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ACOUSTICS

ACOUSTIC REPORT FOR PLANNING

REVISION 01 – 16 DECEMBER 2020

Audit sheet.

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Executive summary.

There are proposals to redevelop the existing Clarendon Centre, located between Cornmarket Street and Queen Street, in Oxford City Centre. The proposals are to redevelop the existing buildings forming the Clarendon Centre to provide a new mixed used scheme consisting of a new commercial laboratory facility, new office and commercial space and new student residential accommodation. The scheme will be completed over three phases:

Phase 1 – New commercial laboratory facility, with ground floor retail unit, in the west area of the site;

Phase 2 – New office and student accommodation development in the north and northeast areas of the site;

Phase 3 – New office and commercial development to the central and east areas of the site.

This report has been prepared to support the planning application for the proposed scheme.

Environmental sound survey.
An environmental sound survey has been undertaken to establish the existing sound environment at the site and the surrounding areas. The survey consisted of unattended long-term measurements undertaken at four locations across the site over a period of six days.

Façade sound insulation for student accommodation.
The existing sound environment has an impact on the design of the facade and the ventilation strategy. Indoor ambient noise levels can be controlled with suitable consideration to the ventilation strategy and design of the external façade. An early-stage assessment has been carried out to understand the implications of the existing sound environment on the design. This has been summarised as follows:

- Preliminary calculations have been undertaken to determine the likely sound reduction performance needs of the student residential accommodation.
- The calculations indicate that requirements can be achieved with relatively standard performance, acoustic double-glazed window units and trickle vent systems.
- It is understood that the concept design preference is for acoustically rated trickle vents to bedrooms, with MEV extract in the en-suite bathrooms and natural ventilation to shared kitchens with mechanical extract. It is assumed that occasional purge ventilation, for expelling fumes or odours, would be through opening windows.

Following a review of survey data from a recent previous scheme on the Clarendon Centre site, the night-time sound levels measured in September 2020 to the north of the site may be lower than they would be under normal periods due to several night-clubs on Frewin Court currently being closed due to COVID-19. Additional measurements may be required if/when the night-clubs are operational again to capture more representative sound levels and the façade specification may need to be revisited.

Plant noise emission limits.
External plant noise emission limits at the nearest residential properties have been proposed based on the measured baseline sound conditions and on the requirements of the local authority.

The existing offices within North Bailey House and surrounding buildings were unoccupied at the time of the survey due to COVID-19, meaning that existing building services plant associated with the nearby offices will not have been operational. As such background sound levels measured are likely to be lower than those during normal periods. Additional measurements may be required once the offices are re-occupied to capture more representative background sound levels.

Selections for the building services plant equipment are not available at this early stage but initial guidance on the type of acoustic mitigation measures expected to be required to achieve the proposed plant noise limits has been given.

On the basis of the initial assessments, noise is not expected to pose an obstacle in the granting of planning permission for the scheme.

1. Introduction.

There are proposals to redevelop the existing Clarendon Centre, located between Cornmarket Street and Queen Street, in Oxford City Centre. The proposals are to redevelop the existing buildings forming the Clarendon Centre to provide a new mixed used scheme consisting of a new commercial laboratory facility, new office and retail space and new student residential accommodation. The redevelopment of the site will be carried out over three phases.

An environmental sound survey has been undertaken at the site to understand the local acoustic environment and establish typical baseline conditions. The results from the survey have been used to provide initial guidance on the acoustic performance required for the façade and set limits for building services plant noise emissions in line with local noise policy.

This report provides a summary of the sound levels measured at the site, outlines the assessments undertaken, and has been produced to support the planning application for the project.

As this report contains technical terminology, a glossary of terms is provided in Appendix A.

2. Site description.

The site is located between Cornmarket Street and Queen Street, in Oxford City Centre, in a primarily commercial area. The existing buildings on the site consist of various retail and office properties forming the Clarendon Centre. The site and its surroundings are shown in Figure 1.

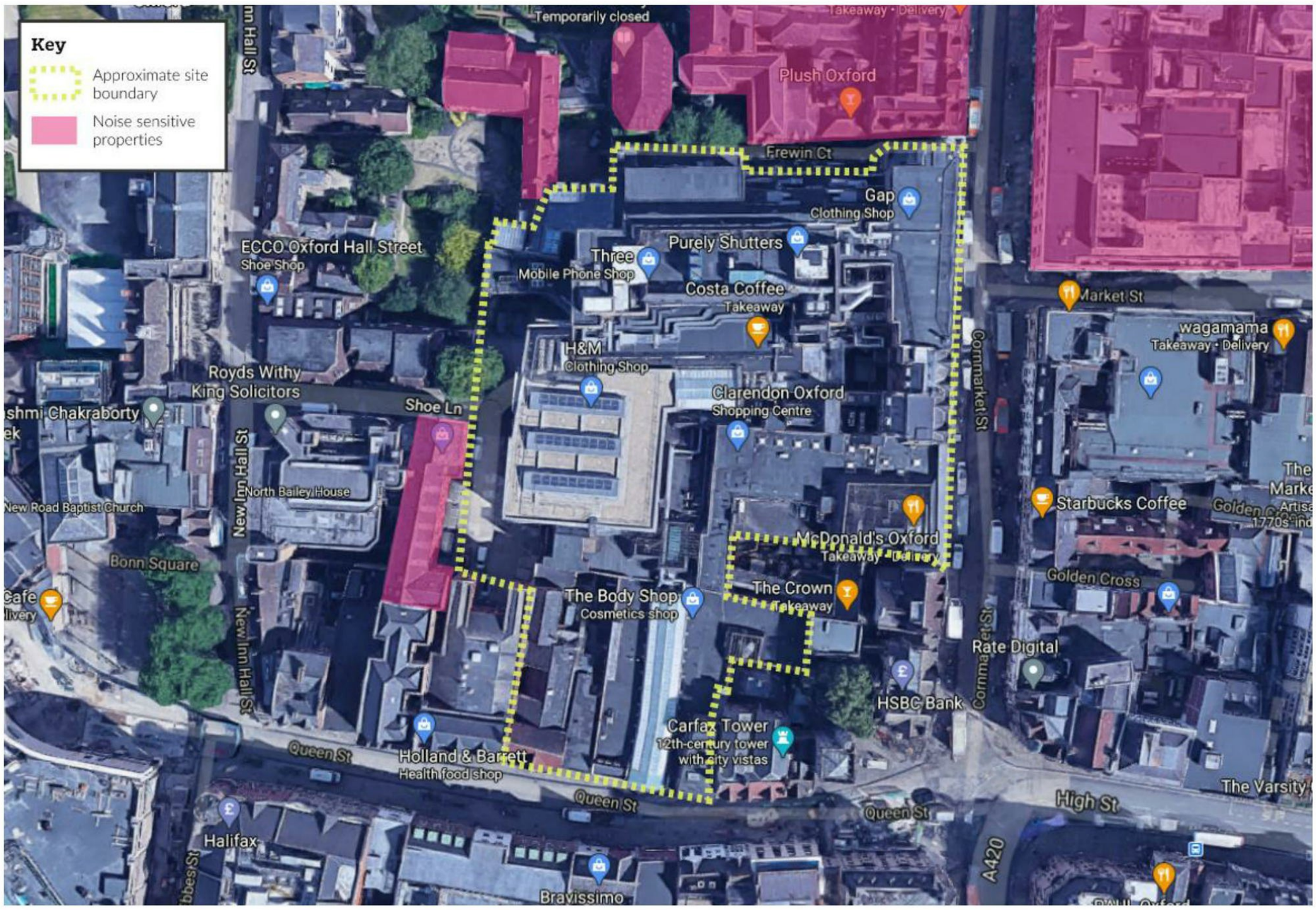


Figure 1 Site and surroundings. (Image source: Google Maps)

While the majority of the surrounding buildings are commercial in nature, there are several residential properties in the neighbouring area as highlighted in Figure 1. These include existing student accommodation to the north and west of the site, and new student accommodation provided by the Northgate House development (currently under construction) to the northeast of the site.

The existing sound environment in the vicinity of the site is controlled by existing building services (primarily building services associated with the Clarendon Centre that will be replaced as part of the redevelopment), traffic activity from nearby roads and pedestrian activity from nearby areas.

To the southeast of the site, sound from the external courtyard of The Crown public house is also prevalent.

2.1 Proposed development.

The proposed development will involve demolition of parts of the existing buildings to provide a new mixed used scheme consisting of a new commercial laboratory facility, new office and retail space and new student residential accommodation.

The scheme will be completed over three phases:

Phase 1 – New commercial laboratory facility, with ground floor retail unit, in the west area of the site;

Phase 2 – New office and student accommodation development in the north and north east areas of the site;

Phase 3 – New office and retail development to the central and east areas of the site.

Approximate locations of the three phases of the development are presented in Figure 2 below.

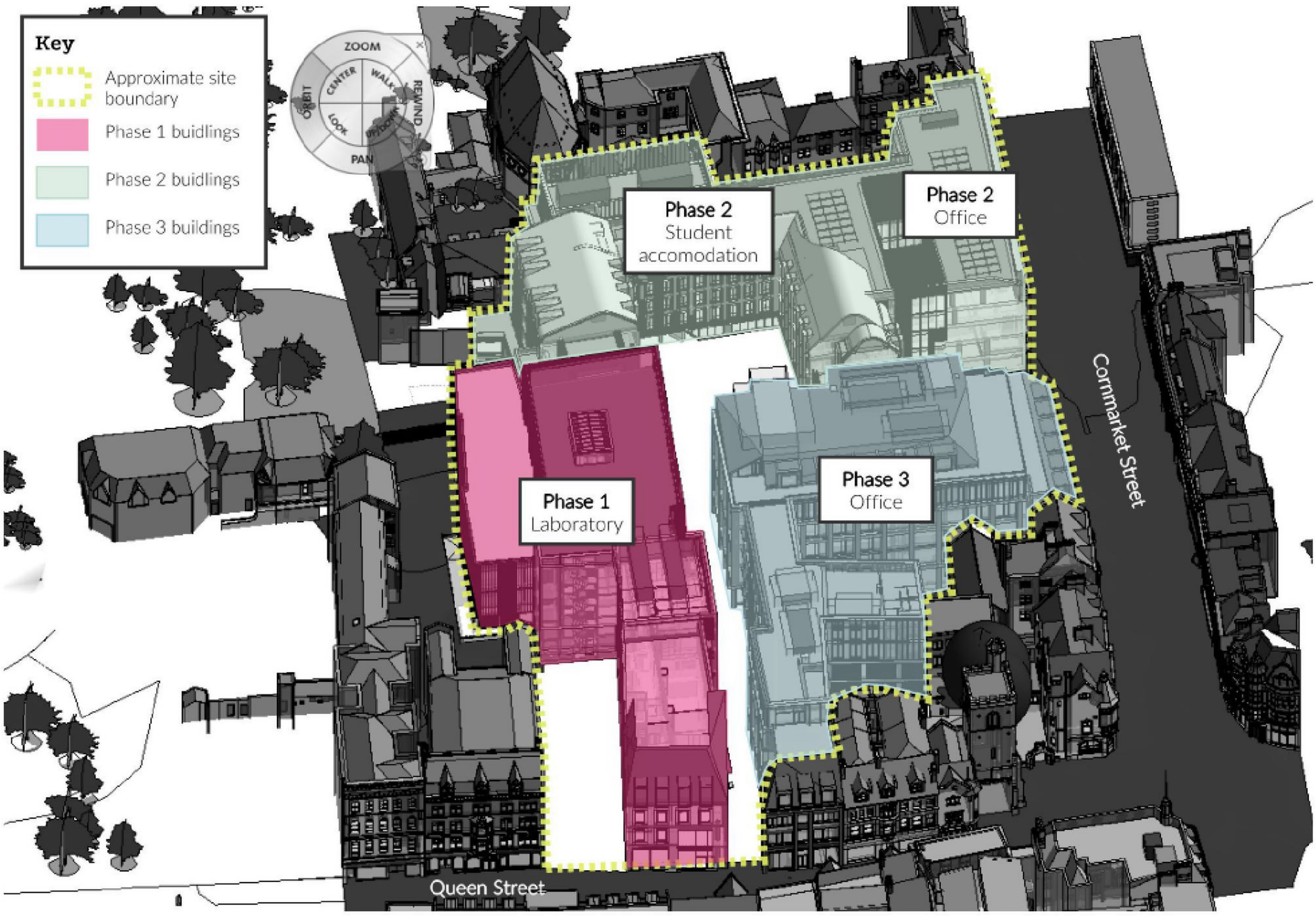


Figure 2 Approximate locations of the three phases of the proposed development.

3. Policy and guidance.

3.1 General references.

The survey and assessment have been carried out in accordance with the following policy and guidance:

- National Planning Policy Framework (NPPF,2019);
- Noise Policy Statement for England (NPSfE for DEFRA);
- Oxford Local Plan 2036, Adopted June 2020;
- British Standard BS 4142:2014 *Methods for rating and assessing industrial and commercial sound*;
- British Standard BS 8233:2014 Guidance on sound insulation and noise reduction for buildings;
- British Standard BS 7445:2003 *Description and measurement of environmental noise*.

3.2 Noise Policy Statement for England.

The Noise Policy Statement for England (NPSE) sets out the long-term vision of Government noise policy to:

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

The NPSE advises that noise impacts should be assessed on the basis of adverse and significant adverse effect. The NPSE does not provide any specific guidance on assessment methods or noise limits. However, the concepts summarised in Table 1 are introduced and can be applied when considering the significance of noise impacts.

Table 1 Observed Effect Levels

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

3.3 British Standard BS 4142:2014 Methods for rating and assessing industrial and commercial sound.

Current Government advice to Local Planning Authorities in both England and Wales makes reference to BS 4142 as being the appropriate guidance for assessing commercial operations and fixed building services plant noise. This British Standard provides an objective method for rating the likelihood of complaint from industrial and commercial operations. It also describes means of determining noise levels from fixed plant installations and determining the background noise levels that prevail on a site.

The assessment of impacts is based on the subtraction of the measured background noise level from the rating level determined. The rating level is the source noise level (either measured or predicted) corrected for tone or character (if necessary). The difference is compared to the following criteria to evaluate the impact.

- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact.
- A difference of around +5 dB indicates is likely to be an indication of an adverse impact.
- Where the rating level does not exceed the background noise level, this is an indication of the specific sound source having a low impact.

3.4 British Standard BS 8233:2014 Guidance on sound insulation and noise reduction for buildings.

BS 8233 recommends internal ambient noise levels for dwellings. The recommendations stated within BS 8233 are provided in Table 2

Table 2 Internal ambient noise levels recommended for dwellings

Location	Day time (07:00 – 23:00)	Night (23:00 – 07:00)
Living Rooms	35 dB $L_{Aeq, 16hour}$	-
Bedroom	35 dB $L_{Aeq, 16hour}$	30 dB $L_{Aeq, 8hour}$

Guidance from BS 8233 also recommends that regular individual events occurring at night-time should be limited in bedroom areas to prevent sleep disturbance. It is recommended that a limit of 45 dB L_{Afmax} is adopted in line with World Health Organisation guidelines.

3.5 Local planning policy.

The Local Planning Authority for the development site is Oxford City Council (OCC). The detailed framework for land use policies is set in the Oxford Local Plan 2036.

Policy RE8 of the Oxford Local Plan states that:

"Planning permission will only be granted for development proposals which manage noise to safeguard or improve amenity, health, and quality of life.

Planning permission will not be granted for development that will generate unacceptable noise and vibration impacts.

Planning permission will not be granted for development sensitive to noise in locations which experience high levels of noise, unless it can be demonstrated, through a noise assessment, that appropriate attenuation measures will be provided to ensure an acceptable level of amenity for end users and to prevent harm to the continued operation of existing uses."

3.6 Proposed plant noise criteria.

In the absence of prescriptive guidance for plant noise emission limits within the OCC planning policy, a review of recent planning applications in the area around the development site was undertaken, including the following schemes:

- Northgate House (18/00258/FUL)
- TK Maxx Clarendon Centre (19/00510/FUL)
- Brasenose College (19/02601/FUL)

The plant noise emission limits at the most affected noise sensitive receivers for all three of these schemes are set to be equal to the measured background sound levels, which aligns with the guidance set out in BS 4142.

Based on the review, and the context on the local sound environment, a 'rating level' equal to the measured background sound level has been proposed as the plant noise design criterion at the most affected noise sensitive receivers.

OCC were approached to discuss the proposed acoustic assessment methodology. Edward Davis from Environmental Health confirmed that the proposed approach was acceptable in an email dated 30/10/2020, presented in Appendix C for reference.

4. Environmental sound survey.

An environmental sound survey was carried out between 16th September and the 22nd September 2020 to establish typical baseline conditions on the site. The survey comprised five days of unattended long-term measurements at four positions across the site.

A summary of the daytime and night-time measured survey results is presented in Figure 3 and Figure 4. Further details of the survey work undertaken, including the equipment information are presented in Appendix B.

Position L1
Measurement position L1 was located on the roof of an existing building, to the north of the site, in a position overlooking residential properties in this area. Background sound levels measured at this position are considered representative of those experienced by residential properties to the north of the site and ambient sound levels measured at this position are considered representative of levels experienced by the north façade of the proposed student accommodation at the time of the survey.

A review of the survey data for the TK Maxx Clarendon Centre scheme (19/00510/FUL) has indicated that night-time sound levels to the north of the site may typically be higher than those measured during the current survey. This appears to be mainly due to the noise breakout from several night clubs on Frewin Court, including The Cellar and Plush, that are currently closed due to COVID-19.

As such, there is some uncertainty in the night-time sound levels measured, and additional measurements may be required if/when the night-clubs are operational again, to capture more representative sound levels.

Position L2
Measurement position L2 was located on the roof of an existing building, in the centre of the site, in a position overlooking the courtyard of The Crown public house. This position captured representative sound levels from activity associated with the public house.

Position L3
Measurement position L3 was located on the front terrace of the existing office building on Cornmarket Street, to the northeast of the site, in a position overlooking the new Northgate House student accommodation development in this area. Background sound levels measured at this position are considered representative of those experienced by residential properties to the northeast of the site.

During the survey period, the Northgate House development overlooked by measurement position L3 was an active construction site. Sound levels measured during times this site was in operation are dominated by construction noise. Sound levels measured during these periods have not been considered when determining typical background levels to set building services plant noise emission limits.

Position L4
Measurement position L4 was located on the roof of the neighbouring existing North Bailey House building, to the west of the site, in a position overlooking residential properties in this area. Background sound levels measured at this position are considered representative of those experienced by residential properties to the west of the site at the time of the survey.

It should be noted that the existing offices within the North Bailey House and nearby buildings are currently unoccupied due to COVID-19, meaning that existing building services plant associated with the offices will not have been operational at the time of the survey. As such, there is some uncertainty in the background sound levels measured, with existing background levels when all offices are in operation likely to be higher than those measured.

Additional measurements may be required once the offices are re-occupied to capture more representative background sound levels.

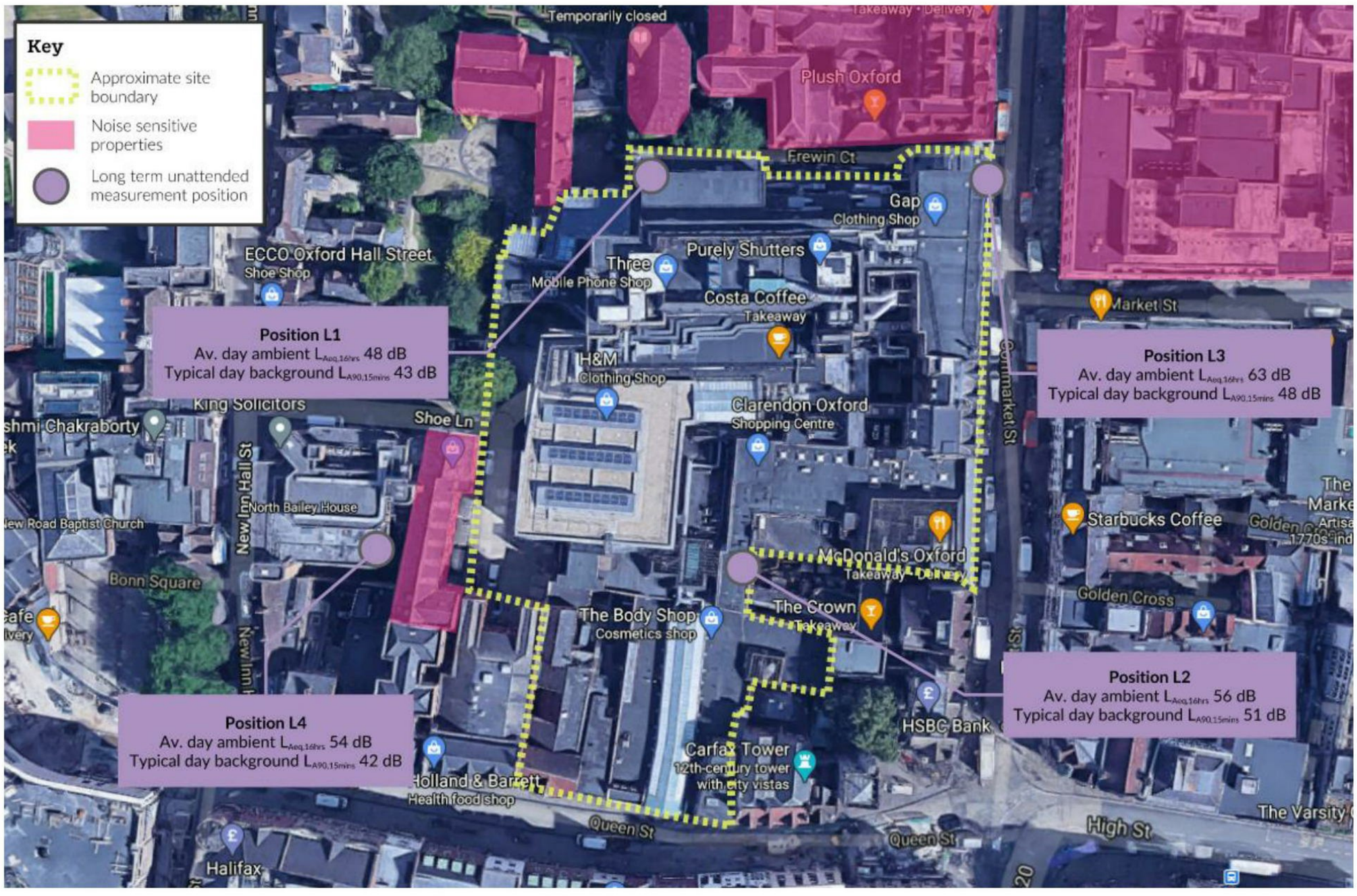


Figure 3 Sound survey measurement locations and summary of daytime measured results.

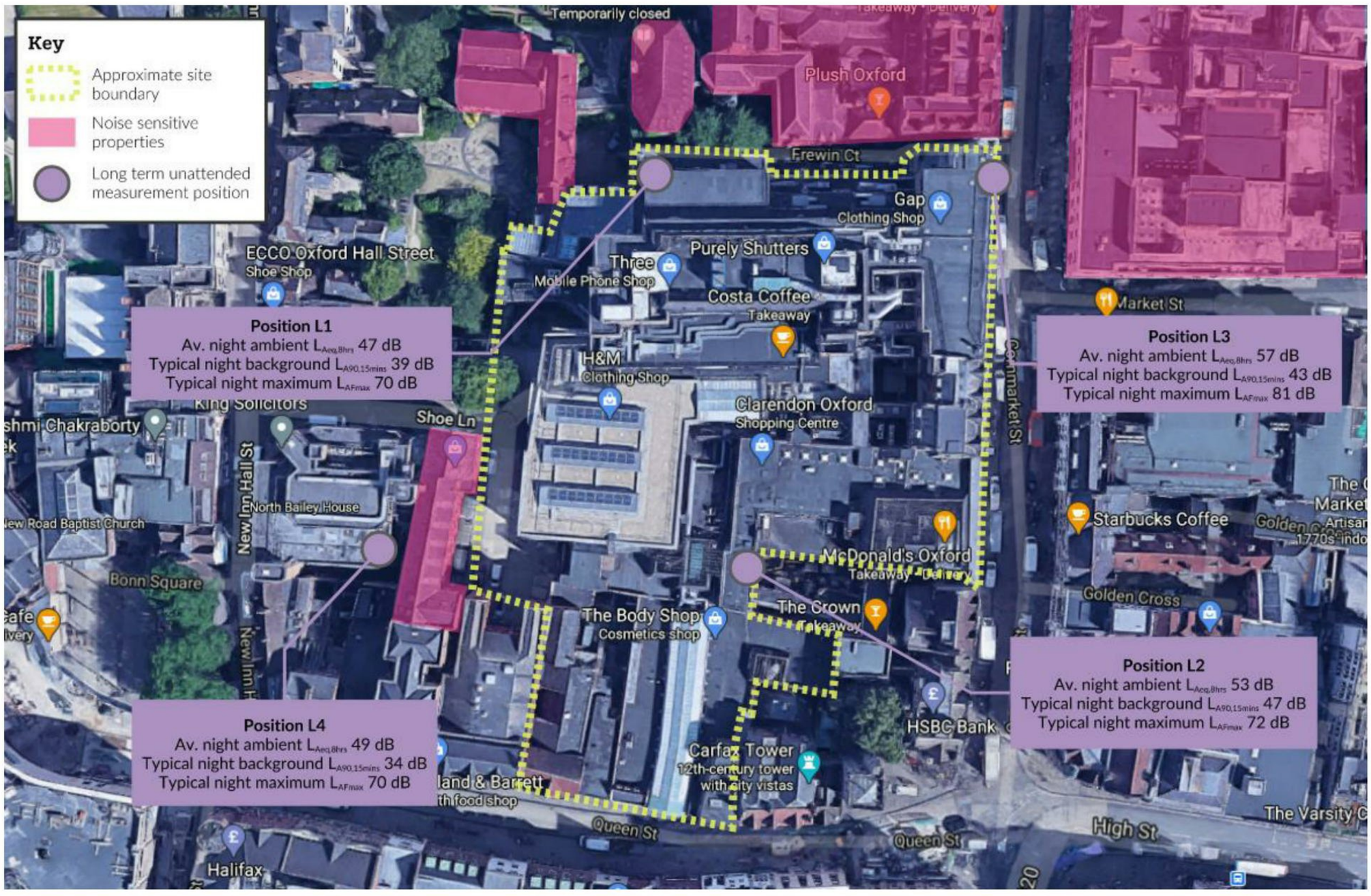


Figure 4 Sound survey measurement locations and summary of night-time measured results.

5. Façade sound insulation for student accommodation.

New student residential accommodation will form part of the Phase 2 works of the proposed scheme. In order to achieve suitable internal ambient noise criteria within the student accommodation, in line with BS 8233, the building façade must provide sufficient sound reduction. The overall sound reduction performance will depend on the reduction provided by each individual element (i.e. external walls, windows, roof, vents etc.).

The Phase 1 commercial laboratory facility and the Phase 3 office and retail development are not classed as noise sensitive by OCC and as such a façade assessment is not required for planning. The façades of these buildings will be designed to achieve suitable internal sound levels in line with industry standard guidance and client requirements.

5.1 Sound reduction of the building envelope.

The sound reduction performance of the building envelope depends on the external noise levels incident on the façades and the proposed design criteria for the internal noise levels of specific rooms, dependant on their use.

External noise levels refer to both average noise level L_{Aeq} and maximum noise level L_{AFmax}, predicted to be incident on the façades.

Based on the level differences between external noise levels and proposed internal noise levels, initial recommendations for the sound reduction performance for the windows (accounting for glazing, seals, frames etc.) are given in Table 3 to allow suitable internal sound levels to be achieved within bedrooms and living rooms.

The recommended sound reduction indices are based on the performances required to meet the ambient (L_{Aeq}) and maximum (L_{AFmax}) noise criteria set out in Table 2.

Table 3 Notional sound insulation values of proposed window systems.

Façade	Period	Room	Measured external noise level, dB	Proposed internal noise level, dB	Laboratory sound reduction index, dB R_w
North façade of student accommodation	Day ($L_{Aeq,16hr}$)	Livingroom	48	35	18
	Night ($L_{Aeq,8hr}$)	Bedroom	47	30	22
	Night Max (L_{AFmax})	Bedroom	70	45	30

It can be seen from Table 3 that the initial recommendation for windows and glazing systems are driven by night-time maximum noise events.

At the planning application stage, allowance should be made for relatively standard performance double glazed window systems. An example of a typical glazing configuration capable of achieving the recommended performance is given in Table 4.

Table 4 Examples of suitable glazing configurations for information.

Minimum recommended R_w dB	Example of typical glazing configuration
30	4mm float glass + 12mm cavity + 6mm float glass

Noise levels incident on the south façade of the student accommodation building are expected to be similar to those effecting the north façade. It was not possible to measure existing sound levels representative of this façade due to sound levels in this area being dominated by existing plant that will be removed as part of the redevelopment.

The window specification will be refined as the design develops through the RIBA stages post planning. It should be noted that the recommendations in Table 3 are based on level differences only and should be reviewed at detailed design stages once room layouts are finalised and more detailed calculations can be undertaken.

Solid elements of the façade and the roofs should achieve a sound insulation performance of at least 40 dB R_w. This is achievable with both traditional and suitably built-up light-weight systems.

As discussed in Section 4, night-time sound levels measured in September 2020 to the north of the site may be lower than they would be under normal periods as a result of the night-clubs on Frewin Court currently being closed due to COVID-19.

Additional measurements may be required if/when the night-clubs are operational again to capture more representative sound levels and the façade specification may need to be revisited.

5.2 Ventilation strategy.

Noise will also need to be accounted for in the design and specification of the ventilation system for the student accommodation. If natural ventilation through trickle vents is preferred, these will need to offer acoustic performance, the precise rating depending on opening size.

It is understood that the concept design preference to meet Part F of Building Regulations for the student residential areas is for acoustically rated trickle vents to bedrooms, with MEV extract in the en-suite bathrooms and natural ventilation to shared kitchens with mechanical extract. It is assumed that occasional purge ventilation, for expelling fumes or odours, would be through opening windows.

The rating of proposed acoustically rated trickle vents will be specified as the design develops through the RIBA stages post planning.

6. Plant noise emission limits.

6.1 Normal operating plant.

Noise emissions from any equipment introduced in the area will need to be controlled to minimise the impact on the local sound environment as required by the local authority. Noise associated with fixed plant is to be assessed following the BS 4142 methodology.

Based on the measured background sound levels, noise levels due to building services associated with the proposed development are advised to meet the following noise level criteria shown below in Table 5. These noise limits are proposed at one metre from the nearest noise sensitive receptors highlighted in Section 2.

These are based on the typical background noise levels measured at position L1 (for properties to the north of the site), position L3 (for properties to the northeast of the site) and position L4 (for residential properties to the west of the site), which are deemed representative of the closest façade of the nearest relevant noise sensitive receptors.

Table 5 Building services noise emission limits – normal operating plant.

Location	Period	Representative background noise levels measured, $L_{A90,15min}$ (dB)	Plant rating noise limit at the nearest noise sensitive receiver, $L_{Ar,Tr}$ (dB)
North of the site	Daytime (07:00 – 23:00)	43	43
	Night-time (23:00 -07:00)	39	39
Northeast of the site	Daytime (07:00 – 23:00)	48	48
	Night-time (23:00 -07:00)	43	43
West of the site	Daytime (07:00 – 23:00)	42	42
	Night-time (23:00 -07:00)	34	34

It should be noted that these are the combined operational noise levels of plant at the nearest noise sensitive façade. As such, the combined operational noise levels of all plant are required to achieve the noise limits defined within Table 5.

For plant noise that is tonal, contains a specific character or is intermittent, the limits of Table 5 above should include a character correction as defined within BS 4142: 2014.

As discussed in Section 4, background noise levels measured at Position L4 during the environmental sound survey are likely to be lower than under normal periods due to the existing offices within and near North Bailey House being currently unoccupied due to COVID-19 and their plant being switched off. Additional measurements may be required once the offices are re-occupied to capture more representative background sound levels and the plant noise limits set out in Table 5 may need to be revisited.

6.2 Life safety plant.

It is normally accepted that life safety plant (e.g. generators, smoke extract fans, etc.) operate to a relaxed limit compared to normally operating plant. It is proposed that any mechanical or electrical plant equipment specifically designed for emergency use (and allowance for testing) is to achieve 10 dB above the measured typical background sound levels. This is specified on the basis that the plant is only tested for short periods on weekdays between 09:00 and 17:00.

Table 6 Life safety plant noise emission limits.

Location	Period	Representative background noise levels measured, $L_{A90,15min}$ (dB)	Life safety plant rating noise limit at the nearest noise sensitive receiver, $L_{Ar,Tr}$ (dB)
North of the site	Daytime (07:00 – 23:00)	43	53
Northeast of the site	Daytime (07:00 – 23:00)	48	58
West of the site	Daytime (07:00 – 23:00)	42	52

7. Building services noise.

External plant will be required to meet the plant noise limits set out in Section 6.

At this stage, the services design is still being developed and selections of items of building services plant are still to be made. It is understood that the main items of external fixed plant associated with the different phases of the scheme will include the following:

Table 7 Main items of external building services equipment

Phase	Location	External plant items
Phase 1	Roof level	– 2no. Air source heat pumps (ASHP); – 5no. Air handling units (AHU).
	Ground floor level	– Space allocation for tenant plant area.
Phase 2	Lower roof level	– 1no. Air source heat pumps (ASHP); – 1no. DX condensing unit; – 2no. VRF condensing unit areas for retail.
	Main roof level	– 2no. Air handling units (AHU); – 12no. VRF condensing units; – 3no. Kitchen extract fans; – 1no. Toilet extract fan.
Phase 3	Lower roof level	– 1no. DX condensing unit; – 16no. VRF condensing units; – 1no. Toilet extract fan.
	Main roof level	– 2no. Toilet extract fans.

7.1 Proposals.

Currently proposed roof plant layouts for the three phases are presented below in Figure 5 to Figure 7.

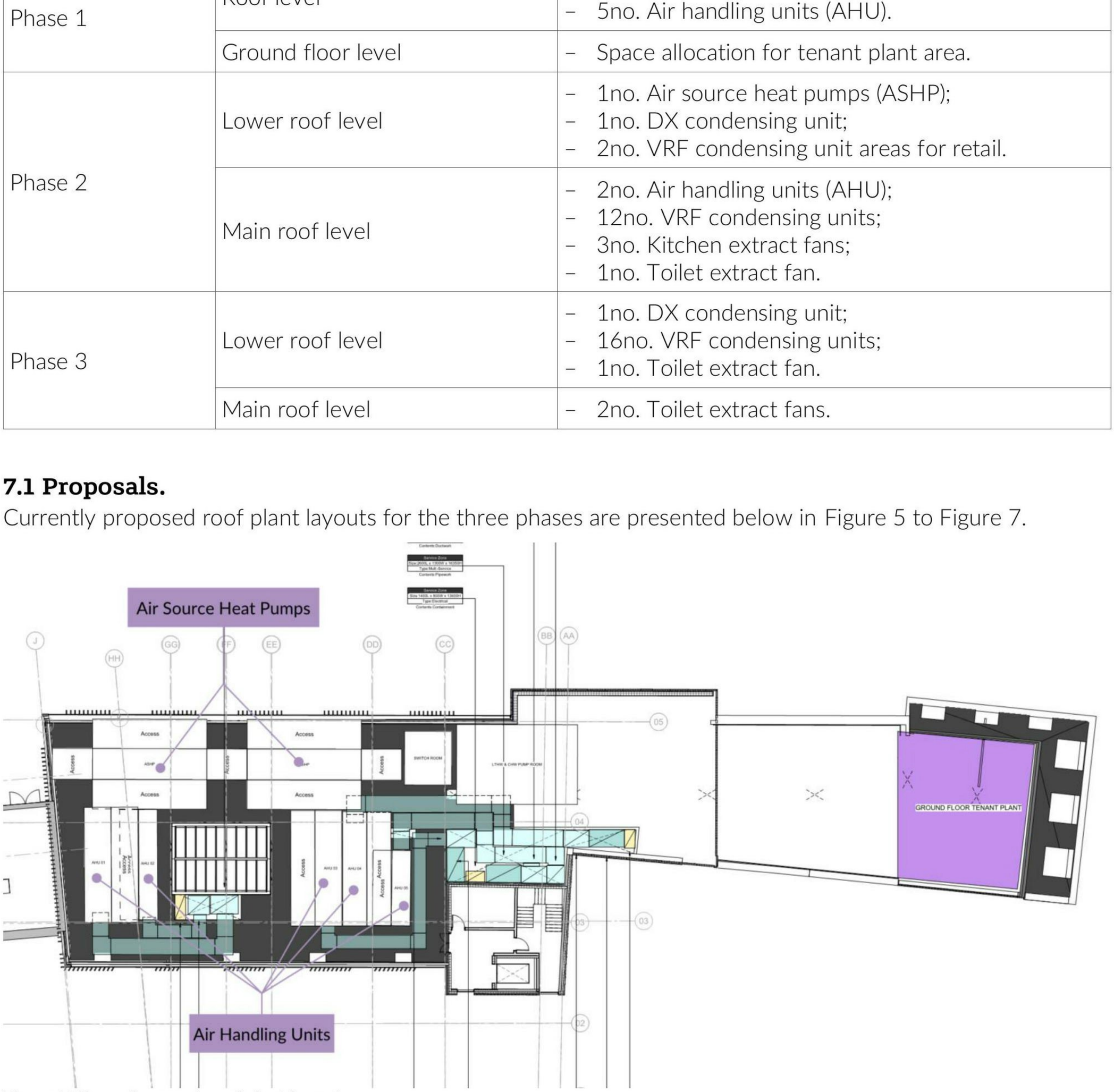


Figure 5 Phase 1 current roof plant layout.

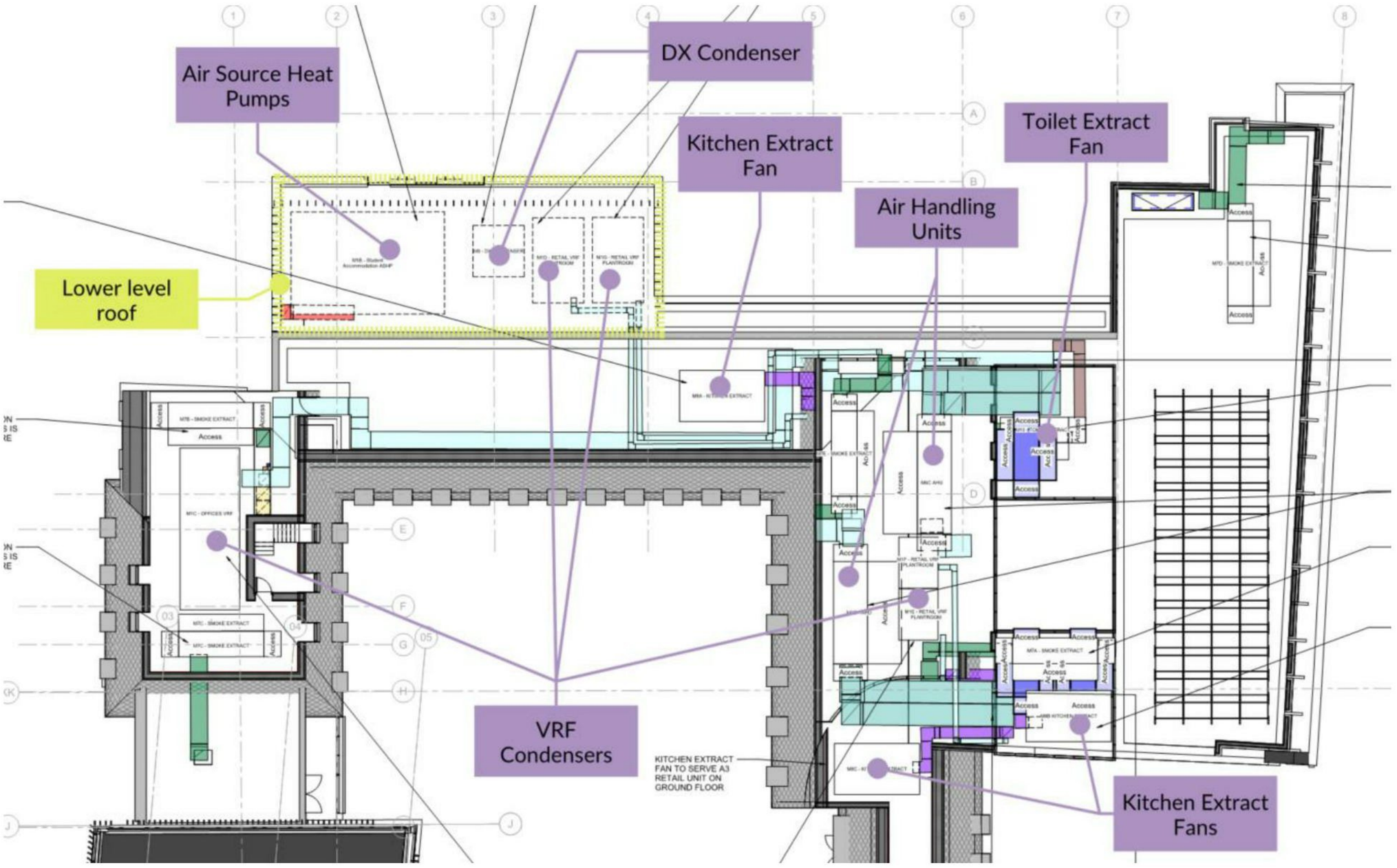


Figure 6 Phase 2 current roof plant layout.

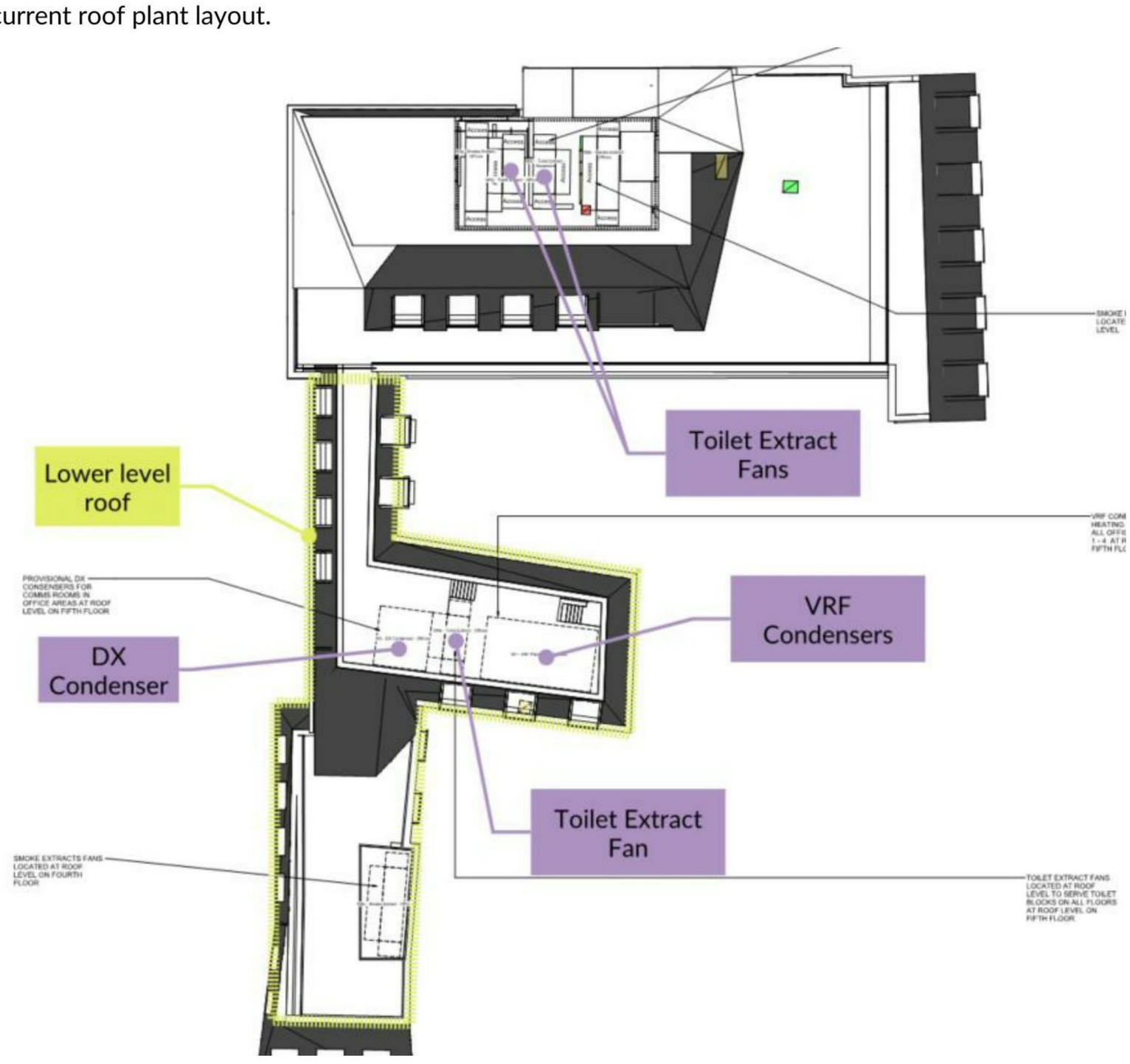


Figure 7 Phase 3 current roof plant layout.

As selections are not currently available, initial guidance has been provided in Table 8 on appropriate acoustic mitigation measures to allow for, for the various plant items, at this stage. In general, low noise plant items should be selected where possible to help reduce the requirement for additional acoustic mitigation.

Table 8 Potential acoustic mitigation measures for different plant items

Plant item	Potential acoustic mitigation measures
Air source heat pumps (ASHP)	– Acoustic attenuation pack – Localised solid acoustic screening
Air handling units (AHU)	– Atmosphere side attenuators – Acoustic lagging of the AHU casing
VRF and DX condensing units	– Localised solid acoustic screening – Acoustic enclosures
Kitchen, toilet and fume extract fans	– Atmosphere side attenuators – Acoustic lagging of the extract fan casing – Localised solid acoustic screening
Air compressors	– Localised solid acoustic screening – Acoustic enclosures

Due to their proximity to the nearest residential properties, particular care will be needed when specifying appropriate acoustic mitigation for the ASHPs on the roof of Phase 1 and the ASHP on the lower roof of Phase 2. The units are expected to require acoustic attenuation packs and localised solid acoustic screening.

In order to help inform the selection of plant items, and based on the current plant layouts, initial overall sound power limits have been set for the attenuated ASHPs for the Phase 1 and Phase 2 buildings, these are given in Table 9. It should be noted that these limits do not take into account potential screening of the plant items from localised solid acoustic screening which will help mitigate noise breakout from these plant items.

It should be noted that for now these limits are based on the whole plant noise emission limit being apportioned to ASHPs as they are likely to be the noisiest plant items. As such, the remaining plant items set out in Table 7 will need to be designed out.

Table 9 Individual sound power level limits for ASHPS

Plant Item	Initial sound power level limit, dB(A)
Phase 1 Air Source Heat Pumps (for each individual ASHP)	72
Phase 2 Air Source Heat Pump	70

As the services design develops through the RIBA stages post planning, appropriate acoustic mitigation will be specified in order to meet the plant noise limits set out in Section 6.

8. Conclusion.

There are proposals to redevelop the existing Clarendon Centre, located between Cornmarket Street and Queen Street, in Oxford City Centre. The existing buildings will be redeveloped over three phases.

An environmental sound survey, consisting of unattended long-term sound measurements at multiple locations across the site, has been undertaken to establish the existing sound environment at the site and the surrounding areas.

An early-stage assessment has been carried out to understand the implications of the existing sound environment on the design of the façade of the student accommodation block. This has been summarised as follows:

- Preliminary calculations have been undertaken to determine the likely sound reduction performance needs of the student residential accommodation.
- The calculations indicate that requirements can be achieved with relatively standard performance, acoustic double-glazed window units and trickle vent systems.
- It is understood that the concept design preference is for acoustically rated trickle vents to bedrooms, with MEV extract in the en-suite bathrooms and natural ventilation to shared kitchens with mechanical extract. It is assumed that occasional purge ventilation, for expelling fumes or odours, would be through opening windows.

Based on the measured existing sound levels, indoor ambient noise levels can be controlled with suitable consideration to the ventilation strategy and design of the external façade.

Following a review of survey data from a recent previous scheme on the Clarendon Centre site, night-time sound levels measured in September 2020 to the north of the site may be lower than they would be under normal periods as a result of several night-clubs on Frewin Court currently being closed due to COVID-19. Additional measurements may be required if/when the night-clubs are operational again to capture more representative sound levels and the façade specification may need to be revisited.

External plant noise emission limits at the nearest residential properties have been proposed based on the measured baseline sound conditions and on the requirements of the local authority.

The existing offices within the North Bailey House and surrounding buildings near the site were unoccupied at the time of the survey due to COVID-19, meaning that existing building services plant associated with the offices will not have been operational. As such background sound levels measured are likely to be lower than those during normal periods. Additional measurements may be required once the offices are re-occupied to capture more representative background sound levels.

Selections for the building services plant equipment are not available at this early stage but initial guidance on the type of acoustic mitigation measures expected to be required to achieve the proposed plant noise limits has been given.

On the basis of the initial assessment, noise is not expected to pose an obstacle in the granting of planning permission for the scheme.

Appendix A – Glossary of acoustic terms.

Sound

Sound is produced by mechanical vibration of a surface, which sets up rapid pressure fluctuations in the surrounding air.

The Sound Pressure

The Sound Pressure is the force (N) of sound on a surface area (m^2) perpendicular to the direction of the sound. The SI-units for the Sound Pressure are Nm^{-2} or Pa (Pascal).

Sound is measured with microphones responding proportionally to the sound pressure – *p*. The power is proportional to the square of the sound pressure.

The Sound Pressure Level

The human ear has an approximately logarithmic response to sound pressure over a very large dynamic range. The lowest audible sound pressure approximately 2×10^{-5} Pa (2 ten billionths of an atmosphere) and the highest is approximately 100 Pa.

It is therefore convenient to express the sound pressure as a logarithmic decibel scale related to this lowest human audible sound, where:

$$L_p = 10\ log\left(\frac{p^2}{{p_{ref}}^2}\right) = 10\ log\left(\frac{p}{p_{ref}}\right)^2 = 20\ log\left(\frac{p}{p_{ref}}\right)$$

Where: L_p *= sound pressure level (dB)*

p *= sound pressure (Pa)*

$p_{ref} = 2 \times 10^{-5}$ *– reference sound pressure (Pa)*

In accordance with the logarithmic scale, doubling the sound pressure level gives an increase of 6 dB.

Decibel (dB)

The decibel is the unit used to quantify sound pressure levels as well as sound intensity and power levels.

In accordance with the logarithmic scale, an increase of 10 dB in sound pressure level is equivalent to an increase by a factor of 10 in the sound pressure level (measured in Pa). Subjectively, this increase would correspond to a doubling of the perceived loudness of the sound.

Frequency

The rate at which the pressure fluctuations occur determines the pitch or frequency of the sound. The frequency is expressed in Hertz (Hz) or cycles per second.

Octave and Third Octave Bands

An octave is the interval between two points where the frequency at the second point is twice the frequency of the first.

There are many methods of describing the frequency content of a noise. The most common methods split the frequency range into defined bands, in which the mid-frequency is used as the band descriptor and in the case of octave bands is double that of the band lower. For example, two adjacent octave bands are 250 Hz and 500 Hz.

Third octave bands provided a fine resolution by dividing each octave band into three bands. For examples, third octave bands would be 160 Hz, 250 Hz and 315 Hz for the same 250 Hz octave band.

The human ear is sensitive to sound over a range of frequencies between approximately 20 Hz to 20 kHz and is generally more sensitive to medium and high frequency than to low frequencies within the range. This is the basis of the A-weighting.

A-Weighting

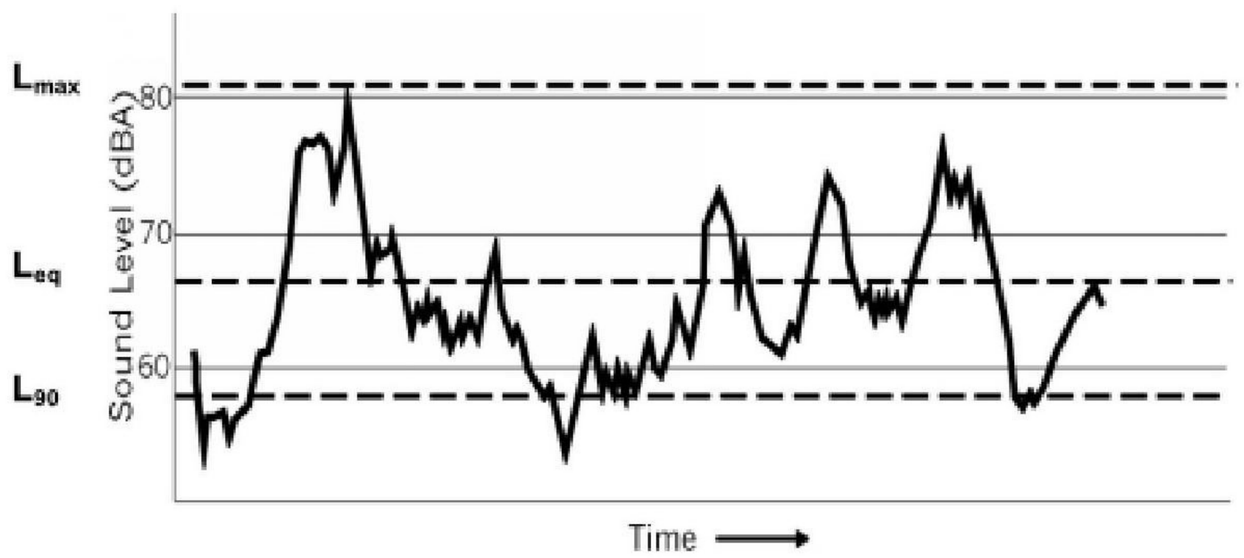
The A-weighting is a correction term applied to the frequency range in order to mimic the sensitivity of the human ear to noise. It is generally used to obtain an overall noise level from octave or third octave band frequencies.

An A weighted value would be written as dB(A), or including A within the parameter term.

Noise Units

In order to assess environmental noise, measurements are carried out by sampling over specific periods of time, such as five minutes, the statistically determined results being used to quantify various aspects of the noise.

The figure below shows an example of sound level varying with time. Because of this time variation the same period of noise can be described by several different levels. The most common of these are described below.



$L_{eq,T}$

The $L_{eq,T}$ is a parameter defined as the equivalent continuous sound pressure level over a defined time period 'T'. It is the sound pressure level equivalent to the acoustic energy of the fluctuating sound signal.

The $L_{eq,T}$ can be thought of as an 'average' sound pressure level over a given time period (although it is not an arithmetic average). Typically the $L_{eq,T}$ will be an A-weighted noise level in dB(A) and is commonly used to describe all types of environmental noise sources.

$L_{01,T}$

The $L_{01,T}$ is a parameter defined as the sound pressure level exceeded for 1% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter.

$L_{10,T}$

The $L_{10,T}$ is a parameter defined as the sound pressure level exceeded for 10% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter and is generally used to describe road traffic noise.

$L_{90,T}$

The $L_{90,T}$ is a parameter defined as the sound pressure level exceeded for 90% of the measurement period 'T'.

It is a statistical parameter and cannot be directly combined to other acoustic parameter and is generally used to describe the prevailing background noise level.

$L_{max,T}$

The $L_{max,T}$ is a parameter defined as the maximum noise level measured during the specified period 'T'.

Specific Noise Level, $L_{Aeq,Tr}$

This is the equivalent continuous A-weighted sound pressure level at the assessment position due to a specific noise source operating over a given time interval.

Rating level, $L_{Ar,Tr}$

Specific sound level plus any adjustment for the characteristic features of the sound.

Free Field

A measurement taken in the free field is at least 3.5m from reflecting vertical surfaces and 1.2m from the ground.

Façade

A measurement is influenced by the reflection of sound from the façade of a building within 3.5m. A façade measurement is made 1m in front of the vertical building surface.

R_w

A single-number quantity which characterizes the airborne sound insulation of a material or building element in the laboratory. See BS EN ISO 717-1: 1997.

Appendix B – Environmental sound survey.

Methodology.

The survey comprised five days of unattended automatic noise measurements by four different sound level meters at various locations at existing roof level. The positions of these noise monitors are shown in Figure 3 and Figure 4. This measurement positions were all at a height of approximately 1.2 metres above roof level and are considered to be free-field.

Measurements recorded consisted of fifteen-minute samples of ambient sound levels ($L_{Aeq,15min}$ in dB), maximum noise levels ($L_{Amax,15min}$ in dB) and background noise levels ($L_{A90,15min}$ in dB) between Wednesday 16th September and the Monday 22nd September 2020.

Equipment.

The equipment used during the survey is detailed in Table 10. All equipment used was within dates of calibration and calibration certificates are available on request. All sound level meters and microphones were calibrated before and after the measurements and no significant calibration drift was observed.

Table 10 Equipment details used during the environmental sound survey.

Location	Component	Manufacturer	Model	Serial Number	Date of calibration	Calibration certificate
Position L1	Sound Level Meter	Rion	NL-52	00342839	09/07/2020	UCRT20/1612
	Microphone	Rion	UC-59	06360	09/07/2020	UCRT20/1612
	Pre-amp	Rion	NH-25	42867	09/07/2020	UCRT20/1612
	Acoustic Calibrator	Rion	NC-74	34536109	14/02/2020	UCRT20/1193
Position L2	Sound Level Meter	Rion	NL-31	110032	14/02/2020	UCRT20/1193
	Microphone	Rion	UC-53A	102143	14/02/2020	UCRT20/1193
	Pre-amp	Rion	NH-21	00134	14/02/2020	UCRT20/1193
	Acoustic Calibrator	Rion	NC-74	34536109	14/02/2020	UCRT20/1193
Position L3	Sound Level Meter	Rion	NL-52	00331833	12/06/2019	UCRT19/1677
	Microphone	Rion	UC-59	04900	12/06/2019	UCRT19/1677
	Pre-amp	Rion	NH-25	21784	12/06/2019	UCRT19/1677
	Acoustic Calibrator	Rion	NC-74	34536109	14/02/2020	UCRT20/1193

Location	Component	Manufacturer	Model	Serial Number	Date of calibration	Calibration certificate
Position L4	Sound Level Meter	Rion	NL-52	01276555	26/06/2020	UCRT20/1561
	Microphone	Rion	UC-59	12612	26/06/2020	UCRT20/1561
	Pre-amp	Rion	NH-25	76774	26/06/2020	UCRT20/1561
	Acoustic Calibrator	Rion	NC-74	34536109	14/02/2020	UCRT20/1193

Results.

Ambient sound levels.

A summary the ambient sound levels measured is presented in Table 11 to Table 14 below. The results of the unattended measurements have been calculated into daytime ($L_{Aeq,16hr}$) and night-time ($L_{Aeq,8hr}$) equivalent levels.

Table 11 Summary of long-term monitoring undertaken at Position L1 (L_{Aeq})

Date	Ambient sound pressure levels measured (dB) at Position L1	
	Daytime (07:00 - 23:00) $L_{Aeq, 16hr}$	Night-time (23:00 - 07:00) $L_{Aeq, 8hr}$
Wed 16/09/2020	48*	48
Thurs 17/09/2020	49	45
Fri 18/09/2020	49	48
Sat 19/09/2020	47	48
Sun 20/09/2020	47	45
Mon 21/09/2020	49*	-

*Measurement period did not cover a whole 16-hour daytime period

Table 12 Summary of long-term monitoring undertaken at Position L2 (L_{Aeq})

Date	Ambient sound pressure levels measured (dB) at Position L2	
	Daytime (07:00 - 23:00) $L_{Aeq, 16hr}$	Night-time (23:00 - 07:00) $L_{Aeq, 8hr}$
Wed 16/09/2020	57*	52
Thurs 17/09/2020	56	52
Fri 18/09/2020	56	53
Sat 19/09/2020	57	53
Sun 20/09/2020	56	52
Mon 21/09/2020	54*	-

*Measurement period did not cover a whole 16-hour daytime period

Table 13 Summary of long-term monitoring undertaken at Position L3 (L_{Aeq})

Date	Ambient sound pressure levels measured (dB) at Position L3	
	Daytime (07:00 - 23:00) $L_{Aeq, 16hr}$	Night-time (23:00 - 07:00) $L_{Aeq, 8hr}$
Wed 16/09/2020	62*	57
Thurs 17/09/2020	64	57
Fri 18/09/2020	64	57
Sat 19/09/2020	59	56
Sun 20/09/2020	58	56
Mon 21/09/2020	67*	-

*Measurement period did not cover a whole 16-hour daytime period

It should be noted that during the survey period, the Northgate development overlooked by measurement position L3 was an active construction site. Ambient sound levels measured during times this site was in operation are dominated by construction noise. This can be seen in the weekday daytime sound levels presented in Table 13.

Table 14 Summary of long-term monitoring undertaken at Position L4 (L_{Aeq})

Date	Ambient sound pressure levels measured (dB) at Position L4	
	Daytime (07:00 - 23:00) $L_{Aeq, 16hr}$	Night-time (23:00 - 07:00) $L_{Aeq, 8hr}$
Wed 16/09/2020	57*	47
Thurs 17/09/2020	53	47
Fri 18/09/2020	52	51
Sat 19/09/2020	53	50
Sun 20/09/2020	53	45
Mon 21/09/2020	51*	-

*Measurement period did not cover a whole 16-hour daytime period

Time histories of the L_{Aeq}, L_{A90} and L_{Amax} from the unattended measurements recorded at positions L1 to L4 are shown in Figure 20 to Figure 23.

Background sound levels.

In line with the requirements of BS 4142, in order to "*quantify what is typical during particular time periods*", statistical analysis of the measured background sound levels ($L_{A90,15min}$) has been undertaken. The periods of interest have been taken as daytime (07:00 to 23:00) and night-time (23:00 to 07:00).

Position L1

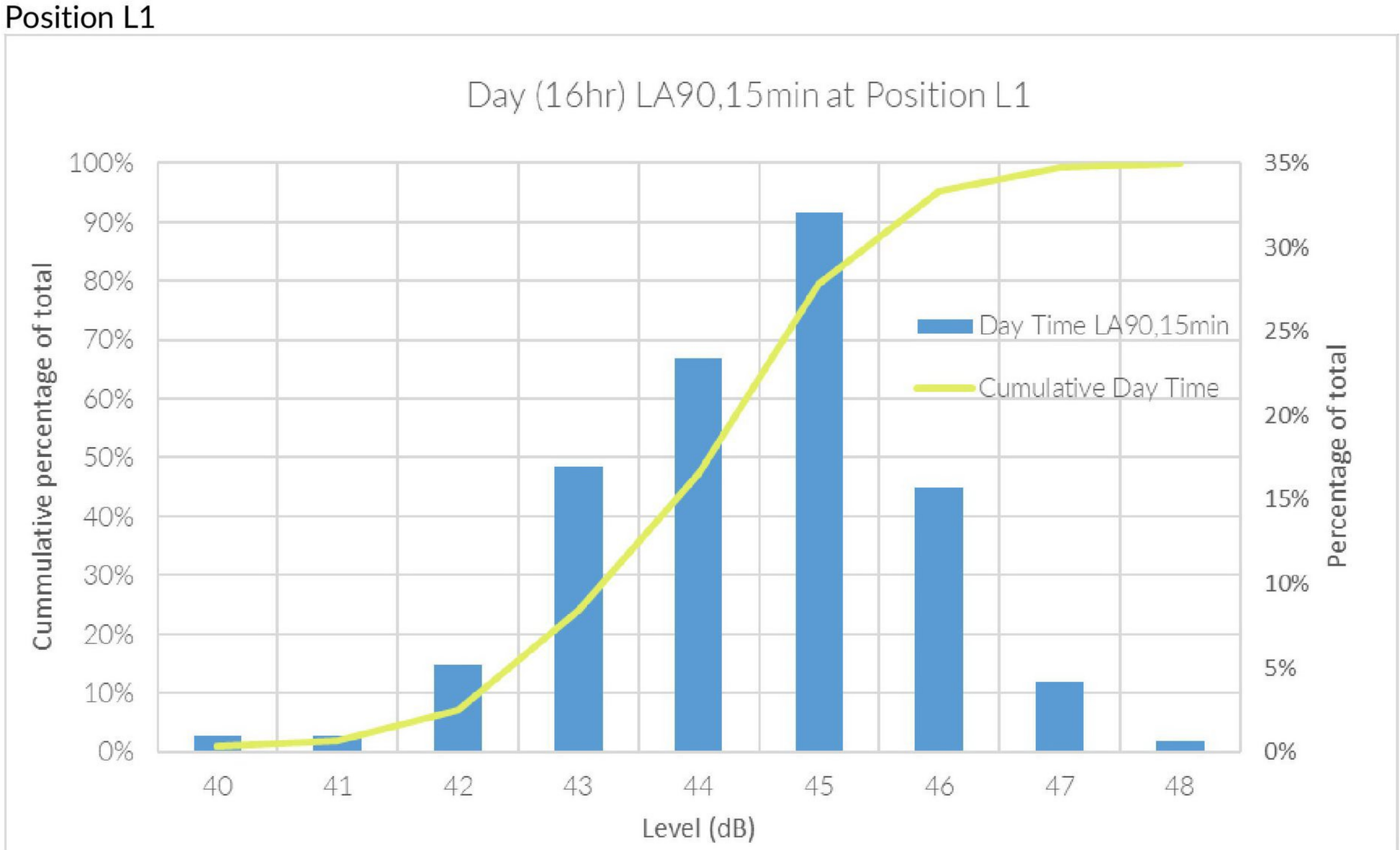


Figure 8 Statistical analysis of measured daytime background sound levels – Position L1

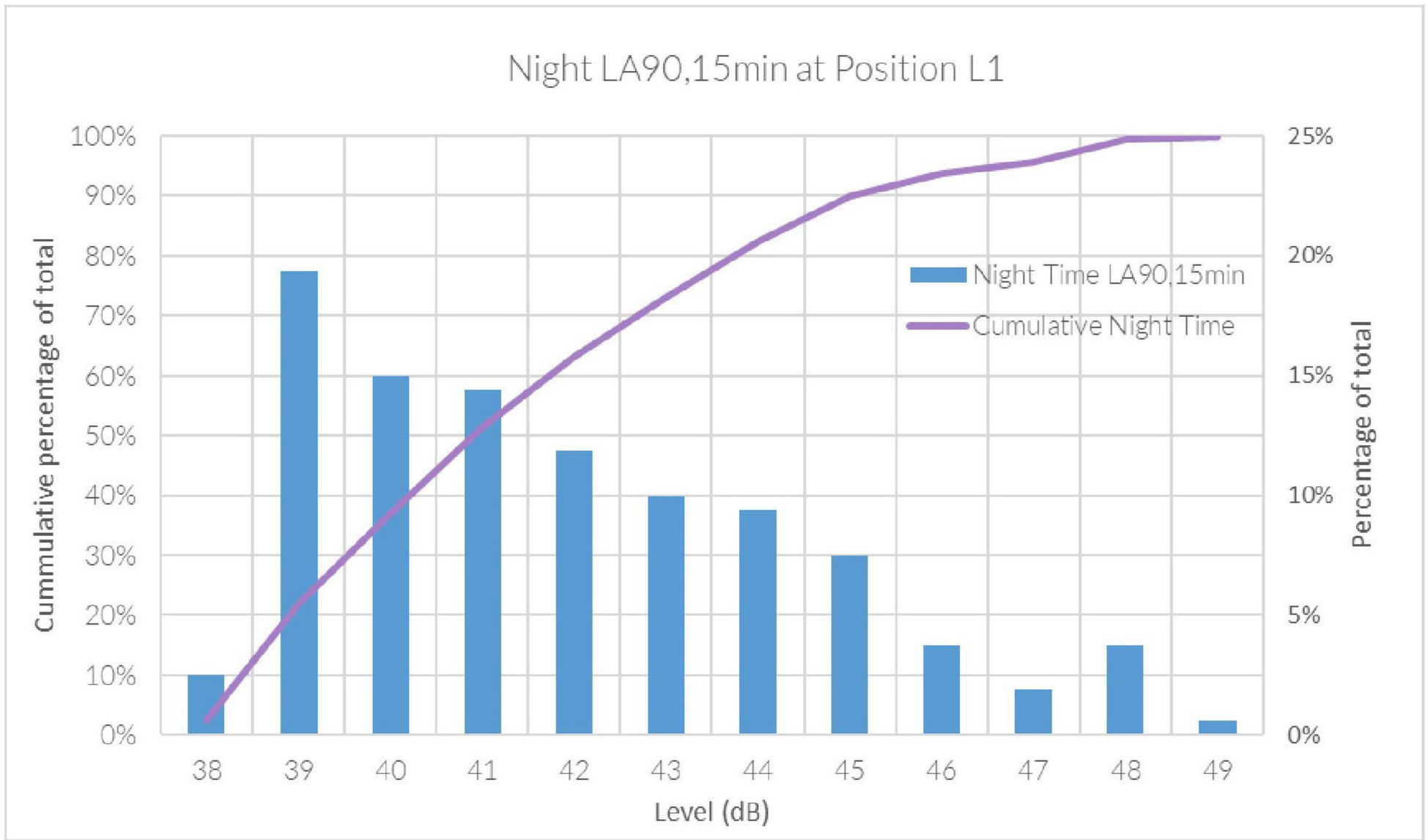


Figure 9 Statistical analysis of measured night-time background sound levels – Position L1

Position L2

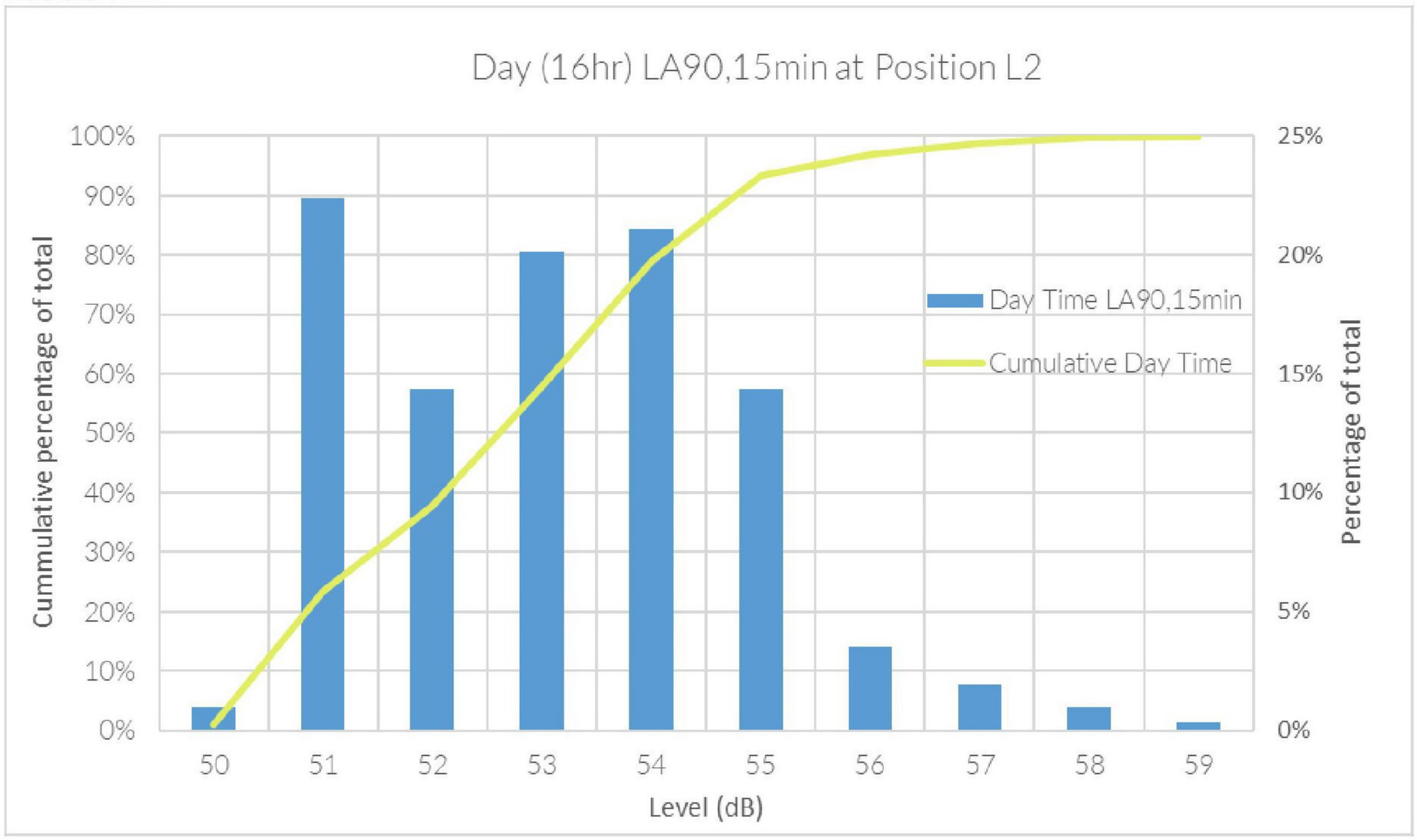


Figure 10 Statistical analysis of measured daytime background sound levels – Position L2

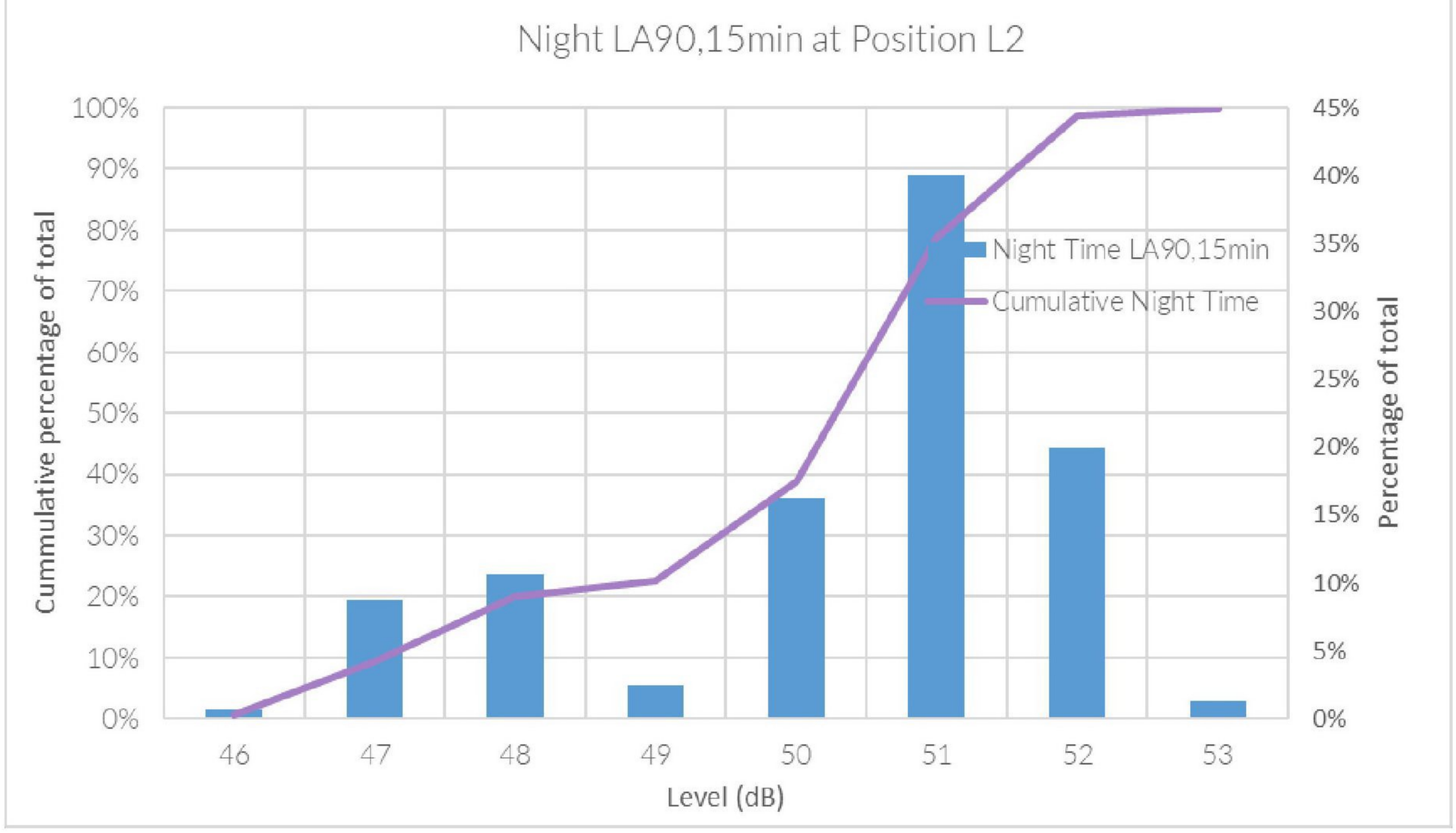


Figure 11 Statistical analysis of measured night-time background sound levels – Position L2

Position L3

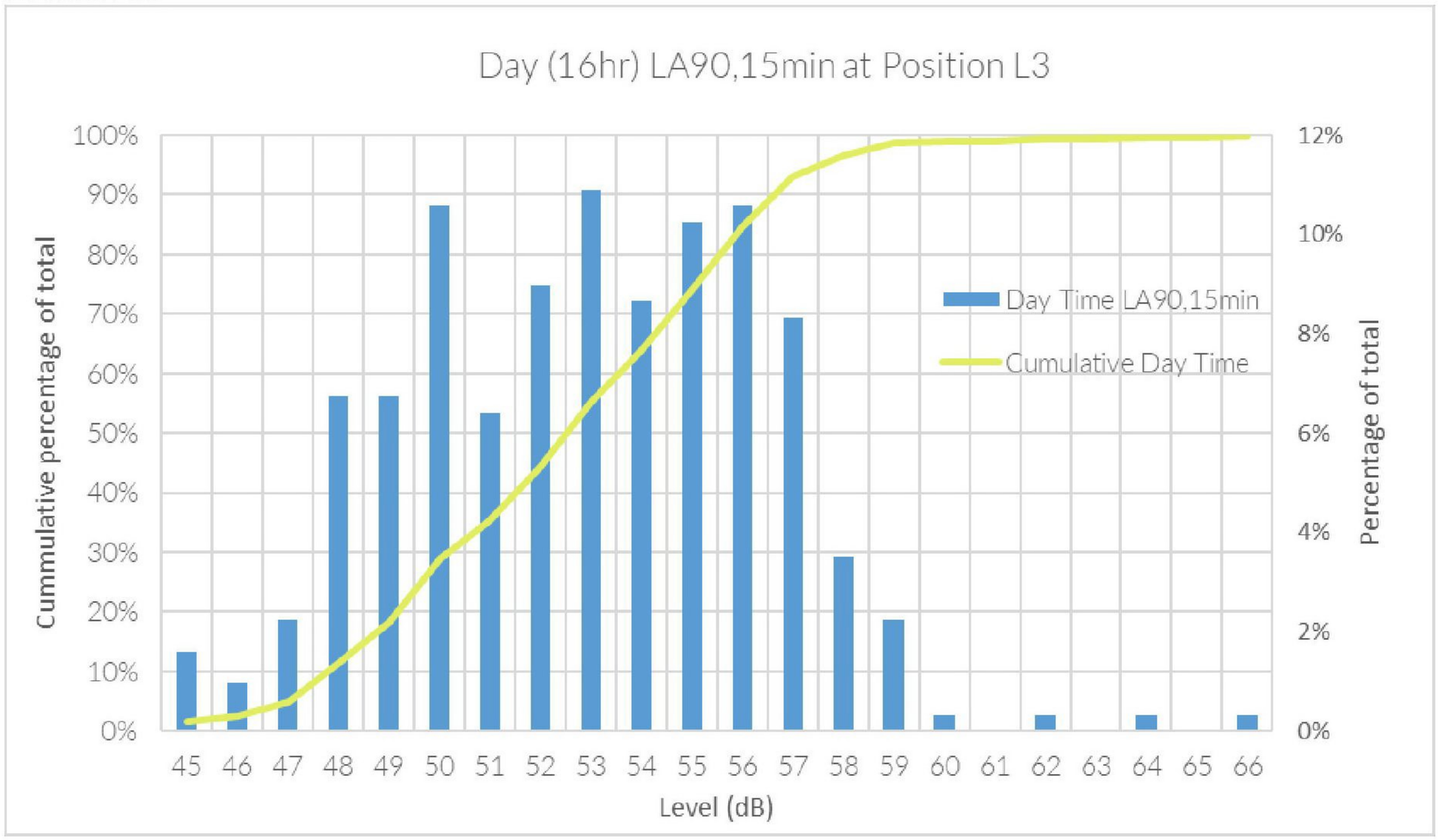


Figure 12 Statistical analysis of measured daytime background sound levels – Position L3

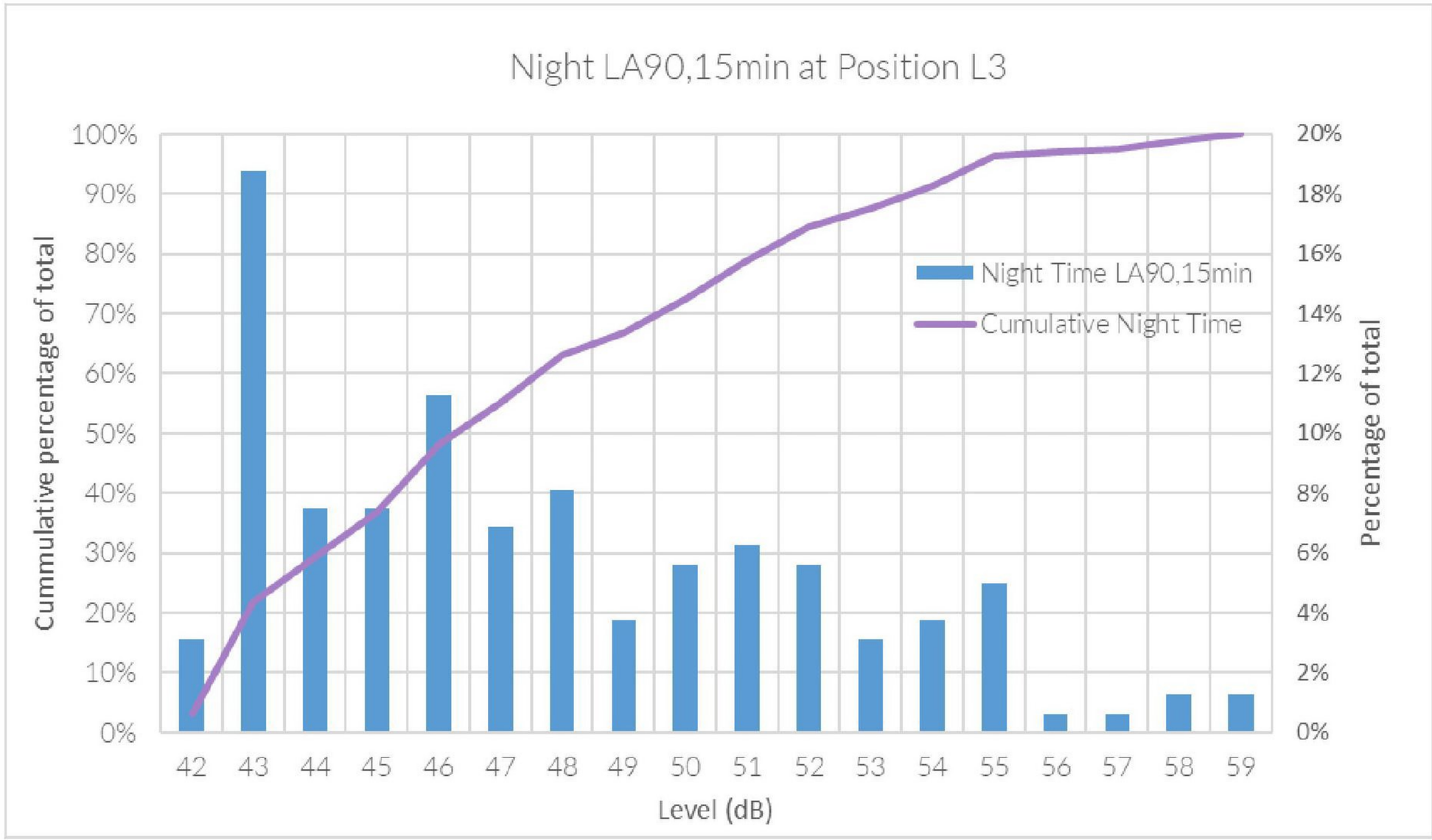


Figure 13 Statistical analysis of measured night-time background sound levels – Position L3

Position L4

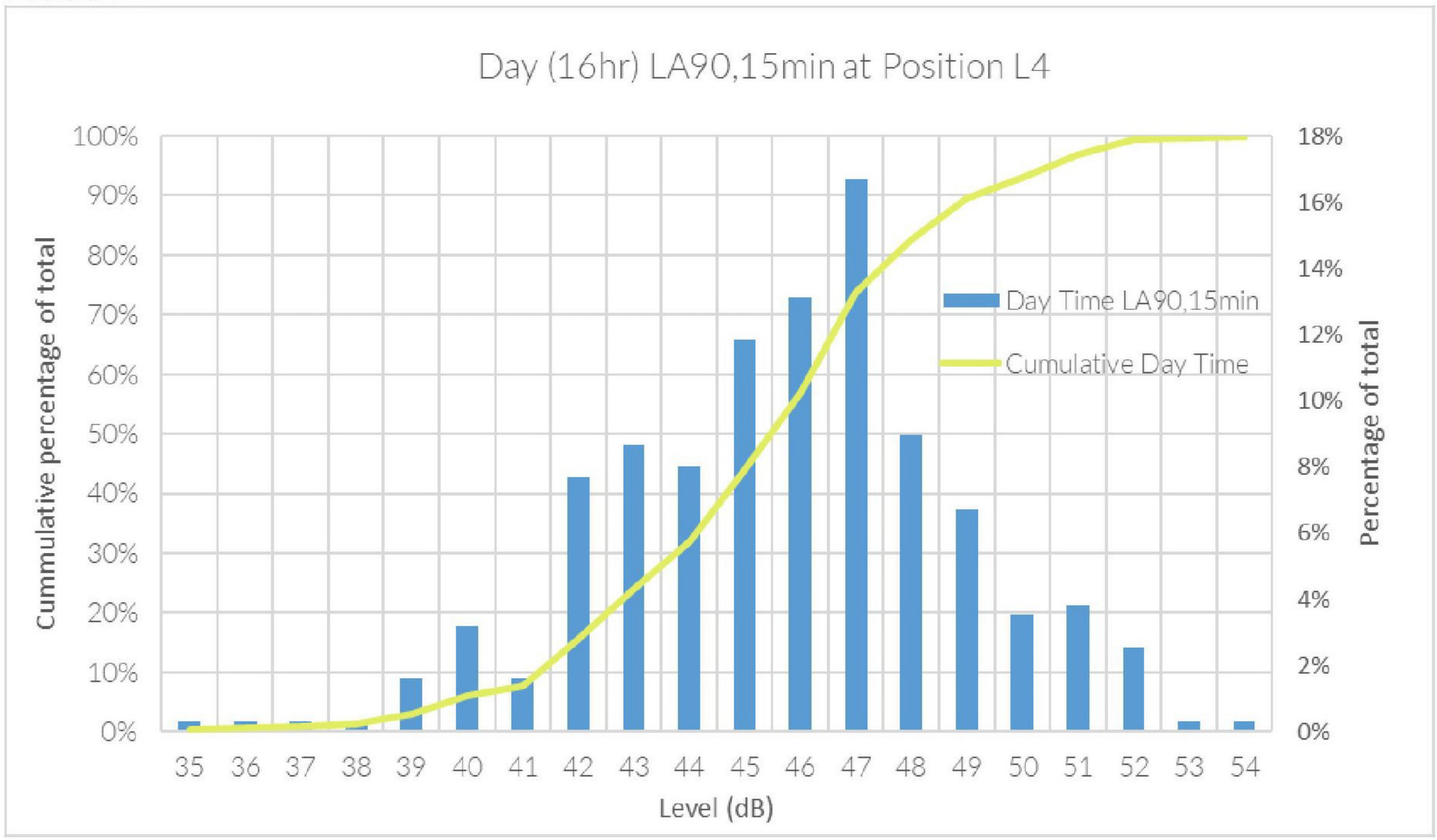


Figure 14 Statistical analysis of measured daytime background sound levels – Position L4

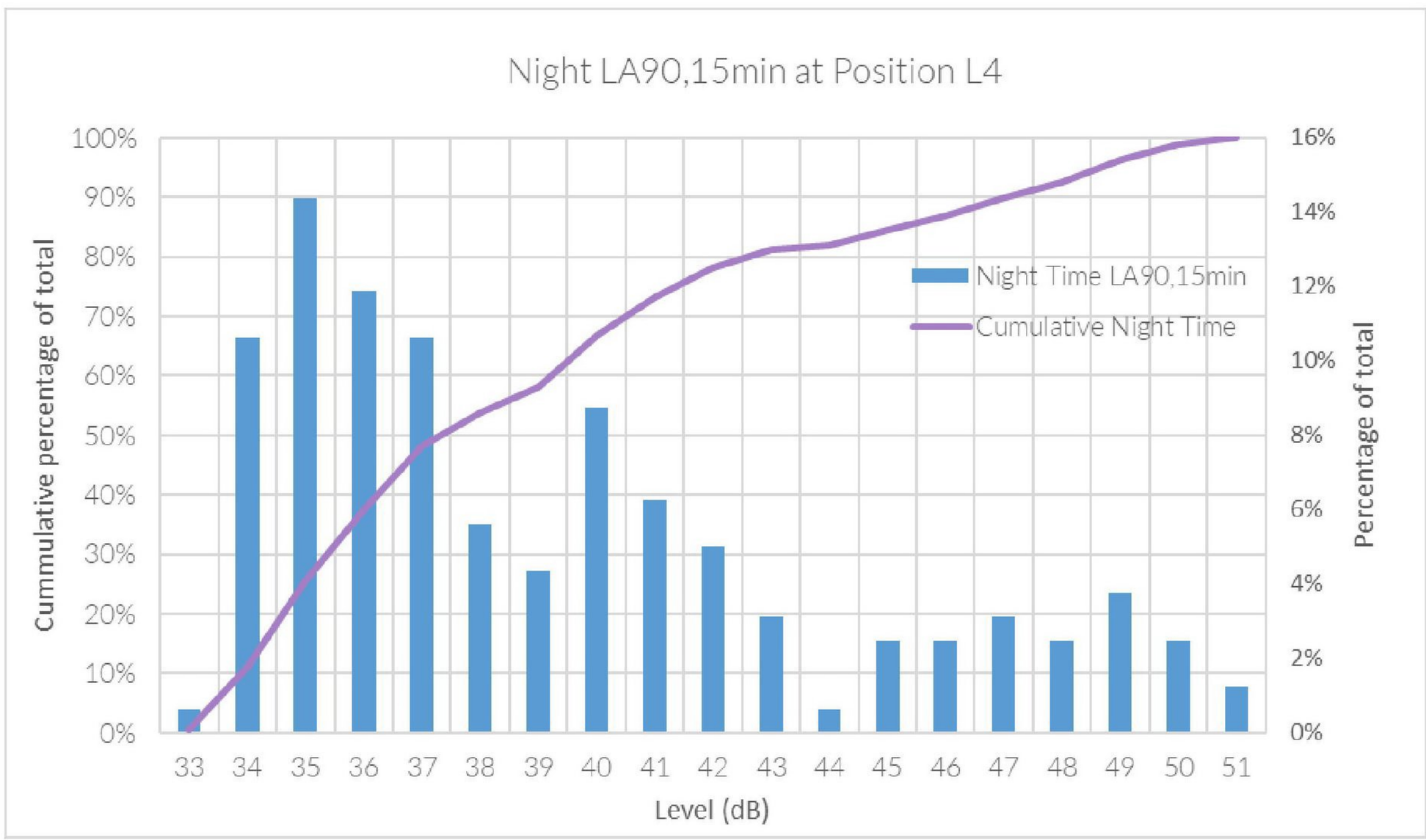


Figure 15 Statistical analysis of measured night-time background sound levels – Position L4

From the above statistical analysis charts, the time history charts included in Figure 20 to Figure 23 and given the context of the area, the following background sound levels have been determined representative for the periods of interest for each measurement position and corresponding receptors.

Table 15 Typical background sound levels determined from statistical analysis

Position	Period	Typical background sound level dB $L_{A90,15min}$
L1	Daytime (07:00 - 23:00)	43
	Night-time (23:00 - 07:00)	39
L2	Daytime (07:00 - 23:00)	51
	Night-time (23:00 - 07:00)	47
L3	Daytime (07:00 - 23:00)	48
	Night-time (23:00 - 07:00)	43
L4	Daytime (07:00 - 23:00)	42
	Night-time (23:00 - 07:00)	34

Maximum sound levels.
Statistical analysis of the measured maximum sound levels (L_{AFmax}) has also been undertaken to determine representative maximum sound levels at the different measurement positions, removing erroneous measurements. The analysis has concentrated on night-time periods (23:00 to 07:00).

Position L1

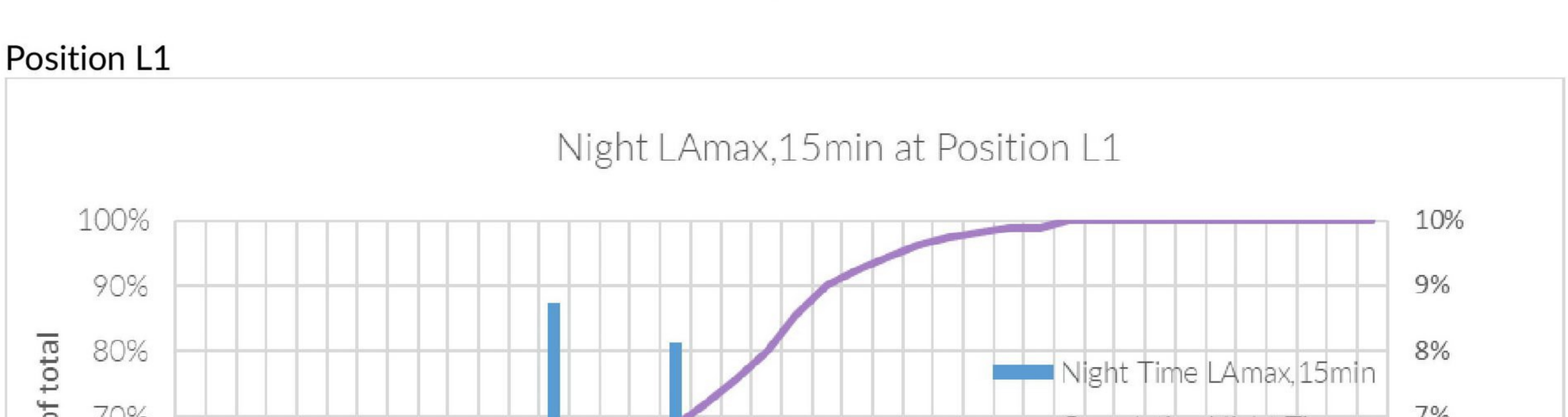


Figure 16 Statistical analysis of measured night-time maximum sound levels – Position L1

Position L2

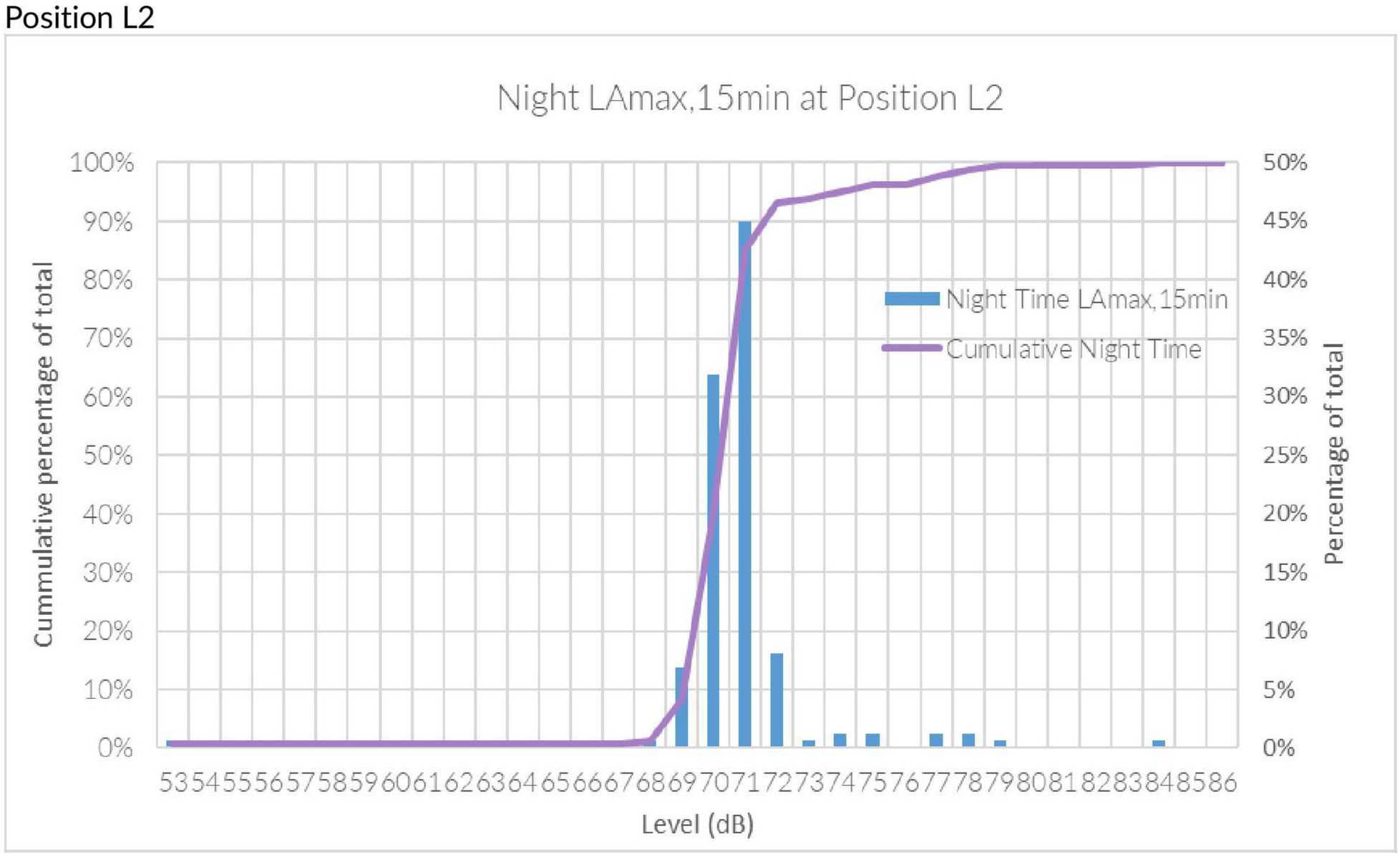


Figure 17 Statistical analysis of measured night-time maximum sound levels – Position L2

Position L3

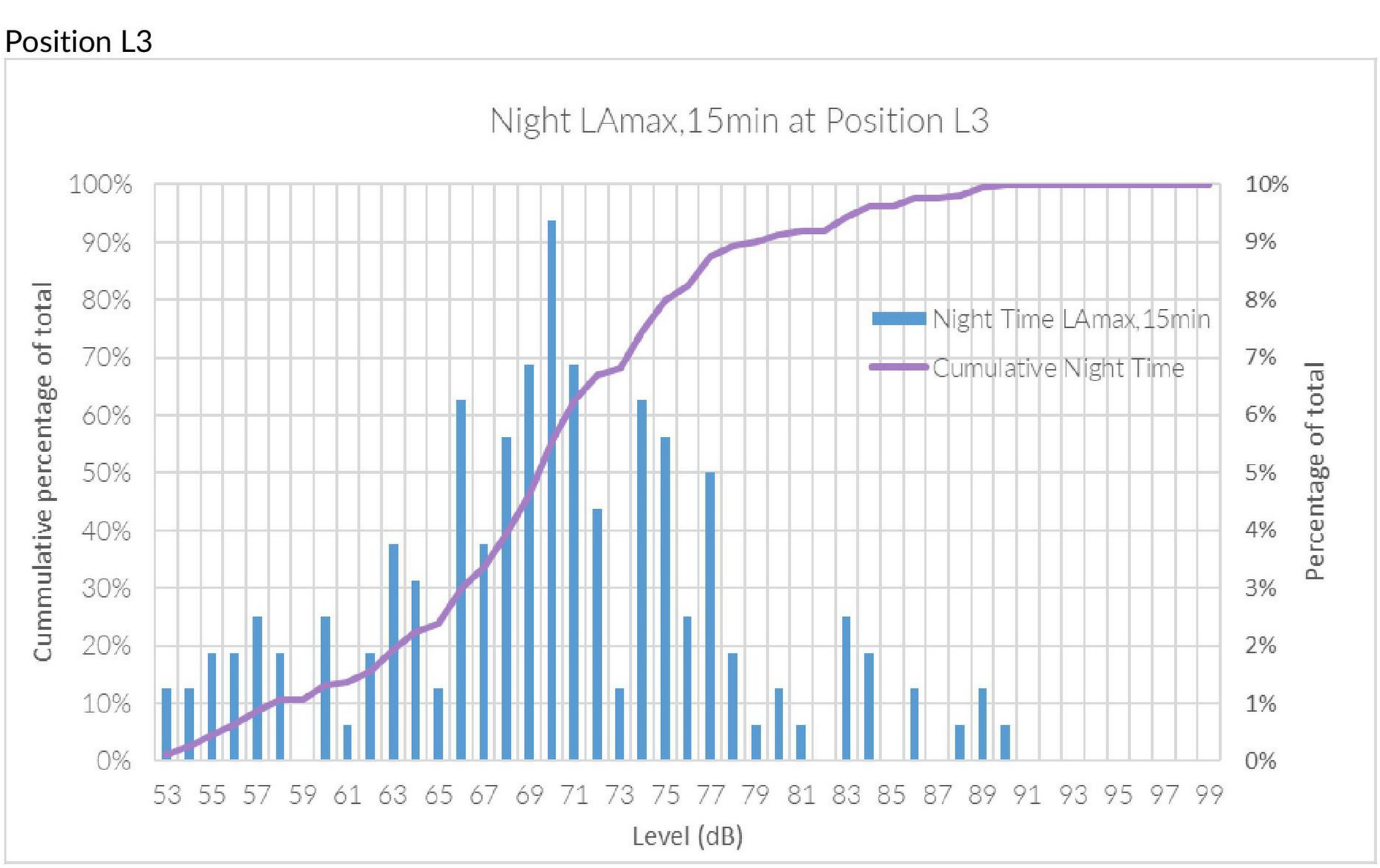


Figure 18 Statistical analysis of measured night-time maximum sound levels – Position L3

Position L4

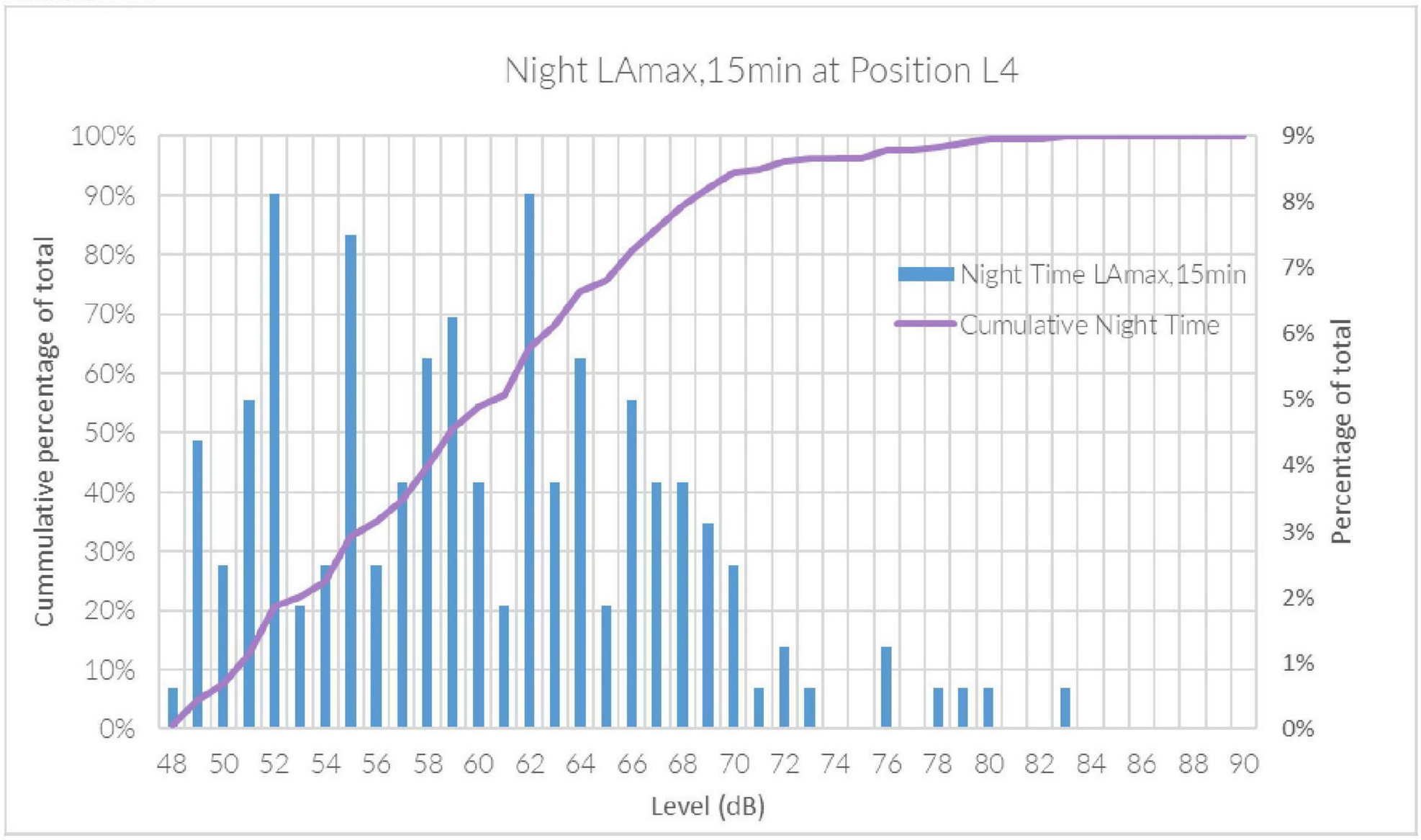


Figure 19 Statistical analysis of measured night-time maximum sound levels – Position L4

From the above statistical analysis charts, the time history charts included in Figure 20 to Figure 23 and given the context of the area, the following maximum sound levels have been determined representative for the periods of interest for each measurement position.

Table 16 Typical background sound levels determined from statistical analysis

Position	Period	Representative maximum sound level dB L_{AFmax}
L1	Night-time (23:00 - 07:00)	70
L2	Night-time (23:00 - 07:00)	72
L3	Night-time (23:00 - 07:00)	81
L4	Night-time (23:00 - 07:00)	70

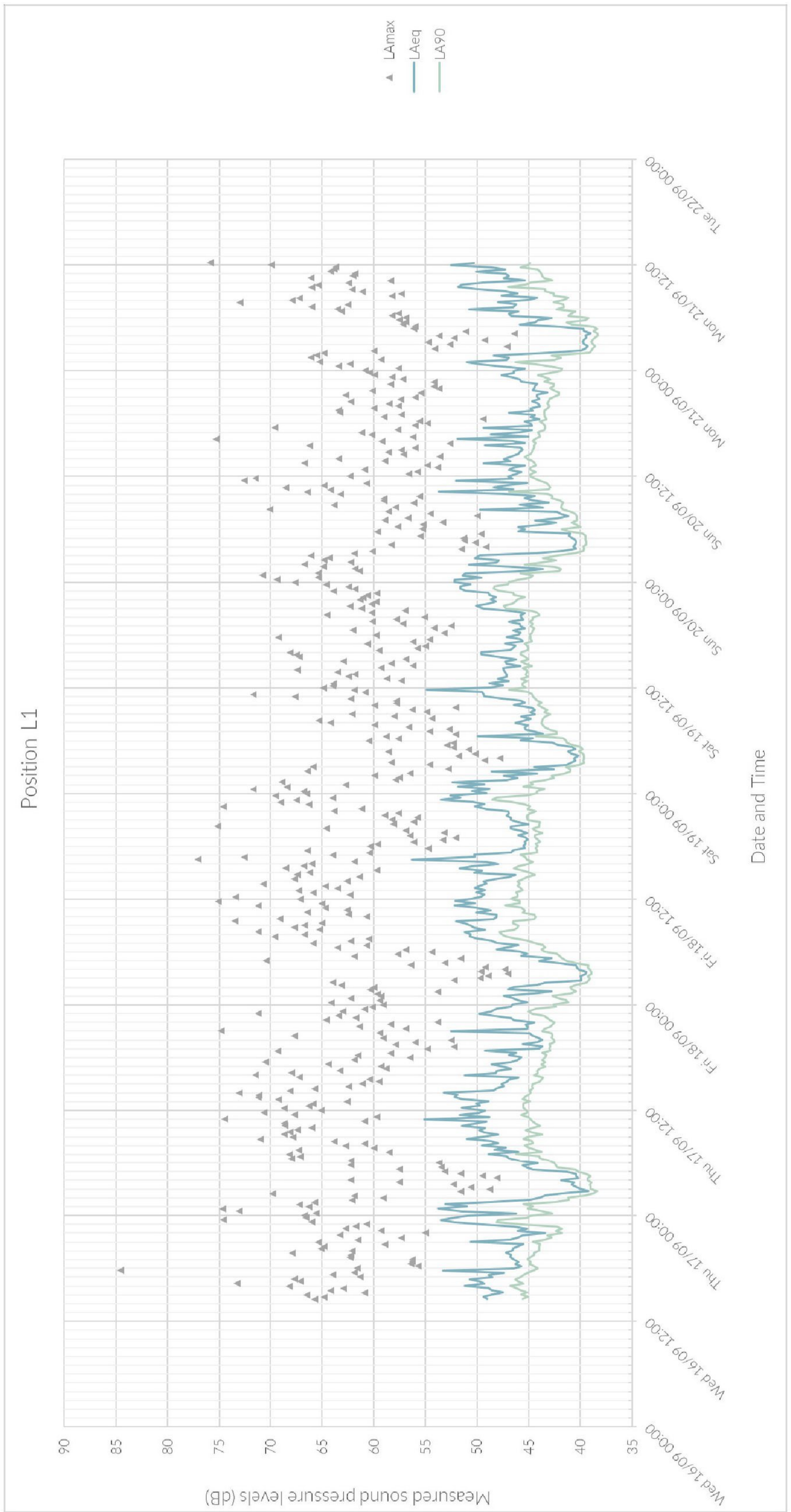


Figure 20 Time history of measured results from unattended monitoring position L1

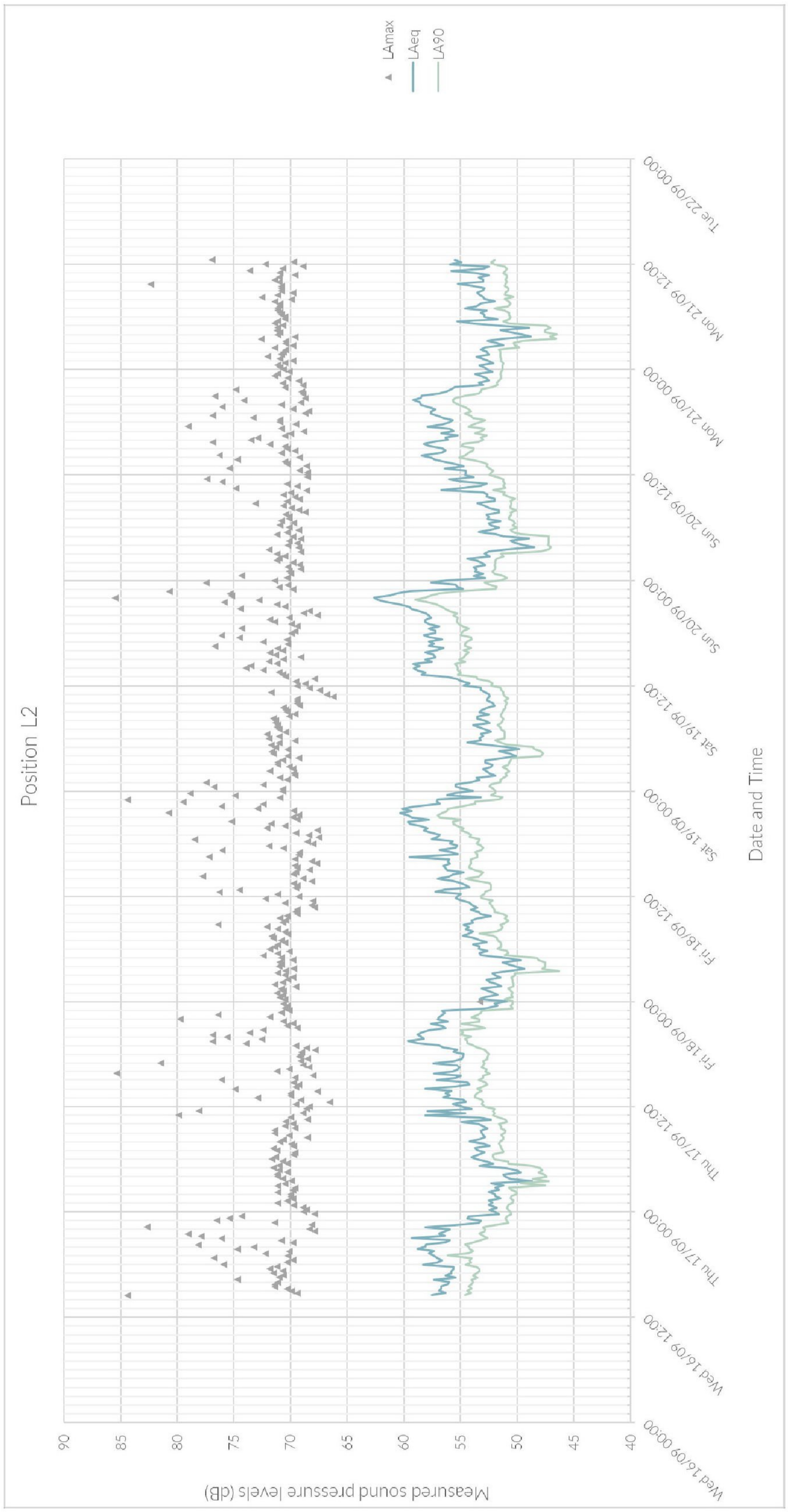


Figure 21 Time history of measured results from unattended monitoring position L2

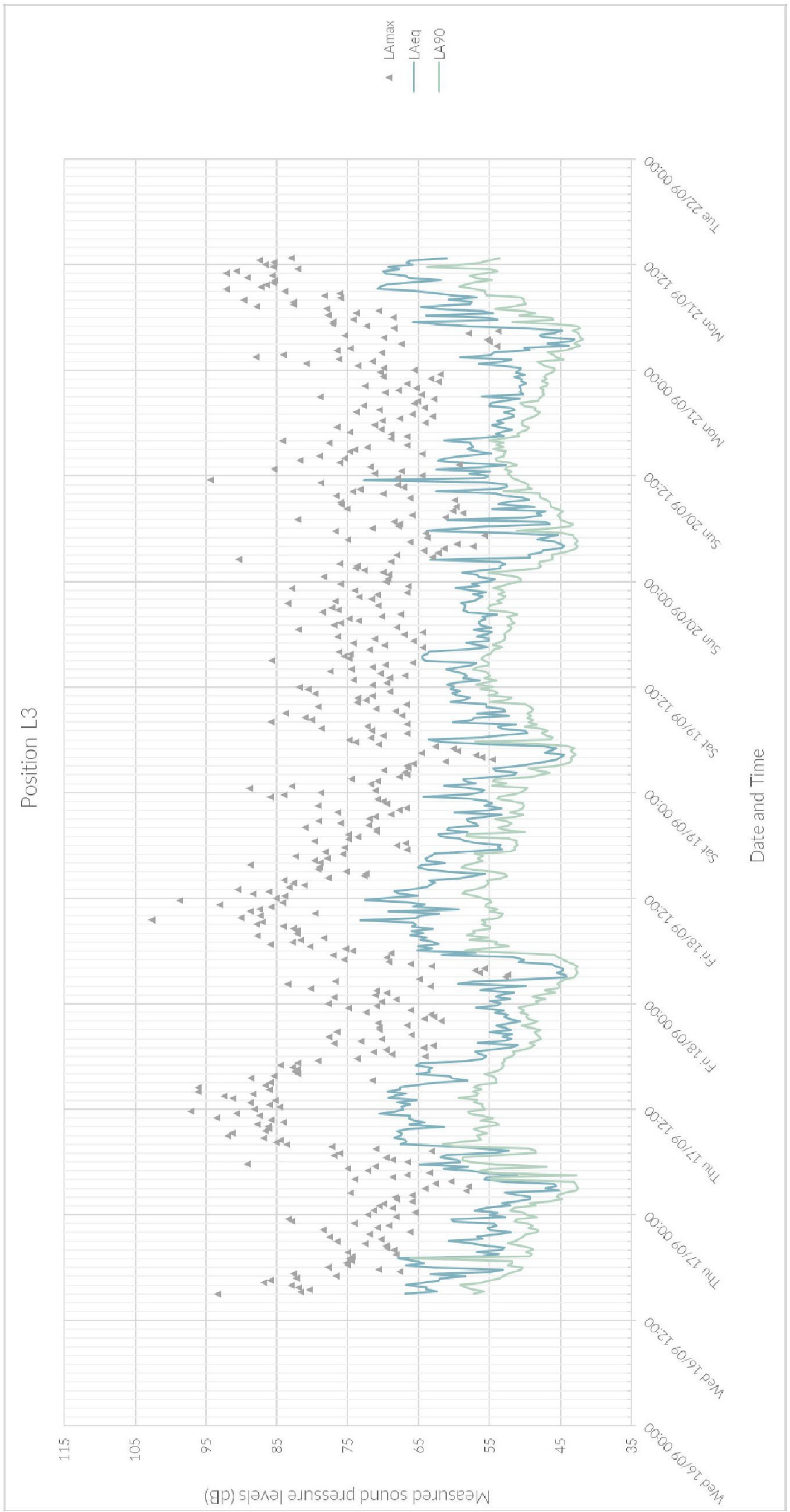


Figure 22 Time history of measured results from unattended monitoring position L3

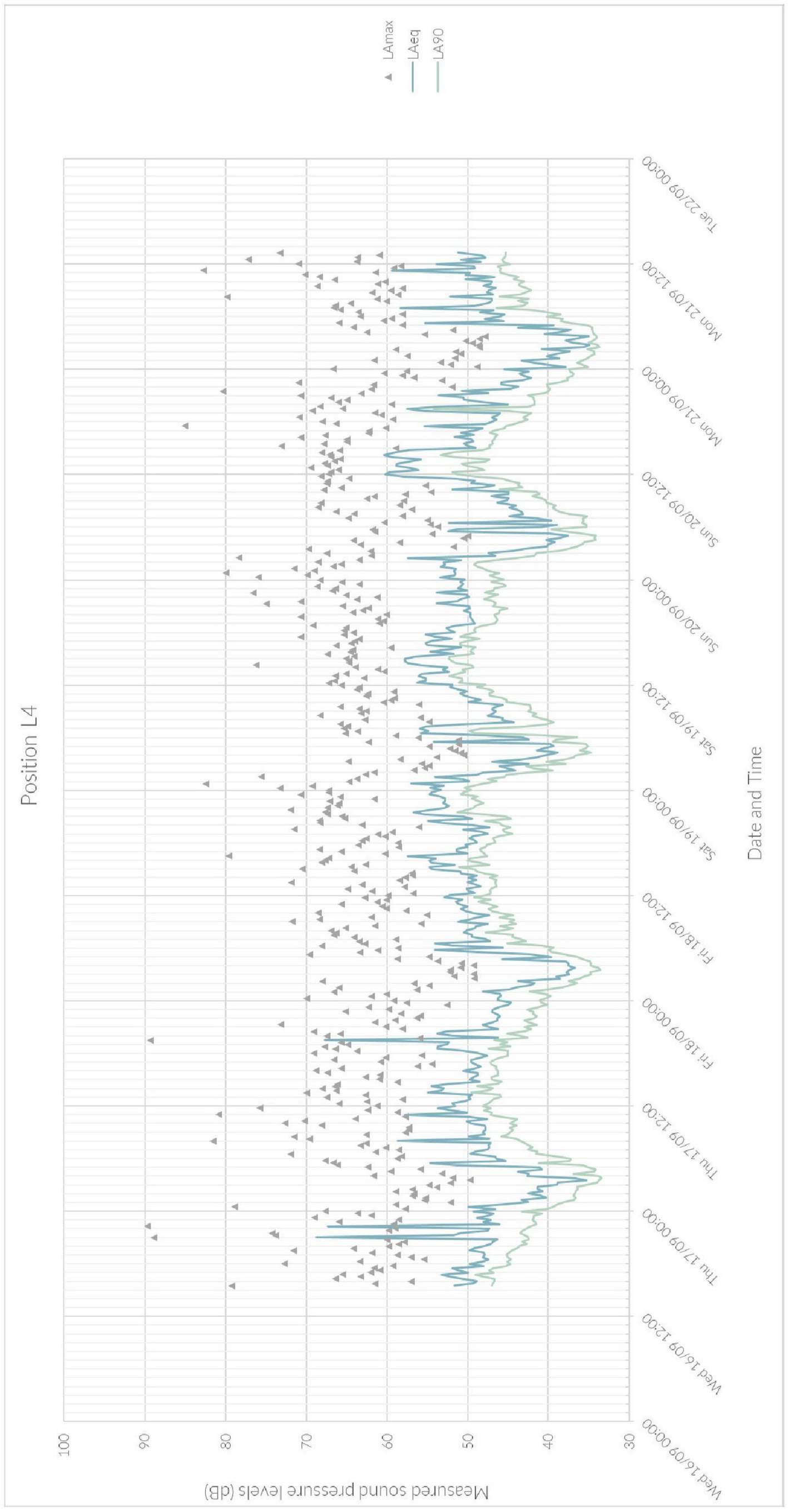


Figure 23 Time history of measured results from unattended monitoring position L4

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