inacoustic

Hagshaw Long Duration Electricity Storage (LDES), Coalburn, Scotland

Noise Impact Assessment for Planning Application

30th April 2025

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Version	Comments	Date	Authored By	Checked By	Project Number
1	Noise Assessment	10/04/2025	Victor Valeron BEng MSc MIOA	Neil Morgan MSc MIOA	24-595
2	Client Comments	23/04/2025	Victor Valeron BEng MSc MIOA	Dan Pope BSc (Hons) MIOA	24-595
3	Figure Updated	30/04/2025	Victor Valeron BEng MSc MIOA	Dan Pope BSc (Hons) MIOA	24-595

The findings and opinions expressed are relevant to the dates of the site works and should not be relied upon to represent conditions at substantially later dates. If additional information becomes available which may affect our comments, conclusions or recommendations, the author reserves the right to review the information, reassess any new potential concerns and modify our opinions accordingly.

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1. Introduction

1.1. Overview

inacoustic has been commissioned to assess the impact of sound arising from a proposed Long Duration Electricity Storage (LDES) facility (the 'Proposed Development') on Land at Conexus West, Coalburn, Lanark, ML11 0RL (the 'Site').

This report details the existing acoustic environment at the nearest noise sensitive receptors (NSRs), as well as the potential sound emissions associated with the Proposed Development.

The assessment considers the potential sound generation from the plant associated with the Proposed Development, with respect to existing background sound levels in the area. The assessment methodology contained in British Standard 4142:2014+A1:2019 '*Methods for rating and assessing industrial and commercial sound*'[1] has been used.

Accordingly, this technical report has been produced to accompany the Section 36 Consent Application to the Scottish Government and is based upon environmental sound measurements undertaken at the Site and a subsequent 3-dimensional sound modelling exercise.

This assessment is necessarily technical in nature; therefore a glossary of terms is included in Appendix A to assist the reader.

1.2. Scope and Objectives

The scope of the assessment can be summarised as follows:

- A sound monitoring survey was undertaken at discrete locations representative of the closest NSRs to the Site;
- A 3-dimensional sound modelling exercise, in order to quantify the potential sound generation of the Proposed Development;
- An assessment of potential sound impacts with respect to the prevailing acoustic conditions at the nearest NSRs; and
- Recommendation of mitigation measures, where necessary, to comply with the requirements of BS 4142:2014+A1:2019 and Technical Advice Note Assessment of Noise (2011).

[1] British Standards Institute, British Standard 4142:2014+A1:2019. *Methods for rating and assessing industrial and commercial sound*, 2019.

2. Legislation and Policy Framework

The development proposals for the Site are guided by the policy directives and guidance set out in the following section.

2.1. Relevant Policies

2.1.1. Scottish Government: National Planning Framework 4

Policy 11:

"e) In addition, project design and mitigation will demonstrate how the following impacts are addressed:

i. impacts on communities and individual dwellings, including, residential amenity, visual impact, noise and shadow flicker;"

Policy 23:

"e) Development proposals that are likely to raise unacceptable noise issues will not be supported. The agent of change principle applies to noise sensitive development. A Noise Impact Assessment may be required where the nature of the proposal or its location suggests that significant effects are likely."

2.1.2. Scottish Government: National Planning Framework 4 - Annex D – Six Qualities of Successful Places

2. Pleasant: Supporting attractive natural and built spaces:

"Designing for:

• protection from the elements to create attractive and welcoming surroundings, including provision for shade and shelter, mitigating against noise, air, light pollution and undesirable features, as well as ensuring climate resilience, including flood prevention and mitigation against rising sea levels"

2.1.3. South Lanarkshire Local Development Plan 2

The South Lanarkshire Local Development Plan 2, adopted on 9 April 2021, promotes the continued growth and regeneration of South Lanarkshire, whilst at the same time protecting and enhancing the environment.

In terms of noise, the following policies are highlighted.

Policy 5 Development Management and Placemaking

…The development shall not have an unacceptable significant adverse impact on the amenity of any nearby residential properties in terms of overshadowing, overlooking or other loss of residential amenity as a result of light, noise, odours, dust or particulates or other emissions

Appendix 1

Specific to renewable energy, Appendix 1 checklist estates that '*All applications for wind turbine developments should be accompanied by a site specific noise assessment. Noise assessments may also be required for other renewable energy developments.*'

2.1.4. Technical Advice Note: Assessment of Noise (2011)

For the assessment of operational noise from the proposed operations, consideration is also given to the TAN to PAN 1/2011[2]. PAN 1/ 2011 states:

"The purpose of a Noise Impact Assessment (NIA) is to demonstrate whether any significant adverse noise impacts are likely to occur and if so, identify what effective measures could reduce, control and mitigate the noise impact".

Before a NIA is commissioned, planning authorities and applicants are advised to:

- Agree any potential limits of noise and/or the relevant NIA methodology in the context of the Proposed Development, its location and the surrounding area.
- Establish criteria for assessing any significant adverse noise impact or predict and describe ambient noise levels (including noise from transport sources) that the Proposed Development is likely to generate and/or is likely to be subjected to.

In "*Example 2: New Noisy Development Affecting a Noise Sensitive Building*", the TAN sets out a procedure for assessing the noise impact on residential property when industrial development is proposed which is based on some of the principles described in BS4142 but does not adhere to the BS4142 method of evaluation.

The TAN assessment of noise impact from an industrial development is based on an estimate of the change in ambient noise level, $L_{Aeq,T}$ before and after the development is operational. It does not use the difference between rating noise and background noise to assess the Magnitude of Impact. The *"magnitude of noise impacts"* relating to the change in ambient noise level before and after the development is operational, as proposed in the TAN and adopted in this instance to provide context to the BS4142 assessment, are shown in Table 1.

[2] Planning Advice Note (PAN) 1/2011, Scottish Government

TABLE 1: MAGNITUDE OF IMPACT

Magnitude	Change in Ambient Noise Level, $L_{Aeq,T}$ (dB)
Major	>5
Moderate	3 to 4.9
Minor	1 to 2.9
Negligible	0.1 to 0.9
No change	0

When assessing the noise impact from an industrial development the TAN suggests that the noise *"sensitivity"* of each receptor is determined based on the relationship between the amenity associated with a NSR and its susceptibility to noise. NSRs which have amenities associated with low noise levels, such as residential properties, are allocated with a 'High' level of sensitivity.

Based on the sensitivity of the receivers, the magnitudes of impact, and taking into account any additional qualitative factors such as frequency spectrum of the source, period of day the source will run etc., the TAN method assigns *"levels of significance"* for all receptors, as shown in Table 2.

TABLE 2: SIGNIFICANCE OF EFFECTS

Magnitude of Impact (After – Before) $L_{Aeq,T}$ (dB)	Sensitivity of receptor based on *"likelihood of complaint"* x = Rating, $L_{Ar,Tr}$ – Background, $L_{A90,T}$ (dB)		
	Low	Medium	High
Major (≥5)	Slight/Moderate	Moderate/Large	Large/Very Large
Moderate (3 to 4.9)	Slight	Moderate	Moderate/Large
Minor (1 to 2.9)	Neutral/Slight	Slight	Slight/Moderate
Negligible (0.1 to 0.9)	Neutral/Slight	Neutral/Slight	Slight
No change (0)	Neutral	Neutral	Neutral

For a *"Large"* level of significance the TAN suggests that mitigation be employed such that resultant adverse effects are likely to have a Moderate or Slight significance. The Levels of significance where mitigation should be implemented are highlighted in Table 2.

2.2. Assessment Criteria

2.2.1. Consultation with Environmental Health

Consultation with South Lanarkshire Council's Environmental Health Officer has been undertaken. A summary of the EHO-suggested assessment criteria is presented below:

"The developer shall ensure that (prior to the development first coming into use) the noise levels (including all noise from the development source) comply with the following:

Between the hours of 08:00 and 20:00 the measured noise rating level emitted from development ($L_{Ar,1hr}$) shall not exceed the background noise level ($L_{A90,15\,min}$) by more than 4dB within the curtilage of any pre-existing residential amenity area. This shall be measured in accordance with British Standard BS 4142:2014+A1:2019 – Method for Rating and Assessing Industrial and Commercial Sound.

Between the hours of 20:00 and 08:00 the noise rating level emitted from the development ($L_{ar,15\,min}$) shall not exceed the background noise level ($L_{A90,15min}$) by more than 4dB within the curtilage of any pre-existing residential amenity area. This shall be measured in accordance with BS 4142:2014+A1:2019 Method for Rating and Assessing Industrial and Commercial Sound.

This is based on a locally agreed planning arrangement (times are not typical of the standard).

The external noise levels resultant from the development as they affect any pre-existing residential property shall not exceed;

1. *an $L_{Aeq,16hr}$ of 55dB during daytime (07:00 – 23:00) in any garden amenity areas, when measured free-field.*
2. *an $L_{Aeq,8hr}$ of 45dB during night-time (23:00 – 07:00) in any garden amenity areas, when measured free-field.*
3. *The external noise shall not give rise to instantaneous noise events at any time that exceed an L_{Amax} of 60dB during night-time (23:00 – 0700). An assumption of 15dB attenuation is assumed for a partially open window.*

The Internal Noise Rating Values resultant from the development, as measure within any residential property, shall not exceed of NR 15 at any time to ensure that it remains inaudible.

It should be noted that the fixed limits of $L_{Aeq,16hr}$ of 55dB during daytime and $L_{Aeq,8hr}$ of 45dB during night-time are the less onerous of the noise requirements, and they will be comfortably achieved by default if the rating sound level does not exceed the prevailing background sound level by more than 4dB *in BS 4142:2014+A1:2019* terms, or by achieving an internal NR 15. As such, these two will be the focus of this assessment.

2.2.2. BS4142:2014+A1:2019

BS4142:2014+A1:2019 *Methods for Rating and Assessing Industrial and Commercial Sound* sets out a method to assess the likely effect of sound from factories, industrial premises or fixed installations and sources of an industrial nature in commercial premises, on people who might be inside or outside a dwelling or premises used for residential purposes in the vicinity.

The procedure contained in BS4142:2014+A1:2019 for assessing the effect of sound on residential receptors is to compare the measured or predicted sound level from the source in question, the $L_{Aeq,T}$ *specific sound level*, immediately outside the dwelling with the $L_{A90,T}$ background sound level.

Where the sound contains a tonality, impulsivity, intermittency and other sound characteristics, then a correction depending on the grade of the aforementioned characteristics of the sound is added to the specific sound level to obtain the $L_{Ar,Tr}$ *rating sound level*. The effect of uncertainty in sound measurements, data and calculations should also be considered when necessary.

BS4142:2014+A1:2019 states: *"The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs"*. An estimation of the impact of the specific sound can be obtained by the difference of the rating sound level and the background sound level and considering the following:

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

During the daytime, the assessment is typically carried out over a reference time period of 1-hour, with a reference period of 15-minutes used for the night-time assessment. The periods associated with day or night, for the purposes of the Standard, are considered to be 07.00 to 23.00 and 23.00 to 07.00, respectively.

2.2.3. Noise Rating (NR) Assessment Methodology

Noise Rating Curves (NR) are a method for rating the acceptability of indoor environments for the purposes of hearing preservation, speech communication and annoyance. The NR is not defined in any ISO or British Standard, although it is described in Annex B (informative) of '*BS 8233:2014 Guidance on sound insulation and noise reduction for buildings*', as summarised below:

> *'Noise rating (NR) is a graphical method for assigning a single-number rating to a noise spectrum. It can be used to specify the maximum acceptable level in each octave band of a frequency spectrum, or to assess the acceptability of a noise spectrum for a particular application. The method was originally proposed for use in assessing environmental noise, but it is now used in the UK mainly for describing noise from mechanical ventilation systems in buildings. To obtain a rating, the noise spectrum is superposed on a family of NR contours. The NR of the spectrum corresponds to the value of the first NR contour that is entirely above the spectrum.'*

For reference, the values for the NR15 are shown in Table 3, for the frequency range 63 Hz to 8 kHz.'

TABLE 3: NOISE RATING CURVES (NR)

Criteria	Octave Band Sound Pressure Level, Hz (dB)							
	63	125	250	500	1k	2k	4k	8k
NR15	47.3	35.0	25.9	19.4	15.0	11.7	9.3	7.4

The relationship between NR and dB(A) values depends on the spectral characteristics of the noise. As such, NR values cannot be converted directly to dB(A) values, although the following approximate relationship applies: NR $\cong$ dB(A) – 6.

In this instance, for the calculation of the indoor ambient noise levels from the outdoor free-field levels predicted by the noise modelling software, a sound difference outside-to-inside will be assumed to be 15 dB, as advised by Environmental Health.

To support this, it is noted that the Napier report titled NANR116: *'Open/closed window research' – Sound Insulation Through Ventilated Domestic Windows'* which has been authored for DEFRA, demonstrates that a partially openable window will achieve an attenuation of between 12-18 dBA.

2.2.4. Relative Change in Ambient Noise Level

The IEMA Guidelines[3] define 'Noise Impact' as the difference in the acoustic environment before and after the implementation of the proposals, also known as the magnitude of change. In circumstances where a noise environment may be altered by addition or removal of a noise source, considered to be largely anonymous or within the prevailing acoustic character of an area, for example, changes to traffic quantum or patterns, it is normal to consider this relative change in ambient noise level. The assessment, therefore, considers this phenomenon to add context.

The impact scale adopted in this assessment is shown in Table 4 below, which relates to established human responses to noise, in line with '*Table 7-12 Effect Descriptors'* of the IEMA Guidelines and in the context of TAN.

TABLE 4: IMPACT SCALE FOR COMPARISON OF FUTURE NOISE AGAINST EXISTING NOISE

Noise Level Change dB(A)	Subjective Response	Significance	TAN Magnitude of Impact
Less than 1.0	No perceptible	Negligible	Negligible
1.0 – 2.9	Barely perceptible	Minor impact	Minor
3.0 – 4.9	Noticeable	Moderate impact	Moderate
5.0 – 9.9	Up to a doubling or halving of loudness	Substantial impact	Major
10.0 or more	More than a doubling or halving of loudness	Major impact	-

The criteria above reflect the key benchmarks that relate to human perception of sound. A change of 3 dB(A) is generally considered to be the smallest change in environmental noise that is perceptible to the human ear. A 10 dB(A) change in noise represents a doubling or halving of the perception of loudness. The difference between the minimum perceptible change and the doubling or halving of the perceived noise level is split to provide greater definition to the assessment of changes in noise level.

It is considered that the criteria specified in Table 4 provide a good indication as to the likely significance of changes in noise levels in this case and can be used to inform the context in which the sound occurs in order to assess the impact of noise from the Proposed Development.

[3] Institute of Environmental Management & Assessment (IEMA), Version 1.2 (November 2014). Guidelines for Environmental Noise Impact Assessment

3. SITE DESCRIPTION

3.1. Site and Surrounding Area

The Application Site is located to the southwest of junction 11 of the M74, approximately 1.5km to the south of Coalburn and approximately 1.5km to the north of Douglas.

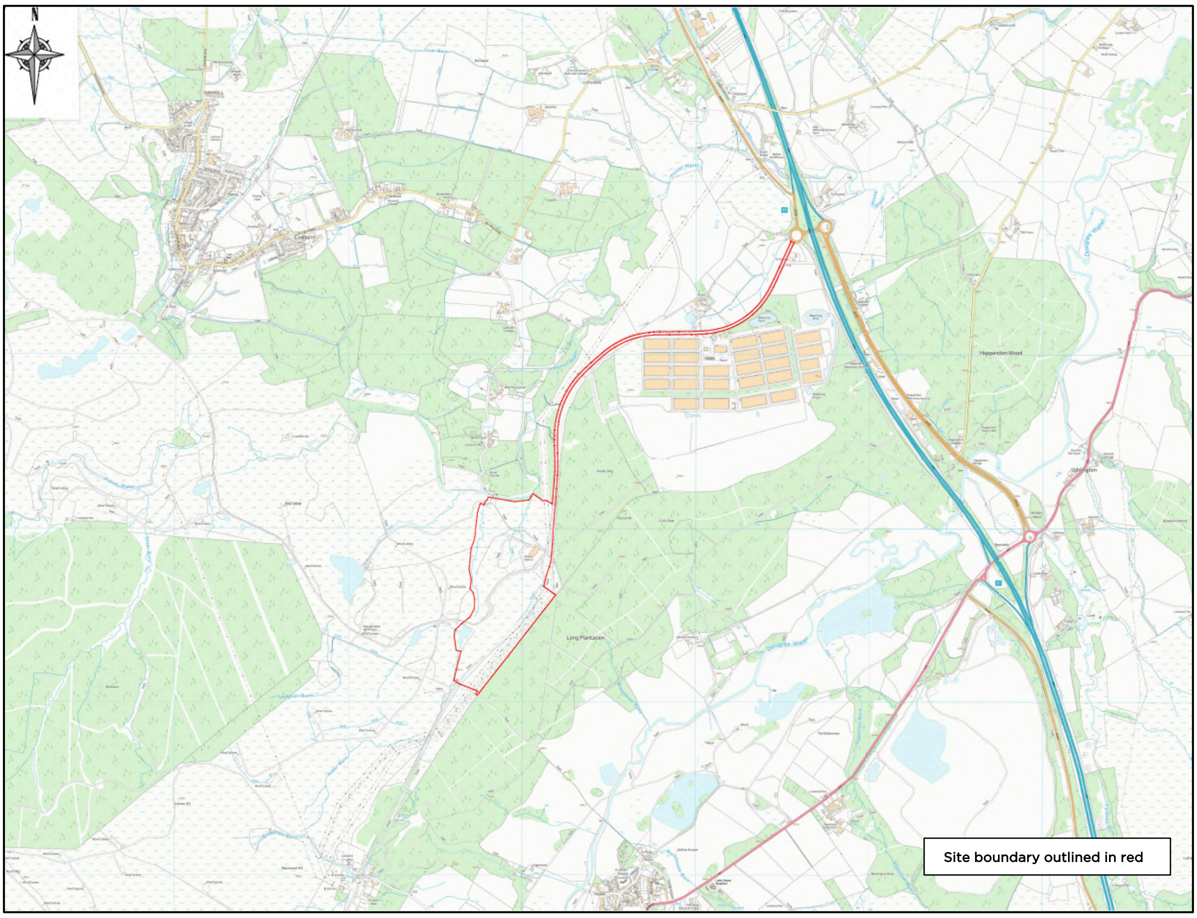
The Site now forms part of the Hagshaw Energy Cluster, an established strategic location for large-scale renewable energy projects. The site itself is split by the existing access road which runs northeast to southwest through the site, this road will be retained but realigned slightly to maximise the development footprint.

The Site is approximately 2km southwest of the M74 corridor and is surrounded by open fields to the northwest, west and southwest and by woodland to the northeast, east and southeast.

The sound environment at the area is influenced by distant road traffic noise from the M74 corridor to the northwest and natural sounds such as birdsong.

The Proposed Development site and the surrounding area can be seen in Figure 2.

FIGURE 1: PROPOSED DEVELOPMENT SITE AND SURROUNDING AREA



3.2. Noise Sensitive Receptors

The closest identified third party NSRs to the Site are set out in Table 5 below, with an aerial image of their locations relative to the Site shown in Figure 2.

TABLE 5: NSR OVERVIEW

ID	Coordinates		Approx. distance to development infrastructure
	Easting	Northing	
NSR1 – Westerhouse	282803	633476	500m
NSR2 – Gardens House	284001	632378	950m
NSR3 – Douglas Estate	283671	631164	1,400m
NSR4- Edgewood	283061	631056	1,150m
NSR5 – Station House	282147	630945	1,300m

FIGURE 2: PROPOSED DEVELOPMENT SITE AND NOISE-SENSITIVE RECEPTORS (NSRS)

3.3. Proposed Development Overview

The Proposed Development is expected to utilise flow battery technology, with initial designs based on Vanadium Flow Battery technology (VFB), which will provide up to 12 hours of Long Duration Electricity Storage to the National Grid.

VFB store energy in two liquid electrolyte solutions containing vanadium ions in different oxidation states. During charging, energy is used to drive a redox reaction where vanadium ions in the positive electrolyte are reduced and in the negative electrolyte, they are oxidised. During discharging, the process reverses. This flow of ions through a membrane between the two electrolytes generates a flow of electrons, producing electricity.

While energy storage itself is silent, the cooling systems for batteries and inverter stations produce sound. The sound generating items across the Proposed Development are shown below in Table 6 below, with the Proposed Development layout shown in Figure 3 overleaf.

TABLE 6: SOUND GENERATING ITEMS

Sound Generating Items	Quantity
LDES Battery Modules	13,608
PCS Inverters	162
String Control Units	1,141
400kV Transformers	2

LDES battery modules will be triple stacked. PCS Inverters will include double and single units, and all String Control Units are single units. The substations and ancillary equipment will be located in the southern area of the site.

FIGURE 3: PROPOSED DEVELOPMENT LAYOUT

4. Baseline Sound Survey

4.1. Overview

The prevailing acoustic conditions in the area have been determined by an environmental sound survey conducted during both daytime and night-time periods between Thursday 13th and Tuesday 18th March 2025.

4.2. Measurement Details

All sound measurements were undertaken by a consultant certified as competent in environmental sound monitoring, and, in accordance with the principles of British Standard 7445:2003 '*Description and measurement of environmental noise*'[4].

All sound measurement equipment used during the survey conformed to Type 1 specification of British Standard 61672:2013 '*Electroacoustics. Sound level meters*. Part 1 *Specifications*'[5]. A full inventory of this equipment is shown in Table 7 below.

Table 7: Inventory of Sound Measurement Equipment

Position	Make, Model & Description	Serial Number	Calibration Certificate Number	Calibration Due Date
MP1	Rion NL-52 Sound Level Meter	01009671	141898	21/03/2025
	Rion NH-25 Preamplifier	9976		
	Rion UC-59 Microphone	18146		
MP2	Rion NL-53 Sound Level Meter	01141572	CONF012507	21/01/2027
	Rion NH-25 Preamplifier	44514		
	Rion UC-59 Microphone	26705		
MP3	Rion NL-52 Sound Level Meter	00764926	1163903	17/06/2026
	Rion NH-25 Preamplifier	76427		
	Rion UC-59 Microphone	12922		
All	Rion NC-74 Acoustic Calibrator	35246906	TCRT23/01043	07/04/2026

The sound measurement equipment used during the survey was field calibrated at the start and end of the measurement period. A calibration laboratory has calibrated the field calibrator used within the twelve months preceding the measurements. A drift of less than 0.2 dB in the field calibration was found to have occurred on the sound level meter.

The weather conditions during the survey were conducive to environmental noise measurement; it being dry, with wind speeds typically below 5 ms^{-1}. A rain gauge was installed on site for the duration of the survey. When periods of inclement weather or atypical sounds were noted to occur, they have been removed from the dataset used to derive the typical background sound level. The microphones were fitted with protective windshields for the measurements.

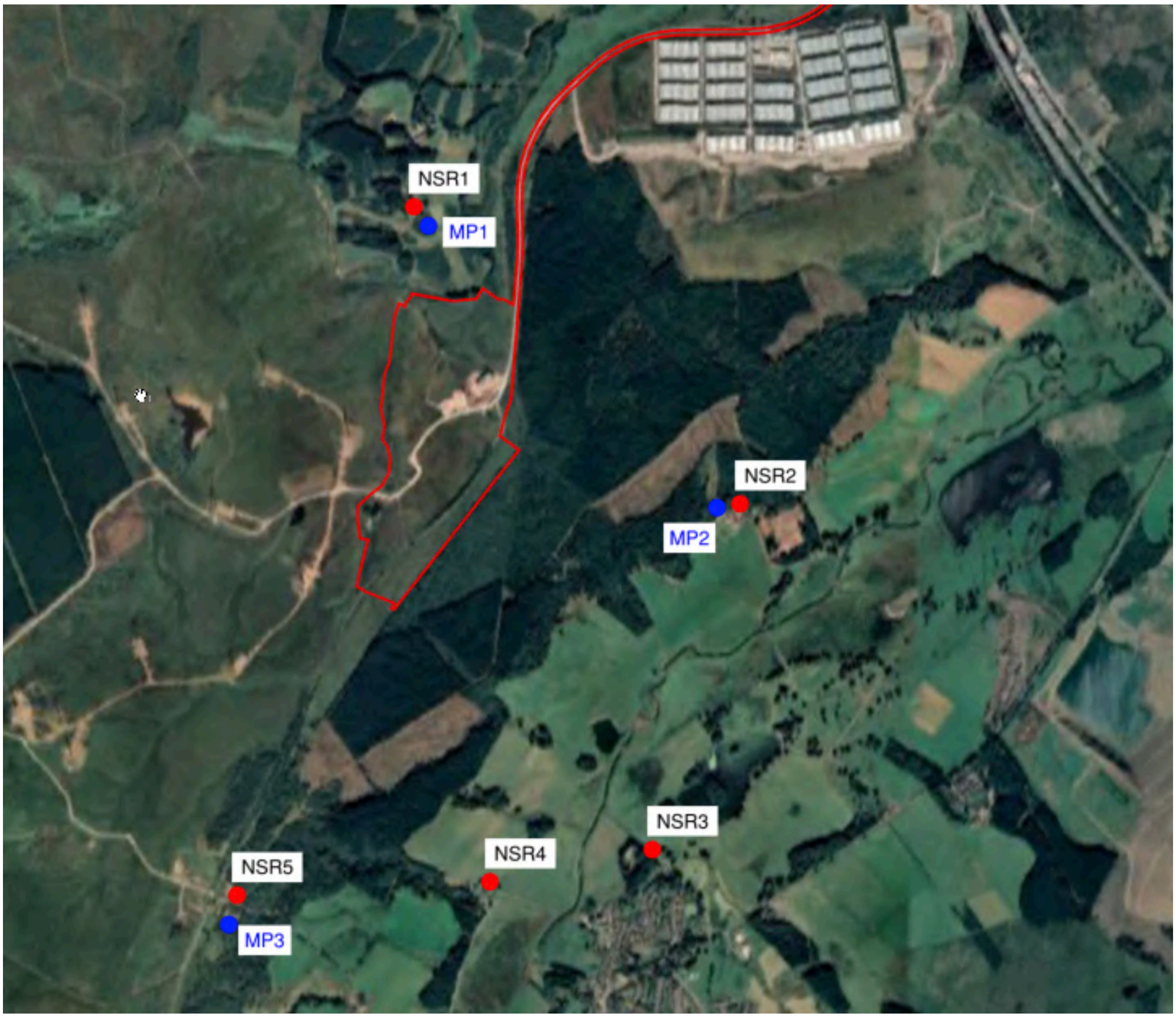
[4] British Standards Institute, British Standard 7445: 2003: *Description and measurement of environmental noise*, 2003.
[5] British Standards Institute, British Standard 61672: 2013: *Electroacoustics. Sound level meters*. Part 1 *Specifications*, 2013.

The measurement positions are described in Table 8, with an aerial photograph indicating their location shown in Figure 4.

TABLE 8: MEASUREMENT POSITION DESCRIPTION

Measurement Position	Description
MP1	A largely unattended daytime and night-time measurement of sound at a location representative of the closest noise-sensitive receptors to the north of the site. The microphone was located at NSR1, approximately 500m to the northwest of the site infrastructure, at 1.5 metres above local ground level, under free-field conditions. The sound environment at this location was influenced by distant road traffic noise from the M74, approximately 2km northeast of the monitoring position, and natural sounds such as birdsong. Noise from nearby wind turbines was not audible during setting up or collection of the Sound Level Meter. This position is deemed representative of NSR1.
MP2	A largely unattended daytime and night-time measurement of sound at a location representative of the closest noise-sensitive receptors to the east of the site. The microphone was located in the garden of NSR2, approximately 950m to the east of the site infrastructure, at 1.5 metres above local ground level, under free-field conditions. The sound environment at this location was influenced by distant road traffic noise from the M74, approximately 1,700m northeast of the monitoring position, and natural sounds such as birdsong. Some outdoor works were being undertaken at the property during the survey. These periods have been removed from the data set used to derive the typical background sound levels. This position is deemed representative of NSR2.
MP3	A largely unattended daytime and night-time measurement of sound at a location representative of the closest noise-sensitive receptors to the south and southeast of the site. The microphone was located at NSR5, approximately 1,300m to the south of the site infrastructure, at 1.5 metres above local ground level, under free-field conditions. The sound environment at this location was influenced by very distant road traffic noise from the M74, approximately 4Km northeast of the monitoring position, and natural sounds such as birdsong. Noise from nearby wind turbines was not audible during setting up or collection of the Sound Level Meter. This position is deemed representative of NSR3, NSR4 and NSR5.

Figure 4: Measurement Positions (MPs)



4.3. Sound Indices

The parameters reported are the average Equivalent Continuous Sound Level, $L_{Aeq,T}$, the statistical index (typical) Background Sound Level, $L_{A90,T}$, as well as the typical Maximum Sound Pressure Level, L_{AFmax}. An explanation of the sound units presented is given in Appendix A.

For clarity, it is noted that the background sound level ($L_{A90,T}$) is an underlying level of sound over a period, T, and might in part be an indication of relative quietness at a given location. It does not reflect the occurrence of transient and/or higher sound level events and is generally governed by continuous or semi-continuous sounds.

The measured L_{Aeq}, L_{AFmax}, and L_{AF90} sound levels are presented as time histories in a graph in Appendix B. Furthermore, the statistical distribution of the measured background sound levels to derive the typical representative $L_{A90,T}$ values are presented in a graphical format in Appendix C.

4.4. Summary Results

The summarised results of the environmental sound measurements, during the day and night-time periods, can be seen below in Table 9. As requested by Environmental Health, daytime periods have been considered to be 08:00-20:00 and night-time periods 20:00-08:00. Representative background sound levels $L_{A90,T}$ have been selected through statistical analysis. Values have been rounded to the nearest whole number.

TABLE 9: SOUND MEASUREMENT RESULTS

Measurement Position	Period	$L_{Aeq,T}$ (dB)	$L_{AF90,T}$ (dB)	L_{AFmax} (dB)
MP1	Day	43	**33**	62
	Night	42	**31**	60
MP2	Day	43	**36**	68
	Night	40	**30**	55
MP3	Day	41	**32**	62
	Night	38	**32**	57

5. Operational Sound Assessment

5.1. Sound Propagation Modelling

5.1.1. Source Data

The A-weighted sound power levels associated with the Proposed Development can be seen below in Table 10. It is common that technical infrastructure applications are determined well ahead of the procurement and purchase of the plant and equipment required. In these circumstances it is typical to specify maximum noise levels from 'candidate plant' based on existing technology, to be achieved by scheme design.

Table 10: Sound Source Data – Maximum Plant Sound Specification Level

Plant	Quantity	Maximum Sound Power Level per unit, L_{wA} (dB)*	Indicative Sound Pressure Level at 10m, L_{pA} (dB)*
LDES Battery Modules	13,608	60	32
PCS Inverters	162	78	50
String Control Units	1,141	70	42
400kV Transformers	2	92	61

** Sound power level (SWL/L_W) is the amount of sound energy emitted by a source, while sound pressure level (SPL) is the level of sound energy at a specific location. SWL is independent of distance and environment, while SPL depends on both. Some suppliers provide their data in terms of SPL at a given distance rather than SWL. SWL, however, is a more objective metric for noise assessment, as it can be used in the noise modelling to predict the SPL at any distance, under various environmental conditions. Thus, our noise specifications are provided primarily as derived SWL to enable a transparent and robust comparison between different suppliers. Indicative SPL at 10m distance from the plant are also provided for reference.*

Confirmation from the selected plant manufacturers that the above sound levels are achieved should always be sought prior to plant procurement.

These input parameters are intended as acoustic specifications, to determine the likely sources of noise impact and whether attenuation is likely to be required, such that acoustic feasibility is demonstrated for the purposes of planning consideration.

5.1.2. Calculation Process

Calculations were carried out using Cadna/A, which undertakes its calculations in accordance with guidance given in ISO9613[6], which considers a worst-case downwind propagation to all receptors.

5.1.3. Model Assumptions

Given that the land between the Proposed Development and nearest receptors is largely soft, the ground factor has been set to 1 within the calculation software (with the exception of the Site compound which has been set to G=0.2), with 2 orders of reflection. 1/3 octave frequency spectra have been used in the calculations. It has been assumed that all plant will operate simultaneously, representing a worst-case scenario, although this is an unlikely occurrence as all of the units are independent of each other and usually operate as per demand.

In order to accurately model the land surrounding the development, an AutoCAD DXF drawing was produced, which was based on data provided by the Ordnance Survey, along with associated LIDAR Composite DTM topographic contours.

5.1.4. Mitigation by Design

In order to reduce the potential noise impact of the Proposed Development, an iterative assessment of suitable noise mitigation techniques has been undertaken.

Table 10 shows the maximum sound power level required to achieve compliance at the nearest receptors.

An efficient way to reduce noise from the cooling systems will be using variable fan speed, where the fan speed of the cooling system automatically adjusts based on ambient temperature to ensure optimal performance and noise management. For the typical climate in Scotland, this is expected to allow the plant to operate at inherently low fan speeds while meeting the plant cooling demands. Should this not be sufficient to meet the noise specification limits presented in Table 10, alternative mitigation measures should be employed, such as plant fitted with a noise reduction kit comprising external acoustic baffles to the air inlets and outlets, or housed within an acoustic enclosure capable of reducing the total sound power level to those presented in Table 10.

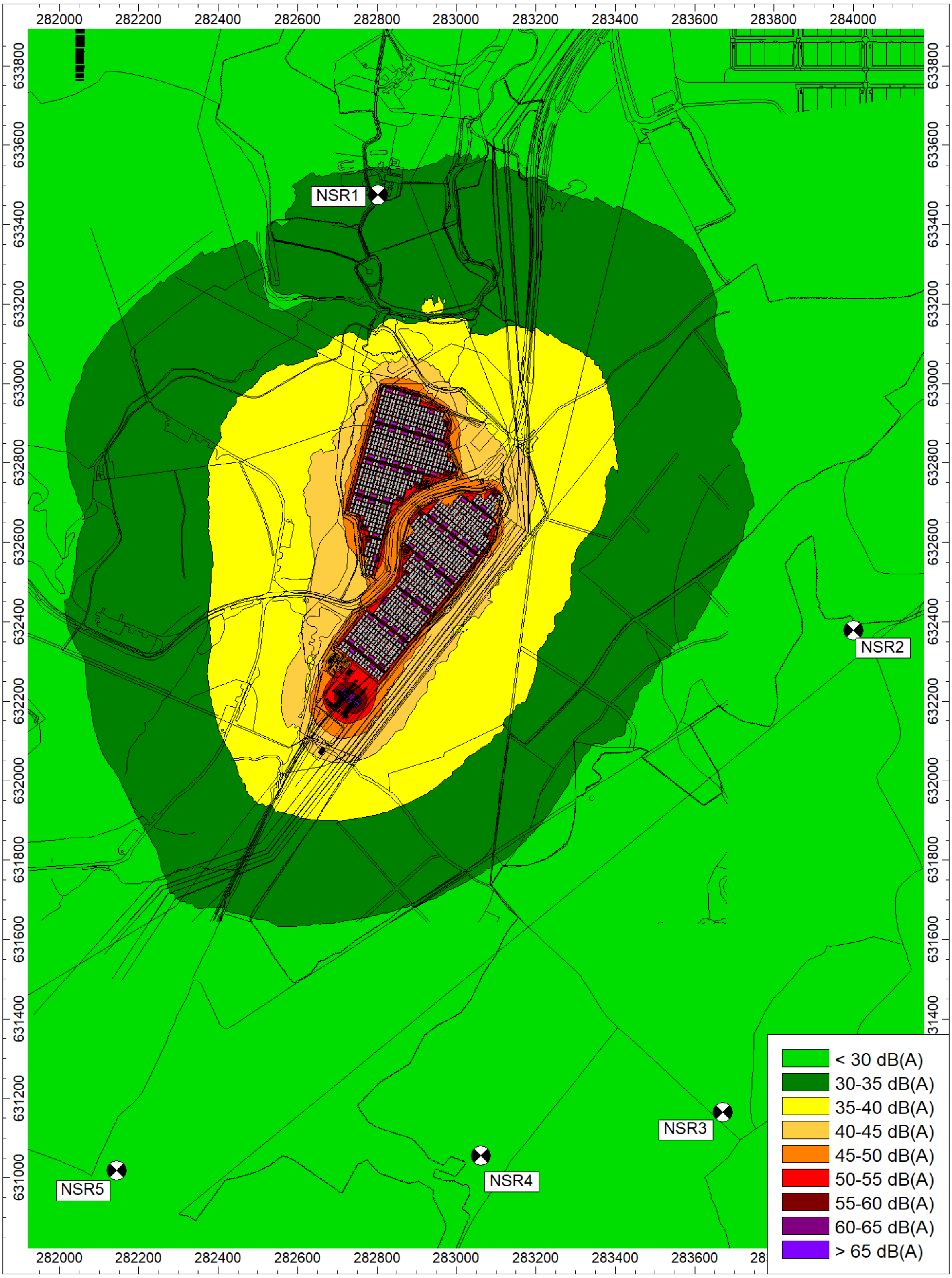
It is the responsibility of the contractor/manufacturer to provide test documentation confirming that the ultimately selected plant does not exceed the noise specifications set out in this report.

5.1.5. Specific Sound Level Map

The sound map at 4m above ground, representative of a first floor window, can be seen in Figure 5 overleaf. This shows the predicted 'worst-case' specific sound level emissions from the Proposed Development, based on the maximum sound power levels in Table 10.

[6] *ISO 9613-1:1993 and ISO 9613-2:2024: Acoustics - Attenuation of sound during propagation outdoors. Part 1: Calculation of the absorption of sound by the atmosphere and Part 2: Engineering method for the prediction of sound pressure levels outdoors*

Figure 5: Specific Sound Level Map



5.1.6. Specific Sound Level Summary

A summary of the predicted specific sound levels at the closest NSRs, based on the sound map shown in Figure 5 can be seen below in Table 11.

TABLE 11: PREDICTED SPECIFIC SOUND LEVEL SUMMARY

NSR	Specific Sound Level (dB)
1	31
2	22
3	19
4	20
5	23

5.2. Assessment

5.2.1. Rating Penalty Principle

Section 9 of BS4142:2014+A1:2019 describes how the rating sound level should be derived from the specific sound level, by determining a rating penalty. BS4142:2014+A1:2019 states:

"Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level. Where such features are present at the assessment location, add a character correction to the specific sound level to obtain the rating level. This can be approached in three ways:

a) subjective method;
b) objective method for tonality;
c) reference method."

Given that the Proposed Development is not operational, the subjective method has been adopted to derive the rating sound level from the specific sound level. This is discussed in Section 9.2 of BS4142:2014+A1:2019, which states:

"Where appropriate, establish a rating penalty for sound based on a subjective assessment of its characteristics. This would also be appropriate where a new source cannot be measured because it is only proposed at that time, but the characteristics of similar sources can subjectively be assessed.

Correct the specific sound level if a tone, impulse or other characteristics occurs, or is expected to be present, for new or modified sound sources."

BS4142:2014+A1:2019 defines four characteristics that should be considered when deriving a rating penalty, namely; tonality; impulsivity; intermittency; and other sound characteristics, which are defined as:

Tonality

A rating penalty of +2 dB is applicable for a tone which is *"just perceptible"*, +4 dB where a tone is *"clearly perceptible"*, and +6 dB where a tone is *"highly perceptible"*.

Impulsivity

A rating penalty of +3 dB is applicable for impulsivity which is *"just perceptible"*, +6 dB where it is *"clearly perceptible"*, and +9 dB where it is *"highly perceptible"*.

Intermittency

BS4142:2014+A1:2019 states that when the *"specific sound has identifiable on/off conditions, the specific sound level ought to be representative of the time period of length equal to the reference time interval which contains the greatest total amount of on time … if the intermittency is readily distinctive against the residual acoustic environment, a penalty of +3 dB can be applied."*

Other Sound Characteristics

BS4142:2014+A1:2019 states that where *"the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a penalty of +3 dB can be applied."*

5.2.2. Rating Penalty Assessment

Considering the content of Section 5.2.1, an assessment of the various sound sources associated with the Proposed Development, in terms of whether any rating penalties are applicable, has been detailed in Table 12 below.

TABLE 12: RATING PENALTY ASSESSMENT

Sound Characteristic	Penalty	Discussion
Tonality	0 dB	The primary source of noise generation from energy storage projects is the fans serving the inverters and battery cooling systems, that typically generate aerodynamic broadband sound, which should be achieved by design. As such no rating penalty correction should be applied for Tonality.
Impulsivity	0 dB	Inverters and battery cooling systems operate continuously without the audibility or prominence of sudden sounds. As such, no rating penalty correction should be applied for Impulsivity.
Intermittency	0 dB	Inverters and battery cooling systems operate continuously during the battery charging/discharging process, which takes longer than 100% of the BS4142 reference time interval (1 hour during the day and 15 minutes during the night). The cooling system will then switch off during the cool down period, but gradually and not simultaneously on all units, with no identifiable on/off character. As clarified by the Association of Noise Consultants (ANC) Technical Note on BS 4142:2014+A1:2019, dated March 2020, if a source is considered to be ON for 100% of the reference time interval, an Intermittency correction should not, therefore, be applied.
Other Sound Characteristics	0 dB	ESS systems do not have acoustic features present such as a whine, hiss, screech, non-tonal hum, rattle or rasp that can attract attention. By its electrical nature, HV Transformers may emit a distinct 100Hz tone at source that can be identified as a 'hum'. However, the noise from the transformers is much lower than from the cumulative noise of all inverters and batteries themselves. The noise specifications provided in this assessment ensure that the specific broadband noise level from the HV Transformers at the closest receptor is less than 20dBA (<25dB lineal at 100 Hz), ensuring that transformer noise, including any potential 100Hz 'hum', will not be audible at the receptor location, due to the lower sensitivity of the human ear at low frequencies and masking from the residual acoustic environment. For reference only, the value of the '*Criterion curve for assessment of low frequency noise*' from NANR45[7] is 38 dB (lineal) at 100Hz within a room. As such, since the predicted outdoor sound level from the HV Transformers is lower than this internal benchmark, low frequency noise is not expected to be a core consideration. As such, no rating penalty correction should be applied for 'Other Sound Characteristics'.

In summary, no rating penalty has been included in the assessment.

[7] *'Procedure for the assessment of low frequency noise complaints' Revision 1, December 2011, Contract no NANR45, University of Salford produced for Defra*

5.2.3. Uncertainty

BS4142:2014+A1:2019 requires that the level of uncertainty in the measured data and associated calculations is considered in the assessment. The Standard recommends that steps should be taken to reduce the level of uncertainty.

Measurement Uncertainty

BS4142:2014+A1:2019 states that measurement uncertainty depends on a number of factors, including the following, which are applicable to the Proposed Development:

"   …

b) the complexity and level of variability of the residual acoustic environment;
…
d) the location(s) selected for taking the measurements;
…
g) the measurement time intervals;
h) the range of times when the measurements have been taken;
i) the range of suitable weather conditions during which measurements have been taken;
…
k) the level of rounding of each measurement recorded; and
l) the instrumentation used."

Each of the measurement uncertainty factors outlined above have been considered, and the good practice employed for reducing uncertainty is discussed in Table 13 below.

TABLE 13: MEASUREMENT UNCERTAINTY FACTORS

Measurement Uncertainty Factor Reference	Discussion
b)	Residual acoustic environment is relatively constant, hence no correction for a complex residual acoustic environment.
d)	Measuring at positions representative of the closest affected receptors to the site has enabled the determination of robust background sound levels.
g)	Measurement time intervals were set in accordance with BS4142:2014+A1:2019, hence no further correction needs to be made.
h)	Measurements were undertaken over a continuous 5-day period, including midweek and weekend periods.
i)	No periods of significant wind or precipitation were noted.
k)	Measured values were rounded to 0.1 dB, therefore rounding would not have had a significant impact on the overall typical background sound levels.
l)	The acoustic measurement equipment accorded with Type 1 specification of British Standard 61672, and were deployed with appropriate wind shields.

In this instance the uncertainty of the measurement is not expected to have any significance to the outcome of the assessment.

Calculation Uncertainty

BS4142:2014+A1:2019 states that calculation uncertainty depends on a number of factors, including the following, which are applicable to the Proposed Development:

" ...

- *b) uncertainty in the operation or sound emission characteristics of the specific sound source and any assumed sound power levels;*
- *c) uncertainty in the calculation method;*
- *d) simplifying the real situation to "fit" the model (user influence on modelling); and*
- *e) error in the calculation process."*

Each of the calculation uncertainty factors outlined above have been considered, and the good practice employed for reducing uncertainty is discussed in Table 14 below.

TABLE 14: CALCULATION UNCERTAINTY FACTORS

Calculation Uncertainty Factor Reference	Discussion
b)	Sound source levels are based on robust candidate plant data, to be achieved by the design.
c)	Calculations were undertaken in accordance with ISO 9613-2, which is considered a *"validated method"* by BS4142:2014+A1:2019.
d)	The real situation has not been simplified for the purposes of this assessment.
e)	ISO 9613-2 indicates that there is a ±3 dB accuracy to the prediction method, therefore, an uncertainty factor of ±1 dB is considered appropriate and proportional, given the separation distances involved.

In this instance the uncertainty of the calculation is not expected to have any significance to the outcome of the assessment.

It is also noted that because the assessment considers a worst-case scenario, such as downwind sound propagation (which in reality cannot happen at all NSRs at the same time) the relevance of the uncertainty is further reduced.

5.2.4. BS4142:2014+A1:2019 Assessment

The rating sound level, as calculated from the predicted specific sound level at the NSRs based on the maximum sound emission levels at source set out in Table 10, has been assessed in accordance with BS4142:2014+A1:2019, and can be seen in Table 15 and Table 16 for the daytime and night-time respectively.

TABLE 15: BS4142 ASSESSMENT – DAYTIME (08:00-20:00)

NSR	Specific Sound Level (dB)	Rating Penalty (dB)	Rating Sound Level (dB)	Daytime Background Sound Level (dB)	Excess of Rating over Background Sound Level (dB)
1	31	0	31	33	-2
2	22	0	22	36	-14
3	19	0	19	32	-13
4	20	0	20	32	-12
5	23	0	23	32	-10

TABLE 16: BS4142 ASSESSMENT – NIGHT-TIME (20:00-08:00)

NSR	Specific Sound Level (dB)	Rating Penalty (dB)	Rating Sound Level (dB)	Night-time Background Sound Level (dB)	Excess of Rating over Background Sound Level (dB)
1	31	0	31	31	0
2	22	0	22	30	-8
3	19	0	19	32	-13
4	20	0	20	32	-12
5	23	0	23	32	-9

It can be seen that the Proposed Development is predicted to have rating sound levels that do not exceed the prevailing background sound level at the nearest NSRs, which in BS4142:2014+A1:2019 terms represent a 'Low Impact', depending on the context, which is discussed overleaf.

The predicted levels are also comfortably below the 4dB above background set as a limit by South Lanarkshire Council's Environmental Health Officer during consultation.

5.2.5. Discussion on Context

The results set out in Table 15 and Table 16 identify that the operation of the scheme, as proposed, can occur without affecting the amenity of the closest residential receptors to the site, on the basis of a worst-case operational scenario.

BS4142:2014+A1:2019, however, recognises the importance of the context in which a sound occurs when assessing impacts.

It is noted that the assessment considers a worst-case scenario, with all batteries charging/discharging at the same time and downwind noise propagation to all receptors.

As such, the calculated noise levels from the Proposed Development are likely to be an overprediction based on a worst-case scenario which is unlikely to happen in reality for any prolonged period of time.

As part of the wider context and benefits of the proposed scheme, it is also important to note the role that these type of energy developments fulfil, in working towards achieving the targets set by the Climate Change Act 2019, with a date for net zero emissions of all greenhouse gases by 2045, as set in the updated Scotland's 2018-2032 Climate Change Plan set out by the Energy and Climate Change Directorate of the Scottish Government.

5.2.6. Noise Rating (NR) Assessment

A summary of the predicted external free-field sound levels at the closest NSRs, in full octave frequency bands, can be seen below in Table 17.

TABLE 17: PREDICTED OUTDOOR SOUND LEVEL SUMMARY – OCTAVE FREQUENCY BANDS

NSR	Octave Band Sound Pressure Level, Hz (dB)								dB(A)
	63	125	250	500	1k	2k	4k	8k	
1	32	30	33	29	27	20	<10	<10	31
2	27	24	28	19	14	<10	<10	<10	22
3	24	22	26	16	10	<10	<10	<10	19
4	24	23	27	15	8	<10	<10	<10	20
5	26	24	28	21	16	<10	<10	<10	23

For the calculation of the indoor ambient noise levels from the outdoor free-field levels predicted by the software, the sound level difference from outside-to-inside has been assumed to be 15 dB. The following frequency spectrum has been used for a partially open window, obtained by the statistically derived $D_{n,e}$ (dB) insulation ratings for window openings presented in Table 5-6 of the NANR116 report, and scaled to match the 15 dB broadband sound reduction.

TABLE 18: OUTSIDE-TO-INSIDE SOUND LEVEL DIFFERENCE – PARTIALLY OPEN WINDOW

Description	Octave Band Sound Level Difference, Hz (dB)								D_w
	63	125	250	500	1k	2k	4k	8k	
Partially Open Window	19	13	14	15	12	16	18	16	15

The resultant indoor noise levels within the nearest dwellings are presented below in Table 19.

TABLE 19: PREDICTED INDOOR SOUND LEVEL SUMMARY

NSR	Octave Band Sound Pressure Level, Hz (dB)								dB(A)	NR
	63	125	250	500	1k	2k	4k	8k		
1	13	17	19	14	15	<5	<5	<5	18	15
2	8	11	14	<5	<5	<5	<5	<5	8	2
3	5	9	12	<5	<5	<5	<5	<5	5	0
4	5	10	13	<5	<5	<5	<5	<5	6	1
5	7	11	14	6	<5	<5	<5	<5	9	4

It can be seen that the Proposed Development, with the proposed maximum plant noise specifications presented in Table 10, is predicted to meet the NR 15 recommended by the Council.

6. Cumulative Noise Assessment

This Cumulative Noise Impact Assessment considers noise impacts from other relevant existing and proposed noise-generating facilities in the vicinity of the Proposed Development.

The study area for the wider assessment of potential cumulative impacts was set at 5 km within the EIA Screening Report for the Proposed Development. Following a review of other relevant existing and proposed noise-generating facilities in the vicinity of the Proposed Development it is considered that only other developments within ca. 1.5 km of the outer edge of the Site have the potential to give rise to any significant cumulative noise effects. Therefore, the assessment of cumulative noise effects has been extended to a 1.5 km diameter area from the outer edge of the main body of the Application Site (refer to Figure 6). Due to sound reduction with distance, any development at further distance will have no impact on any of the NSRs potentially affected by noise from the Proposed Development.

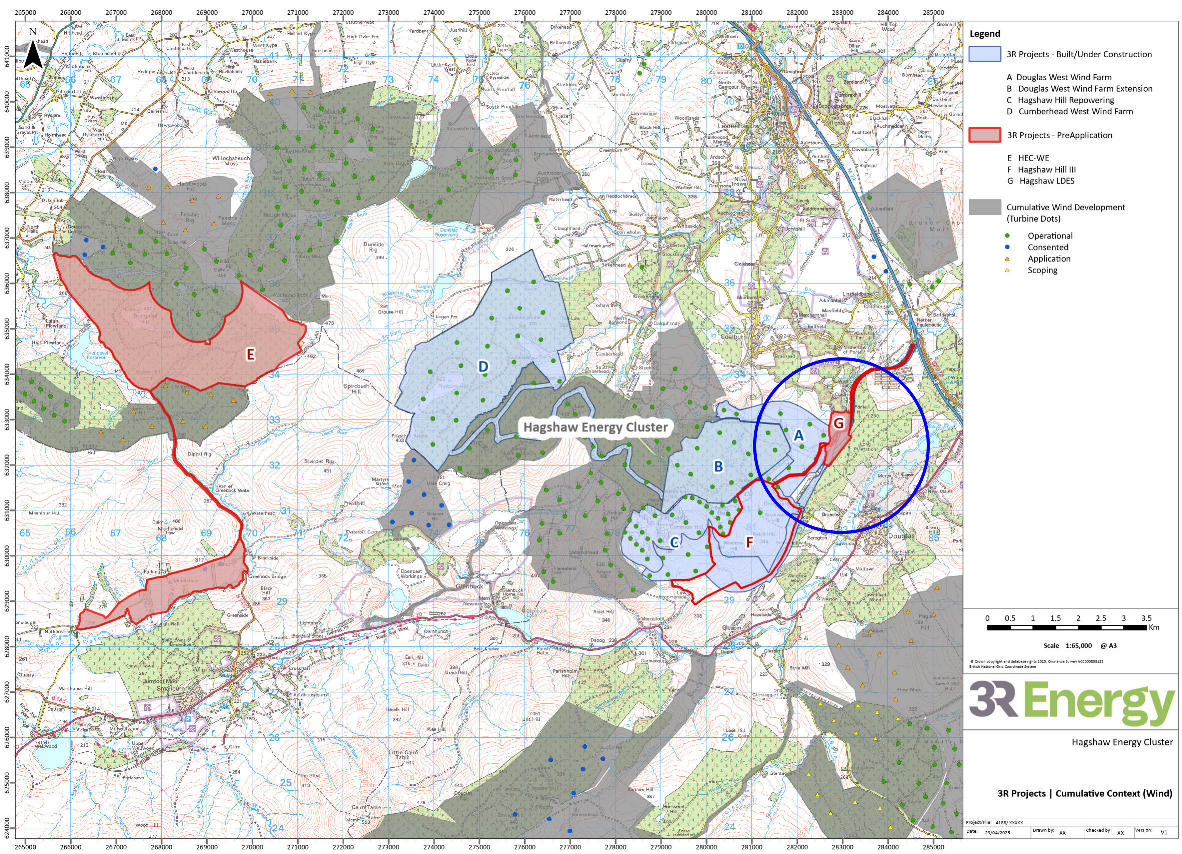
The following schemes shown in Table 20 have been identified for potential cumulative noise effects. A plan showing the wider cumulative context and the study area for this assessment is presented in Figure 6. It is noted that the Dewars Bonded Warehouse lies within the 1.5 km study area but it is understood that this facility is for whisky maturation only, and no processing or manufacturing takes place at this location, so it has therefore not been included within the assessment.

Table 20: Cumulative Scheme

Scheme & Capacity	Technology	Planning Reference	Status	Comments
[1] Douglas West. 45 MW	Wind	CL/15/0273 CL/17/0477	Operational	Wind turbines typically operate at wind speeds above 4-5m/s. The Proposed Development has been designed to not exceed the prevailing background sound levels when wind speeds are below 5m/s. At higher wind speeds, the background sound level will increase and therefore the sound from the Proposed Development will be further below the derived background sound levels. Noise limits for Wind Turbines, as set out in ETSU R97, are typically 5dB(A) above the background sound level, with value increasing with wind speed over a range of up to 12m/s. In low noise environments, ETSU R97 sets a fixed limit of 43 dB(A) As such, under conditions when the wind turbines have the potential to generate noise, the sound from the Development (predicted to not exceed 31 dBA as shown in Table 11) will be lower than the prevailing background sound level and much lower than the operational noise limit for the turbines. It can therefore be concluded that cumulative noise impacts from the Proposed Development and a wind turbine development are unlikely to generate an adverse effect on the nearest noise-sensitive receptors, due
[1] Douglas West Extension. 78 MW	Wind	P/19/0628	Under Construction	

Scheme & Capacity	Technology	Planning Reference	Status	Comments
				to the spatial distribution and nature of wind turbine schemes and differences in operational profile with the Proposed Development. As such, it is considered that any further assessment of wind turbine developments can be scoped out of the cumulative assessment with the LDES.
Erection of wood fuel drying facility on Land at The Former Dalquhandy Opencast Coal Site West Of Junction 11 Of M74 South Lanarkshire11 of M74	Wood Fuel	CL/16/0157	Approved	This development, understood to be currently in operation, is within the Proposed Development Site (not shown in Figure 6) and therefore has the potential to generate cumulative noise impacts. '*Dalquhandy Wood Fuel Drying Facility Updated Noise Impact Assessment*', by Energised Environments, version 2 dated 25th March 2016 has been considered for the cumulative noise impact assessment.

FIGURE 6: CUMULATIVE CONTEXT AND STUDY AREA (BLUE CIRCLE)



The predicted maximum specific sound levels from each scheme at mutual Noise-Sensitive Receptors and calculated cumulative sound levels are presented in Table 21.

Table 21: Predicted Specific Sound Levels (Free-Field Outdoor Sound Levels)

Proposed Development		Wood Fuel Facility (CL/16/0157)[1]		Cumulative Noise Level dB(A)
Receptors	Rating Sound Level, dB(A)	Equivalent Receptor in Noise Report	Rating Sound Level, dB(A)	
NSR1	31.4	R1	30.3	33.9
NSR2	22.2	R8	27.8	28.9
NSR4	19.6	R10	21.4	23.6

[1] *Taken from 'Dalquhandy Wood Fuel Drying Facility Updated Noise Impact Assessment', by Energised Environments, version 2 dated 25th March 2016*

Table 22 and Table 23 below present the BS 4142:2014+A1:2019 cumulative assessment at the assessed residential receptors.

Table 22: BS 4142:2014+A1:2019 Cumulative Assessment – Daytime

Receptor	Cumulative Sound Level, L_{ArTr} (dB)	Daytime Background Sound Level, $L_{A90,T}$ (dB)	Excess over Background Sound Level (dB)
NSR1	34	33	+1
NSR2	29	36	-7
NSR4	24	32	-8

Table 23: BS 4142:2014+A1:2019 Cumulative Assessment – Night-time

Receptor	Cumulative Sound Level, L_{ArTr} (dB)	Daytime Background Sound Level, $L_{A90,T}$ (dB)	Excess over Background Sound Level (dB)
NSR1	34	31	+3
NSR2	29	30	-1
NSR4	24	32	-8

It can be seen that the cumulative sound level is predicted to not exceed the prevailing background sound levels by more than 4 dB, which represents the limit set by the Council for the Proposed Development alone, which in BS 4142:2014+A1:2019 terms can be deemed a 'Low Cumulative Impact'.

As part of the context, it is noted that the cumulative assessment assumes a very worst-case scenario of all plant in both developments operating simultaneously and downwind direction to all NSRs.

Table 24 and Table 25 below also presents the effect of the cumulative schemes on the relative change in ambient noise levels at the assessed residential receptors, with reference to the TAN and IEMA guidelines outlined in Section 2.

TABLE 24: ASSESSMENT OF RELATIVE CHANGE IN SOUND LEVELS - DAYTIME

Receptor	Combined Cumulative Sound Level from All Sites	Current Ambient Sound Level $L_{Aeq,T}$	Predicted Future Ambient Sound Level	Change in Ambient Sound Level	Significance/ Magnitude of Impact
NSR1	33.9	43.4	43.9	0.5	Negligible
NSR2	28.9	43.1	43.3	0.2	Negligible
NSR4	23.6	40.5	40.6	0.1	Negligible

TABLE 25: ASSESSMENT OF RELATIVE CHANGE IN SOUND LEVELS – NIGHT-TIME

Receptor	Combined Cumulative Sound Level from All Sites	Current Ambient Sound Level $L_{Aeq,T}$	Predicted Future Ambient Sound Level	Change in Ambient Sound Level	Significance/ Magnitude of Impact
NSR1	33.9	42.3	42.9	0.6	Negligible
NSR2	28.9	39.5	39.9	0.4	Negligible
NSR4	23.6	38.1	38.3	0.2	Negligible

It is noted that, as a worst-case, a 'Negligible' change in ambient sound levels could be experienced at all NSRs.

7. Conclusion

inacoustic has been commissioned to assess the impact of sound arising from a proposed Long Duration Electricity Storage (LDES) facility on Land at Conexus West, Coalburn, Lanark, ML11 0RL.

This technical noise assessment has been produced to accompany a Section 36 Consent Application made to the Scottish Government Energy Consents Unit within the administrative boundary of South Lanarkshire Council and is based upon environmental noise measurements undertaken at the site and a subsequent 3-dimensional noise modelling exercise.

The assessment considers the potential noise generation from the plant associated with the Proposed Development, with respect to existing sound levels in the area, including mitigation measures presented in Section 5.1.4.

The assessment methodology contained in British Standard 4142: 2014+A1:2019 *Method for rating and assessing industrial and commercial sound* has been used in conjunction with supplementary acoustic guidance.

The assessment concludes that the Proposed Development will give rise to rating sound levels that do not exceed the measured background sound level in the area by more than 4 dB, and internal noise levels that do not exceed the NR15, and as such the Proposed Development is compliant with the requirements of South Lanarkshire Council's Environmental Health Department.

Since the Proposed Development also conforms to British Standard and National and Local Planning Policy requirements, it is concluded that noise should not be a considered constraint to the approval of this Planning Application, providing that the plant is constructed and operated in accordance with the acoustic assumptions and recommendations set out within this report.

8. Appendices

8.1. Appendix A – Definition of Terms

Sound Power	Sound Power is the total sound energy radiated by a sound source and measured in watts (W).
Sound Power Level	Sound Power Level (SWL or L_W) is the sound power relative to a standard reference power of 1pW, on a decibel scale. It is the amount of sound energy emitted by a source and it is independent of distance and environment.
Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level (Sound Level)	The Sound Pressure Level (SPL or L_p) is the sound pressure relative to a standard reference pressure of 20μPa (20×10^{-6} Pascals) on a decibel scale. It is the level of sound energy at a specific location and it is dependent of distance and environment.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s1 and s2 is given by 20 log10 (s1 / s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20μPa.
A-weighting, dB(A)	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Noise Level Indices	Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.
$L_{eq,T}$	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
$L_{max,T}$	A noise level index defined as the maximum noise level during the period T. L_{max} is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
$L_{90,T}$	A noise level index. The noise level exceeded for 90% of the time over the period T. L_{90} can be considered to be the "average minimum" noise level and is often used to describe the background noise.
$L_{10,T}$	A noise level index. The noise level exceeded for 10% of the time over the period T. L_{10} can be considered to be the "average maximum" noise level. Generally used to describe road traffic noise.
Free-Field	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5m
Facade	At a distance of 1m in front of a large sound reflecting object such as a building façade.
Fast Time Weighting	An averaging time used in sound level meters. Defined in BS 5969.

In order to assist the understanding of acoustic terminology and the relative change in noise, the following background information is provided.

The human ear can detect a very wide range of pressure fluctuations, which are perceived as sound. In order to express these fluctuations in a manageable way, a logarithmic scale called the decibel, or dB scale is used. The decibel scale typically ranges from 0 dB (the threshold of hearing) to over 120 dB. An indication of the range of sound levels commonly found in the environment is given in the following table.

TABLE 26: TYPICAL SOUND LEVELS FOUND IN THE ENVIRONMENT

Sound Level	Location
0dB(A)	Threshold of hearing
20 to 30dB(A)	Quiet bedroom at night
30 to 40dB(A)	Living room during the day
40 to 50dB(A)	Typical office
50 to 60dB(A)	Inside a car
60 to 70dB(A)	Typical high street
70 to 90dB(A)	Inside factory
100 to 110dB(A)	Burglar alarm at 1m away
110 to 130dB(A)	Jet aircraft on take off
140dB(A)	Threshold of Pain

The ear is less sensitive to some frequencies than to others. The A-weighting scale is used to approximate the frequency response of the ear. Levels weighted using this scale are commonly identified by the notation dB(A).

In accordance with logarithmic addition, combining two sources with equal noise levels would result in an increase of 3 dB(A) in the noise level from a single source.

A change of 3 dB(A) is generally regarded as the smallest change in broadband continuous noise which the human ear can detect (although in certain controlled circumstances a change of 1 dB(A) is just perceptible). Therefore, a 2 dB(A) increase would not be normally be perceptible. A 10 dB(A) increase in noise represents a subjective doubling of loudness.

A noise impact on a community is deemed to occur when a new noise is introduced that is out of character with the area, or when a significant increase above the pre-existing ambient noise level occurs.

For levels of noise that vary with time, it is necessary to employ a statistical index that allows for this variation. These statistical indices are expressed as the sound level that is exceeded for a percentage of the time period of interest. In the UK, traffic noise is measured as the L_{A10}, the noise level exceeded for 10% of the measurement period. The L_{A90} is the level exceeded for 90% of the time and has been adopted to represent the background noise level in the absence of discrete events. An alternative way of assessing the time varying noise levels is to use the equivalent continuous sound level, L_{Aeq}.

This is a notional steady level that would, over a given period of time, deliver the same sound energy as the actual fluctuating sound.

To put these quantities into context, where a receiver is predominantly affected by continuous flows of road traffic, a doubling or halving of the flows would result in a just perceptible change of 3 dB, while an increase of more than 25%, or a decrease of more than 20%, in traffic flows represent changes of 1 dB in traffic noise levels (assuming no alteration in the mix of traffic or flow speeds).

Note that the time constant and the period of the noise measurement should be specified. For example, BS 4142 specifies background noise measurement periods of 1 hour during the day and 15 minutes during the night. The noise levels are commonly symbolised as $L_{A90,1hour}$ dB and $L_{A90,15mins}$ dB. The noise measurement should be recorded using a 'FAST' time response equivalent to 0.125 ms.

8.2. Appendix B – Sound Measurement Results

FIGURE 7: MEASURED TIME HISTORY – MP1

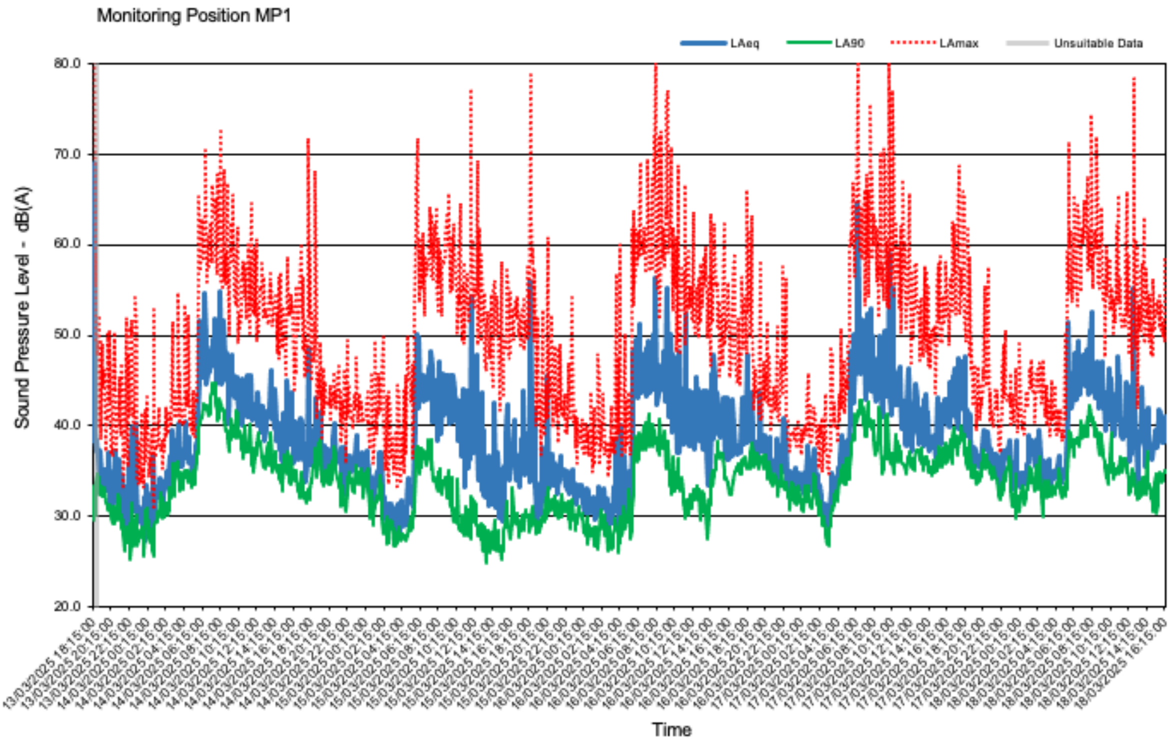


FIGURE 8: MEASURED TIME HISTORY – MP2

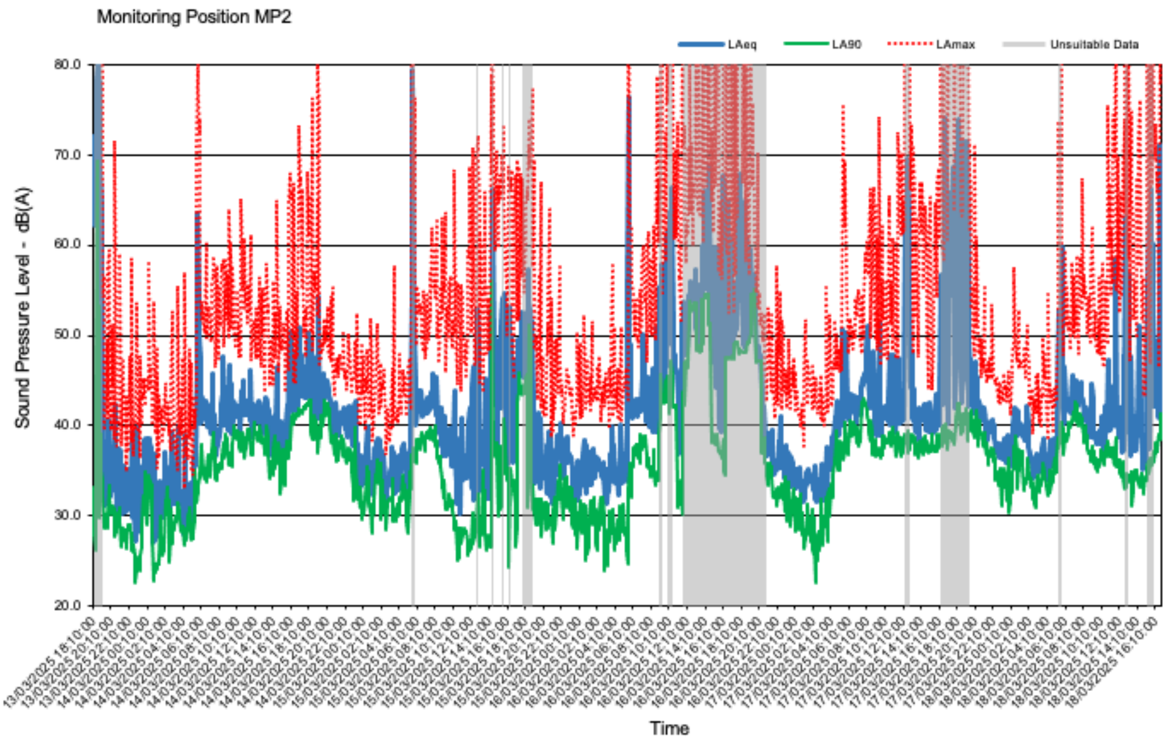
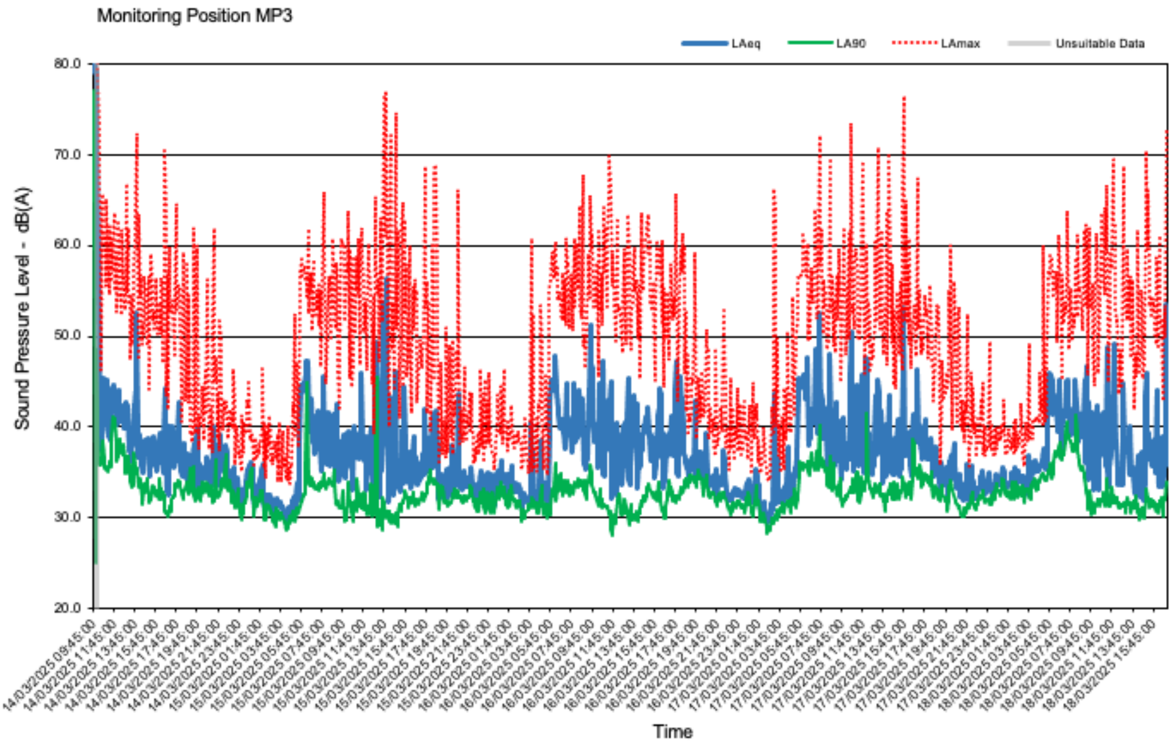


Figure 9: Measured Time History – MP3



8.3. Appendix C – Statistical Analysis

FIGURE 10: STATISTICAL ANALYSIS OF L_{A90} BACKGROUND – DAYTIME - MP1

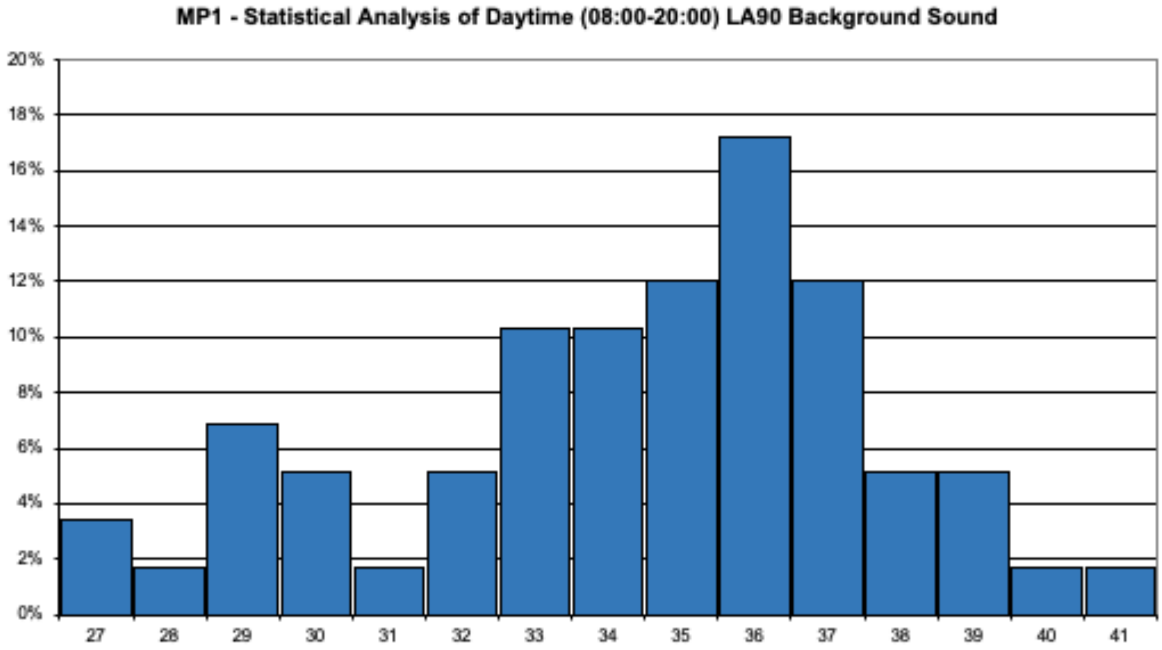


FIGURE 11: STATISTICAL ANALYSIS OF L_{A90} BACKGROUND – NIGHT-TIME – MP1

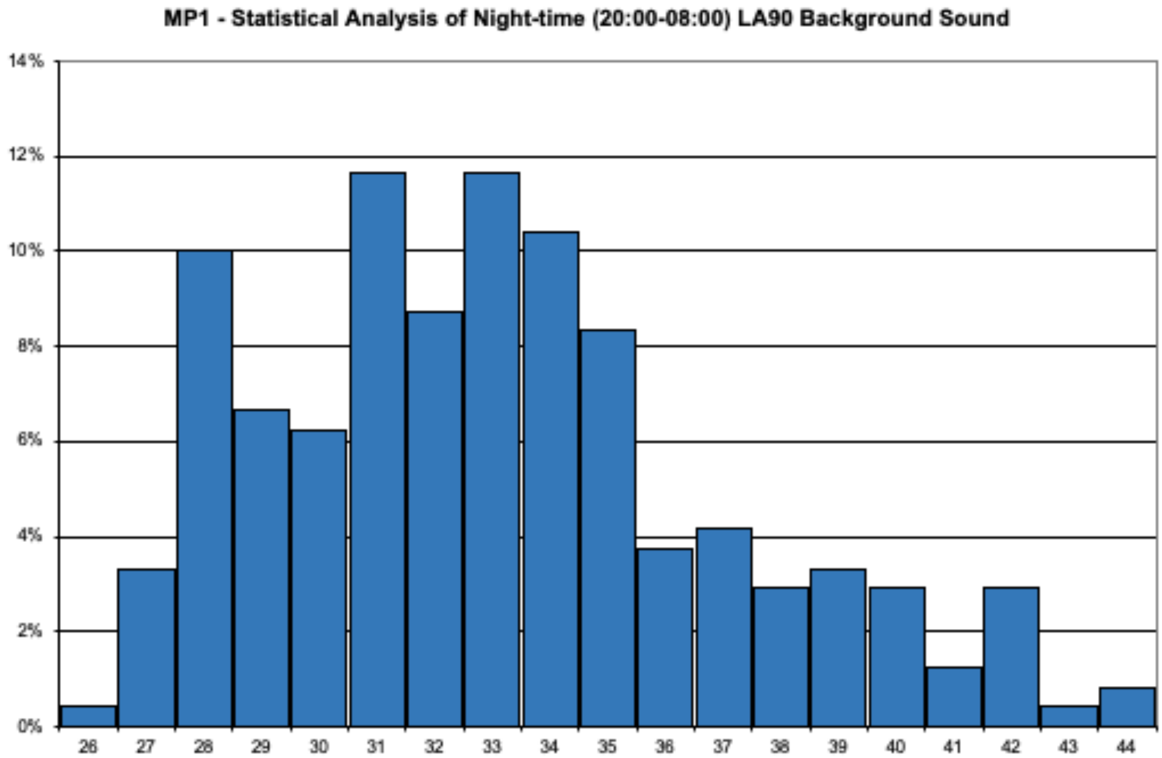


Figure 12: Statistical Analysis of L_{A90} Background – Daytime – MP2

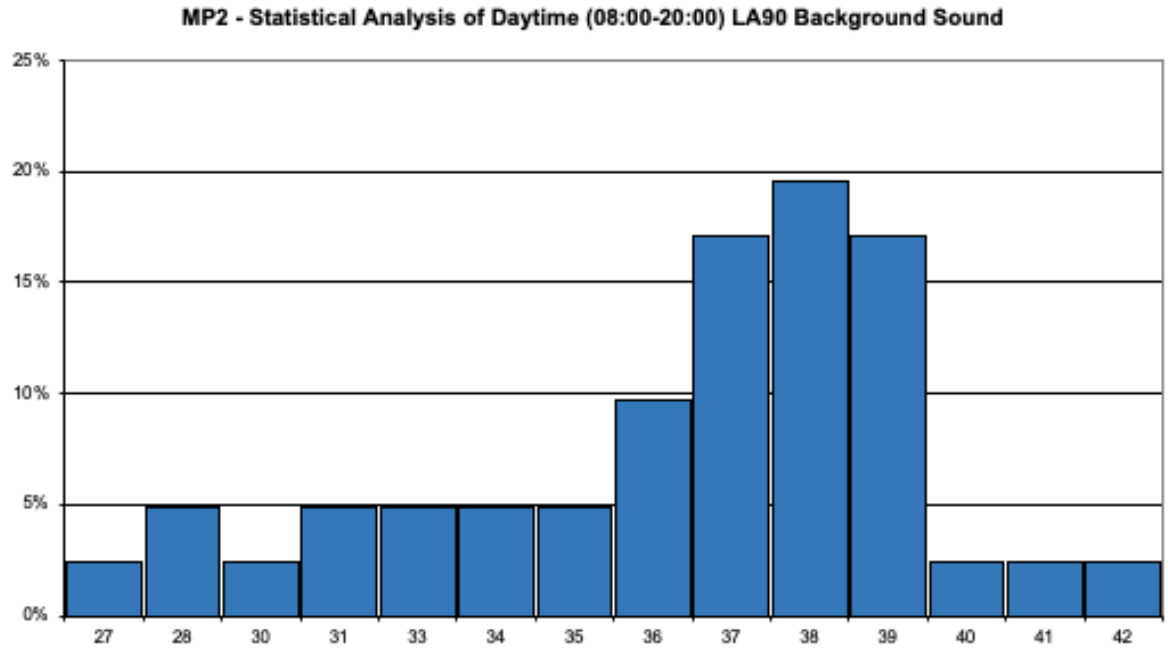


Figure 13: Statistical Analysis of L_{A90} Background – Night-Time – MP2

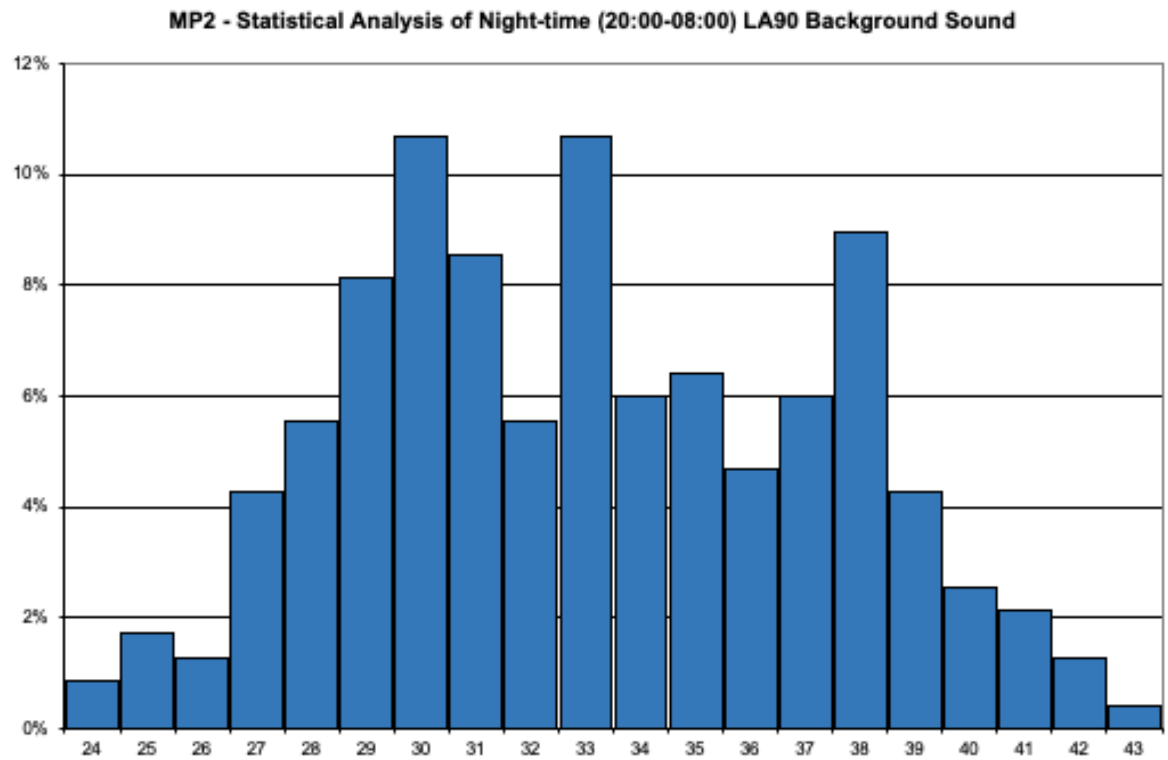


FIGURE 14: STATISTICAL ANALYSIS OF L_{A90} BACKGROUND – DAYTIME – MP3

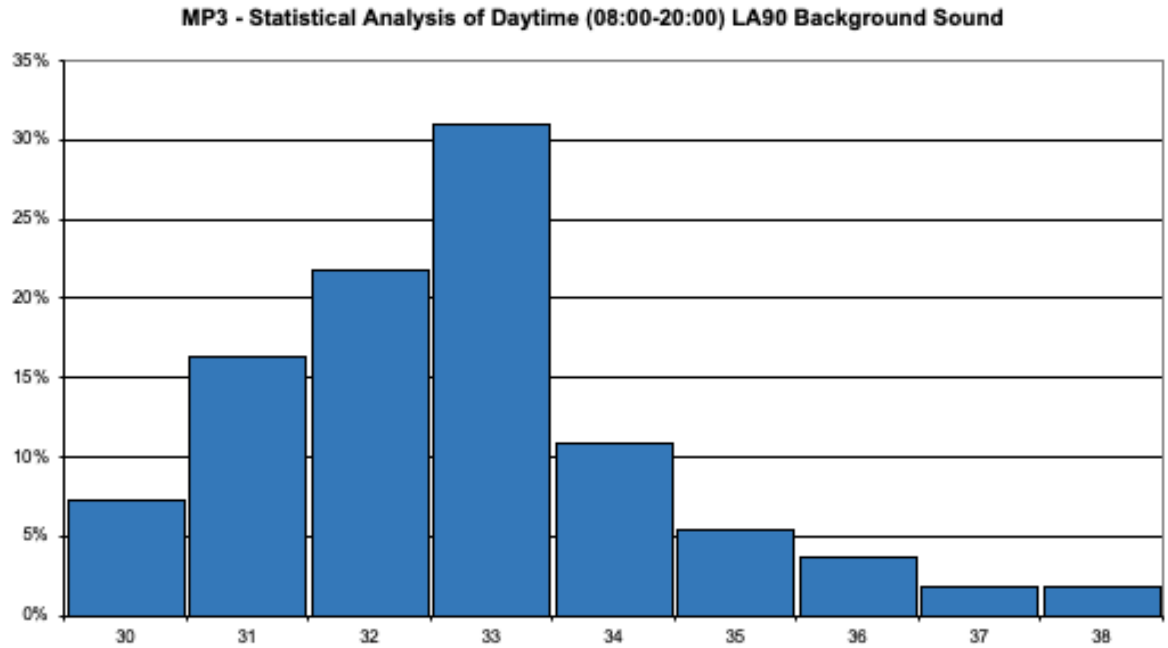


FIGURE 15: STATISTICAL ANALYSIS OF L_{A90} BACKGROUND – NIGHT-TIME – MP3