to noise also depends on frequency content, time of occurrence, duration of sound and psychological factors such as emotion and expectations. The following table is a reasonable guide to help explain increases or decreases in sound levels for many acoustic scenarios.

Change in sound level (dB)	Change in perceived loudness
1	Imperceptible
3	Just barely perceptible
6	Clearly noticeable
10	About twice as loud
20	About 4 times as loud

Barriers

Outdoor barriers can be used to reduce environmental noises, such as traffic noise. The effectiveness of barriers is dependent on factors such as its distance from the noise source and the receiver, its height and its construction.

Reverberation control

When sound falls on the surfaces of a room, part of its energy is absorbed and part is reflected back into the room. The amount of reflected sound defines the reverberation of a room, a characteristic that is critical for spaces of different uses as it can affect the quality of audio signals such as speech or music. Excess reverberation in a room can be controlled by the effective use of sound-absorbing treatment on the surfaces, such as fibrous ceiling boards, curtains and carpets.