Nile + Villiers, Sunniside, Sunderland

Noise impact assessment

11021.2

22nd December 2023

Revision A

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1 Summary

1.1 This report has been prepared to accompany a planning application for a proposed mixed-use development entitled Nile + Villiers, at Sunniside, Sunderland. The development consists of circa 80 residential dwellings and 400 m^2 of commercial space.

1.2 Noise levels from road traffic, commercial premises and entertainment noise affecting the proposed development have been measured during the day and night, and the façade noise impact calculated.

1.3 Noise propagation across the site is calculated in environmental noise modelling software, CadnaA.

1.4 The existing noise risk at the site is assessed in accordance with current planning policy, relevant standards and noise practice guidance.

1.5 The façade sound insulation design is considered with windows closed to reduce the calculated noise impact to below the lowest adverse effect level. Alternative provision should be made for whole dwelling ventilation according to the Building Regulations, Approved Document F (AD-F).

1.6 The acoustic performance requirements for glazing are summarised in Table 1.

1.7 Where music noise impacts on the facades of the northern-most dwellings, a potential building façade construction detail is described in Section 12 calculated to be capable of controlling low-frequency sound to an appropriate level.

1.8 Noise levels in all gardens are calculated to be below the guideline desirable limit of 50 dB $L_{Aeq,16hr}$ without requiring any further noise mitigation.

1.9 Barriers of 1.8 m height are required to reduce garden noise levels to be below the required noise levels. The location of the proposed barriers are shown in Figure 8. To be effective in practice, the barrier should have no cracks or gaps, be continuous to the ground, and have a surface density ≥ 10 kg/m^2 such as a close boarded timber fence or brick wall.

1.10 Based on the details outlined in this report, the noise risks identified are mitigated and minimised, and the site is considered suitable for residential development.

Façade affected	Glazing performance	Example products (others also feasible)	Potential AD-F ventilation strategy
	≥ 41 dB $R_w + C_{tr}$ and ≥ 32 dB R at 63 Hz	Pilkington 8/16/12.8 mm	MVHR
	≥ 30 dB $R_w + C_{tr}$ and ≥ 28 dB R at 63 Hz	Pilkington 4/16/6.8 mm	
	≥ 27 dB $R_w + C_{tr}$ And ≥ 16 dB R at 63 Hz	Saint-Gobain 4 (12) 4 mm	

Table 1: Summary of minimum sound insulation treatment

Figure 1: Façade sound insulation mark-up

2 Introduction

2.1 A mixed-use development entitled Nile + Villiers, has been proposed at Sunniside, Sunderland. The development consists of circa 80 residential dwellings and 400 m^2 of commercial space.

2.2 Apex Acoustics has been commissioned to undertake a noise survey and assessment of the potential noise impact on the proposed development site in support of a full planning application.

2.3 The primary noise sources considered in this assessment are:

- Road traffic noise on High Street West, Villiers Street, Coronation Street and Nile Street
- Commercial noise from 'MJE Auto Technician & Recovery Service' (hereafter referred to as 'car workshop')
- Music noise from 'Dance Lab' and 'Pop Recs'

2.4 The site location in respect to the noise sources is shown in Figure 2.

2.5 The purpose of this report is to identify appropriate acoustic design parameters and the manner in which these may be achieved in practice.

2.6 The scope of our appointment includes:

- Measure the existing noise environment during the day and night at four locations;
- Calculate the highest noise impact on the worst affected façade;
- Determine potential noise impact under whole dwelling ventilation condition according to Approved Document F strategies; and
- Provide a detailed scheme for the mitigation of noise to reduce the risk of adverse effect, in accordance with local and national policy requirements.

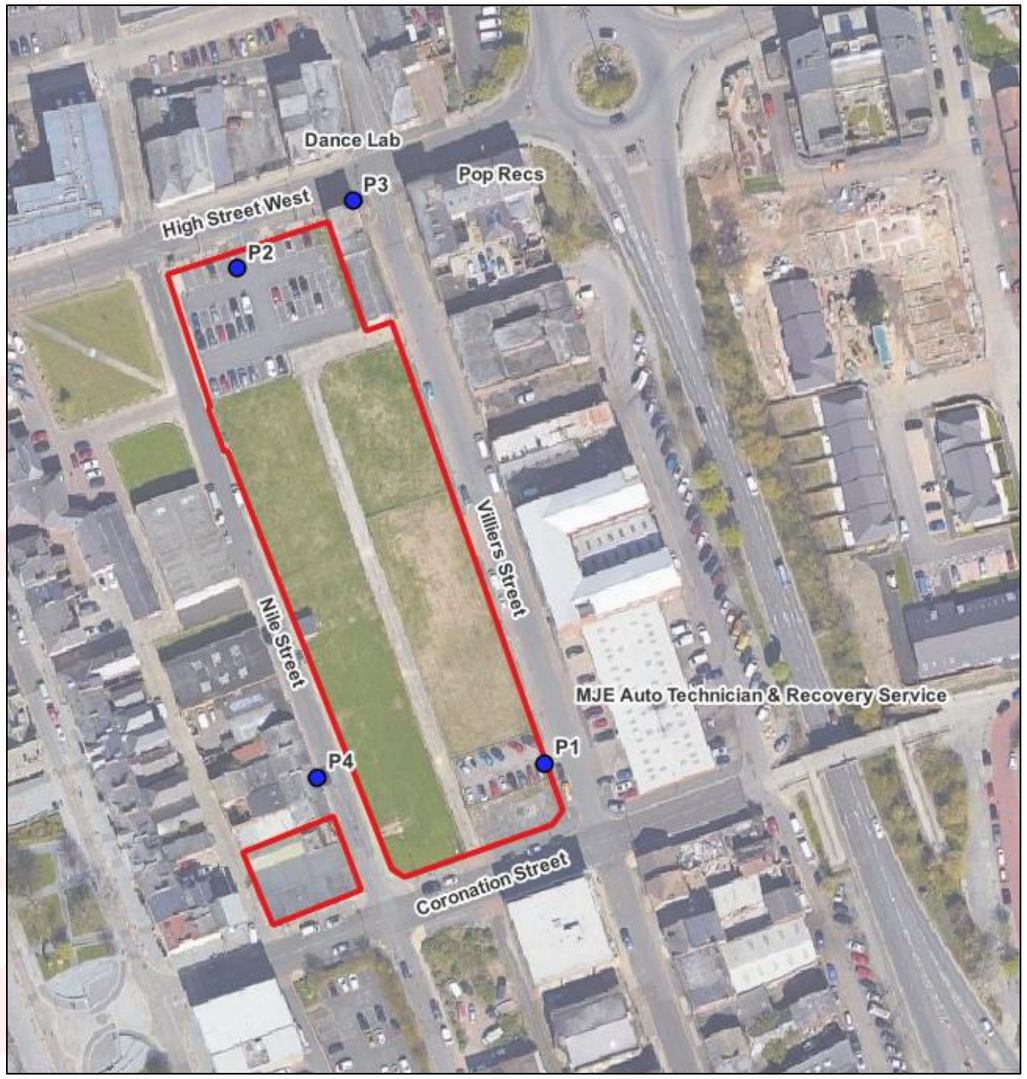


Figure 2: Site location outlined in red and measurement positions indicated by blue markers

3 Planning policy and noise criteria

3.1 National Planning Policy Framework (NPPF)

3.2 The National Planning Policy Framework[Ref1] (NPPF), sets out the Government's planning policies for England and how these should be applied. It provides a framework within which locally-prepared plans for housing and other development can be produced. In respect of noise, Paragraph 180, 191 and 193 of the NPPF states the following:

3.3 Paragraph 180:

"e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability…"

3.4 Paragraph 191:

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

a) mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life[69 [See Explanatory Note to the Noise Policy Statement for England]];

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

3.5 Paragraph 193:

"Planning policies and decisions should ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs). Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed. "

3.6 Noise Policy Statement for England (NPSE)

3.7 The Noise Policy Statement for England[Ref2] states three policy aims as follows:

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

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

3.8 The NPSE defines adverse noise impact as follows:

- No Observed Effect Level (NOEL)
  This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.
- Lowest Observed Adverse Effect Level (LOAEL)
  This is the level above which adverse effects on health and quality of life can be detected.
- Significant Observed Adverse Effect Level (SOAEL)
  This is the level above which significant adverse effects on health and quality of life occur

3.9 The first two aims of the NPSE require that no significant adverse impact should occur and that, where a noise level which falls between a level which represents the lowest observable adverse effect and a level which represents a significant observed adverse effect, then according to the explanatory notes in the statement:

"… all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life whilst also taking into consideration the guiding principles of sustainable development. This does not mean that such effects cannot occur."

3.10 It is considered that meeting the internal ambient noise level limits given in BS 8233, which are in line with those given by the World Health Organisation[Ref3] adequately achieve the first and second aims of the NPSE.

3.11 Professional Practice Guidance on Planning & Noise

3.12 Professional Practice Guidance on Planning & Noise: New Residential Development[Ref4] (ProPG) is a guidance document on the management of noise within the planning system in England for new build housing developments.

3.13 The document draws together guideline limits for internal noise levels from external transport sources from other sources of guidance, including BS 8233[Ref5] and the World Health Organisation (WHO) Guidelines for Community Noise.

3.14 These criteria are consistent with those usually adopted by the Local Environmental Health Department and are presented in Table 2.

Activity	Location	Guideline upper limit, dB		
		$L_{Aeq,\ daytime}$	$L_{Aeq,\ night\text{-}time}$	L_{AFmax}
Resting	Living room	35	-	-
Dining	Dining room	40	-	-
Sleeping (daytime resting)	Bedroom	35	30	45

Table 2: Internal noise level requirements

3.15 The daytime period is defined as the 16 hours between 07:00 to 23:00 hours and the night-time period is defined as the 8 hours between 23:00 to 07:00 hours.

3.16 With regards to the night-time L_{AFmax} criterion, ProPG states:

"In most circumstances in noise-sensitive rooms at night (e.g. bedrooms) good acoustic design can be used so that individual noise events do not normally exceed 45 dB $L_{Amax,F}$ more than 10 times a night."

3.17 It is considered that the adopted internal ambient noise level targets align with the LOAEL following the terminology of the NPSE, such that meeting these targets adequately achieves the aims of the NPPF and NPSE.

3.18 ProPG states:

"Once internal L_{Aeq} levels exceed the target levels by more than 10 dB, they are highly likely to be regarded as "unacceptable" by most people, particularly if such levels occur more than occasionally."

3.19 Internal ambient noise levels 10 dB above the daytime and night-time values in Table 2 are therefore identified as the SOAEL.

3.20 ProPG guidance on external amenity area assessments "reflects and extends the advice contained in BS 8233:2014 and the current Government guidance in PPG-Noise". Relevant guidance from these sources is summarised in the document as follows:

- "If external spaces are an intrinsic part of the overall design, the acoustic environment of those spaces should be considered so that they can be enjoyed as intended."
- "The acoustic environment of external amenity areas that are an intrinsic part of the overall design should always be assessed and noise levels should ideally not be above the range 50-55 dB $L_{Aeq,\ 16\ hr}$."
- "These guideline values may not be achievable in all circumstances where development might be desirable. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces."

3.21 The BS 8233 'desirable' value of 50 dB $L_{Aeq,\ 16\ hr}$ in external amenity areas is identified as the LOAEL.

3.22 Following DEFRA[Ref6] guidance on the possible identification of LOAELs and SOAELs, 66 dB $L_{Aeq,\ 16\ hr}$ is identified as the SOAEL.

3.23 **BS 4142**

3.24 BS 4142[Ref7] defines an assessment method to quantify the potential level for adverse impact from commercial and / or industrial noise sources impacting upon sound sensitive receptors i.e. residential properties.

3.25 The method estimates the impact significance by comparing the Rated noise against the background sound levels, as summarised below:

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 + 5dB is likely to be an indication of an adverse impact, depending on the context.

3.26 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 sources having a low impact, depending on the context.

3.27 The terminology used in BS 4142 to describe the various levels of potential adverse impact is respect to the PPG-N noise hierarchy, are summarised Appendix A.

3.28 **Proposals and discussion with SCC**

3.29 The internal noise level requirements from ProPG shown in Table 2 are appropriate for 'anonymous' noise sources such as road traffic.

3.30 BS 8233 notes that lower noise limits might be appropriate for noise sources which have a specific character, such as a distinguishable tone, strong low frequency content, or is irregular enough to attract attention.

3.31 As discussed further in this report, there are noise sources identified which are considered to have a specific character, i.e. music associated with Pop Recs and Dance Lab, and various activities associated with the car workshop.

3.32 With reference to Para. 193 of the NPPF, where such noise sources are considered to impact on portions of the proposed residential development, it is proposed that the façade (including glazing and ventilation strategy) be designed to achieve an internal noise level of ≤ NR 20 in bedrooms and living rooms.

3.33 This proposed criterion was discussed and agreed with Joanne Dodson, Senior Environmental Health Officer at Sunderland City Council.

4 Noise sources and measurements

4.1 Measurements

4.2 Measurements of the existing noise environment were made over several time periods. The locations of the noise measurements are shown on Figure 2.

4.3 A 24-hour unattended noise survey was undertaken between 11:29 on the 4th August 2023 and 11:46 on the 5th August 2023 at P1, to capture road traffic noise from Villier Street and Coronation Street, as well as noise from the car workshop.

4.4 A two hour attended noise survey was undertaken between 18:58 and 20:58 on the 3rd August 2023 at P3, to capture noise from Dance Lab and Pop Recs. The survey time was selected to capture noise from a live music event at Pop Recs.

4.5 A daytime measurement was undertaken over three consecutive hours between 10:08 and 13:09 on the 7th August 2023 at P2, in accordance with the shortened measurement procedure outlined in paragraph 43 of Calculation of Road Traffic Noise[Ref8] (CRTN). A night time measurement between 23:00 on the 15th August and 00:00 on the 16th August 2023 was also undertaken at the same location.

4.6 A previous 24-hour unattended noise survey was undertaken between 10:34 on the 4th July 2023 and 09:01 on the 5th July 2023 at the façade of buildings on Nile Street, at P4, to capture road traffic noise from Nile Street and any noise from the nearby commercial premises.

4.7 For sound level measurements at P1, P2 and P3, the microphone was located at 1.5m above ground level, away from other reflecting surfaces, such that the measurements are considered to be free-field.

4.8 The survey at P4 was conducted with the microphone extended on a pole from an upper floor window at a height of 5 m. The reported noise levels have had a 3 dB correction applied to determine free-field levels.

4.9 The equipment used is listed in Table 3.

Equipment	Model	Serial no.
Sound Level Meter	NTi XL2	A2A-04045-D2
Calibrator	Larson Davis CAL 200	11705
Sound Level Meter	NTi XL2	A2A-12269-E0
Calibrator	Larson Davis CAL 200	13404
Sound Level Meter	NTi XL2	A2A-14205-E0
Calibrator	Larson Davis CAL 200	15308

Table 3: Equipment used

4.10 All sound level meters and calibrators used meet the technical specifications of BS 7445[Ref9] and have current calibration certificates traceable to national standards. The equipment was field-calibrated before and after the measurement with no significant drift in sensitivity noted.

4.11 Weather conditions were mainly dry, with some short periods of rain, and wind speeds below 5 m/s. Any periods of rain were removed from the noise data, as shown in Appendix B.

4.12 The time histories of the $L_{Aeq,T}$ recorded are shown in Appendix B. Daytime hours are taken to be 0700 to 2300, and night time hours 2300 to 0700.

4.13 **Noise sources**

4.14 The most significant noise source affecting the proposed development during the daytime was road traffic on High Street West and activity from the car workshop. During the evening period (after 1900 hours) noise from Dance Lab and Pop Recs was significant, however it is noted events from these premises is sporadic, rather than every night. At night, road traffic is the dominant source on High Street West, however car movements were minimal.

4.15 **Noise levels captured at P1**

4.16 Noise levels captured at P1 are shown in Table 4. On site observations, and a review of the noise data, found noise from the car workshop to be the dominant noise source during the early morning and daytime. Noise from the car workshop was observed from 0600 to 1700 hours, consisting of periodic bangs and crashes, power tools and generator noise, as well as background music noise played by the employees. Noise from road traffic on Villiers Street and Coronation Street was also observed, however was not dominant at this location. Noise from seagulls was also observed, however has been excluded from the data.

Noise Source	Parameter	dB(A)	Octave band centre frequency, Hz Measured A-weighted noise levels, dB							
			63	125	250	500	1k	2k	4k	8k
Car workshop	L_{Aeq}	**61**	36	43	46	51	56	56	53	50
	Daytime $L_{AF,max}$*	**87**								
Ambient noise levels – road traffic	Daytime, $L_{Aeq,\ 16\ hr}$	**58**	36	40	46	51	54	52	48	43
	Night time, $L_{Aeq,\ 8\ hr}$	**51**	26	38	37	39	48	45	41	29
	Night time, $L_{AF,max}$*	**68**								
*only a single figure rating is provided for the L_{Amax}										

Table 4: Measured noise levels at P1

4.17 **Noise levels captured at P2**

4.18 Noise levels captured at P2 are shown below. On site observations, and a review of the noise data, found noise from road traffic to be the dominant noise source. Noise from seagulls was also observed, however has been excluded from the data. Noise from Dance Lab and Pop Recs is likely to be audible at this location, being in close proximity, however this location is only concerned with the consideration of road traffic on High Street West.

4.19 The measured values of the L_{A10} for three consecutive daytime hours are shown in Table 5.

Time Period	Measured noise level, dB $L_{A10,\ 1\ hr}$
First hour	63.7
Second hour	64.4
Third hour	63.9

Table 5: Measured L_{A10} over three consecutive hours

4.20 $L_{A10,\ 18\ hr}$ noise levels have been calculated from the measured $L_{A10,\ 1\ hr}$ over three consecutive hours in accordance with the shortened measurement procedure detailed in CRTN.

4.21 The methodology of the Transport Research Laboratory[Ref10] has been used to determine day ($L_{Aeq,\ 12\ hr}$), evening ($L_{Aeq,\ 4\ hr}$) and night-time ($L_{Aeq,\ 8\ hr}$) noise levels. Day and evening levels have been summed with an appropriate time weighting to determine the daytime $L_{Aeq,16\ hr}$.

4.22 The measured noise spectrum has been shifted to meet the calculated single-figure values.

4.23 In regard to the L_{Amax}, the highest 1 minute maximum noise level has been taken from the one hour night time noise survey, to represent the L_{Amax} levels experienced at the development.

4.24 The calculated and measured daytime and night-time noise levels are shown in Table 6.

Parameter	dB(A)	Octave band centre frequency, Hz Measured A-weighted noise levels, dB							
		63	125	250	500	1k	2k	4k	8k
Daytime, $L_{Aeq, 16\ hr}$	61	39	44	51	56	58	52	46	38
Night time, $L_{Aeq, 8\ hr}$	53	30	35	42	47	50	43	37	30
Night time, L_{AFmax}*	74								
*only a single figure rating is provided for the L_{Amax}									

Table 6: Calculated and measured A-weighted noise levels at P2

4.25 **Noise levels captured at P3**

4.26 Noise levels captured at P3 are shown in Table 7. On site observations found noise from Dance Lab and Pop Recs to be audible during an evening period. The noise was sporadic, however clearly audible. Music noise from Dance Lab was audible for a 10 minute period between 1930 and 1940 hours, when patrons were leaving the venue. The music was that of a dance genre. Music noise from Pop Recs was audible from 1950 until 2100 hours, being of rock genre. Noise from patrons travelling to and from the venue was also observed.

Noise Source	Parameter	dB(A)	Octave band centre frequency, Hz Measured A-weighted noise levels, dB							
			63	125	250	500	1k	2k	4k	8k
Dance Lab	Music Noise L_{Aeq}	**54**	35	39	45	46	51	47	38	28
Pop Recs	Music Noise, L_{Aeq}	**57**	46	48	46	48	53	50	44	32
	Patron Noise (people talking), L_{Aeq}	**61**	38	40	47	54	57	55	48	40
*only a single figure rating is provided for the L_{Amax}										

Table 7: Measured noise levels at P3

4.27 **Noise levels captured at P4**

4.28 Noise levels captured at P4 are shown in Table 8. Noise monitoring was undertaken on the façade, however levels have been corrected to determine free field levels (-3dB). On site observations found noise from road traffic on Nile Street to be the dominant source. Noise from nearby commercial premises was also noted. In regard of this, ProPG states the following:

4.29 *"In the special case where industrial or commercial noise is present on the site but is "not dominant" (i.e where the impact would be rated as lower than adverse (subject to context) if a BS 4142:2014 assessment was to be carried out), its contribution may be included in the noise level used to establish the degree of risk (and if included, this should be clearly stated)."*

4.30 *"The judgement on whether or not to undertake a BS 4142 assessment to determine dominance should be proportionate to the level of risk. In low risk cases a subjective judgement of dominance, based on audibility, would normally be sufficient."*

4.31 Whilst on-site, it was noticed that the noise from the nearby commercial premises was not dominant, and as such, its contribution is included in the noise break-in calculations, as recommended in ProPG.

Parameter	dB(A)	Octave band centre frequency, Hz							
		63	125	250	500	1k	2k	4k	8k
Daytime, $L_{Aeq, 16\ hr}$	**55**	35	39	42	47	52	48	43	38
Night time, $L_{Aeq, 8\ hr}$	**53**	25	29	33	37	50	50	40	24
Night time, $L_{AF,max}$*	**71**								
*only a single figure rating is provided for the L_{Amax}									

Table 8: Measured noise levels at P4

4.32 **Background sound levels**

4.33 Measured background $L_{A90,15min}$ sound levels captured at P4 have been considered representative of typical daytime and night time levels experienced across the site. This location was chosen, being least impacted by commercial noise, and having the longest period of monitoring. The selected levels are shown in Table 9 and the analysis of the selected representative background sound level is shown in Appendix C.

Measurement Position	Background sound level, dB $L_{A90, 15\ min}$	
	Daytime	Night-time
P4	46	36

Table 9: Representative background sound levels

5 Noise impact on the site

5.1 Noise transmission and propagation is modelled using proprietary software, Cadna/A[Ref11]. This models noise propagation outdoors according to ISO 9613[Ref12].

5.2 The modelling parameters used, source of data and details are described in Table 10.

Parameter	Source	Details
Model dimensions	Google Earth	British Transverse Mercator coordinates
Site location and layout	Architects' drawings	Architects' drawings, Reference 13
Topography –within site	Site observations and Google Street view	Modelled with no changes in topography
Topography –Outside of site	Site observations and Google Street view	Modelled with no changes in topography
Building heights – proposed buildings	Drawings	Architects' drawings
Building heights – outside of site	Site observations and Google Street view	3 m per storey + 2 m roof (residential properties)
Receptor positions	Site observations and Google Street view	On the façade closest to the source at a height of 1.5 m, 4 m, 6.5 m and 9 m to represent ground, first, second and third floor window heights respectively
Building and barrier absorption coefficient	ISO 9613-2	0.21 to represent a reflection loss of 1 dB
G, Ground factor	ISO 9613-2	Hard ground, G = 0; Porous ground, G = 1 (locally on model)
Max. order of reflections	Apex Acoustics	Three

Table 10: Modelling parameters and assumptions

5.3 Measured daytime and night-time noise levels have been used to ascribe sound power levels to the surrounding roads, commercial and entertainment noise, and the noise impact at the proposed building façades has been calculated.

5.4 Measured maximum noise levels due to vehicle passes have been used to attribute sound power levels to a point source. The position of the point source has been shifted along the road to calculate the potential worst-case noise impact at each building façade.

5.5 A plan view of the CadnaA model is shown in Figure 3.

5.6 The calculated noise contour results for the daytime $L_{Aeq,\ 16\ hr}$ and night-time $L_{Aeq,8\ hr}$ are shown in the following figures.

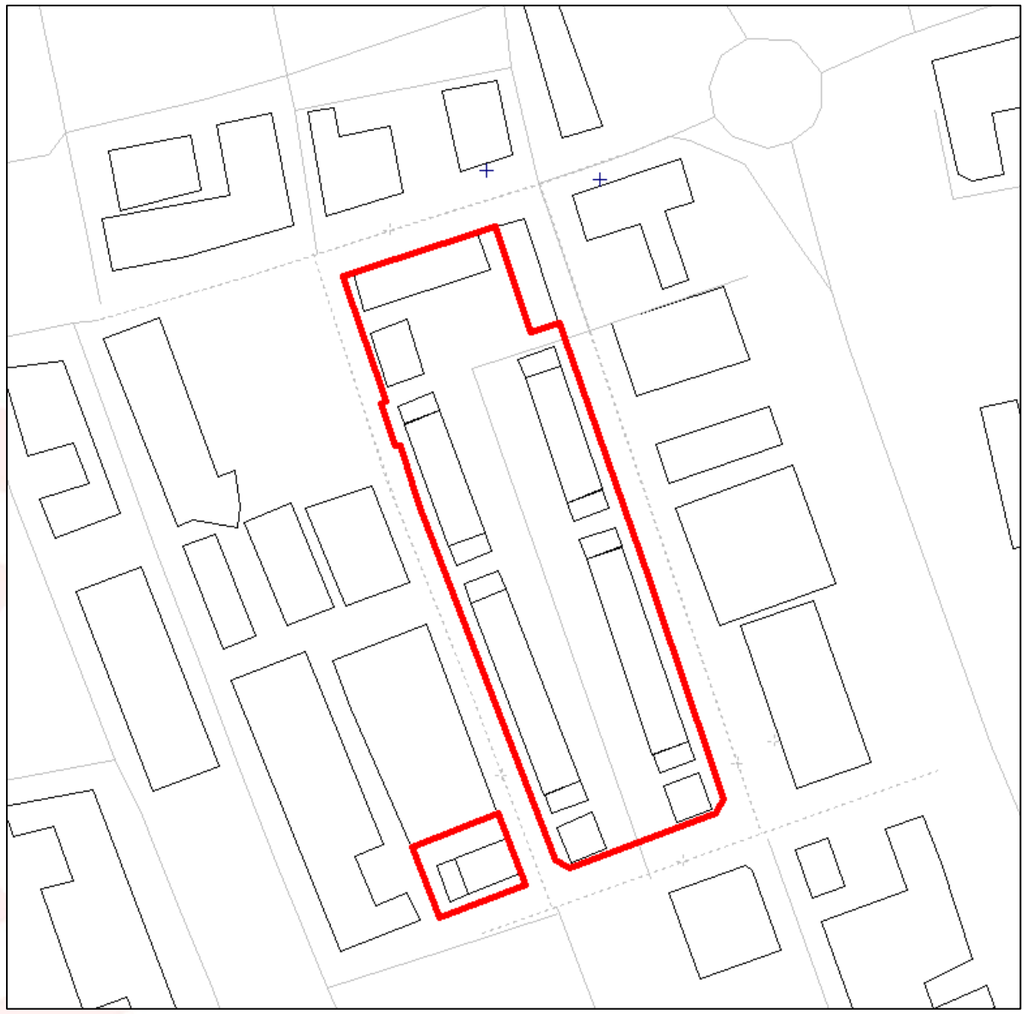


Figure 3: Plan view of the CadnaA model

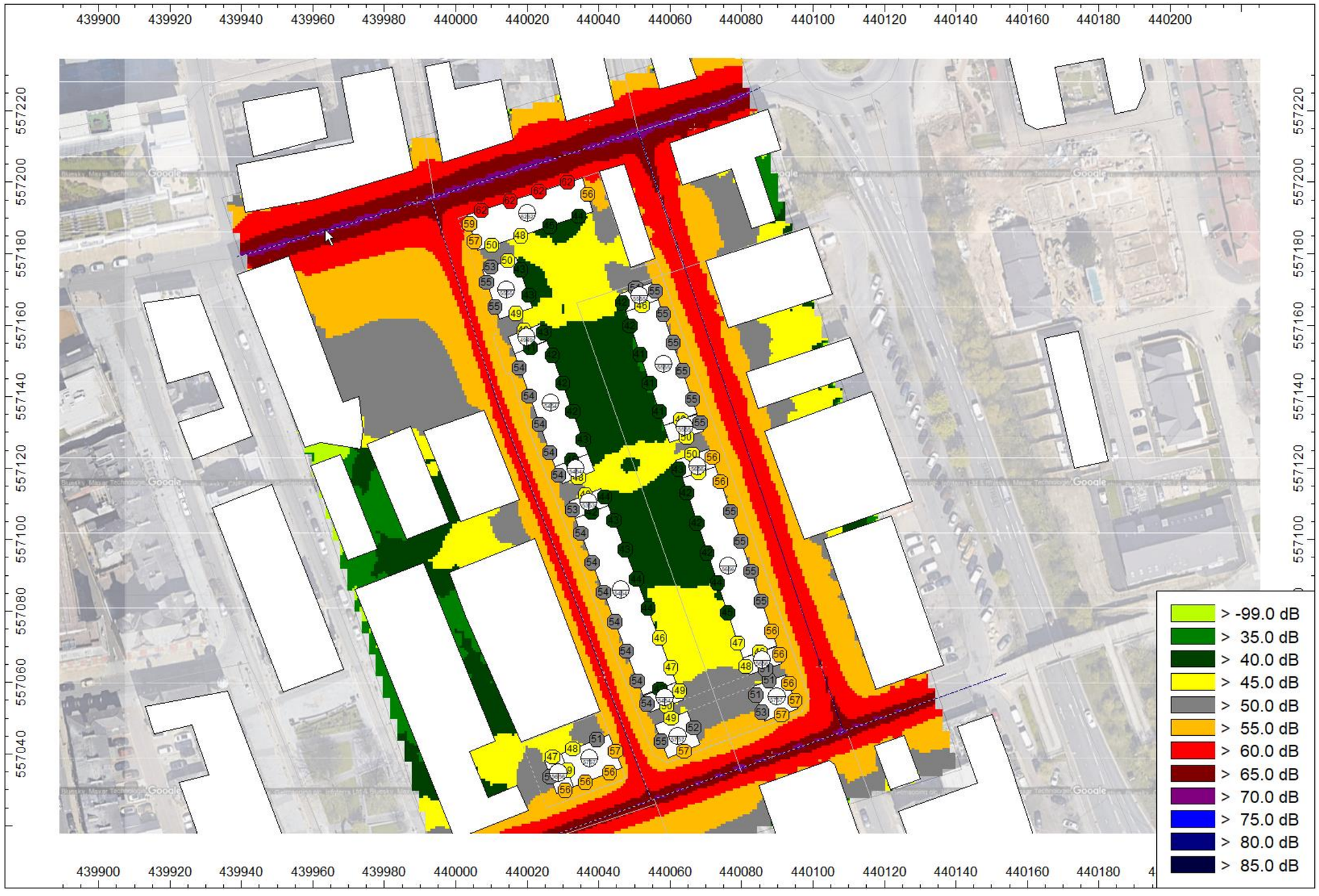


Figure 4: Plan viewing $L_{Aeq,\ 16\ hr}$ sound contours at 1.5 m above ground – road traffic noise
Maximum noise levels at any height shown on building's facades

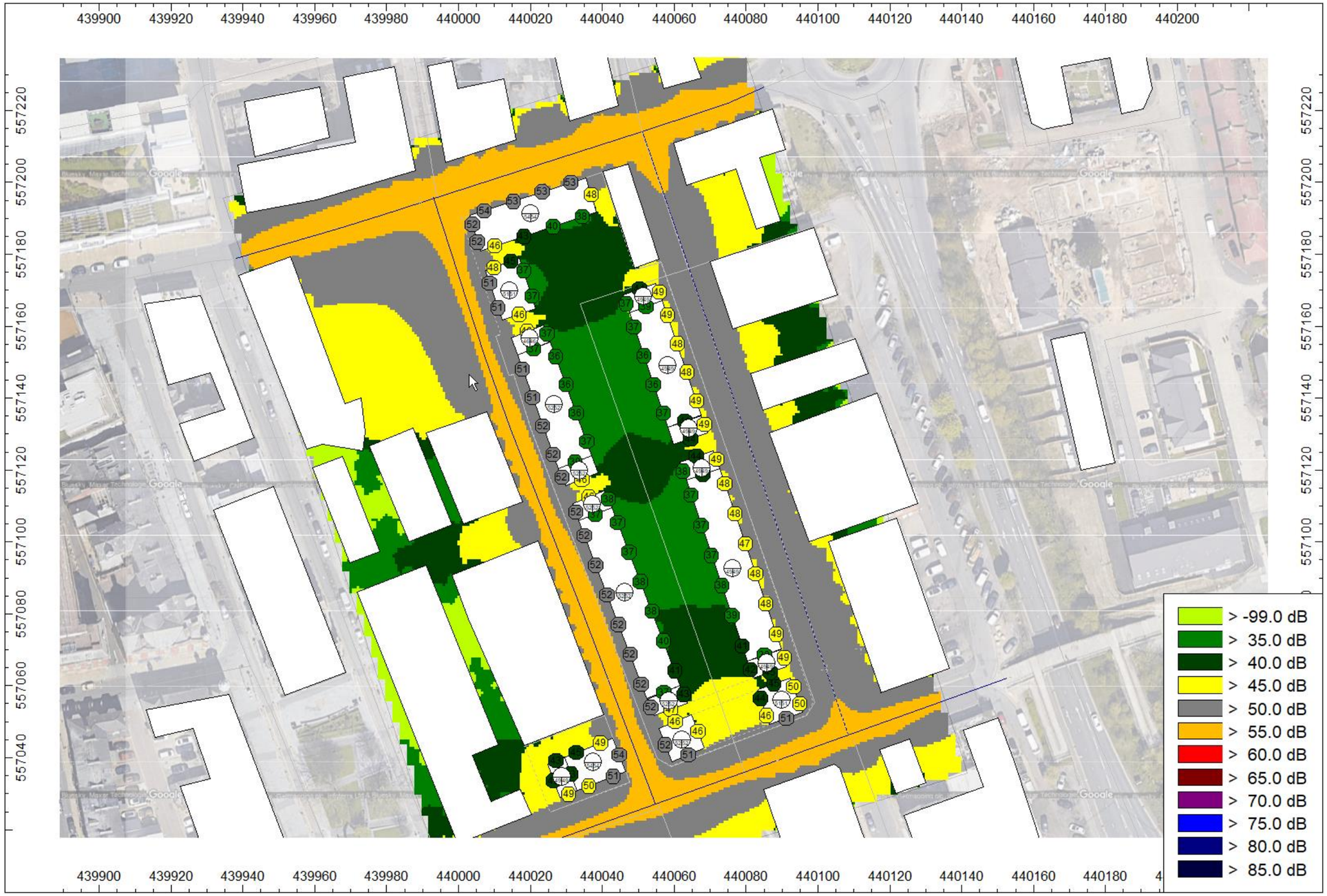


Figure 5: Plan viewing $L_{Aeq,\ 8\ hr}$ sound contours at 4 m above ground – road traffic
Maximum noise levels at any height shown on building's facades

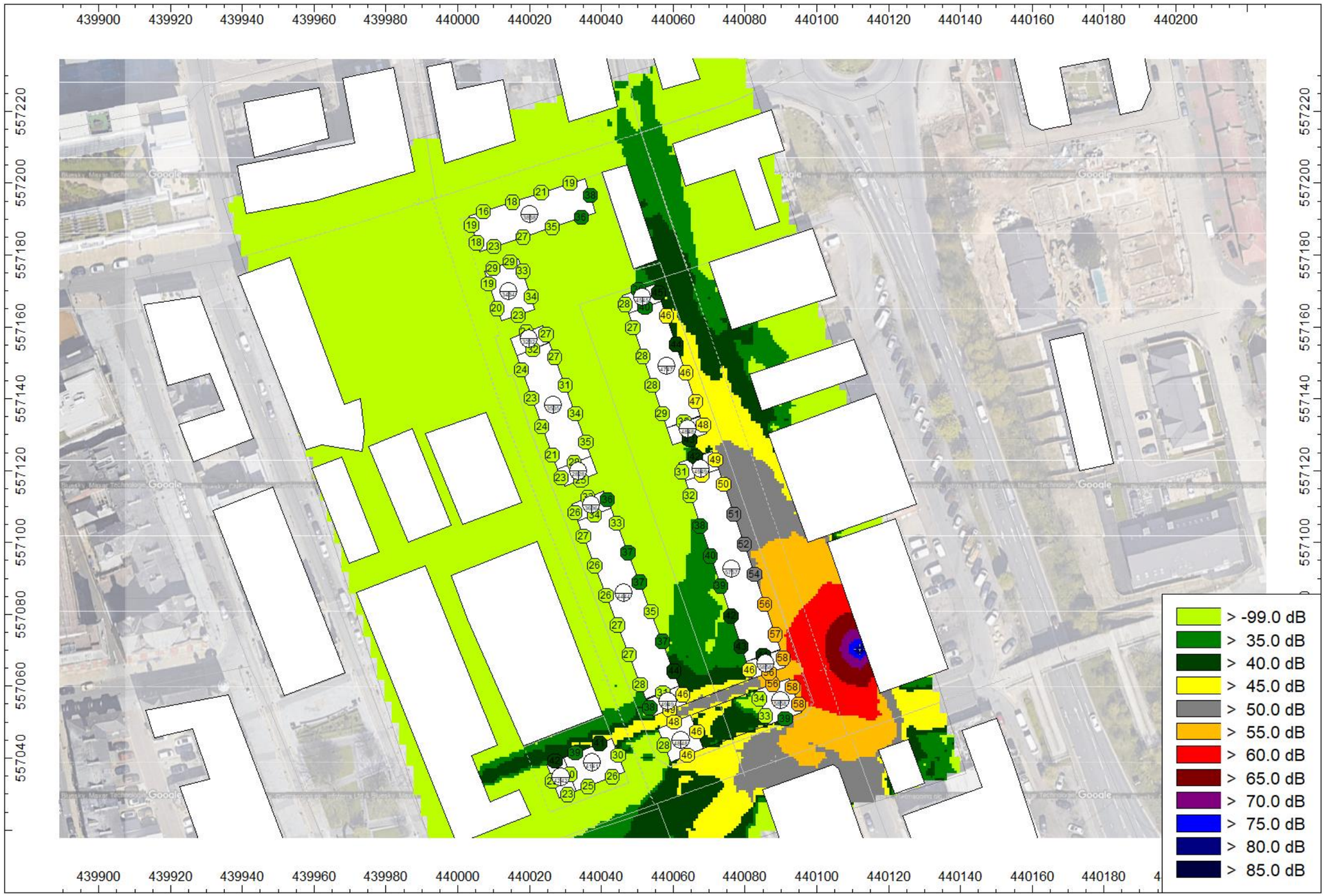


Figure 6 Plan viewing $L_{Aeq,\,1\,hr}$ sound contours at 1.5 m above ground – commercial noise
Maximum noise levels at any height shown on building's facades

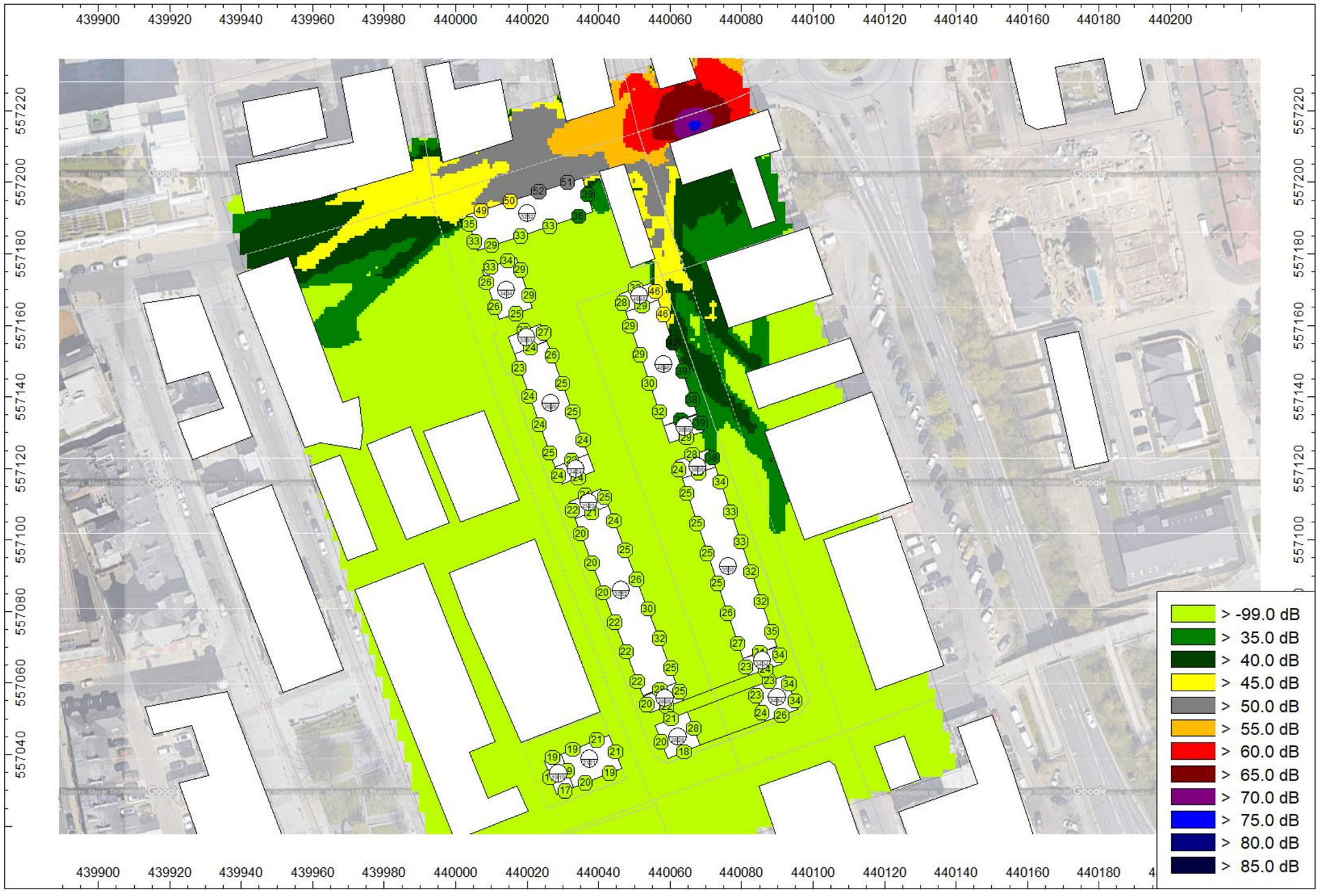


Figure 7 Plan viewing $L_{Aeq,}$ sound contours at 4 m above ground – entertainment noise
Maximum noise levels at any height shown on building's facades

6 Noise impact – road traffic noise

6.1 Modelled free-field noise levels at the windows of the most exposed rooms which are used in the façade sound insulation calculations are shown in Table 11.

6.2 Octave band $L_{Aeq,T}$ noise levels in the 125 Hz to 2 kHz calculation range indicated in BS 8233 have been adjusted to match the single figure measured A-weighted noise level.

Façade affected	Parameter	dB(A)	Octave band centre frequency, Hz A-weighted free-field noise level, dB				
			125	250	500	1k	2k
High St W Façade	$L_{Aeq,16\ hr}$	**62**	45	50	55	59	54
	$L_{Aeq,8\ hr}$	**53**	37	41	46	50	45
	L_{AFmax}	**77**					
Villiers St Façade	$L_{Aeq,16\ hr}$	**56**	38	42	47	53	51
	$L_{Aeq,8\ hr}$	**49**	37	34	35	46	45
	L_{AFmax}	**64**					
Coronation St Façade	$L_{Aeq,16\ hr}$	**56**	39	43	48	53	52
	$L_{Aeq,8\ hr}$	**50**	38	34	36	47	42
	L_{AFmax}	**64**					
Nile St Façade	$L_{Aeq,16\ hr}$	**55**	38	41	46	52	49
	$L_{Aeq,8\ hr}$	**52**	29	32	36	48	48
	L_{AFmax}	**64**					

Table 11: A-weighted external free-field noise levels used to calculate façade sound insulation

6.3 With the assumption of an openable window for ventilation purposes, which provides 13 dB attenuation, internal noise guideline levels during the daytime and night-time period would be exceeded. Therefore, windows will need to be closed, with an alterative means of ventilation provided to allow guideline noise levels to be met.

6.4 The façade sound insulation required to meet guideline noise levels is discussed in Section 10.

7 Noise impact – entertainment noise

7.1 Entertainment noise was audible at the northern and eastern boundaries of the proposed development. Modelled free-field noise levels at the windows of the most exposed rooms which are used in the façade sound insulation calculations are shown in Table 12.

Façade affected	Parameter	dB(A)	Octave band centre frequency, Hz Measured A-weighted noise levels, dB							
			63	125	250	500	1k	2k	4k	8k
High St W façade	Music Noise L_{Aeq}	**52**	41	41	40	43	48	46	39	26
Villiers St façade	Music Noise, L_{Aeq}	**46**	29	35	34	37	43	41	33	16

Table 12: A-weighted external free-field noise levels used to calculate façade sound insulation

7.2 A Noise Rating (NR) curve can be used to determine acceptable indoor noise levels from external sources, such as entertainment noise. It is proposed that in this instance the NR 20 curve internally is appropriate for speech intelligibility and to prevent sleep disturbance. The spectral values of the NR 20 curve are shown in Table 13.

Parameter	Octave band centre frequency, Hz (A weighted)						
	63	125	250	500	1k	2k	4k
Music Noise Limit - NR 20	25	23	22	21	20	18	15

Table 13: NR 20 spectrum values

7.3 Using the noise levels from Table 12, and assuming an open window provides 13 dB attenuation, it is predicted that NR 20 cannot be achieved internally with windows open.

7.4 Therefore, windows will need to be closed, with an alternative means of ventilation provided in order to meet the required spectral values.

7.5 The façade sound insulation required to meet NR 20 is discussed in Section 12.

8 Assessment Results – Commercial noise

8.1 Commercial noise from the car workshop was audible at the southeastern boundary of the proposed development. Modelled free-field noise levels of commercial noise at the windows of the most exposed rooms are presented in Table 14.

Façade affected	Commercial Noise - Parameter	dB(A)	Octave band centre frequency, Hz Measured A-weighted noise levels, dB							
			63	125	250	500	1k	2k	4k	8k
Villiers St façade	L_{Aeq}	**58**	37	39	40	46	53	53	50	45
	L_{Amax*}	**82**								
Coronation St façade	L_{Aeq}	**46**	25	27	28	34	41	41	38	33
	L_{Amax*}	**68**								
*only a single figure rating is provided for the L_{Amax}										

Table 14: A-weighted external free-field noise levels used to calculate façade sound insulation

8.2 In order to assess the impact of commercial noise, an assessment in accordance with BS 4142 has been undertaken, as shown in Table 15.

8.3 The results of the assessment show commercial noise is likely to cause a significant adverse impact on residents. With windows open, noise is likely to be audible internally, which may cause disturbance to residents.

8.4 Therefore, windows will need to be closed, with an alternative means of ventilation provided in order to reduce the impact.

8.5 The façade sound insulation required to reduce the impact from commercial noise is discussed in Section 13.

Parameter	Daytime assessment		Night-time assessment		Relevant clause of BS 4142	Commentary
	Eastern façade	Southern façade	Eastern façade	Southern façade		
Measured residual sound level L_r,	58 dB $L_{Aeq, 18\ hour}$		51 dB $L_{Aeq, 8\ hour}$		7.3.2	The L_r was measured at the location of the nearest proposed receptor.
Background sound level	46 dB $L_{A90, 15\ min}$		36 dB $L_{A90, 15\ min}$		8.1.4	Considered representative of the assessment period based on statistical analysis detailed in Appendix C.
Specific sound level L_s, due to car workshop	58 dB $L_{Aeq, 1\text{-}hr}$	46 dB $L_{Aeq, 1\text{-}hr}$	58 dB $L_{Aeq, 15\text{-}min}$	46 dB $L_{Aeq, 15\text{-}min}$	7.3.6	The calculated L_s contours across the site due to all sources during the assessment period are shown in Figure 6.
Acoustic feature correction	+ 10 dB		+ 10 dB		9.2	A subjective assessment to determine acoustic features is undertaken, and the following penalties are considered applicable: • +4dB for tonality, which is clearly perceptible at the noise receptor. This is to account for tonal elements of bangs and clashes of metal which were observed during the survey. • +6dB for impulsivity which is clearly perceptible at the noise receptor. This is to account for bangs and crashes which were observed during the survey.
Rating level, $L_{Ar,Tr}$	68 dB	56 dB	68 dB	56 dB		
Uncertainty of assessment					10	Background data was obtained over a 24-hr period, accounting for the changing acoustic environment. The location is representative of all NSRs in proximity to the proposed development. Weather conditions were favourable during the measurement period. Uncertainty in the calculated impact has been reduced by the use of a calculation method in accordance with ISO 9613-2.
Excess of $L_{Ar,Tr}$ over background sound level	+ 22 dB	+ 10 dB	+ 32 dB	+ 20 dB	11	The assessment indicates a **significant adverse impact.** When considering the context of Appendix D, and the mitigation in Section 13, the assessment result indicates the likelihood of a **low impact during the daytime and night-time period.**

Table 15: BS 4142 assessment results, based on current proposals

9 External amenity area assessment

9.1 The gardens for all plots are considered as an intrinsic part of the overall design. The design has positioned all external amenity areas within the central area of the development, and housing situated along the site boundaries. The majority of the external amenity areas are therefore screened from noise sources in the vicinity of the development.

9.2 When considering road traffic noise, Figure 4 shows the majority of external amenity areas are below 55 dB $L_{Aeq, 16\ hr,}$ except for those adjacent to Coronation Street.

9.3 In regard to commercial noise, all gardens are below 55 dB $L_{Aeq, 1\ hr}$, however it is recommended external noise levels should be reduced further due to the tonal and impulsive nature of the noise, aiming to meet a background noise level of 46 dB(A).

9.4 Entertainment noise is calculated to be 46 dB(A) in external amenity areas, meeting background noise levels. No further mitigation is recommended in regard to this.

9.5 In order to meet the requirements outlined above, 1.8m high close boarded fences are recommended, as outlined on Figure 8.

9.6 Noise levels in external amenity areas are not considered further.

Figure 8: Location of recommended 1.8m high close boarded fencing (shown in blue)

10 Noise and Approved Document F ventilation conditions

10.1 The proposed development will be required to meet Part F of the Building Regulations with regard to the whole dwelling ventilation condition, as described in Approved Document F[Ref16] (AD-F).

10.2 It is understood that mechanical ventilation with heat recovery (MVHR) ventilation system as described by AD-F is proposed for all dwelling types, and therefore trickle ventilators are not required.

11 Achieving internal noise levels – road traffic noise

11.1 **Façade sound insulation calculations**

11.2 Free-field noise levels at the windows of the most exposed rooms which are used in the façade sound insulation calculations are shown in Table 11.

11.3 Octave band $L_{Aeq,T}$ noise levels in the 125 Hz to 2 kHz calculation range indicated in BS 8233 have been adjusted to match the single figure calculated A-weighted noise level.

11.4 The calculation method for façade sound insulation is in accordance with BS 8233 and the principles of BS EN 12354-3[Ref14].

11.5 From ISO 16283[Ref15], the reverberation time is typically 0.5 seconds across the relevant frequency range for a furnished living room. This value is used for both living rooms and bedrooms.

11.6 Details of the methodology used to calculate internal noise levels are provided on our website: https://www.apexacoustics.co.uk/calculation-facade-sound-insulation/.

11.7 The minimum glazing performances presented in the summary table are calculated to be required to reduce noise levels to below the LOAEL for internal noise levels in those rooms most exposed to external noise ingress.

11.8 Noise levels in less exposed but similarly protected rooms will be lower and therefore also comply with the internal noise level targets.

11.9 The most exposed rooms are those with the largest ratio of window area to room volume, as well as those closest and most exposed to the noise sources.

11.10 Example glazing units that achieve the required performance standards are shown in Table 1.

11.11 The room and window dimensions used in the calculations are taken from the architects' plans and elevations. The façade mark up is shown in the Summary section.

11.12 The sound reduction of the non-glazed portion of the facade is much higher than that of the glazing and ventilation provision. Therefore, noise penetration through the non-glazed portion of the facade is disregarded as relatively insignificant with regards to control of road traffic noise.

11.13 Calculated internal noise levels on the basis of the identified minimum performance requirements are presented in Table 16.

11.14 An example full calculation for the worst affected location is shown in Appendix E, based on manufacturers test data from the example glazing products.

Façade affected (see Figure 1)	Room affected	Calculated internal level		
		Daytime dB $L_{Aeq,\ 16\ hr}$	Night-time dB $L_{Aeq,\ 8\ hr}$	Night-time dB $L_{Amax,\ F}$
	Bedroom	29	20	45
	Living room	28	-	-

Table 16: Summary of calculated worst-case internal noise levels

11.15 Based on the proposed façade sound insulation provision and the level and frequency of the measured maximum noise event, 45 dB $L_{Amax,\ F}$ is unlikely to be exceeded more than 10 times per night, and is therefore below the LOAEL described in paragraph 3.16.

12 Achieving internal noise levels – entertainment noise

12.1 Façade sound insulation calculations

12.2 Free-field noise levels at the windows of the most exposed rooms which are used in the façade sound insulation calculations are shown in Table 17.

12.3 Octave band $L_{Aeq,T}$ noise levels in the 63 Hz to 8 kHz calculation range required to encompass the music noise spectrum have been adjusted to match the single figure calculated A-weighted noise level.

Façade affected	Parameter	dB(A)	Octave band centre frequency, Hz Measured A-weighted noise levels, dB							
			63	125	250	500	1k	2k	4k	8k
	Music Noise L_{Aeq}	**52**	41	41	40	43	48	46	39	26
	Music Noise, L_{Aeq}	**46**	30	34	34	37	43	41	33	23

Table 17: A-weighted external free-field noise levels used to calculate façade sound insulation

12.4 The calculation method for façade sound insulation is as described above.

12.5 The minimum glazing performances presented in the summary table are calculated to be required to reduce noise levels to below the LOAEL for internal noise levels in those rooms most exposed to external noise ingress.

12.6 Noise levels in less exposed but similarly protected rooms will be lower and therefore also comply with the internal noise level targets.

12.7 The most exposed rooms are those with the largest ratio of window area to room volume, as well as those closest and most exposed to the noise sources.

12.8 Example glazing units that achieve the required performance standards are shown in Table 1.

12.9 The room and window dimensions used in the calculations are taken from the architects' plans and elevations. The façade mark up is shown in the Summary section.

12.10 To control the low frequency content of the music noise requires enhancements to the proposed timber external wall build up; the minimum wall sound reduction requirements are shown below.

12.11 The constructions shown below are calculated to offer suitable low frequency sound reduction performance.

Maisonettes facing High St W:

- batten hung facade wall system
- 80mm *rainscreen slab*
- 18 mm cement particle board
- 140 mm timber studs
- 140mm mineral wool frame therm 32 full fill between studs
- independent stud
- 2 x 12.5 mm Smart Ply Pro, ***OR*** 1 x 12.5 mm Smart Ply Pro + 1 x12.5 mm OSB
- 25 mm service void on timber battens
- 12.5 mm WallBoard

Terrace dwellings to the northern end of Villiers St

- batten hung facade wall system
- 1 x 12 mm OSB sheathing
- single 140 mm timber studs
- 100 mm mineral wool insulation within void
- 1 x 12.5 mm Smart Ply Pro/OSB
- 25 mm service void on timber battens
- 1 x 12.5 mm WallBoard

12.12 Based on the proposed façade sound insulation provision, NR 20 would be met in all rooms exposed to entertainment noise.

13 Achieving internal noise levels – commercial noise

13.1 **Façade sound insulation calculations**

13.2 Free-field noise levels at the windows of the most exposed rooms which are used in the façade sound insulation calculations are shown in Table 18.

13.3 Octave band $L_{Aeq,T}$ noise levels in the 125 Hz to 2 kHz calculation range indicated in BS 8233 have been adjusted to match the single figure calculated A-weighted noise level.

Façade affected	Commercial Noise - Parameter	dB(A)	Octave band centre frequency, Hz Measured A-weighted noise levels, dB							
			63	125	250	500	1k	2k	4k	8k
	L_{Aeq}	**58**	37	39	40	46	53	53	50	45
	L_{Amax*}	**82**								
	L_{Aeq}	**58**	37	39	40	46	53	53	50	45
	L_{Amax*}	**77**								
	L_{Aeq}	**58**	37	39	40	46	53	53	50	45
	L_{Amax*}	**72**								

Table 18: A-weighted external free-field commercial noise levels used to calculate façade sound insulation

13.4 The calculation method for façade sound insulation is described as above.

13.5 The minimum glazing performances presented in the summary table are calculated to be required to reduce noise levels to below the LOAEL for internal noise levels in those rooms most exposed to external noise ingress.

13.6 Noise levels in less exposed but similarly protected rooms will be lower and therefore also comply with the internal noise level targets.

13.7 The most exposed rooms are those with the largest ratio of window area to room volume, as well as those closest and most exposed to the noise sources.

13.8 Example glazing units that achieve the required performance standards are shown in Table 1 in the Summary.

13.9 The room and window dimensions used in the calculations are taken from the architects' plans and elevations. The façade mark up is shown in the Summary section.

13.10 Based on the proposed façade sound insulation provision, NR 20 would be met in all rooms exposed to commercial noise, and 40 dB $L_{Amax,F}$ from commercial noise is unlikely to be exceeded.

14 Conclusion

14.1 The existing noise impact across the proposed development site has been assessed in support of a Planning Application.

14.2 Noise levels in all gardens are calculated to be below the guideline upper limit of 55 dB $L_{Aeq,\ 16\ hr}$ with mitigation in place.

14.3 The potential implications for the design of the façade sound insulation under whole dwelling conditions as described by AD-F is discussed, and the glazing acoustic performance requirements to achieve the indoor noise level targets are identified in Table 1.

14.4 Based on the existing noise risks and details outlined in this report, the site is considered suitable for residential development.

15 References

1 National Planning Policy Framework, Department for Communities and Local Government, December 2023.

2 Noise Policy Statement for England, Department for Environment, Food and Rural Affairs, March 2010.

3 Guidelines for Community Noise, Edited by Birgitta Bergland, Thomas Lindvall, Dietrich H Schwela, World Health Organisation, 1999.

4 Association of Noise Consultants (ANC), Institute of Acoustics (IOA) and Chartered Institute of Environmental Health (CIEH), "ProPG: Planning & Noise - New Residential Development," May 2017.

5 BS 8233: 2014, Guidance on sound insulation and noise reduction for buildings.

6 AECOM Environment on behalf of DEFRA, NANR316 Possible options for the identification of SOAEL and LOAEL in support of the NPSE, December 2015.

7 BS4142:2014 + A1:2019 Methods for rating and assessing industrial and commercial sound

8 Calculation of Road Traffic Noise, Department of Transport, 1988.

9 BS 7445:2003, Description and measurement of environmental noise. Guide to quantities and procedures.

10 Transport Research Laboratory / Defra, Method for converting the UK road traffic noise index $L_{A10,\,18\,hr}$ to the EU noise indices for noise mapping, 2006.

11 Cadna/A environmental noise modelling software, version 2020, Datakustik GmbH.

12 ISO 9613: Acoustics - Attenuation of sound during propagation outdoors.

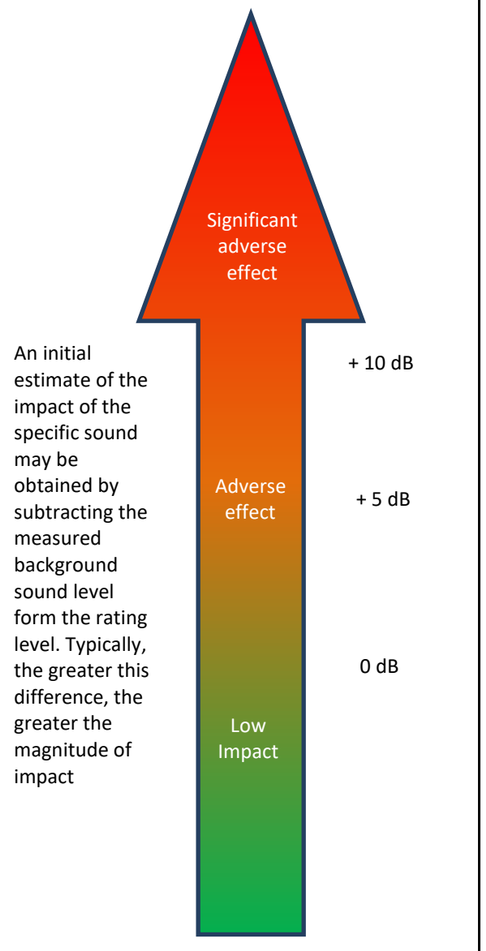
13 Architects Drawings, ref 2321-XSX-00-ZZ-DR-A-2310

14 BS EN 12354-3:2000, Building Acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 3: Airborne sound insulation against outdoor sound.

15 BS EN ISO 16283-1:2014 Acoustics – Field measurement of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation.

16 Approved Document F 2021 Edition, The Building Regulations 2000.

Appendix A Noise exposure hierarchy

<table>
<tr><th colspan="4">Planning Practice Guidance - Noise</th><th rowspan="2">BS 4142: Initial estimate of external noise risk significance</th></tr>
<tr><th>Noise</th><th>Example of outcomes</th><th>Increasing effect level</th><th>Action</th></tr>
<tr><td>Present and very distributive</td><td>Extensive and regular changes in behaviour, attitude or other physiological response and/or an inability to mitigate effect of noise leading to psychological stress, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory</td><td>Unacceptable Adverse Effect</td><td>Prevent</td><td rowspan="11"> 
</td></tr>
<tr><td>Present and distributive</td><td>The noise causes a material change in behaviour, attitude or other physiological response, 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.</td><td>Significant Observed Adverse Effect</td><td>Avoid</td></tr>
<tr><td colspan="4">Significant Observed Adverse Effect Level (SOAEL)</td></tr>
<tr><td>Present and intrusive</td><td>Noise can be heard and causes small changes in behaviour, attitude or other physiological response, 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 small actual or perceived change in the quality of life.</td><td>Observed Adverse Effect</td><td>Mitigate and reduce to a minimum</td></tr>
<tr><td colspan="4">Lowest Observed Adverse Effect Level (LOAEL)</td></tr>
<tr><td>Present and not intrusive</td><td>Noise can be heard, but does not cause any change in behaviour, attitude or other physiological response. Can slightly affect the acoustic character of the area but not such that there is a change in the quality of life.</td><td>No Observed Adverse Effect</td><td>No specific measures required</td></tr>
<tr><td colspan="4">No Observed Adverse Effect Level (NOAEL)</td></tr>
<tr><td>Not present</td><td>No effect</td><td>No Observed Effect</td><td>No specific measures required</td></tr>
<tr><td colspan="4">No Observed Effect Level (NOEL)</td></tr>
</table>

Appendix B Time Histories

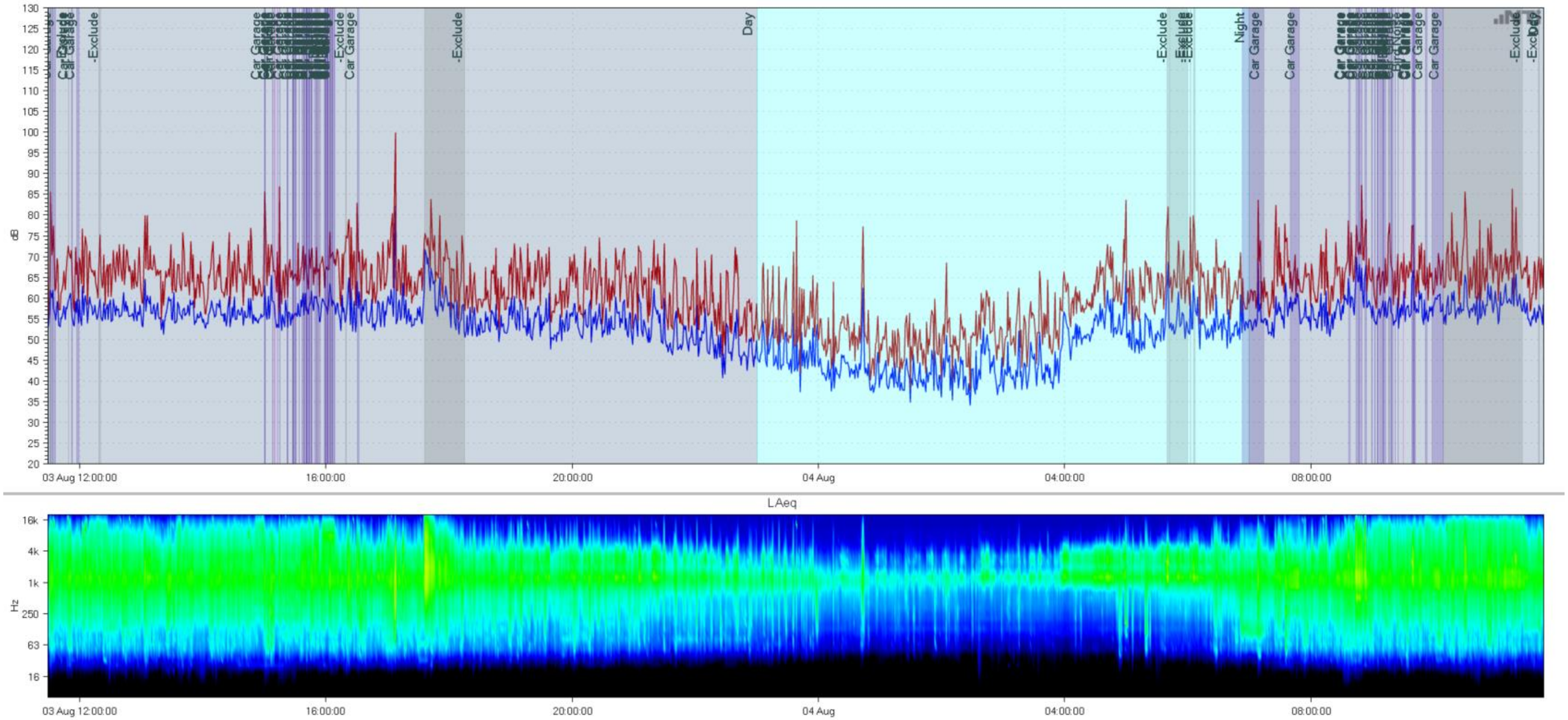


Figure 9 Time history of the recorded $L_{Aeq,1min}$ (blue) and L_{AFmax} (red), and spectrograph – P1

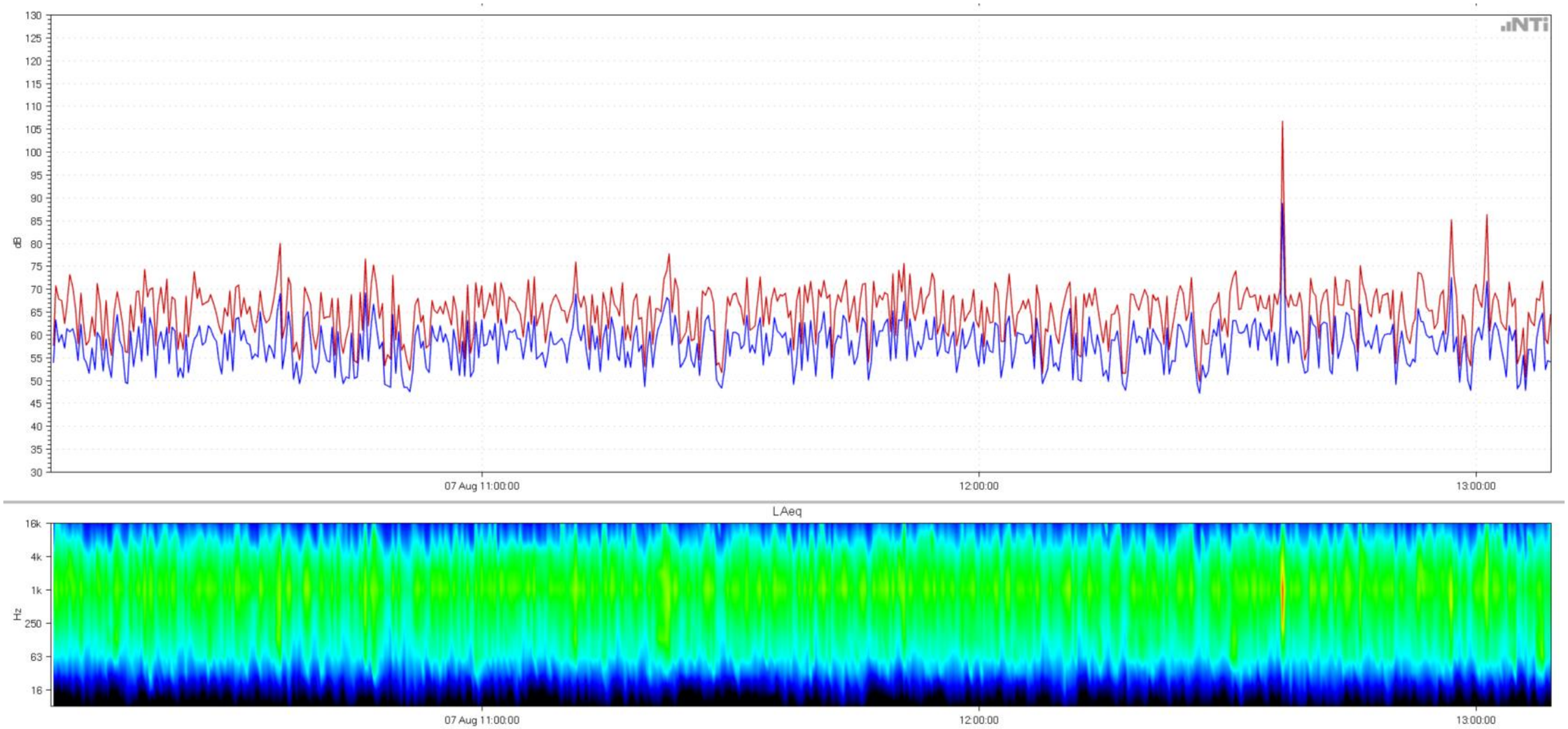


Figure 10 Time history of the recorded $L_{Aeq,5sec}$ (blue) and L_{AFmax} (red), and spectrograph – P2 daytime

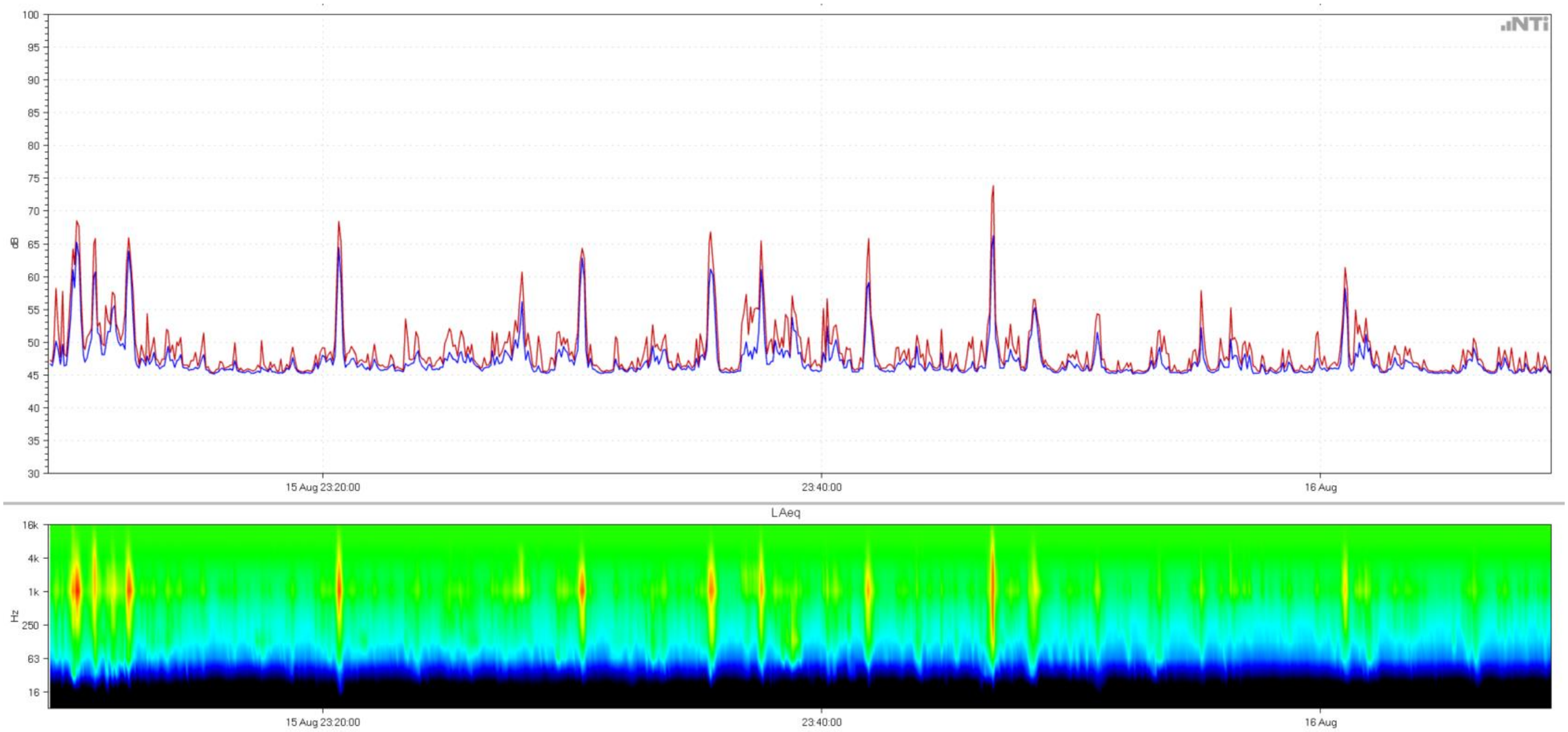


Figure 11 Time history of the recorded $L_{Aeq,5sec}$ (blue) and L_{AFmax} (red), and spectrograph – P2 night-time

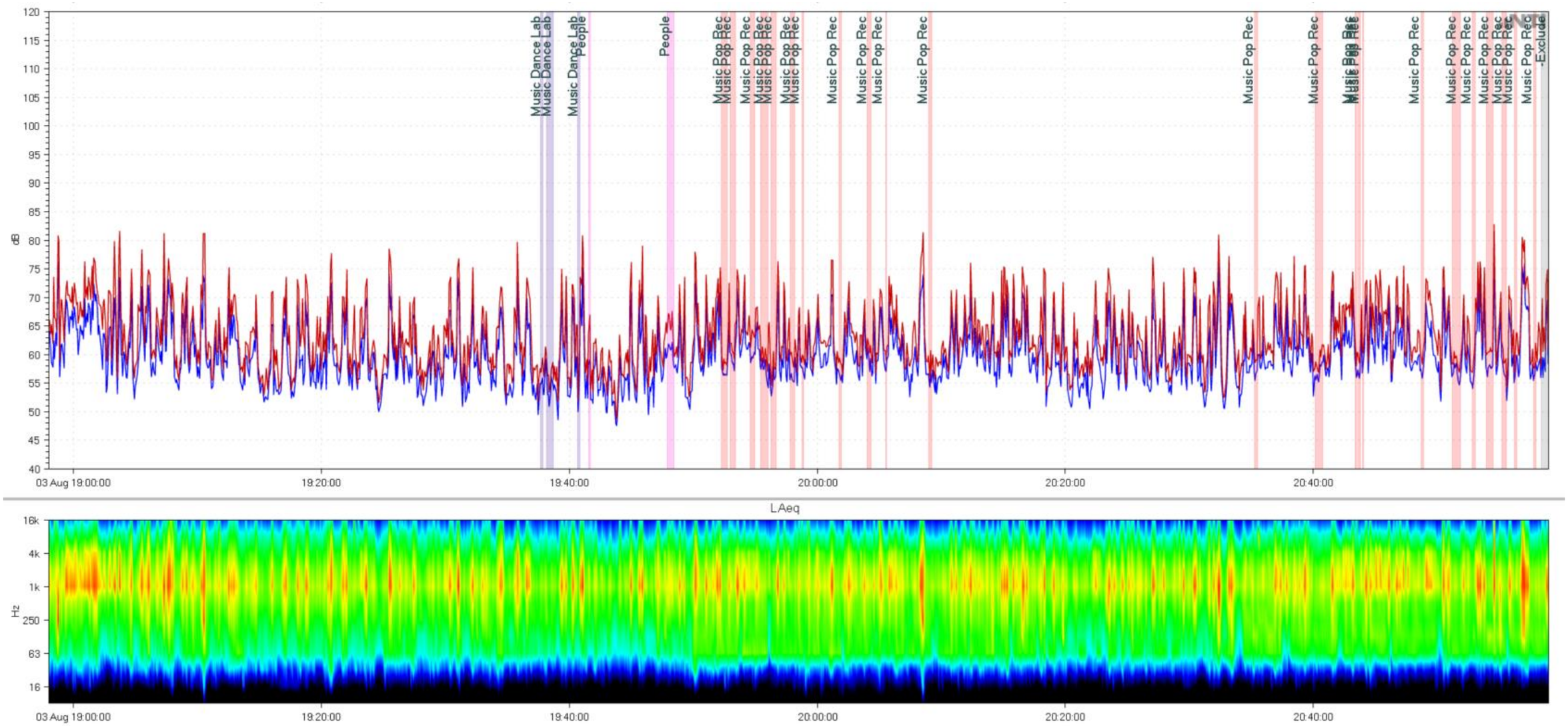


Figure 12 Time history of the recorded $L_{Aeq,5sec}$ (blue) and L_{AFmax} (red), and spectrograph – P3

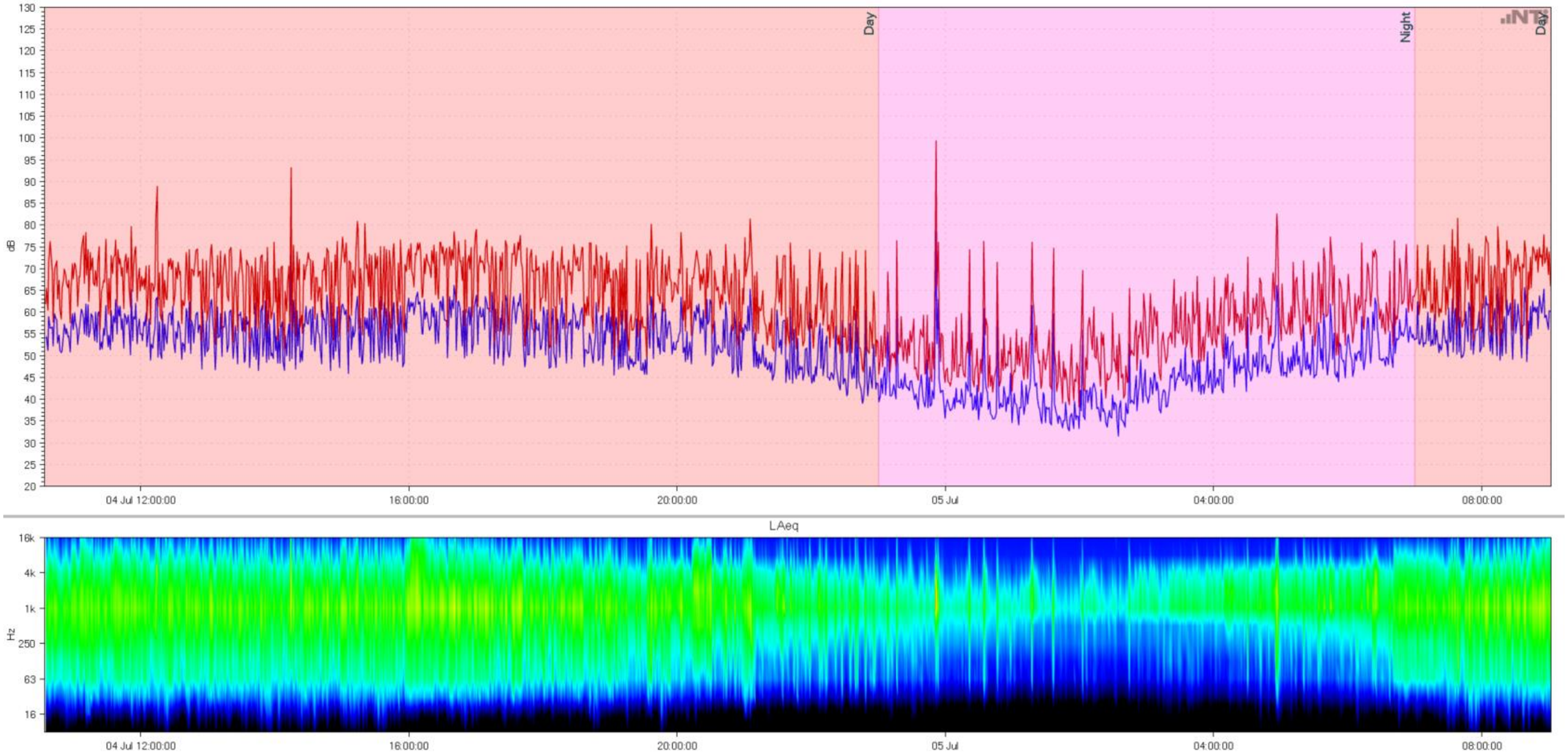


Figure 13 Time history of the recorded $L_{Aeq,1min}$ (blue) and L_{AFmax} (red), and spectrograph – P4

Appendix C Selection of background sound level

C.1 The measured daytime and night time $L_{A90,15min}$ levels are shown in Table 19.

Time (hh:mm)	$L_{A90, 15\ min}$(dB)	Time (hh:mm)	$L_{A90, 15\ min}$ (dB)	Time (hh:mm)	$L_{A90, 15\ min}$ (dB)
10:30	56.9	18:00	56.5	01:30	48.2
10:45	55.0	18:15	58.4	01:45	35.8
11:00	58.2	18:30	55.8	02:00	45.6
11:15	57.5	18:45	57.0	02:15	37.6
11:30	58.3	19:00	56.4	02:30	42.2
11:45	58.9	19:15	51.6	02:45	43.2
12:00	57.7	19:30	57.6	03:00	42.3
12:15	57.0	19:45	56.1	03:15	44.1
12:30	56.6	20:00	55.7	03:30	46.5
12:45	56.8	20:15	59.5	03:45	45.5
13:00	57.8	20:30	56.1	04:00	49.1
13:15	57.2	20:45	54.1	04:15	49.0
13:30	56.1	21:00	57.4	04:30	51.2
13:45	57.1	21:15	51.5	04:45	57.2
14:00	66.0	21:30	54.8	05:00	48.8
14:15	57.3	21:45	51.0	05:15	50.1
14:30	57.5	22:00	51.5	05:30	54.7
14:45	58.2	22:15	50.1	05:45	50.9
15:00	59.0	22:30	52.0	06:00	51.7
15:15	56.9	22:45	50.3	06:15	57.1
15:30	58.0	23:00	46.3	06:30	52.8
15:45	58.6	23:15	49.5	06:45	55.9
16:00	61.3	23:30	42.5	07:00	56.1
16:15	59.3	23:45	70.0	07:15	54.4
16:30	61.3	00:00	39.5	07:30	59.3
16:45	58.8	00:15	48.8	07:45	58.1
17:00	60.6	00:30	49.4	08:00	59.8
17:15	58.2	00:45	47.3	08:15	58.5
17:30	59.9	01:00	39.7	08:30	59.1
17:45	56.4	01:15	50.6	08:45	60.9

Table 19: Measured background sound levels, $L_{A90, 15\ min}$

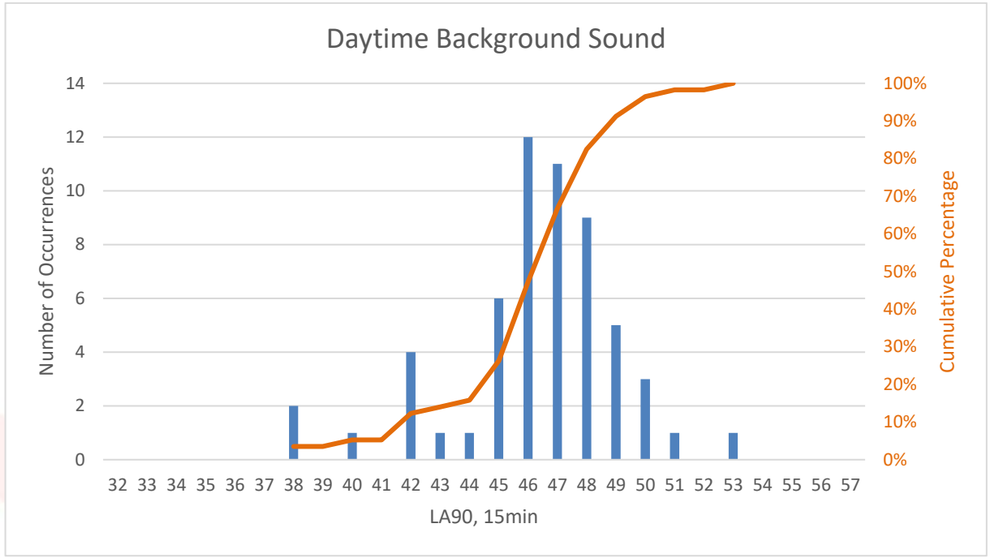


Figure 14: Analysis of daytime background levels, $L_{A90, 15\ min}$

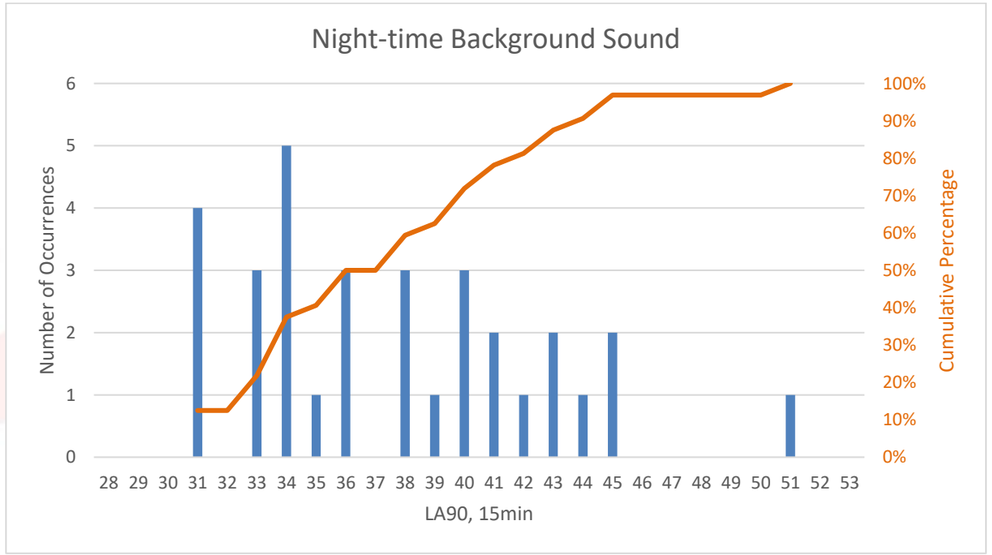


Figure 15: Analysis of night-time background levels, $L_{A90, 15\ min}$

Appendix D Context of acoustic environment

D.1 Assessment of context

*BS 4142 states the **ALL** of following factors are to be considered for 'context':*

1. *The absolute sound level e.g. a where the residual level are higher than the rating levels, the rating levels might have less significance.*
2. *The character and level of residual sound compared to character of the specific sound – this might include acoustic features such as frequency content, but also existing soundscape features e.g. An agricultural soundscape, industrial soundscape etc.*
3. *The sensitivity of the receptor*

Absolute sound level

D.2 To determine the first context test in BS 4142 it is necessary to determine whether the residual and background sound levels are high or low. Section 11 of BS4142 states:

"For a given difference between the rating level and the background sound level, the magnitude of the overall impact might be greater for an acoustic environment where the residual sound level is high than for an acoustic environment where the residual sound level is low.

Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night.

Where residual sound levels are very high, the residual sound might itself result in adverse impacts or significant adverse impacts, and the margin by which the rating level exceeds the background might simply be an indication of the extent to which the specific sound source is likely to make those impacts worse."

D.3 During the daytime and night-time, the residual level is high. The rating level is very high, greatly exceeding the background level. The rating level is likely to be audible during the daytime and night-time period.

Character and level of residual and specific sound

D.4 The specific sound from the car garage (i.e. engine noise from cars/vans and impulsive noise from tools) will differ to the residual sound once the proposed development is in place, being mainly road traffic noise. Although the car garage will be somewhat in keeping with the noise sources I the area, the tonality and impulsivity of the car garage will be noticeable.

D.5 The residual noise levels at the NSRs are 58dB during the daytime, and 51dB during the night-time. As shown in Table 15, the specific sound levels are up to 60dB, during the daytime and night-time. These levels are above the residual levels, having an impact on the absolute level during the daytime and night-time.

D.6 When taking the above into consideration the noise impact will not change.

Sensitivity of Receptor

D.7 With regard to pertinent factors to be taken into consideration, Section 11 of BS 4142 states;

"The sensitivity of the receptor and whether dwellings or other premises used for residential purposes will already incorporate design measures that secure good internal and/or outdoor acoustic conditions, such as:

i) facade insulation treatment;

ii) ventilation and/or cooling that will reduce the need to have windows open so as to provide rapid or purge ventilation; and

iii) acoustic screening."

D.8 During the daytime, when residents are likely to be outside, they will not benefit from any attenuation via the façade. The proposed mitigation will provide acoustic screening to the development. Predicted noise levels are well below guideline levels outdoors, and unlikely to be audible above the residual sound level. At night, residents are usually indoors, and will therefore benefit from attenuation via the façade of the dwelling, as specified in the Summary section.

D.9 When considering the sensitivity of the receptor and typical use of a dwelling, the noise impact is likely to be less than identified.

D.10 Summary

D.11 The calculated $L_{Ar,Tr}$ is below external and internal guideline noise levels during the daytime and night-time, with mitigation in place.

D.12 The proposed development is considered to have a low impact at assessment locations.

Appendix E Example façade sound insulation calculations

E.1 Road traffic noise calculations

Terrace Maisonette	
Volume, V / m^3	25
Window area, S / m^2	3
Reverberation Time, T / s	0.5

Daytime $L_{Aeq,T}$ (dB)	dB(A)	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz
External free-field noise, L_{1in}	**55**	39	41	46	52	49
Glazing: 4/12/4 mm, R		24	20	25	35	38
Equation 1, L_2(a)	**24**	14	20	20	16	10

Night-time $L_{Aeq,T}$ (dB)	dB(A)	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz
External free-field noise, L_{1in}	**52**	29	32	36	48	48
Glazing: 4/12/4 mm, R		24	20	25	35	38
Equation 1, L_2(a)	**16**	4	10	10	11	9

E.2 Commercial noise calculations

Terrace Maisonette	
Volume, V / m^3	35
Window area, S / m^2	3
Reverberation Time, T / s	0.5

Commercial $L_{Aeq,T}$ (dB)	dB(A)	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
External free-field noise, L_{1in}	**58**	37	39	40	46	53	53	50
Glazing: 8/16/12.8 mm, R		32	25	32	41	46	46	59
Equation 1, L_2(a)	**14**	2	11	5	2	4	4	-12
Wall: As W5 with sacrificial lining, R		15	25	35	44	49	48	54
Equation 2, L_2(b)	**25**	24	16	7	4	6	7	-2
Total noise through all elements, L_2	**25**	**24**	**18**	**9**	**6**	**9**	**9**	**-1**

E.3 Music noise calculations

Commercial Maisonette	
Volume, V / m^3	14
Window area, S / m^2	1
Reverberation Time, T / s	0.5

Music LAeq, T (dB)	**dB(A)**	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**	**4 kHz**
External free-field noise, L_{1in}	**52**	41	41	40	43	48	46	39
Glazing: 4/16/6.8 mm, R		28	24	21	32	45	53	50
Equation 1, L_2(a)	**20**	11	15	17	9	1	-9	-13
Wall: 1 x 18mm Cemboard, 140mm void twin stud, mineral wool, 2 x 12.5mm OSB, 25mm void, 12.5mm wallboard, R		21	37	45	52	56	55	61
Equation 2, L_2(b)	**22**	22	6	-3	-7	-6	-7	-20
Total noise through all elements, L_2	**24**	**22**	**15**	**17**	**9**	**2**	**-5**	**-12**