

Acoustic Associates Sussex Ltd

Planning Condition Noise Assessment

Site: 'Roseland', The Causeway, Arundel

Client: Birchside Management Ltd

Planning Reference: LY/9/17/PL

Report by: George Orton BEng(Hons) MIOA

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Issue 2



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Issue 1	09/10/2017	
Issue 2	27/10/2017	New top floor (in roof) flat

1 Introduction

Acoustic Associates have been appointed to undertake an acoustic assessment of the proposed 'Roseland', The Causeway, Arundel development.

The development has gained planning approval albeit with certain conditions. Planning conditions 12, 13 & 14 relate to noise. The planning conditions are discussed in section 4.

The development will demolish the existing buildings and build a new block of residential apartments in its place.

Transportation (road and rail) noise has been measured, close to where the development will be built, prior to the existing building being demolished.

The report assesses the following:

- Noise levels affecting the proposed development.
- Mitigation Measures to reduce internal noise levels so that the planning condition noise criteria can be achieved.

Noise propagation around the proposed development has been predicted using the computer program IMMI (Wolfel).

The noise levels for the day and the night time period have been assessed in terms of and following the guidelines of the documents listed below:

- BS8233 (Sound insulation and noise reduction for buildings) 2014
- ISO9613 (Attenuation of sound during propagation outdoors) 1996

Noise mitigation measures have been recommended and if they are implemented by the developer it is considered that the "Pre-Commencement" planning conditions criteria will be achieved.

2 Context, Noise Criteria & Noise Assessment Methodology

2.1 Context

The proposed development will comprise of one block of flats (2 on ground floor, 2 on first floor and one second floor flat built into the roof)

All of the existing buildings will be demolished to make way for the new development. The proposed site layout plan can be seen in the appendix. The development has gained planning approval, albeit with certain conditions.

Planning condition 12, 13 & 14, which relate to noise has been copied below:

12: Before the development commences the applicant shall submit an Acoustic Report to demonstrate the predicted noise levels at and within the proposed noise sensitive residential units as may be caused by any road, railway, or other source of noise within the locale. As necessary, a scheme shall then be provided to demonstrate that the internal noise levels within the residential units will conform to the "indoor ambient noise levels for dwellings" guideline values specified within BS 8233: 2014, Guidance on Sound Insulation and Noise Reduction for Buildings, which shall be submitted to and approved in writing by the Local Planning Authority. The scheme should take into account the correct number of air changes required for noise affected rooms. Please note that this authority will be unlikely to accept any other than mechanically treated forced air ventilation in the case that high levels of noise exposure are indicated in habitable rooms. The work specified in the approved scheme shall be carried out in accordance with the approved details prior to occupation of the premises and be retained thereafter.

13: Prior to the commencement of the development, a scheme shall be submitted to and approved in writing by the Local Planning Authority to demonstrate that the noise levels within the external amenity area of the proposed residential units, as applicable, will conform to the "design criteria for external noise" upper guideline value of 55 dB LAeq,T, as specified within BS 8233: 2014, Guidance on Sound Insulation and Noise Reduction for Buildings. The work specified in the approved scheme shall then be carried out in accordance with the approved details prior to occupation of the premises and be retained thereafter.

14: Before first occupation of any dwelling where unacceptably high levels of noise are likely to be experienced, then post validation testing shall be undertaken by a competent person to determine compliance with the acoustic report and BS8233. This must be submitted and agreed in writing with the Local Planning Authority before first occupation.

2.2 Criteria

Based upon the wording of the condition it is recommended that criteria are provided by:

- BS8233 (Sound insulation and noise reduction for buildings) 2014

Calculations of noise propagation will follow the principles detailed within:

- ISO9613 (1996) Attenuation of sound during propagation outdoors

Calculations of noise break-in will follow the principles detailed within:

BS8233 (Sound insulation and noise reduction for buildings) 2014

2.3 BS8233 Noise Criteria

Table 5 of BS8233 provides the following guideline values:

Activity	Location	Time period of day	
		07:00-23:00	23:00-07:00
Resting	Living Rooms	35dB L _{Aeq,16hour}	-
Dining	Dining Room/Area	40dB L _{Aeq,16hour}	-
Sleeping (daytime resting)	Bedroom	35dB L _{Aeq,16hour}	30dB L _{Aeq,8hour}

Table 1: BS8233 Criteria

With regard to external amenity areas BS8233 (7.7.3.2 Design criteria for external noise) states the following:

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

Further to the above, Planning Practice Guidance 2014 (Noise) states the following:

Are there further considerations relating to mitigating the impact of noise on residential developments? Yes – the noise impact may be partially off-set if the residents of those dwellings have access to: A relatively quiet, protected, external publically accessible amenity space (e.g. a public park or a local green space designated because of its tranquillity) that is nearby (e.g. within a 5 minutes walking distance).

3 Unattended Noise Survey Baseline Conditions and Results

An unattended noise survey was carried out from the 29/09 to the 04/10 2017 in order to measure Road/Rail noise levels affecting the proposed development. Noise measurements were conducted on top of the site hoarding fence.

The noise monitoring locations can be seen in the survey noise models found in the appendix.

3.1 Baseline Conditions

- Survey carried out by: George Orton BEng (Hons) MIOA
- Equipment used: Castle Mirus - Type 1 Sound Level Meter
- Weather conditions: Variable (showers); Wind: variable direction
Probable gusts in excess of 5ms⁻²

Meters were calibrated before and after commencing the noise measurements (@94dB no drift).

The microphone was approximately 3.5m from the ground and well away from any other reflective surfaces with the exception of the fence below.

As the reflective surface was not behind the microphone the results will be classified as freefield. This may result in noise levels that are marginally higher than a true freefield value.

All noise levels in the report, including those predicted by the noise model, will be free-field unless stated otherwise.

3.2 Noise Survey Results

At this position the dominant noise source is the road (see next sections). The survey data has been used to calculate the 16hr day time and the 8hr night time period noise levels:

Date 2017	Day	Freefield dBA	
		L _{Aeq} 07:00-23:00hrs	L _{Aeq} 23:00-07:00hrs
29/09	Friday	-	52.1
30/09	Saturday	57.3	52.3
01/10	Sunday	57.9	53.8
02/10	Monday	59.7	54.5
03/10	Tuesday	59.4	54.8
Average all		59	54
Average weekdays		60	55

Table 2: Unattended Noise Survey Levels

4 Rail Noise Survey Baseline Conditions and Results

Attended rail noise measurements were also conducted on the 04/10/2017.

4.1 Baseline Conditions

- Survey carried out by: George Orton BEng (Hons) MIOA
- Equipment used: Norsonic - Type 1 Sound Level Meter
- Weather conditions: Dry; Wind: Gusts up to around 5ms⁻²

Meters were calibrated before and after commencing the noise measurements (@94dB no drift). The microphone was approximately 1.5m from the ground and well away from any other reflective surfaces I.E. free field. All noise levels in the report, including those predicted by the noise model, will be free-field unless stated otherwise. The chosen location was closer to the railway line (see appendix) in order to measure railway noise levels in absence of extraneous noise sources (Road noise).

4.2 Rail Noise Survey Results

Short measurements were completed for various train pass-by events. The measurements were started when the train noise was audible and finished when the train passed by and was inaudible. These measurements will be used to aid with the completion of the computer noise model.

The results can be seen in the table below:

Train Type	Freefield dBA		
	L _{Aeq}	L _{Amax}	SEL
North Stop	66	79.6	84.4
South No Stop	76.8	85.9	89.3
South Stop	67.7	72.7	85.5
North No Stop	78.3	84.7	88.1

Table 3: Rail Noise Survey Levels

5 Prediction of Rail Noise

In order to calibrate the noise model the day and night time rail noise levels will be predicted.

5.1 Methodology

The noise levels for the day and night time periods have been predicted, using on site measurements, rather than measuring constantly for 24hrs or more. The predictions have been made using the following information:

- Current time table data which details the number of passenger trains that pass by the site.
- Train Sound Exposure levels were measured on site during the day time. These individual measurements were then grouped into train types based direction and whether they stopped at the station or not.

The above is in accordance with Calculation of Rail Noise 1995 which states the following in section 43 paragraph 2 and 3.

"In order to determine the $L_{Aeq,16h}$ or $L_{Aeq,8h}$ noise level it may be necessary to carry out SEL noise measurements of each train pass-by over the full time period of interest. Exceptions to this may occur when the train mix and speed of individual train types remain reasonably constant over the relevant time period. For this situation, it is acceptable to measure a representative sample of individual train pass bys of each train type running on each track and determine an arithmetic mean value for the SEL for each case."

In paragraph 3 CRN goes on to say that having established by measurement the mean values for the SELs of each train type operating on the railway, the day and the night time noise levels ($L_{Aeq,16hr}$ and $L_{Aeq,8h}$ should be calculated using a formula that is also stated in CRN. The SEL to $L_{Aeq,day/night}$ formula is detailed below and implemented in section 4.

For each train type: $L_{Aeq} = SEL - 10\log T + 10\log N$

- $N =$ no. of events in period (For each train type based upon timetable information)
- $T =$ no. of seconds in period (57600 seconds for the day and 28800 for the night)

It should be noted that a train SEL measured in the daytime is likely to be marginally higher than if an identical train SEL was measured at night time. This is due to the fact that in the daytime the background noise levels are generally higher than at night time and during the train SEL measurement background noise will be "captured" as well as the train noise.

The predicted day and night time noise levels at the survey position have been used to calibrate a noise model (section 6) which predicts noise levels around the whole of the proposed development.

5.2 Rail Noise Prediction at Closest Survey Point

The train table has been reviewed and in general for the day time there will be 2 trains per hour, in each direction, that stop at the station. In general for each stopping train there is also a non-stopping train (trains join or split at Horsham).

For the night time period 6 trains stop at the station on the way to London (North) and 4 trains stop on the way from London (south). Again it is assumed that there will be the same number of non-stopping trains as there is stopping trains.

In paragraph 3 CRN states that having established, by measurement, the mean values for the SELs of each train type operating on the railway, the day and the night time noise levels ($L_{Aeq,16hr}$ and $L_{Aeq,8h}$) can be calculated. The day and the night time period noise level relating to each train type can be calculated using the following formula

$$\text{Train Type } L_{Aeq, \text{ day/night}} = \text{SEL} - 10\log T + 10\log N$$

- N = no. of events in period (For each train type based upon timetable information)
- Day = 07:00-:23:00hrs & Night = 23:00-07:00hrs

T = no. of seconds in period (57600 seconds for the day and

The tables below show the predicted noise levels at the survey position:

Train Type	SEL	N	$L_{Aeq, \text{ day}}$
North Stop	84.4	32	52
South Stop	85.5	32	53
North no stop	88.1	32	56
South no stop	89.3	32	57
Total $L_{Aeq, \text{ day}}$			61

Table 4: Day Time Rail Noise Level

Train	SEL	N	$L_{Aeq, \text{ night}}$
North Stop	84.4	6	45
South Stop	85.5	4	44
North no stop	88.1	6	48
South no stop	89.3	4	48
Total $L_{Aeq, \text{ night}}$			53

Table 5: Night Time Rail Noise Level

5.3 Non Passenger Train Activity

The effect of noise from night time freight train activity is sometimes difficult to assess due to irregularity of freight operations and the non-existence of any useful timetable information. However reference can be made to the Network Rail freight services map (from their Sussex Route Utilisation Strategy RUS (shown in appendix) which demonstrates that there are no timetabled freight trains that operate to the East of Chichester. There is a limited freight service between Chichester and Westbury (Near Yeovil). Network rail state that the south coast railway lines are capable of taking freight traffic however the high number of passenger trains makes it impractical.

There may well be occasional leaf clearing or maintenance trains that operate during the day or night-time period. These trains will be seasonal/infrequent and it is very unlikely that there would be several in a week let alone more than one in any night time hour.

6 Computer Noise Model

In order to see how noise varies at different positions around the proposed development it is possible to produce a noise contour map.

A computer noise model has been completed using the computer package IMMI. The survey data and drawings of the proposed development have been used to complete the noise models. IMMI faithfully implements the propagation method of ISO-9613:1996; Acoustics – Attenuation of sound during propagation outdoors.

6.1 Survey Model Methodology

An "existing site" noise model was completed first to allow the calibration of the noise sources. Nearby buildings were added to the model.

Reception Points (RP)s were added to the model in the location of the two noise survey microphones (RPs predict the noise level at a particular height/position within the model)

Initially the railway line was added as a line noise source and the sound power (day/night) was adjusted so the Rail RP matched the average values in tables 4 & 5. Rail noise source was added first as the survey position was closer to the source and the methodology (SEL) measurements meant that there would have been less affect from extraneous noise sources.

The road noise line source was then added to the model (on elevated section of model as the road gains height as it passes over the railway bridge)

The sound power (day/night) was adjusted so the unattended survey RP matched the average values in table 2 (to predict worst case the higher weekday average was used). The survey models can be seen in the appendix of the report.

6.2 Travis Perkins Yard

There is also a small builder's merchant at a distance of 120m to the South West of the proposed development. Travis Perkins have confirmed the open from 07:00-17:00hrs and would have deliveries between these hours. The sporadic traffic to the yard is discussed later on in the report. During the visits to site no noise was audible from the yard. However to err on the side of caution the noise from a fork lift reverse beacon will be added to the model. This noise source would be the most likely noise source to be audible at the development given the distance.

Previous surveys have measured the noise from forklift beacons at a level of 66/67dBA at 10m. A medium duty beacon will have a noise level of approximately 92dBA at 1m (this is louder than the survey results). Assuming the worst case (test in anechoic room) the sound power would be approximately 103dBA. A conservative estimate is that the beacon will be on continuously for 15minutes per hour for 8 consecutive hours in the day (120mins total). Therefore for the whole of the day the on-time corrected sound power would be 9dB lower (94dBA).

6.3 Final Noise Model

The forklift truck noise was added to the model along with the proposed development building. Additional RPs were added outside bedroom and lounge windows.

The 1st floor daytime contour plot can be seen below:

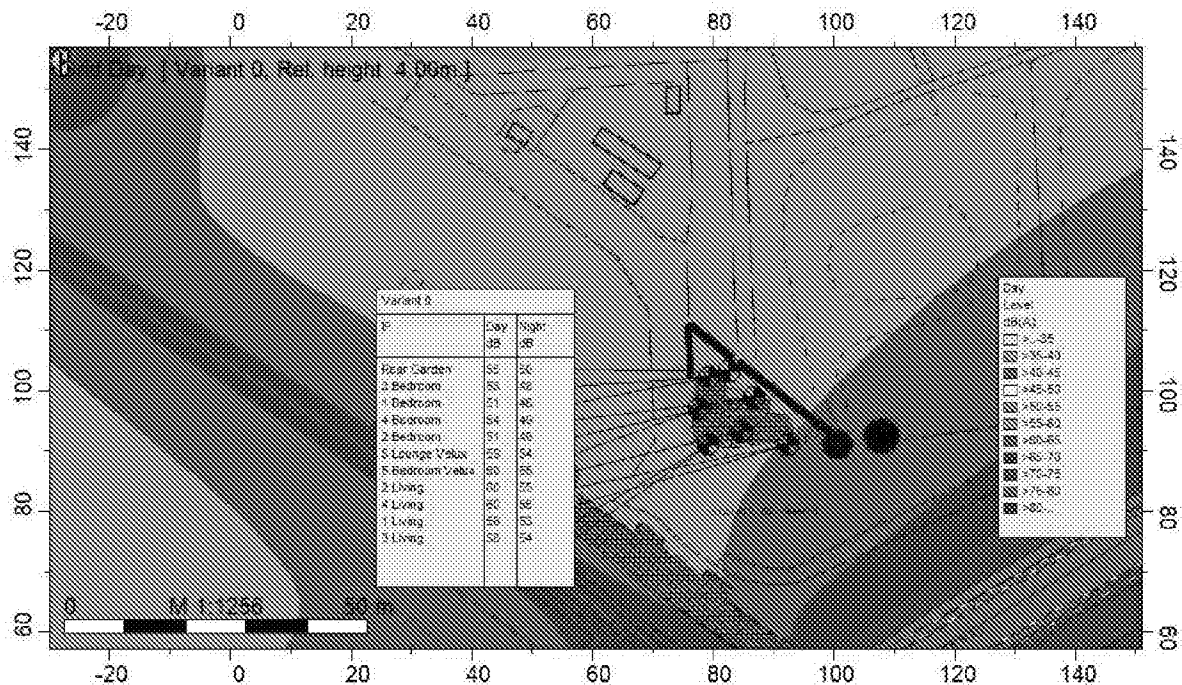


Figure 1: Noise Contour Plot

Further RPs were added 1.5m to show the noise level in the rear amenity space:

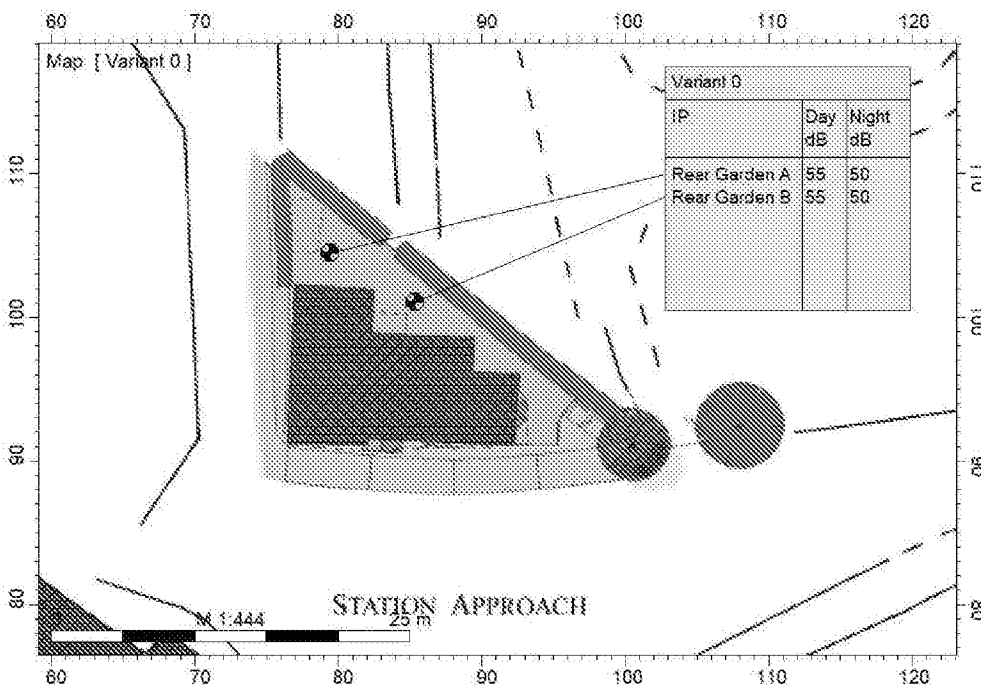


Figure 2: Garden RP Predictions

7 Required Sound Insulation of Building Envelope

The noise model predictions have been used to demonstrate minimum building envelope sound reduction (SRI) required so that the BS8233 criteria can be achieved. *For simplicity worst RPs have been used.*

Model Position	External Noise Level	ReqSRI
4 Bedroom Night	48	18
4 Bedroom Day	53	18
4 Living Day	60	25
5 (roof) Lounge	59	24
5 (roof) Bedroom	55	25

Table 6: Required SRI

7.1 BS8233 Calculations

The BS8233 "Rigorous Calculation" has been used to predict the sound insulation provided by the building envelope (Calculation detailed in BS8233 (6.7.2) and full details of the calculations can be found in the appendix of the report. The calculation was completed for bedrooms and lounge areas on different facades of the development.

The calculation has been used to specify required acoustic performance of glazing. For the calculation tests results from Velfac were used which took into account the frame and the glazing.

Standard trickle vent and Simon Rw trickle vent data has also been used as it is understood that Mechanical Extract Ventilation systems (MEV) will be installed within all plots. Velfac have test results for their windows and glazing together. Other installers may have test results for the glazing (Saint Gobain, Pilkinton Etc.) only. Therefore to account for the lower performance of the frame two specification tables have been completed.

7.2 LA_{max} Rear Bedrooms

LA_{max} levels were also measured during the noise survey. The noise model shows that the worst case noise level (outside bedroom) is 7dB(A) lower than the noise level at the survey position (development design shields bedrooms from night time noise sources). The survey data was recorded in (consecutive) 5 minute measurements.

The survey data was used to predict for a typical night time there will be no more than 3 LA_{max} events, per night, over 45dBA inside if the building SRI is 25dBA (calculated SRI of building envelope). The above would easily achieve the WHO Guidelines for community noise (1999) criteria.

7.3 LA_{max} Room in Roof Bedroom

The noise model shows that the worst case noise level (outside room in roof bedroom) is equal to the noise level at the survey position.

The survey data was used to predict for a typical night time there will be no more than 5 LA_{max} events, per night, over 45dBA inside if the building SRI is 27dBA (calculated SRI of building envelope). The above would easily achieve the WHO Guidelines for community noise (1999) criteria.

7.4 Frame/Glazing and Ventilator Specifications

The table below should be used by window suppliers/installers who have acoustic test results for glazing and frames together:

Room	Frame and Glazing Rw+Ctr ¹	Vent Dnew ²	ReqSRI	BS8233 CalcSRI
Bedrooms	26dB	28dB	18	25
Lounges	26dB	33dB	25	27
Lounge/Bedroom (Roof)	26dB	30dB	24/25	27

Table 7: BS8233 Calculations Window/Frame Test Results

The glazing performance in the table above has been specified in terms of Rw+Ctr (sometimes referred to as Rtraffic). The required Rtraffic levels should be achieved by the glazing on its own.

The Dn,e,w in the table relates to performance for all ventilators for that room for example:

- 1 ventilator required Dn,e,w = 28dB
- 2 ventilator required Dn,e,w = 31dB
- 4 ventilator required Dn,e,w = 34dB

(I.e. Dn,e,w+10LogN where N is number of ventilators)

7.5 Glazing and Ventilator Specifications

The table below should be used by window suppliers/installers who have acoustic test just the glass that will be fitted within a frame:

Room	Glazing Only Rw+Ctr ¹	Vent Dnew ²	ReqSRI	BS8233 CalcSRI
Bedrooms	30dB	28dB	18	25
Lounges	30dB	33dB	25	27
Lounge/Bedroom (Roof)	30dB	30dB	24/25	27

Table 8: BS8233 Calculations Window/Frame Test Results

The glazing performance in the table above has been specified in terms of Rw+Ctr (sometimes referred to as Rtraffic). The required Rtraffic levels should be achieved by the glazing on its own.

The Dn,e,w in the table relates to performance for all ventilators for that room for example:

- 1 ventilator required d Dn,e,w = 28dB
- 2 ventilator required d Dn,e,w = 31dB
- 4 ventilator required d Dn,e,w = 34dB

(I.e. Dn,e,w+10LogN where N is number of ventilators)

8 Discussion and Uncertainty

8.1 Dominant Noise Source

Whilst on site it was subjectively noted that the road noise was the dominant noise source affecting the proposed development. The road has a steady stream of traffic during the day and the night. The train noise is clearly audible at the development site but there are gaps between the train pass-bys. Train station announcements are only very faintly audible at the position of the proposed development.

8.2 Model Uncertainty

The noise model was simplified to include only the A27 road and railway noise sources. The model was calibrated by taking measurements close to the railway line and using a calculation method which eliminates the effect of extraneous noise sources.

A further forklift truck point source was also added to the model based on the sound pressure level as stated in a catalogue. This level was higher than measured in two previous assessments completed by Acoustic Associates.

The noise model did not include a noise source for the traffic that passes the site to the station or to the Builder's Merchant. However the noise created by these traffic movements is likely to be significantly lower than the noise created by the A27 (significantly higher numbers of faster moving vehicles on the A27 compared to the station access road). The model was also completed using the worst case weekday average levels from the survey.

However the noise survey would have picked up the noise created by the vehicles accessing the station and the Builder's Merchants. The noise model was completed based on the levels for the noise survey which would have captured all noise sources. Therefore the noise model predicted levels should be accurate as the development front façade will be exposed to noise levels created by the road and the access road.

Travis Perkins state that deliveries are usually completed during opening hours. On very rare occasions a lorry might arrive early. There could also be the very occasional leaf clearing train pass-by. These sporadic events would not alter the predicted night time level (short duration events). However they may cause L_{Amax} events over the 45dBA criteria (inside the development). This would not be detrimental to the occupier as on this rare occasion there would be no more than 5 events over 45dBA which still easily achieves the WHO criteria.

8.3 BS4142

The planning condition does not mention BS4142 however for completeness the assessment methodology has been briefly followed. The graph in the appendix shows that for a working day (last 2 days) the representative background noise level would be at least 55dBA. The noise model was used to predict that for the worst case receptor (3 Bedroom) the noise created by the forklift was 39dBA. Even with a tonal correction and a contribution from the sporadic traffic pass-bys to the builders yard the noise rating level will not be higher than the background noise level.

9 Conclusion

Noise levels have been measured where the proposed development will be built. Additional measurements have also been completed close to the nearby railway.

Noise levels created by the A27 road, the railway and Travis Perkins forklifts have been assessed. The noise sources have been added to a noise model which predicts the noise levels that will affect the development.

The development has implemented good acoustic design principles by locating bedrooms on the quieter rear façade (the exception being the room in roof bedroom which has small windows in the buildings roof which do not directly face the road due to the angle of the roof).

9.1 Internal Noise Levels

If the noise mitigation measures detailed in section 7 are implemented the internal noise levels would easily achieve the BS8233 noise criteria detailed in section 2.

Mitigation measures have been recommended which have been split into 2 categories:

- Specifications for Glazing in frame
- Specifications for Glazing only (if frame/glass test results are not available)

Therefore if the developer follows the guidance regarding glazing and ventilation it is considered that Planning Condition 12 will be satisfied.

9.2 External Noise Levels

The noise level in the external amenity area has been predicted to be 55dBA during the day. Planning Condition 13 states the following:

Demonstrate that the noise levels within the external amenity area of the proposed residential units, as applicable, will conform to the "design criteria for external noise" upper guideline value of 55 dB LAeq,T, as specified within BS 8233: 2014,

Further to the above, Planning Practice Guidance 2014 (Noise) states the following:

Are there further considerations relating to mitigating the impact of noise on residential developments? Yes – the noise impact may be partially off-set if the residents of those dwellings have access to: A relatively quiet, protected, external publically accessible amenity space (e.g. a public park or a local green space designated because of its tranquillity) that is nearby (e.g. within a 5 minutes walking distance).

The condition target level of 55dBA has just been achieved. It also should be noted that there are numerous other quiet external spaces nearby within the South Downs National Park.

If the developer implements the mitigation measures detailed in this report it is considered that the pre-commencement planning conditions will be satisfied.

10 Appendix

10.1 Noise Models

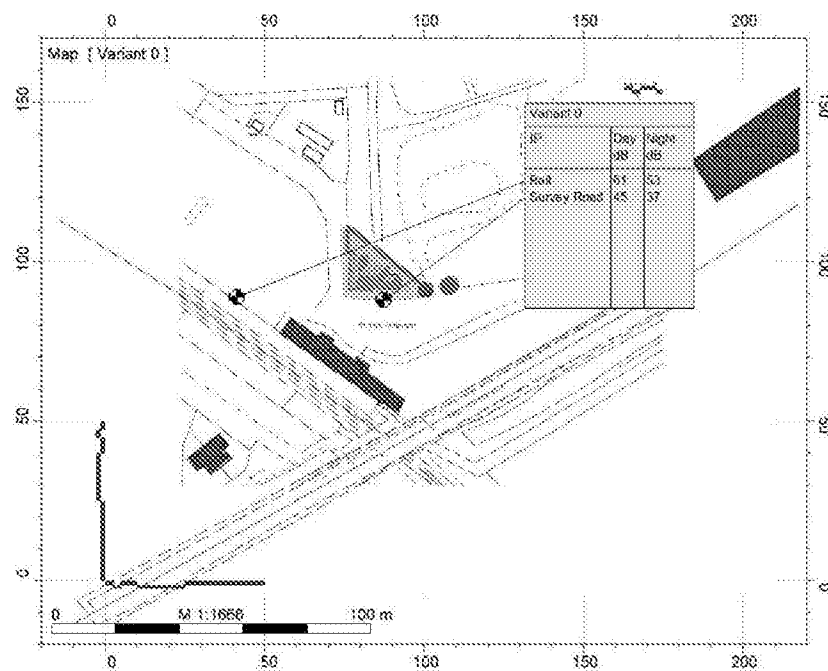


Figure 3: Rail Survey Noise Model

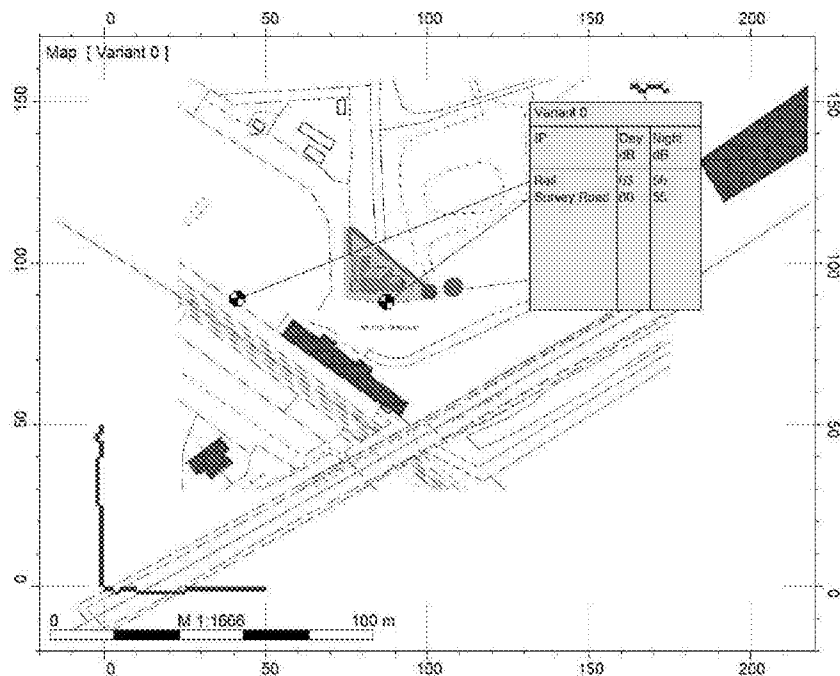


Figure 4: Rail & Road Survey Noise Model

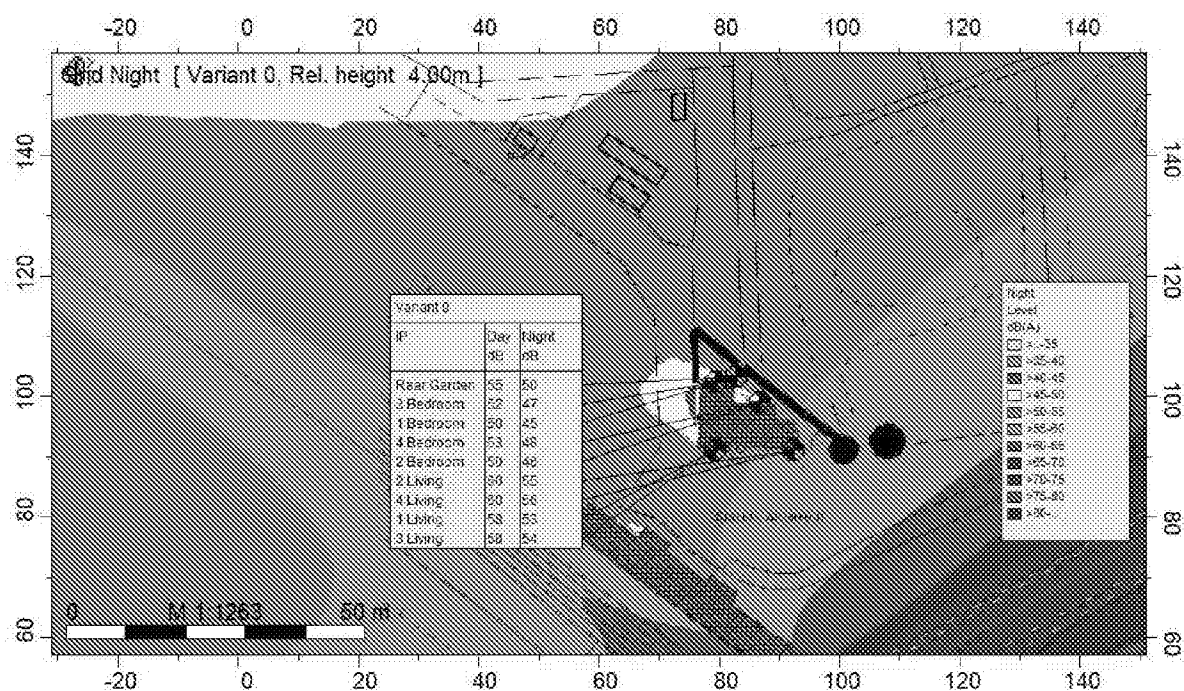


Figure 5: Night-time Noise Model

10.2 SRI Calculations

Non-Frequency Dependent Variables			Key for Table Below	
Term	Derivation	Value		
A_0	Given in BS EN 20140-10 = 10 (m ²)	10	R_{wi}	Sound Reduction of Window (Octave)
S_r	Total Facade Area (m ²)	10	R_{ew}	Sound Reduction Index of External Wall (Octave)
S_{wi}	Window Area (m ²)	1.9	R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
S_{ew}	External Wall Area (m ²)	8.1	A	Equivalent Absorption Area of Rx Room
S_{rr}	Ceiling Area (m ²)	0.00001	$D_{tr,e}$	Insulation of Trickle Vent (BS EN 20140-10)
S	Total Area sound enters the room (m ²)	10		

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
$L_{eq,ff}$	Free-Field External Noise Level (from survey)	55.16	52.02	51.29	52.86	48.09	38.44
$D_{tr,e}$	Typical Trickle Vent predicted to be DnEw28	35	31	30	26	27	32
R_{wi}	Velfac 6/24/6	13.2	22.2	34.1	37.9	32.6	41.9
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	40	39	44	52	60	65
R_{rr}	No Roof	100	100	100	100	100	100
A	Equivalent Absorption Area of Room (BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term From Equation Below	Octave Band Centre Frequency						
	125	250	500	1000	2000	4000	
$L_{eq,ff}$	55.16	52.02	51.29	52.86	48.09	38.44	
$A_0/S \cdot 10^{(-D_{tr,e}/10)}$	0.0003162	0.000794	0.001	0.002511886	0.001995262	0.000630957	
$S_{wi}/S \cdot 10^{(-R_{wi}/10)}$	0.009094	0.001145	7.39E-05	3.08144E-05	0.000104413	1.22674E-05	
$S_{ew}/S \cdot 10^{(-R_{ew}/10)}$	0.000081	0.000102	3.22E-05	5.11075E-06	0.00000081	2.56144E-07	
$S_{rr}/S \cdot 10^{(-R_{rr}/10)}$	1E-16	1E-16	1E-16	1E-16	1E-16	1E-16	
$10 \log_{10}(S/A) + 3$	2.5860731	1.53872	0.9588	0.958800173	1.239087409	1.239087409	
$L_{eq,2}$	37.518729	26.65554	22.6881	27.87670972	22.55235552	7.766109611	
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1	
A-Weighted L_{eq}	21.418729	18.05554	19.4881	27.87670972	23.75235552	8.766109611	

Predicted Building Envelope SRI	25	Velfac 6/24/6
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BS8233 Calculation can be seen below:							
$L_{eq,2} \approx L_{eq,ff} + 10 \log_{10} \left(\frac{A_0}{S} 10^{\frac{-D_{tr,e}}{10}} + \frac{S_{wi}}{S} 10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S} 10^{\frac{-R_{rr}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$							

Figure 6: Bedroom Solution

Non Frequency Dependent Variables			Key for Table Below	
Term	Derivation	Value	R _{wi}	Sound Reduction of Window (Octave)
A ₀	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)
S _t	Total Facade Area (m ²)	14.5	R _{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
S _{wi}	Window Area (m ²)	4.5	A	Equivalent Absorption Area of Rx Room
S _{ew}	External Wall Area (m ²)	10	D _{tr,e}	Insulation of Trickle Vent (BS EN 20140-10)
S _{rr}	Ceiling Area (m ²)	0.00001		
S	Total Area sound enters the room (m ²)	14.5		

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level (from survey)	55.16	52.02	51.29	52.86	48.09	38.44
D _{tr,e}	Simon Frame Vent 33dB	40	36	35	31	32	37
R _{wi}	Velfac 6/24/6	13.2	22.2	34.1	37.9	32.6	41.9
R _{ew}	Cavity Masonry (Brick Cavity with insulation lightweight block)	40	39	44	52	60	65
R _{rr}	No Roof	100	100	100	100	100	100
A	Equivalent Absorption Area of Room (BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details						
Term From Equation Below	Octave Band Centre Frequency					
	125	250	500	1000	2000	4000
L _{eq,ff}	55.16	52.02	51.29	52.86	48.09	38.44
A ₀ /S . 10 ⁴ (-D _{tr,e} /10)	6.897E-05	0.000173	0.000218	0.000547813	0.000435143	0.000137604
S _{wi} /S . 10 ⁴ (-R _{wi} /10)	0.014854	0.00187	0.000121	5.0332E-05	0.000170547	2.00375E-05
S _{ew} /S . 10 ⁴ (-R _{ew} /10)	6.897E-05	8.68E-05	2.75E-05	4.35143E-06	6.89655E-07	2.18088E-07
S _{rr} /S . 10 ⁴ (-R _{rr} /10)	6.897E-17	6.9E-17	6.9E-17	6.89655E-17	6.89655E-17	6.89655E-17
10log ₁₀ (S/A)+3	4.1997532	3.1524	2.57248	2.572480196	2.852767432	2.852767432
L _{eq,2}	41.117785	28.45437	19.50174	23.22825867	18.77028692	3.277151976
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1
A-Weighted L _{eq}	25.017785	19.85437	16.30174	23.22825867	19.97028692	4.277151976

Predicted Building Envelope SRI	27	Velfac 6/24/6
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BS8233 Calculation can be seen below:

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

Figure 7: Lounge Solution

Non Frequency Dependent Variables			Key for Table Below	
Term	Derivation	Value	R_{wi}	Sound Reduction of Window (Octave)
A_0	Given in BS EN 20140-10 = 10 (m ²)	10	R_{ew}	Sound Reduction Index of External Wall (Octave)
S_r	Total Facade Area (m ²)	7	R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
S_{wi}	Window Area (m ²)	0.8	A	Equivalent Absorption Area of Rx Room
S_{ew}	External Wall Area (m ²)	0.00001	$D_{n,e}$	Insulation of Trickle Vent (BS EN 20140-10)
S_{rr}	Ceiling Area (m ²)	6		
S	Total Area sound enters the room (m ²)	7		

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
$L_{eq,f}$	Free-Field External Noise Level (from survey)	55.16	52.02	51.29	52.86	48.09	38.44
$D_{n,e}$	2xSimon Frame Vent 33dB	37	33	32	28	29	34
R_{wi}	Velfac 6/24/6	13.2	22.2	34.1	37.9	32.6	41.9
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	40	39	44	52	60	65
R_{rr}	Tile on Felt, Pitched Roof, 100mm mineral wool on plasterboard ceiling	43	43	43	43	43	43
A	Equivalent Absorption Area of Room (BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term From Equation Below		Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
$L_{eq,f}$		55.16	52.02	51.29	52.86	48.09	38.44
$A_0/S \cdot 10^{(-D_{n,e}/10)}$		0.000285	0.000716	0.000901	0.002264133	0.001798465	0.000568725
$S_{wi}/S \cdot 10^{(-R_{wi}/10)}$		0.0054701	0.000689	4.45E-05	1.8535E-05	6.28047E-05	7.37891E-06
$S_{ew}/S \cdot 10^{(-R_{ew}/10)}$		1.429E-10	1.8E-10	5.69E-11	9.01368E-12	1.42857E-12	4.51754E-13
$S_{rr}/S \cdot 10^{(-R_{rr}/10)}$		4.296E-05	4.3E-05	4.3E-05	4.29589E-05	4.29589E-05	4.29589E-05
$10 \log_{10}(S/A) + 3$		1.0370535	-0.0103	-0.59022	-0.590219426	-0.30993219	-0.30993219
$L_{eq,2}$		33.829321	23.61417	20.65192	25.9314177	20.57733041	6.049077132
A-Weighting		-16.1	-8.6	-3.2	0	1.2	1
A-Weighted L_{eq}		17.729321	15.01417	17.45192	25.9314177	21.77733041	7.049077132

Predicted Building Envelope SRI	27	Velfac 6/24/6
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BS8233 Calculation can be seen below:	
$L_{eq,2} \approx L_{eq,f} + 10 \log_{10} \left(\frac{A_0}{S} 10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S} 10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S} 10^{\frac{-R_{rr}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$	

Figure 8: Velux Bedroom Solution

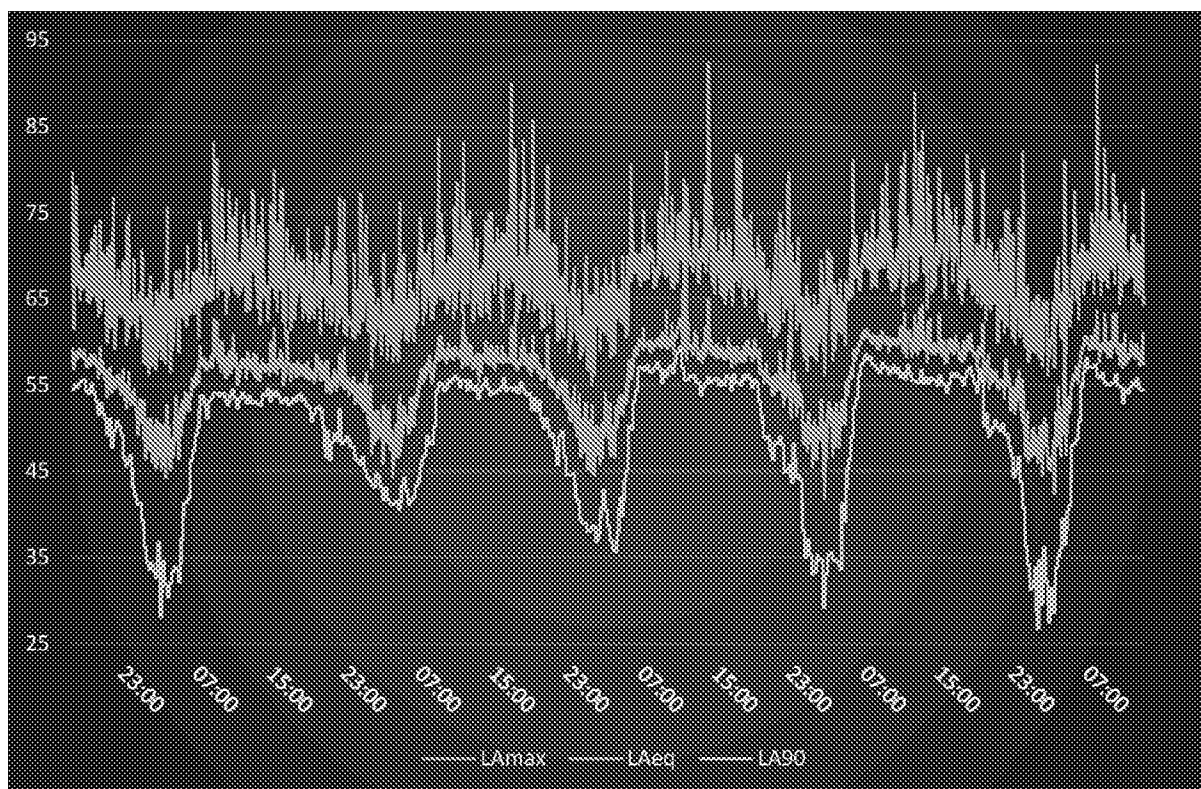


Figure 9: Attended survey graph