MWP

Chapter 12 Noise and Vibration

Brittas Wind Farm Project

Brittas Wind Farm Ltd

November 2024

MWP

Contents

Tables

Figures

Appendices

Project No.	Doc. No.	Rev.	Version	Date	Prepared By	Checked By	Approved By	Status
23318	6001	A	01	16/05/2024	Enfonic	MT	MT	DRAFT for Internal Review
23318	6001	A	02	06.06.2024	Enfonic	MT/Enfonic		DRAFT for Client Reviewed
23318	6001	A	03	19/07/2024	Enfonic	Enfonic/MT	EH	DRAFT for Legal Review
22156	6008	A	04	21/08/2024	Enfonic	Enfonic/MT	EH	DRAFT
22156	6008	A	04	21/08/2024	Enfonic	Enfonic/MT	MT/EH	ISSUE

MWP, Engineering and Environmental Consultants
Address: Reen Point, Blennerville, Tralee, Co. Kerry, V92 X2TK

www.mwp.ie

QUALITY
I.S. EN ISO 9001:2015
NSAI Certified

HEALTH & SAFETY
I.S. ISO 45001:2018
NSAI Certified

ENVIRONMENT
I.S. EN ISO 14001:2015
NSAI Certified

12. Noise and Vibration

12.1 Introduction

Enfonic have been commissioned by Malachy Walsh and Partners to conduct a noise impact assessment in relation to the proposed Brittas Wind Farm (the Proposed Project). This chapter of the Environmental Impact Assessment Report (EIAR) describes the assessment undertaken of the potential noise and vibration on the local residential amenity. The full development description is set out in Chapter 2 of the EIAR.

Noise and vibration impact assessments have been prepared for the construction, operational and decommissioning phases of the proposed project. To inform these assessments, baseline noise levels have been measured at several representative Noise Sensitive Locations (NSLs) and noise predictions to the NSLs within the study area have been prepared for both the construction and operational phases.

Other wind farm developments (operational, permitted or proposed) with the potential for cumulative impacts were identified and assessed as part of this assessment. The list of other wind farms considered are provided in Section 2.5 of the EIAR.

12.1.1 Statement of Authority

This assessment was prepared by the following staff of Enfonic Ltd.

Gary Duffy (Principal Consultant) is the managing director of Enfonic with over 25 years' experience as an acoustic engineer and consultant. He has extensive knowledge in the field of noise measurement, prediction, and impact assessment. He co-wrote the EPA's original guidance note on noise and represented the Institute of Acoustics (IOA) on the technical advisory committee of the Department of the Environment's revision of Part E (Sound Insulation) of the Building Regulations. He is a founder member of the Irish branch of the Institute of Acoustics and a sitting member of the current committee. He has considerable expertise in the assessment of wind turbine noise and conducted many similar impact assessments for EIARs.

David Courtney (Acoustic Consultant) graduated with a BEng. in Mechatronic Engineering from DCU in 2017 and qualified with IOA Diploma in Acoustics and Noise Control (2019) & Certificate in Environmental Noise Measurements (2017). He undertakes all types of noise and vibration surveys in relation to wind turbines planning and compliance, IPPC & IE compliance, BS4142, BS5228 and BS8233 assessments, traffic noise, construction, building acoustics and occupational assessments. He also manages our long-term monitoring sites and provides technical support to our hire services. He has considerable expertise in the assessment of wind turbine noise and conducted many similar impact assessments for EIARs

12.1.2 Fundamentals of Noise

The audible range of sounds can be expressed in terms of Sound Pressure Levels (SPL) and ranges from 0dB (for the threshold of hearing) to 140dB (for the threshold of pain). It should be noted that a doubling in sound energy (such as may be caused by a doubling of traffic flows) increases the SPL by 3dB.

The frequency of sound is the rate at which a sound wave oscillates and is expressed in Hertz (Hz). The sensitivity of the human ear to different frequencies in the audible range is not uniform. For example, hearing sensitivity is most sensitive to the frequency range of language (300Hz-3,000Hz) and decreases substantially as frequency falls.

It is necessary to adjust the measured noise level by an instrument to reflect the sensitivity response of human hearing and the 'A-weighting' system has been defined in the international standard, BS ISO 226:2003 Acoustics (BS ISO 226:2003 Acoustics, 2003) to do this. A SPL measured using 'A-weighting' is expressed in terms of dBA.

An indication of the level of some common sounds on the dBA scale is as follows:

Source.	Decibel Level (dBA)
Threshold of Hearing	0
Rustling Leaves	10
Whisper	20
Quiet Rural Setting	30
Quiet Living Room	40
Suburban Neighbourhood	50
Normal Conversation	60
Busy Street Traffic	70
Vacuum Cleaner	80
Heavy Truck	90
Jackhammer	100
Front Row of Rock Concert	110
Threshold of Pain	130
Military Jet Take-off	140

A glossary of acoustic terminology used in this report is provided in Appendix 12A.

12.2 Assessment Methodology and Significance Criteria

The assessment of impact effects has been undertaken in compliance with the applicable guidance relating to noise and vibration for the construction, operational and decommissioning phases of the proposed project , which are set out within the relevant sections of this chapter.

As set out in Chapter 02, Section 2.4.1 the developer has been granted flexibility to consider three different types of turbines. Each turbine type has different noise emissions and the impact effects of each are considered separately.

The methodology adopted for this noise impact assessment is summarised as follows:

- Review of applicable guidance to identify appropriate noise and vibration criteria for the construction, operational and decommissioning phases;
- Define the study area;
- Quantify the receiving environment through baseline noise surveys at representative Noise Sensitive Locations (NSLs) within the study area;
- Undertake predictive calculations to assess the potential effects associated with the construction and decommissioning phases of the proposed project;
- Undertake predictive calculations to assess the potential effects associated with the operational phase of the proposed project;
- Evaluate the potential noise and vibration effects;

- Specify mitigation measures to reduce, where necessary, the identified potential outward effects relating to noise and vibration from the proposed project; and
- Describe the significance of the residual noise and vibration effects associated with the proposed project.

12.2.1 Description of Effects

In addition to the appropriate impact assessment criteria that will be set out in this chapter, the significance of effects of the proposed project shall be described in accordance with the Environmental Protection Agency (EPA) document *Guidelines on the information to be contained in Environmental Impact Assessment Reports (EIAR), 2022* (EPA Guidelines).

The EPA Guidelines do not however quantify the impacts in decibel terms. In the absence of such information, reference is made to *Guidelines for Environmental Noise Impact Assessment (2014)* from the Institute of Environmental Management and Assessment (IEMA Guideline). The IEMA Guidelines state similar terminology to the EPA Guidelines and quantifies the effect categories in decibel terms for various receptor categories, with residential receptors having the greatest sensitivity to noise.

Table 12-1 presents the effect descriptions and their respective noise level change for residential receptor.

Table 12-1: Effects Description (EPA Guidelines and IEMA Guidelines) and noise level change criteria

EPA Significance of Effect	IEMA Guidelines	Noise Level Change (dB)
Imperceptible	None / Not significant	Less than 2.9
Not Significant		
Slight	Slight	3.0 - 4.9
Moderate	Moderate	
Significant	Substantial	5.0 - 9.9
Very Significant	Very Substantial	Greater than 10.0
Profound		

12.3 Applicable Guidance

12.3.1 Construction Phase

12.3.1.1 Noise

There is no published statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. Local authorities normally control construction activities by imposing limits on the hours of construction works and may consider noise limits at their discretion.

<u>BS 5228-1:2009+A1:2014</u>

In the absence of specific noise limits which may be set by the Local Authority, appropriate construction limits given in *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise* have been adopted in this assessment. This standard provides information on the prediction and measurements of noise from construction sites and operations such as mines and quarries. It also includes a large database of source noise levels for commonly used equipment and activities on construction sites.

The standard provides guidance on the 'threshold of significant effect' in respect of noise impact at dwellings. The method for determining threshold noise levels involves measuring existing ambient noise levels at noise sensitive locations and categorising them A, B or C accordingly, with the relevant threshold level derived from the category as set out in Table 12-2.

Table 12-2. BS 5228 - Example of significant effect at dwellings.

Assessment Category and Threshold Value Period.	Threshold values in Decibel Level (dB)		
	Category A [A)]	Category B [B)]	Category C [C)]
Night-time (23.00–07.00)	45	50	55
Evenings and weekends	55	60	65
Daytime (07.00–19.00) and Saturdays (07.00–13.00)	65	70	75
NOTE 1 A significant effect has been deemed to occur if the total L_{Aeq} noise level, including construction, exceeds the threshold level for the Category appropriate to the ambient noise level. *NOTE 2 If the ambient noise level exceeds the threshold values given in the table (i.e., the ambient noise level is higher than the above values), then a significant effect is deemed to occur if the total L_{Aeq} noise level for the period increases by more than 3 dB due to construction activity.* *NOTE 3 Applied to residential receptors only.*			
A)	Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.		
B)	Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as category A values.		
C)	Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values.		
D)	19.00–23.00 weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays.		
Periods may be amended to suit local conditions			

In general, the noise impact due to the construction phase will be from the specific items of plant used, the duration and phasing of the construction methods, the time of day that each plant will be used and their location.

For the appropriate period (e.g., daytime) the ambient noise level is determined and rounded to the nearest 5dB. At some properties, particularly those located close to busy roads, the ambient noise levels may be relatively high. However, given the rural nature of the site in general, reference has been made to the quietest properties near the proposed project which have ambient noise levels in the range of 45 to 55dB LAeq.T.

Therefore, for the purposes of this assessment, as a worst case, all properties will be afforded a Category A designation.

12.3.1.2 Vibration

The Transport Infrastructure Ireland (TII) (formally National Roads Authority) provides suitable criteria to prevent building damage from vibration in their *Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes (NRA, 2014)* as given in Table 12-3

Table 12-3: Summary of Applicable TII Vibration Criteria.

Allowable vibration (in terms of peak particle velocity) at the closest part of sensitive property to the source of vibration, at a frequency of		
<10Hz	10-50Hz	>50-100Hz
8mm/s	12.5mm/s	20mm/s

12.3.2 Operational Phase

Once operational, the wind turbines will emit an increasing level of noise as wind speed increases. The assessment of wind turbine noise emissions summarised in this chapter is in compliance with current guidance and best practice in relation to acceptable levels of noise from wind farms as contained in the document *Wind Energy Development Guidelines for Planning Authorities* published by the Department of the Environment, Heritage and Local Government in 2006 (WEDG-06).

These guidelines are in turn based on detailed recommendations set out in the UK's Department of Trade and Industry – (Energy Technology Support Unit (ETSU) publication *The Assessment and Rating of Noise from Wind Farms (1996)*. The ETSU document has been used to supplement the guidance contained within the "Wind Energy Development Guidelines" publication where necessary.

12.3.2.1 Wind Energy Development Guidelines (2006)

Section 5.6 of the *Wind Energy Development Guidelines for Planning Authorities* published by the Department of the Environment, Heritage and Local Government (2006) (WEDG-06) outlines the appropriate noise criteria in relation with wind farm developments. The following extract from it set outs the general aim of an impact assessment:

"An appropriate balance must be achieved between power generation and noise impact."

It should be noted that there is no specific advice given by WEDG-06 in relation to what constitutes an 'appropriate balance'..

Furthermore, a Noise Sensitive Location is defined as follows:

"In the case of wind energy development, a noise sensitive location includes any occupied house, hostel, health building or place of worship and may include areas of particular scenic quality or special recreational importance. Noise limits should apply only to those areas frequently used for relaxation of activities for which a quiet environment is highly desirable. Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."

As can be seen from the calculations presented later in this chapter, the various topics identified in this extract have been incorporated into this assessment. It should be noted that the noise limits are defined in terms of the $L_{A90,10min}$ parameter.

"*In general, a lower fixed limit of 45dB(A) or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours."*

This represents the commonly adopted daytime noise criterion in relation to wind farm developments. However, an important caveat should be noted as detailed in the following extract.

"However, in very quiet areas, the use of a margin of 5 dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments which should be recognised as having wider national and global benefits. Instead, in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of the LA90,10min of the wind energy development be limited to an absolute level within the range of 35-40 dB(A)."

In relation to night-time periods the following guidance is given:

"A fixed limit of 43 dB(A) will protect sleep inside properties during the night."

Note again this limit is defined in terms of the $L_{A90,10min}$ parameter. This represents the commonly adopted night-time noise criterion in relation to wind farm developments.

It is proposed to adopt a lower daytime threshold of 40 dB $L_{A90,10min}$ for low noise environments where the background noise is less than 30 dB $L_{A90,10min}$. It should be noted that the EPA document 'Guidance Note for Noise: License Applications, Surveys and assessments in Relation to Scheduled Activities' proposes a daytime noise criterion of 45 dB(A) in 'areas of low background noise'. The proposed lower threshold here is 5 dB more stringent than this level.

A summary of the operational noise limits set out in WEDG-06 is as follows:

- 35 to 40 dB for quiet daytime environments of less than 30dB;
- 45dB for daytime environments greater than 30dB or a maximum increase of 5dB above background noise (whichever is the higher); and
- 43dB for night-time periods or a maximum increase of 5dB above background noise (whichever is the higher).

It should be noted that while the caveat of an increase of 5dB above background for the night-time period is not explicit within the current guidance it is commonly applied in noise assessments prepared and is detailed in numerous examples of planning conditions issued by local authorities and An Bord Pleanála.

12.3.2.2 ETSU-R-97 - The Assessment and Rating of Wind Farm Noise (1997)

The core of the noise guidance contained within the Wind Energy Development Guidelines (2006) document is based on the ETSU publication *The Assessment and Rating of Noise from Wind Farms (ETSU-R-97)*.

ETSU-R-97 calls for the control of wind turbine noise by the application of noise limits at the nearest noise sensitive properties. It is considered that absolute noise levels applied at all wind speeds are not suited to wind turbine developments and therefore best practice is to adopt noise limits relative to background noise levels in the vicinity of the noise sensitive locations. A critical aspect of the noise assessment of wind energy proposals relates to the identification of baseline noise levels through on-site noise surveys.

12.3.2.3 Institute of Acoustics Good Practice Guide

The ETSU-R-7 concepts underwent standardisation and modernisation in 2013 with the Institute of Acoustics publication of the *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (GPG) and six accompanying *Supplementary Guidance Notes*. Numerous improvements in the accuracy and robustness are described, in particular the treatment of wind shear and the general adaptation to larger wind turbines.

This publication which was issued by the Institute of Acoustics in May 2013, is endorsed by the UK, Department of Energy and Climate Change (DECC), the Northern Ireland Executive, the Scottish Executive and the Welsh Assembly and provides guidance on all aspects of the use of ETSU-R-97.

The assessment presented herein adopts the methodology for the background noise surveys, operational noise impact assessment and other recommendations of the GPG.

The guidance and notes are considered to represent best practice and have been adopted for this assessment.

<u>Period definitions</u>

Period definitions adopted from the IoA GPG are as follows:

Daytime Amenity hours are:

- All evening from 18:00 to 23:00hrs;
- Saturday Afternoons from 13:00 to 18:00 hrs, and;
- All day Sunday from 07:00 to 18:00hrs.

Night-time hours are 23:00 to 07:00hrs.

<u>Financially Involved</u>

ETSU-R-97 considers it appropriate to allow a higher level of incident noise associated with turbine operation for properties with occupants that have an interest in the development, both as a higher fixed level (45 dB) and/or a higher level above the prevailing background noise level. It is considered that the occupants of a financially involved property should be direct beneficiaries to allow an increase to the fixed limit noise levels.

This set of criteria has been chosen as it is in line with relevant Irish guidance.

12.3.2.4 Draft Wind Energy Guidelines 2019

In December 2019, the Draft Revised Wind Energy Development Guidelines December 2019 (DRWEDG19) were published for consultation. During the public consultation process considerable concerns in relation to the proposals were expressed by various parties including members of the Institute of Acoustics and various experts in the field of wind turbines noise assessments.

It is acknowledged that this document remains the subject of detailed consultation with interested parties and stakeholders. At the time of writing this chapter, the document is still in draft format, therefore, in line with best practice, the assessment presented in this report is based on the guidance currently outlined in Section 5.6 of the *Wind Energy Development Guidelines for Planning Authorities 2006.*

The original ETSU-R-97 concepts on which both the WEDG06 and DRWEDG19 are based upon, underwent a thorough standardisation and modernisation in 2013 with the Institute of Acoustics publication of the *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* including 6no. *Supplementary Guidance Notes*, all of which bring together the combined experience of acoustic consultants in the UK and Ireland in the application of these methods. Numerous improvements in the accuracy and robustness are described, in particular the treatment of wind shear and the general adaptation to larger wind turbines. The assessment in the EIAR is therefore in full accordance with the latest best-practice methods.

12.3.2.5 Local Planning Guidance

Tipperary County's Development Plan (Section 5.6 Settlement Pattern and Population Densities) states the following in relation to wind farm developments:

"In relation to individual houses and smaller settlements, impacts on residential amenity, such as noise and shadow flicker, will be considered on a case-by-case basis in accordance with the development control standards of the County Development Plan (as varied) and the Wind Energy Guidelines."

It goes on to state the following relevant sections in relation to wind turbine noise:

"Proposals must also demonstrate that the residential amenity will not be impacted by virtue of noise and all applications should be accompanied by a Noise Impact Statement of noise sensitive locations such as occupied dwellings. The Department of the Environment's most up to date Guidelines on Wind Energy shall be adhered to with regard to shadow flicker and noise issues."

12.3.2.6 World Health Organization (WHO) Noise Guidelines for the European Union

The WHO Environmental Noise Guidelines for the European Region (2018) provides health-based recommendations based on average environmental noise exposure of several sources of environmental noise, including wind turbine noise.

However, the quality of evidence used for the WHO research is identified as being 'Low' in relation to wind turbine noise and the document states the following:

"..it may be concluded that the acoustical description of wind turbine noise by means of Lden or Lnight may be a poor characterization of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes…

…Further work is required to assess fully the benefits and harms of exposure to environmental noise from wind turbines and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of wind turbines outweigh the impact on the development of renewable energy policies in the WHO European Region."

The recommendations are therefore conditional and should not currently be applied as target noise criteria for existing or proposed wind turbine development in Ireland.

12.3.2.7 Special Audible Characteristics

Tonal Noise

Tonal noise has been described as containing a discrete frequency component, most often of a mechanical origin. Examples can include the hum from an electrical transformer located at the base of a wind turbine, which can exhibit low frequency tones, the dial tone on a phone, a mid-frequency tone, and whistling which tends to comprise higher frequency tones.

Tonal noise may also be caused by wind turbine components (e.g. meshing gears) or non-aerodynamic instabilities interacting with a rotor blade surface or unstable flows over holes or slits on the turbine nacelle. Improvements in gearbox design and the use of anti-vibration techniques have resulted in significant reductions in mechanical sound generation. The most recent direct drive machines have no high-speed mechanical components and therefore mechanical noise levels are generally reduced.

Mechanical noise in the nacelle can be attenuated by conventional noise control methods. These include measures to reduce vibration forces in moving parts, such as improved acoustic and vibration isolation around rotating equipment, as well as improved sound insulation design of nacelle and machinery housings.

It should be noted that tonal noise is associated with wind turbine operation, and it is not possible to predict an occurrence of tonality at the planning stage. It should also be noted that it is a rare event associated with a limited number of wind farms. While it can occur, it is the exception rather than the rule. For the purposes of noise impact assessments, it is therefore assumed not to be relevant.

Amplitude Modulation

Amplitude modulation (AM) is defined in the IOA Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) document A Method for Rating Amplitude Modulation in Wind Turbine (IOA, 2016) as:

"Periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency (BPF) of the turbine rotor(s)."

It is now generally accepted that there are two mechanisms which can cause amplitude modulation:

- 'Normal' AM, and;
- 'Other' AM (sometimes referred to 'Excessive' AM).

In both cases, the result is a regular fluctuation in amplitude at the Blade Passing Frequency (BPF) of the wind turbine blades (the rate at which the blades of the turbine pass a fixed point). For a three-bladed turbine rotating at 20 rpm, this equates to a modulation frequency of 1Hz.

<u>'Normal' AM</u>

An observer at ground level close to a wind turbine will experience 'blade swish' because of the directional characteristics of the noise radiated from the trailing edge of the blades as it rotates towards and then away from the observer.

This effect is reduced for an observer on or close to the turbine axis, and therefore would not generally be expected to be significant at typical separation distances, at least on relatively level sites.

The Renewable UK AM project (Renewable UK, 2013) has coined the term 'normal' AM (NAM) for this inherent characteristic of wind turbine noise, which has long been recognised and was discussed in ETSU-R-97 in 1996.

<u>'Other' AM</u>

In some cases, AM is observed at large distances from a wind turbine (or turbines). The sound is generally heard as a periodic 'thumping' or 'whoomphing' at relatively low frequencies.

On sites where it has been reported, occurrences appear to be occasional, although they can persist for several hours under some conditions, dependent on atmospheric factors, including wind speed and direction.

It was proposed in the Renewable UK 2013 study that the fundamental cause of this type of AM is transient stall conditions occurring as the blades rotate, giving rise to the periodic thumping at the blade passing frequency.

Transient stall represents a fundamentally different mechanism from blade swish and can be heard at relatively large distances, primarily downwind of the rotor blade. The Renewable UK AM project report adopted the term 'Other AM' (OAM) for this characteristic. The terms 'enhanced' or 'excess' AM (EAM) have been used by others, although such definitions do not distinguish between the source mechanisms and presuppose a 'normal' level of AM, presumably relating back to blade swish as described in ETSU-R-97.

Prediction of AM

It should be noted that AM is associated with wind turbine operation, and it is not possible to predict an occurrence of AM at the planning stage. It should also be noted that it is a rare event associated with a limited number of wind farms. While it can occur, it is the exception rather than the rule.

Renewable UK Research Document states the following in relation to the matter:

"Even on those limited sites where it has been reported, its frequency of occurrence appears to be at best infrequent and intermittent."

"It has also been the experience of the project team that, even at those wind farm sites where AM has been reported or identified to be an issue, its occurrence may be relatively infrequent. Thus, the capture of time periods when subjectively significant AM occurs may involve elapsed periods of several weeks or even months."

"There is nothing at the planning stage that can presently be used to indicate a positive likelihood of OAM occurring at any given proposed wind farm site, based either on the site's general characteristics or on the known characteristics of the wind turbines to be installed."

Assessment of AM

Research and Guidance in the area is ongoing with publications being issued by the Institute of Acoustics (IoA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, A Method for Rating Amplitude Modulation in Wind Turbine Noise (August 2016). The document proposes an objective method for measuring and rating AM. The AMWG does not propose what level of AM is likely to result in adverse community response.

The AMWG does not propose any limits for AM. The purpose of the group is simply to use existing research to develop a Reference Methodology for the measurement and rating of amplitude modulation. The definition of any limits of acceptability for AM, or consideration of how such limits might be incorporated into a wind farm planning condition, is outside the scope of the AMWG's work and is currently the subject of a separate UK Government funded study. For the purposes noise impact assessments, it is therefore assumed not be relevant.

Infrasound and Low Frequency Noise

Low Frequency Noise is noise that is dominated by frequency components less than approximately 200Hz whereas Infrasound is typically described as sound at frequencies below 20Hz. In relation to Infrasound, the following extract from the EPA document Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3) is noted here:

"There is similarly no significant infrasound from wind turbines. Infrasound is high level sound at frequencies below 20Hz. This was a prominent feature of passive yaw "downwind" turbines where the blades were positioned downwind of the tower which resulted in a characteristic "thump" as each blade passed through the wake caused by the turbine tower. With modern active yaw turbines (i.e., the blades are upwind of the tower and the turbine is turned to face into the wind by a wind direction sensor on the nacelle activating a yaw motor) this is no longer a significant feature."

With respect to infrasonic noise levels below the hearing threshold, the World Health Organisation (WHO) document Community Noise (WHO, 1995) has stated that:

"There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects."

In 2010, the UK Health Protection Agency published a report entitled Health Effects of Exposure to Ultrasound and Infrasound, Report of the independent Advisory Group on Non-ionising Radiation. The exposures considered in the report related to medical applications and general environmental exposure. The report notes:

"Infrasound is widespread in modern society, being generated by cars, trains and aircraft, and by industrial machinery, pumps, compressors and low speed fans. Under these circumstances, infrasound is usually accompanied by the generation of audible, low frequency noise. Natural sources of infrasound include thunderstorms and fluctuations in atmospheric pressure, wind and waves, and volcanoes; running and swimming also generate changes in air pressure at infrasonic frequencies.

For infrasound, aural pain and damage can occur at exposures above about 140 dB, the threshold depending on the frequency. The best-established responses occur following acute exposures at intensities great enough to be heard and may possibly lead to a decrease in wakefulness. The available evidence is inadequate to draw firm conclusions about potential health effects associated with exposure at the levels normally experienced in the environment, especially the effects of long-term exposures. The available data do not suggest that exposure to infrasound below the hearing threshold levels is capable of causing adverse effects."

The UK Institute of Acoustics Bulletin in March 2009 included a statement of agreement between acoustic consultants regularly employed on behalf of wind farm developers, and conversely acoustic consultants regularly employed on behalf of community groups campaigning against wind farm developments (IAO JS2009). The intent of the article was to promote consistent assessment practices, and to assist in restricting wind farm noise disputes to legitimate matters of concern. On the subject of infrasound, the article notes:

"Infrasound is the term generally used to describe sound at frequencies below 20Hz. At separation distances from wind turbines which are typical of residential locations the levels of infrasound from wind turbines are well below the human perception level. Infrasound from wind turbines is often at levels below that of the noise generated by wind around buildings and other obstacles.

Sounds at frequencies from about 20Hz to 200Hz are conventionally referred to as low frequency sounds. A report for the DTI in 2006 by Hayes McKenzie concluded that neither infrasound nor low frequency noise was a significant factor at the separation distances at which people lived. This was confirmed by a peer review by a number of consultants working in this field. We concur with this view."

The article concludes that:

"from examination of reports of the studies referred to above, and other reports widely available on internet sites, we conclude that there is no robust evidence that low frequency noise (including 'infrasound') or ground - borne vibration from wind farms, generally has adverse effects on wind farm neighbours".

A report released in January 2013 by the South Australian Environment Protection Authority namely, Infrasound levels near windfarms and in other environments (EPA, 2013) found that the level of infrasound from wind turbines is insignificant and no different to any other source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

The study included several houses in rural and urban areas, both adjacent to and away from a wind farm, and measured the levels of infrasound with the wind farms operating and switched off.

There were no noticeable differences in the levels of infrasound under all these different conditions. In fact, the lowest levels of infrasound were recorded at one of the houses closest to a wind farm, whereas the highest levels were found in an urban office building.

The EPA's study concluded that the level of infrasound at houses near wind turbines was no greater than in other urban and rural environments, and stated that:

"The contribution of wind turbines to the measured infrasound levels is insignificant in comparison with the background level of infrasound in the environment."

A German report, titled "low frequency noise incl. infrasound from wind turbines and other sources" presents the details of a measurement project from 2013. The report was published by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016 and concluded the following in relation to infrasound from wind turbines:

"The measured infrasound levels (G levels) at a distance of approx. 150 m from the turbine were between 55 and 80 dB(G) with the turbine running. With the turbine switched off, they were between 50 and 75 dB(G). At distances of 650 to 700 m, the G levels were between 55 and 75 dB(G) with the turbine switched on as well as off."

"For the measurements carried out even at close range, the infrasound levels in the vicinity of wind turbines – at distances between 150 and 300 m – were well below the threshold of what humans can perceive in accordance with DIN 45680 (2013 Draft)"

"The results of this measurement project comply with the results of similar investigations on a national and international level."

Assessment of Operational Special Characteristics

A summary of appropriate guidance for the assessment of special acoustic characteristics is as follows:

Infrasound and Low Frequency

University of Salford Proposed Criteria for the Assessment of Low Frequency Noise Disturbance, Revision 1

Amplitude Modulation

IOA Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group Final Report, A Method for Rating Amplitude Modulation in Wind Turbine Noise

Tonal

ISO/PAS 20065:2016 Acoustics — Objective method for assessing the audibility of tones in noise — Engineering method.

Should a complaint arise once a development is operational, these characteristics can be assessed using the relative techniques and, if necessary, appropriate mitigations applied.

12.3.2.8 ISO 9613-2:1996

Sound power emission level of wind turbines are provided by manufacturers at source. Noise levels must then be predicted to distant locations such as NSLs and *ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation (1996)* provides guidance on the necessary calculations This standard considers noise attenuation provided by distance, ground absorption, directivity, atmospheric absorption and other relevant factors.

Noise predictions to specific locations are prepared for various wind speeds and the predicted levels compared against the relevant noise criteria to demonstrate compliance.

Typically proprietary software is used to perform calculations to *ISO 1913-2:1996*, provide result data and graphical images.

12.3.2.9 BS 4142:2014

BS 4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound described a method for assessing the impact of a proposed or existing industrial or commercial sound source. This guidance is appropriate for the assessment of non-turbine related noise sources including the Substation and Battery Energy Storage System.

The standard introduces the concept of a Rating Level (L_{Ar}) which considers particular noise characteristics which are likely to increase the likelihood of an adverse impact. These characteristics include tonal component to the noise which may make it more distinguishable and noise of an impulsive nature. Where applicable, penalties may be added to the measured or predicted Specific Noise Level (L_{Aeq}) to account for these.

The Rating Level (L_{Ar}) is compared to the typical Background Level (L_{A90}), measured in the absence of the noise under assessment, to determine the likelihood of an adverse impact.

The ‘context’ of the development and its environs e.g., time of day, nature of the neighbourhood, local attitudes to the development, etc ought also to be considered. There is also a degree of uncertainty applicable to the results e.g., for weather, instrumentation, measurement duration, calculation errors etc which ought to be considered.

12.3.2.10 Vibration

Ground borne vibration waves are attenuated rapidly as they propagate from a source through the substrate. Wind turbines do not generate sufficiently high levels of vibration to be perceptible at any distance beyond the turbine foundations.

Typically, at a distance of 100m from a 1MW turbine unit the level of vibration associated with a turbine is the order of 10-5 mm/s.

As a result little research had been conducted on the subject however a report published by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg, Germany in 2016, *Low frequency noise incl. infrasound from wind turbines and other sources* conducted a vibration study for an operational Nordex N117 – 2.4 MW wind turbine. The report confirmed that at distances of less than 300m from the turbine vibration levels had dropped so far that they could no longer be differentiated from the background vibration levels.

Appropriate vibration criteria for the operational phase is set out in Section 12.3.1.2.

12.3.2.11 Additional Vehicular Activities on Public Roads

Some additional traffic is associated with the operational phase of the proposed project and it is appropriate to assess the effect by calculating the increase in traffic noise levels that will arise because of vehicular movements on the existing public road network.

The corresponding change in traffic noise level is the most appropriate assessment methodology. The IEMA Guidelines set out in Section 12.2.1 consider a change in traffic noise levels of 3 to 4.9 dBA would be noticeable, in excess of 5dBA would be clearly noticeable, and depending on the final noise level, the impact may be moderate or significant. A change is noise level of less that 3dB would be imperceptible;

Furthermore, the UK Design Manual for Roads and Bridges (DMRB, Volume 11, Section 3, Part 7) states that a change in noise level of 1dB $L_{A10,18h}$ is equivalent to a 25% increase or a 20% decrease in traffic flow, assuming other factors remain unchanged and a change in noise level of 3dB $L_{A10,18h}$ is equivalent to a 100% increase or a 50% decrease in traffic flow.

12.3.3 Decommissioning Phase

During the decommissioning phase of the proposed project, there will be some effect on nearby noise sensitive properties due to noise emissions from site traffic and other on-site activities. Similar overall noise levels as those calculated for the construction phase would be expected, as similar tools and equipment will be used. The noise and vibration impacts associated with any decommissioning of the site are considered to be comparable to those outlined in relation to the construction of the proposed project.

12.4 Health Effects of Wind Farms

This section of this noise assessment reviews the literature and findings on the potential health effects of noise from wind farms.

12.4.1 Health Service Executive (HSE) Public Health Medicine Environment and Health Group

In Ireland the HSE Public Health Medicine Environment and Health Group drafted a position paper in 2017 titled Position Paper on Wind Turbines and Public Health. The group identified that there is no published scientific evidence to support adverse effects of wind turbines on health and concluded that:

"Published scientific evidence is inconsistent and does not support adverse effects of wind turbines on health. However, adequate setback distances and meaningful engagement with local communities are recommended in order to address public concern."

12.4.2 The National Health & Medical Research Council

The relevant Australian authority on health issues, the National Health and Medical Research Council (NHMRC), conducted a comprehensive independent assessment of the scientific evidence on wind farms and human health. The findings are contained in the NHMRC Information Paper: Evidence on Wind Farms and Human Health 2015, which concluded:

"After careful consideration and deliberation, NHMRC concluded that there is no consistent evidence that wind farms cause adverse health effects in humans. This finding reflects the results and limitations of the direct evidence and also takes into account the relevant available parallel evidence on whether or not similar noise exposure from sources other than wind farms causes health effects".

12.4.3 Health Canada

Health Canada, Canada's national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014 (Health Canada 2014, Wind Turbine Noise and Health Study: Summary of Results.). The study was initiated in 2012 specifically to gather new data on wind farms and health. The study considered physical health measures that assessed stress levels using hair cortisol, blood pressure and resting heart rate, as well as measures of sleep quality. More than 4,000 hours of wind turbine noise measurements were collected and a total of 1,238 households participated.

No evidence was found to support a link between exposure to wind turbine noise and any of the self-reported illnesses. Additionally, the study's results did not support a link between wind turbine noise and stress, or sleep quality (self-reported or measured). However, an association was found between increased levels of wind turbine noise and individuals reporting of being annoyed

12.4.4 New South Wales Health Department

In 2012, the New South Wales (NSW) Health Department provided written advice to the NSW Government that stated existing studies on wind farms and health issues had been examined and no known causal link could be established.

NSW Health officials stated that fears that wind turbines make people sick are 'not scientifically valid'. The officials wrote that there was no evidence for 'wind turbine syndrome', a collection of ailments including sleeplessness, headaches and high blood pressure that some people believe are caused by the noise of spinning blades.

12.4.5 The Australian Medical Association

The Australian Medical Association put out a position statement, *Wind Farms and Health 2014* (Australian Medical Association, 2014, Wind farms and health). The statement said:

"The available Australian and international evidence does not support the view that the infrasound or low frequency sound generated by wind farms, as they are currently regulated in Australia, causes adverse health effects on populations residing in their vicinity. The infrasound and low frequency sound generated by modern wind farms in Australia is well below the level where known health effects occur, and there is no accepted physiological mechanism where sub-audible infrasound could cause health effects."

12.4.6 Journal of Occupational and Environmental Medicine

The review titled, Wind Turbines and Health: A Critical Review of the Scientific Literature was published in the Journal of Occupational and Environmental Medicine, 2014. An independent review of the literature was undertaken by the Department of Biological Engineering of the Massachusetts Institute of Technology (MIT). The review took into consideration health effects such as stress, annoyance and sleep disturbance, as well as other effects that have been raised in association with living close to wind turbines.

The study found that:

"No clear or consistent association is seen between noise from wind turbines and any reported disease or other indicator of harm to human health."

The report concluded that living near wind farms does not result in the worsening of the quality of life in that particular region.

12.4.7 Summary

The peer reviewed research outlined in the preceding sections supports that there are no negative health effects on people with long term exposure to wind turbine noise. Please refer to Chapter 5 of the EIAR for further details of potential health effects associated with the Proposed Development.

12.5 Baseline Noise Survey of Receiving Environment

A noise survey programme is used to quantify the existing baseline conditions. Analysis of the measured data is used for two purposes:

1. The minimum wind-speed dependant L_{A90} values are used to derive the operational noise limits for the wind turbines, and;

2. The average ambient daytime L_{Aeq} noise levels are used to derive the construction noise limits and for the purposes of describing the EPA effects.

12.5.1 Study Area

The study area is defined in the IoA GPG as:

"The study area should cover at least the area predicted to exceed 35dB L_{A90} up to 10m/s wind speed from all existing and proposed turbines."

An initial noise propagation model at the rated wind speed of the turbines was used to identify the NSLs within the study area. A map showing the 35dB contour and NSLs is provided in Figure 12-1.

A list of the coordinate of the NSLs is provided in Appendix 12C.

12.5.2 Baseline Noise Survey

As required by *ETSU-R-97* a noise monitoring programme is required to establish the background noise levels across a range of wind speeds in the receiving environment.

Several Noise Monitoring Locations (NMLs) were identified as being suitable to represent the ambient noise conditions within the study area and noise monitoring was conducted at the locations shown in Figure 12-2 and detailed in Table 12-4

Figure 12-1: Map with initial 35dB Noise Contour and Noise Sensitive Locations

Figure 12-2. Noise Monitoring Locations.

Table 12-4. NMTs coordinates and descriptions.

Location	Subjective Reaction Magnitude of Impact		Descriptions
	Lat.	Long.	
NMT 1	52.72429	-7.83659	KILKILLAHARA – Edge of Garden, c18m west of house
NMT 2	52.71109	-7.823689	3 BRITTAS – In garden, c4m east of house
NMT 3	52.70045	-7.81283	THE LODGE – On roadside, c18m north of house
NMT 4	52.695606	-7.794588	TOOREEN – In front garden, c26m east of house
NMT 5	52.709652	-7.790768	ROSSESTOWN, E41 A788 In garden. C23m west of house
NMT 6	52.716547	-7.792424	CLOBANNA, In field, c13m west of house

Location	Subjective Reaction Magnitude of Impact		Descriptions
	Lat.	Long.	
NMT 7	52.729841	-7.8191268	CLONAMACOGUE BEG, In garden, C19m east of house

A Noise Monitoring Terminal (NMT) was installed at each of the locations in Table 12-4 and photographs of the installations are given in Appendix 12C.

In addition, wind speed data at various heights was provided by an on-site LiDAR which allowed for later analysis of wind speed dependant noise levels.

12.5.3 Survey Period

The survey was conducted in accordance with *ETSU-R-97* and *IOA GPG*.

Sections 2.9.1 of the IOA GPG states:

"The duration of a background noise survey is determined only by the need to acquire sufficient valid data over the range of wind speeds (and directions, if relevant). It is unlikely that this requirement can be met in less than 2 weeks."

The survey period was between 25-5-2023 and 27-7-2023.The survey period was of sufficient duration to satisfy the IOA GPG requirement to measure adequate data to determine suitable representative background noise levels across an appropriate range of wind speeds.

12.5.4 Instrumentation

Each NMT consisting of a class 1 Sound Level Meter (SLM), outdoor microphone, secondary windscreen, batteries etc. which fully met the requirements set out in ETSU and IOA GPG. Instrumentation details are given in Appendix 12B.

Before and after the measurements, the instruments were field calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator.

Rainfall was monitored using a rain gauge installed at NMT4.The data allowed the removal of noise data during precipitation, in line with best practice outlined in *IOA GPG Supplementary Guidance Note 2: Data Processing and Derivation of ETSU-R-97 Background Curves.*

The microphones were all fitted with double windscreens, mounted between 1.2m and 1.5m above ground level and, situated between 3.5m and 260m from the dwelling. The noise meters were located away from obvious sources of noise such as boiler flues, fans and ephemeral running water. The meters were situated away from hard reflective surfaces such as solid fences and walls.

Noise levels in terms of measurement parameters $L_{Aeq,10min}$ and $L_{A90,10min}$ were logged by each NMT.

12.5.5 Consideration of Wind Shear

Wind shear can be defined as the changes in the relationship between wind speed at different heights. As part of a robust wind farm noise assessment, due consideration should be given to the issue of wind shear which has been considered in accordance with the IOA GPG. It is standard procedure to reference noise data to standardised 10 metre height wind speed. This guidance presents the following equations in relation to the derivation of a standardised wind speed at 10m above ground level:

Equation A

Shear Exponent Profile:

$$U = U_{ref}\left[\frac{H}{H_{ref}}\right]^{m}$$

Where:

U calculated wind speed.
U_{ref} measured wind speed.
H height at which the wind speed will be calculated.
H_{ref} height at which the wind speed is measured.
m shear exponent.

Equation B

Roughness Length Shear Profile:

$$U_1 = U_2 \frac{\ln(H_1/z)}{\ln(H_2/z)}$$

Where:

H_1 the height of the wind speed to be calculated (10m)
H_2 the height of the measured wind speed.
U_1 the wind speed to be calculated.
U_2 the measured wind speed.
z the roughness length.

Note: A roughness length of 0.05m is used to standardise hub height wind speeds to 10m reference height in the *IEC 61400-11:2003* standard, regardless of what the actual roughness length seen on a site may have been. This 'normalisation' procedure was adopted for comparability between test results for different turbine type.

Any reference to wind speed herein should be understood to be the 10m height standardised wind speed reference unless otherwise stated.

The background noise data has been analysed with respect to a 10m standardised height based on the turbine hub height in accordance with the guidance contained in the IoA GPG.

12.5.6 Meteorological Data

In accordance with the IoA GPG, background noise measurements should be correlated with wind speed measurements performed at the proposed site, such that operating noise levels from the turbines may be compared with the noise levels that would otherwise be experienced at a dwelling.

Wind speed and wind direction were provided by an on-site LiDAR which was installed c563m west of the T8 location. Figure 12-3 shows the distribution of wind speed and directions recorded.

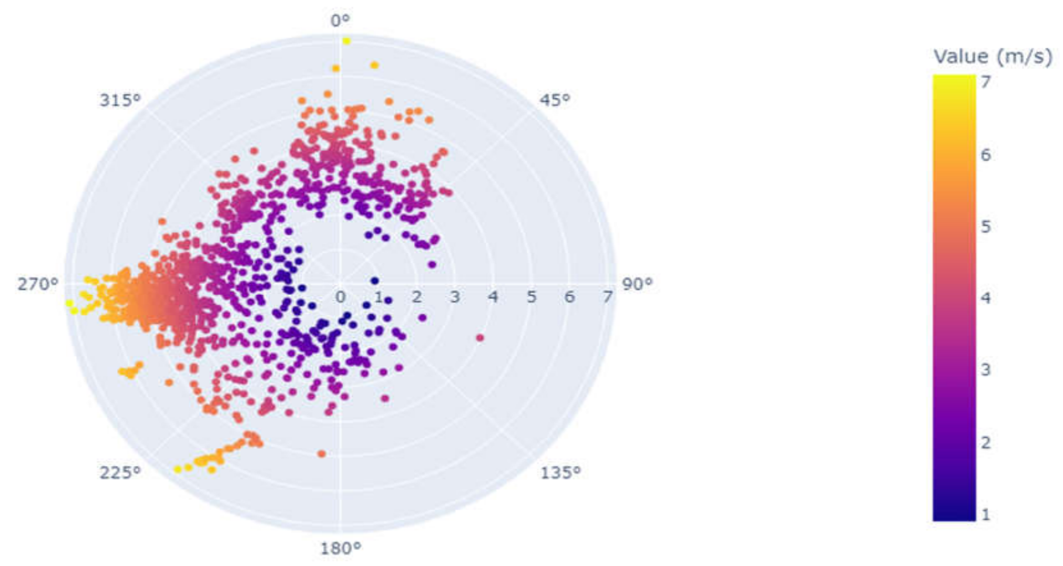

Figure 12-3. Distribution of Measured Standardised 10m height Wind Speed/Direction

12.5.7 Filtering and Analysis of Background Noise Data

Following assessment methods contained in the IoA GPG, the data sets have been filtered to remove issues such as the dawn chorus and the influence of other atypical noise sources. In addition, sample periods affected by rainfall or when rainfall resulted in prolonged periods of atypical noise levels have also been screened from the data sets.

The results presented in the following sections refer to the filtered noise data collated for daytime and night-time amenity periods.

12.5.8 Noise Survey Results

In general, the significant noise sources in the area were noted to be local and distant traffic, domestic activity in and around the residences, wind generated noise from local foliage and other typical anthropogenic sources typically found in such rural settings.

Following IOA GPG and *SNG No. 2 Data Collection* guidance, for the purposes of setting the noise criteria, the prevailing measured background noise levels are calculated using a best fit polynomial regression line though the measured $L_{A90,10min}$ noise data. These are presented for the Daytime amenity and Night-time periods with Green and Red lines respectively, as shown in Figure 12-4 to Figure 12-17 below.

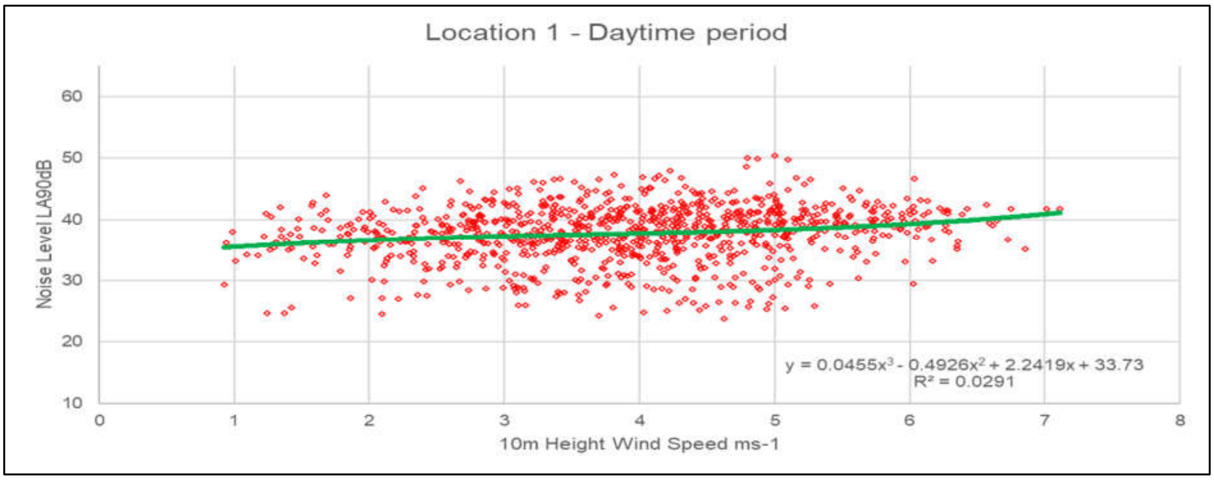

Figure 12-4. NMT 1 – Background noise – Daytime Period

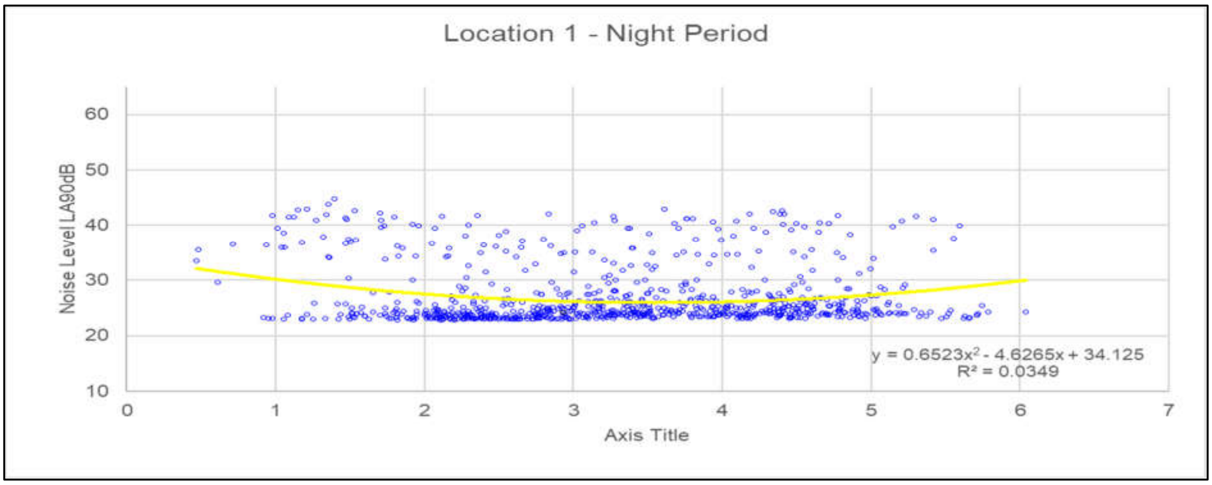

Figure 12-5. NMT1 – Background noise – Night-time period.

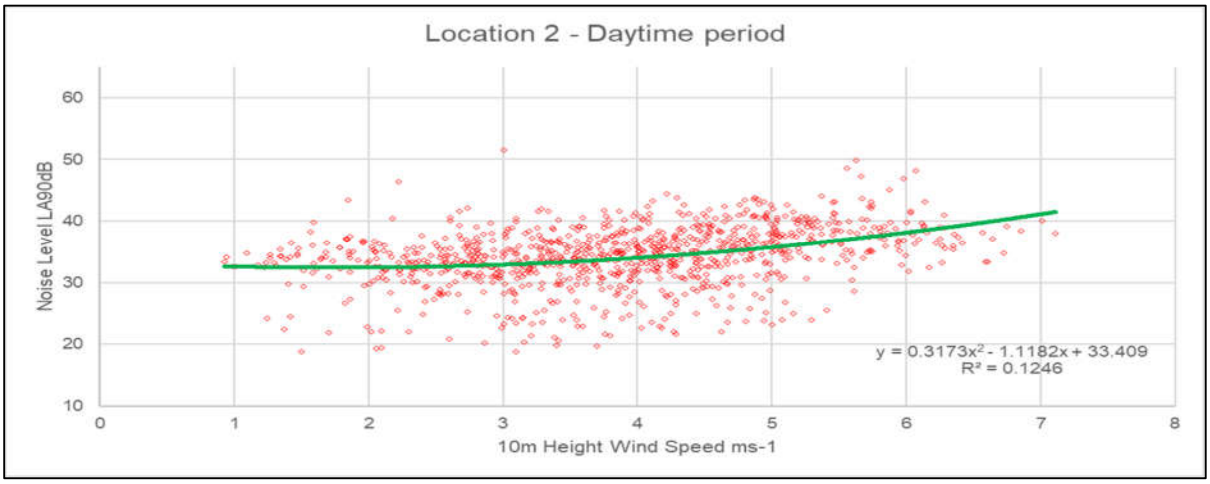

Figure 12-6. NMT2 – Background noise – Daytime period.

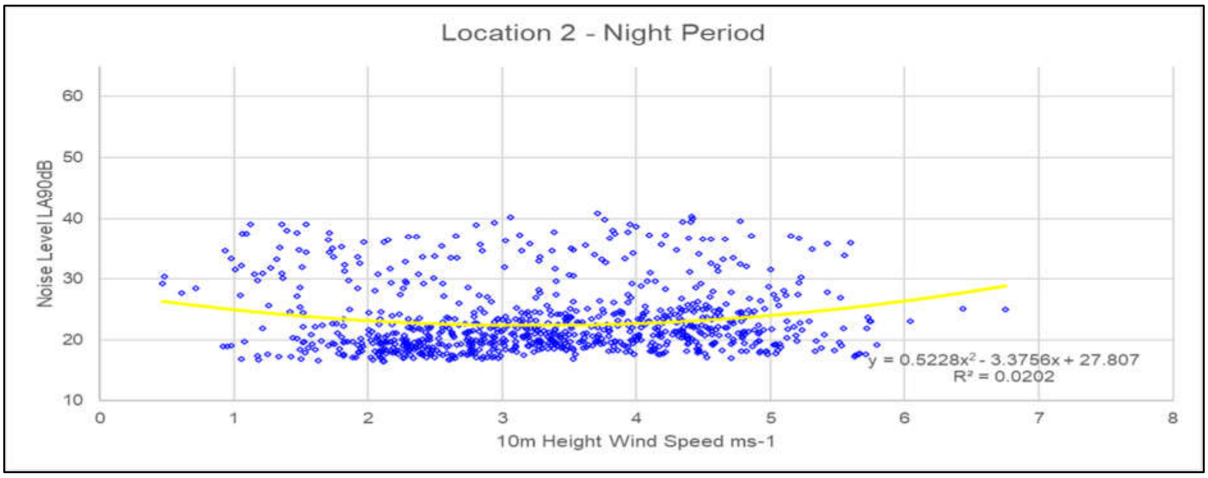

Figure 12-7. NMT2 – Background noise – Night-time period.

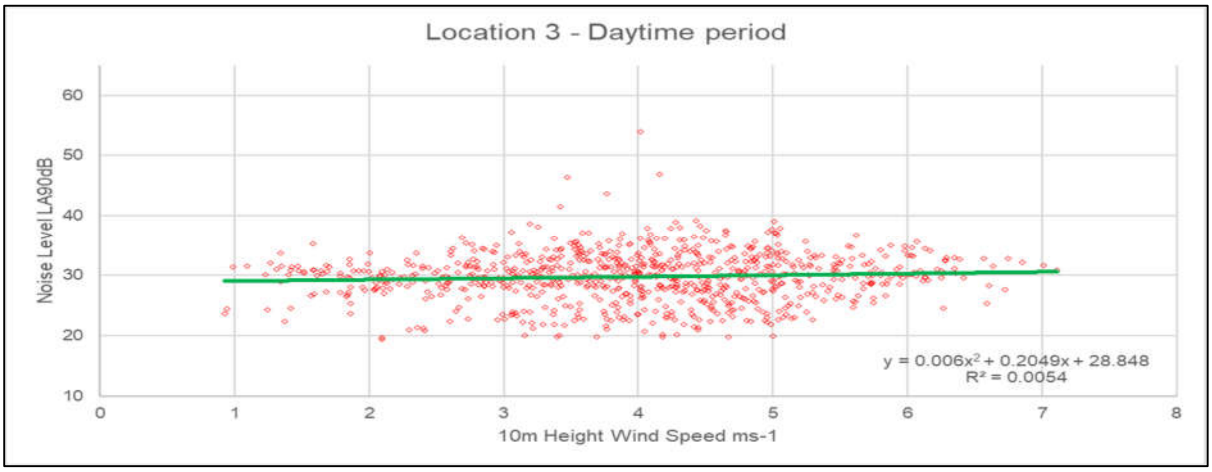

Figure 12-8. NMT3 – Background noise – Daytime period.

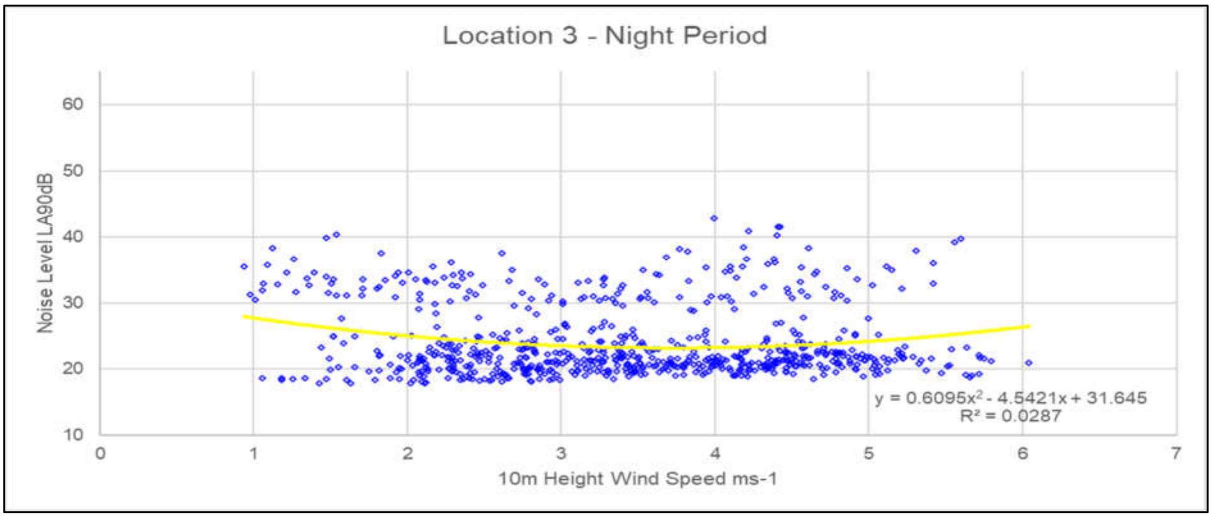

Figure 12-9. NMT3 - Background noise – Night-time period.

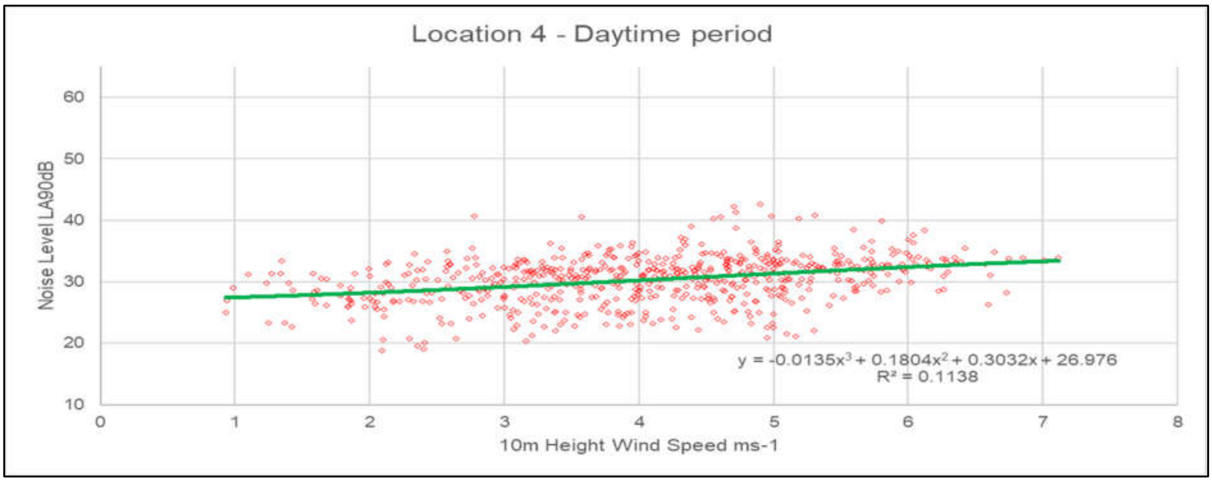

Figure 12-10. NMT4 – Background noise – Daytime period.

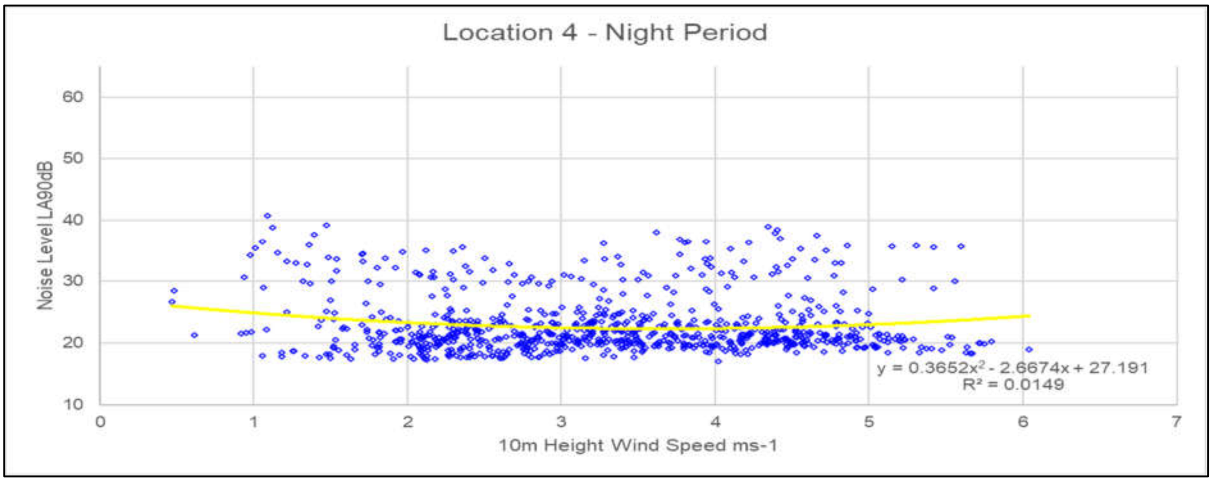

Figure 12-11. NMT4 – Background noise – Night-time period.

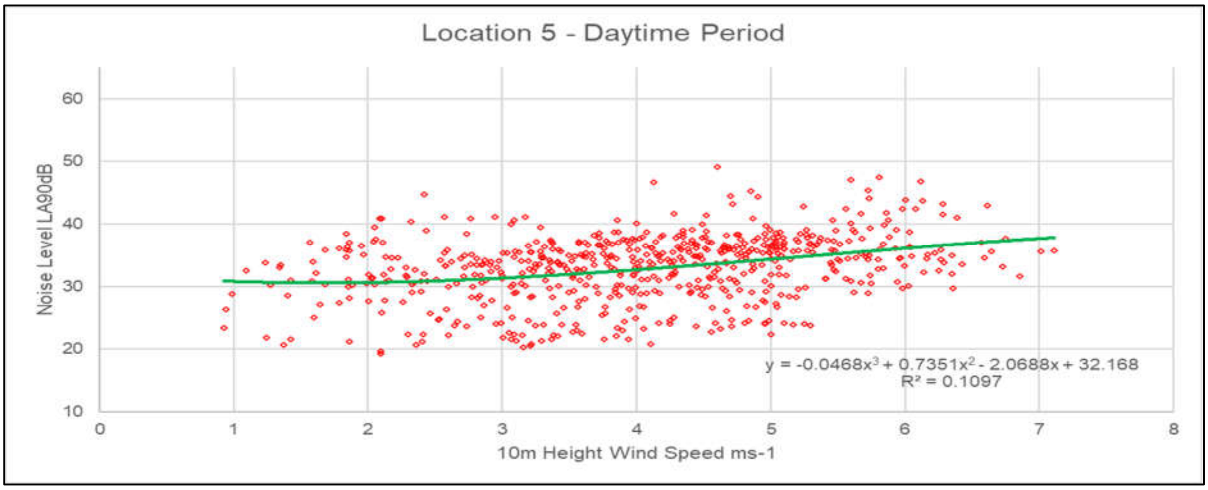

Figure 12-12. NMT5 – Background noise – Daytime period.

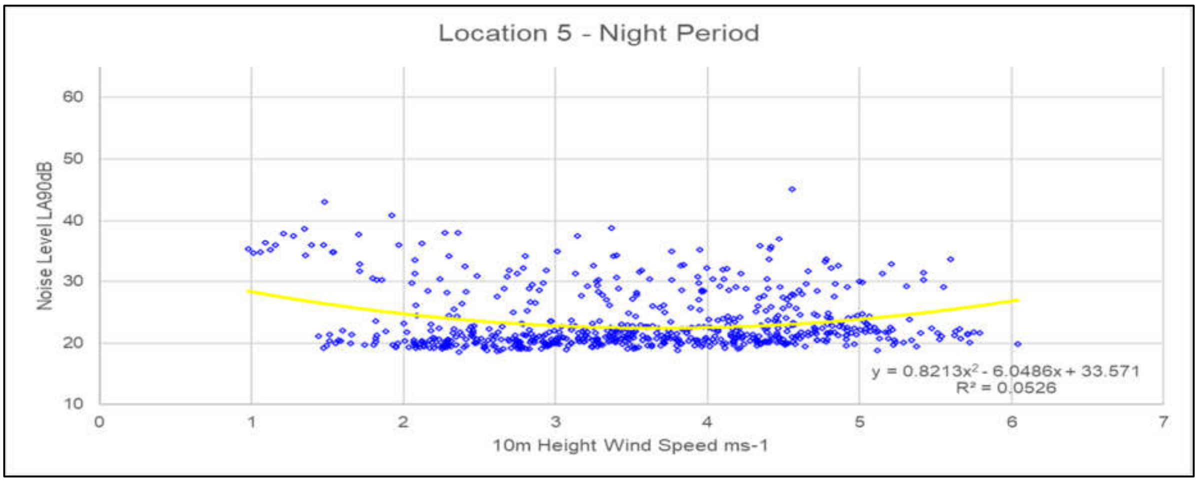

Figure 12-13. NMT5 – Background noise – Night-time period.

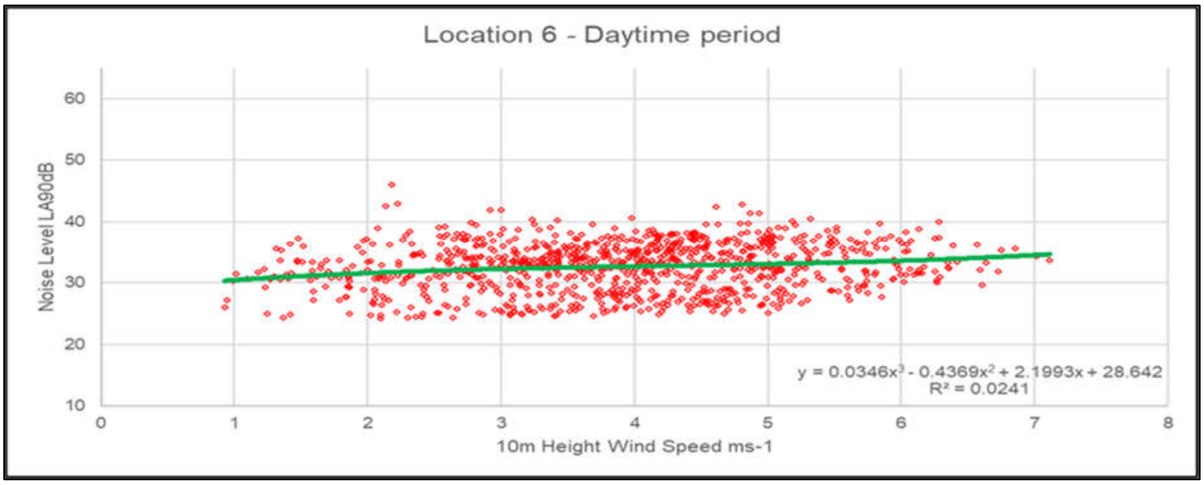

Figure 12-14. NMT6 – Background noise – Daytime period.

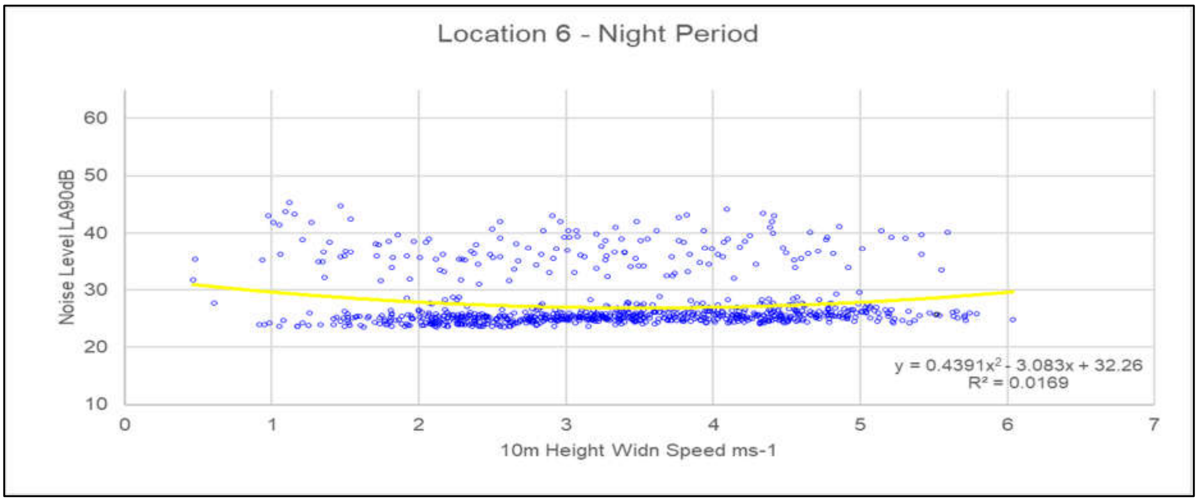

Figure 12-15. NMT6 – Background noise – Night-time period.

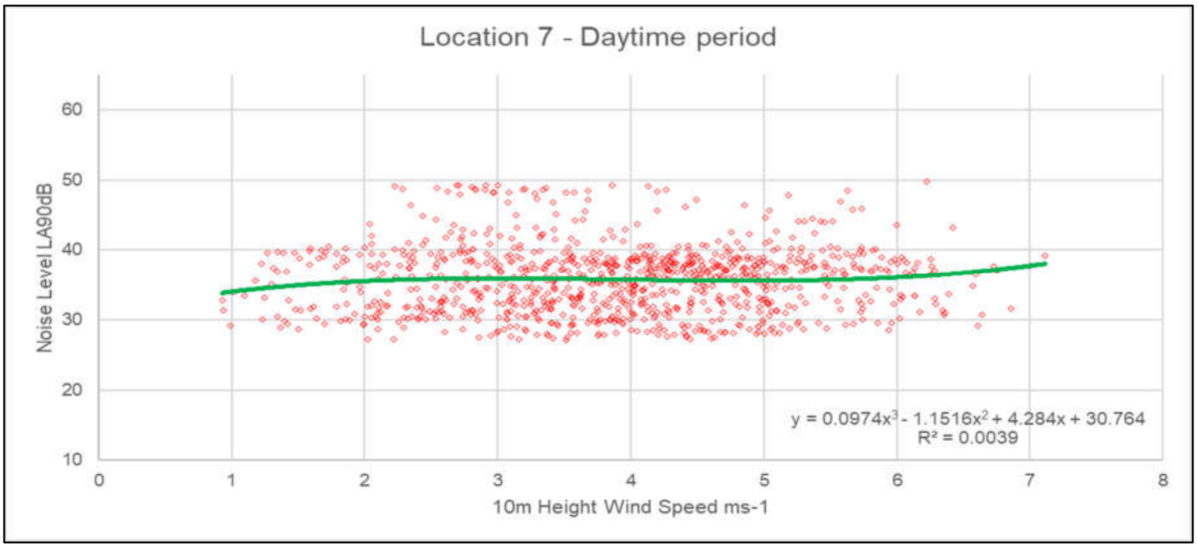

Figure 12-16. NMT7 – Background noise – Daytime period.

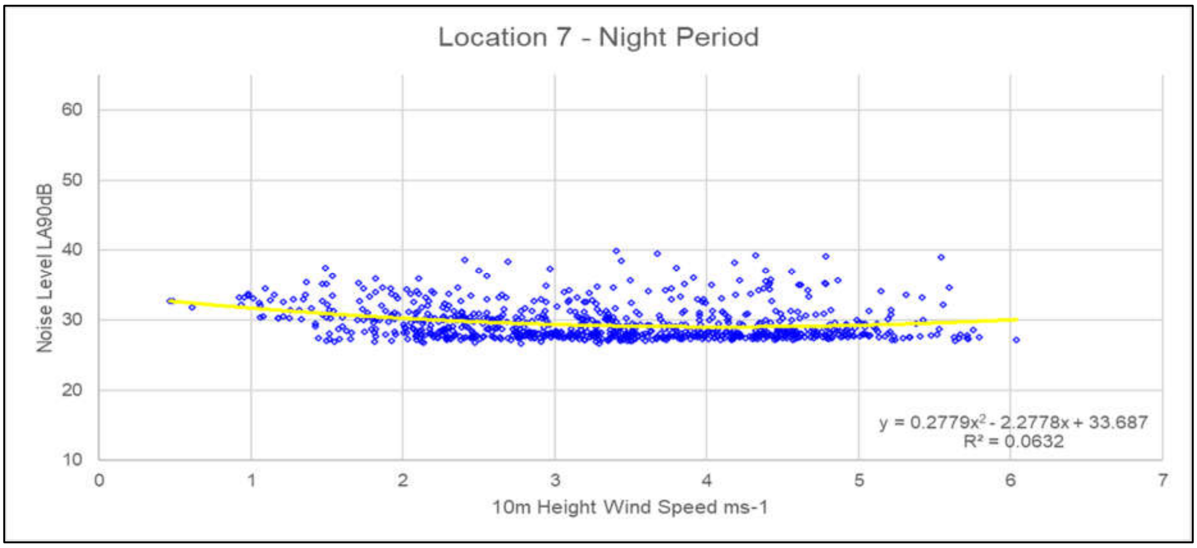

Figure 12-17. NMT7 – Background noise – Night-time period.

12.5.9 Summary of Background Noise Levels

The derived $L_{A90,10min}$ noise levels for each of the monitoring locations for daytime and night-time amenity hours Table 12-5.

Table 12-5. Derived levels of $L_{A90,10min}$ for Various wind speeds.

Location	Period	Derived $L_{A90,10min}$ Levels (dB) at Standardised 10m Height Wind Speeds									
		3	4	5	6	7	8	9	10	11	12
NMT1	Day	37	38	38	39	39	39	39	39	39	39
	Night	26	26	27	30	30	30	30	30	30	30
NMT2	Day	33	34	36	38	38	38	38	38	38	38

Location	Period	Derived $L_{A90,10min}$ Levels (dB) at Standardised 10m Height Wind Speeds									
		3	4	5	6	7	8	9	10	11	12
	Night	22	23	24	26	26	26	26	26	26	26
NMT3	Day	30	30	30	30	30	30	30	30	30	30
	Night	24	23	24	26	26	26	26	26	26	26
NMT4	Day	30	30	31	32	32	32	32	32	32	32
	Night	22	22	23	24	24	24	24	24	24	24
NMT5	Day	33	33	34	36	36	36	36	36	36	36
	Night	22	23	24	26	26	26	26	26	26	26
NMT6	Day	32	33	33	34	34	34	34	34	34	34
	Night	27	27	28	30	30	30	30	30	30	30
NMT7	Day	36	36	36	36	36	36	36	36	36	36
	Night	29	29	29	30	30	30	30	30	30	30
Nominal	Day	30	30	30	30	30	30	30	30	30	30
	Night	22	22	23	24	24	24	24	24	24	24

The Nominal criteria is the lowest background level from all NMTs per wind speed bin. The Nominal criteria are used to set the wind turbine operational noise limits for all Noise Sensitive Locations and a worst-case impact is therefore assessed.

12.5.10 Ambient Noise Levels

Further analysis of the noise survey data provided the average ambient noise levels in terms of L_{Aeq} and L_{A90} levels in order to:

a) Derive the appropriate construction noise limit (L_{Aeq})

b) Describe the EPA significance of effects i.e. comparing with the Noise level Change criteria (L_{Aeq}) set out in Section 12.2.1. and;

c) Provide baseline level for the BS4142 impact assessment of the Substation and BESS (L_{A90}).

The resultant ambient noise levels are given in Table 12-6.

Table 12-6: Summary of Ambient Noise Levels

Period	LAeq (dB)	LA90 (dB)
Daytime	45	35
Night-time	36	30

12.6 Impact Assessment and Potential Effects

12.6.1 Evolution of the Baseline (Do Nothing Scenario)

If the development is not progressed the existing noise environment will remain largely unchanged. Traffic noise is currently the most significant noise source in the area. In the absence of the proposed project, increases in traffic volumes on the local road network would be expected over time and would likely result in a slight but imperceptible increase in the overall baseline noise levels

12.6.2 Construction Phase

Permitted times for construction works will be prescribed by the local authority however, these are likely to be: 07.00 – 19.00pm, Monday to Friday and 07.00 to 14.00pm on Saturdays. Using the background noise levels from Section 12.5.2 and following the methodology from BS5228 set out in Table 12-2, the site is Category A and the appropriate construction noise limits are as follows:

- Monday to Friday 07:00 – 19:00: $L_{Aeq,\,1hr}$ 65dB
- Saturdays 07:00 – 14:00: $L_{Aeq,\,1hr}$ 65dB

Due to the requirement for the concrete pours to be continuous as set out in Chapter 3 the working day may extend outside normal working hours in order to limit the traffic impact on other road users, particularly during peak school and work commuter traffic periods. Such activities are limited to the day of turbine foundation concrete pours, which are expected to be completed in a single day per turbine. Turbine and crane erections may also occasionally occur outside of these times in order to take advantage of low wind periods. Working hours will be confirmed at the outset of the project and any changes in hours will be agreed with the Local Authority.

Subject to agreement with the Local Authority, works along public roads are expected to take place between 07.00 to 19:00, Monday to Friday and 09.00 to 14.00 on Saturdays.

No work will take place on Sundays or bank holidays unless agreed in advance with the Local Authority.

12.6.2.1 Construction Methods

Details on the construction methods are fully set out in the Construction Environmental Management Plan (CEMP) in Appendix 2B of the EIAR and a summary is provided in Table 12-7

Table 12-7. Summary of Proposed Construction Methods.

Element	Construction Method
Wind Turbine Foundations and Hardstands	Wind turbine locations will be cleared, graded, and foundations will be either excavated or piled by rotary core technique. Blasting may be required at wind turbine locations where bedrock is present near the ground surface. Localised sheet steel piling may be required to facilitate soil excavation for formation of the hardstand and turbine base footprint. All excavated soil will be removed and deposited in the soil storage areas on site. An engineered concrete foundation will be installed in the excavated/piled structure location. Backfill will be provided, and grading will be performed in a manner to allow for immediate drainage away from each tower. Construction activities include tree removal, vegetation clearing, topsoil and/or soil stripping, excavation and or piling, grading, foundation construction, final grading and landscaping of temporary works areas.

Element	Construction Method
Meteorological Mast	Removal of vegetation, topsoil and subsoil stripping, excavation, grading, foundation construction, final grading and landscaping of temporary works area.
Site Access	Sightline improvements at the two site access junctions will be required. Construction activities include vegetation clearing, topsoil and/subsoil stripping, aggregate placement and grading, and landscaping of temporary works areas.
Internal Roads	Upgrading and widening of existing site access roads and construction of new excavated roads: Construction activities will include vegetation clearing, topsoil and/or subsoil stripping, excavation, placement of geogrid/ geotextile layer and aggregate, compaction, grading, berm placement and landscaping.
	Construction of new floated roads: Construction activities will include removal of major protrusions or obstructions, placement of geogrid/geotextile layer, importation and placement of stone and aggregate, compaction, grading, berm placement and landscaping.
Internal Underground Electrical Cables	To the extent possible, underground electrical collector cables will be co-located with access roads to minimise the area of construction disturbance. Construction activities include topsoil stripping, trenching, installing electrical cables, and revegetation of disturbed areas where cables are not under the roads.
Substation Compound & Grid Connection	Construction includes removal, topsoil stripping, and excavation of soil overburden, grading, foundation construction, building construction, final grading and landscaping of temporary works area. The underground cable connection to the existing substation at Carrons Wind Farm will require an excavated trench with ducting, approximately 2.54km long. This cable trench will extend along the local road and through an agricultural field. The works will include excavation, ducting bed and surround to ducts with concrete and backfill of trenches with suitable material.
Temporary Construction Compound	Topsoil stripping, excavation of overburden and soil, grading, aggregate placement, compaction and landscaping.
Water Crossings	No in-stream works. Existing crossings: widening using pre-cast piping New crossings: Clear span crossings

The most significant construction elements with potential for adverse noise and vibration impacts are:

1. Wind Turbine Foundations and Hardstands;
2. Substation Compound;
3. Battery Energy Storage System; and
4. Grid Connection.

A variety of items of plant will be in use for the purposes of site preparation, construction works etc, as set out in Section 2.5.6 of Chapter 2 of the EIAR, however exact construction noise impacts cannot be fully quantified at this point. As a working hypothesis, expected typical construction noise predictions have been carried out using guidance set out in *British Standard BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise*. No mitigation measures have been included in the predictions and the results therefore represent a worst case.

MWP

12.6.2.2 Turbines, Hardstands and Meteorological Mast

Each turbine will be supported by a reinforced concrete base or foundation with a central upstand above the base which will be excavated to good ground bearing levels. The foundation will bear onto rock, or other such suitable bearing stratum determined during pre-construction site and geotechnical investigations. The foundation base will be approximately 28m in diameter and installed to an excavation depth of approximately 3m below ground level, depending on ground conditions. Piled foundations may be required depending on the findings of the geotechnical ground investigation which will be carried out prior to the construction phase. Once completed, a portion of the foundation (typically a 6m ø concrete plinth) will be raised above existing ground level by 0.05m to help prevent groundwater ingress to the turbine tower base.

The nearest NSL to a turbine is c570m southeast of Turbine 05 and the construction noise impact assessment to here represents a worse case, with commensurately reduced impacts at NSLs further away.

Indicative noise sources have been identified and predictions of the potential noise emissions at the closest NSL have been calculated and are given in Table 12-8.

Table 12-8. Indicative Wind Turbine Construction Noise Emission Levels.

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dBA)	% on-time[1]	Predicted Noise level at nearest NSL (dBA)
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79	100	44
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77	80	41
Excavator Mounted Rock Breaker (C9.12)	Excavation in rocky areas	85	80	49
Piling Operations (C.12.14)	Standard pile driving	88	50	49
General Construction (Various)	All general activities plus deliveries of materials and plant	84	80	48
Concrete Mixer Truck and Concrete Pump (C.4.27)	Turbine Foundations	75	80	39
Dumper Truck (C.4.4)	Backfilling Turbine Foundations	76	80	40
Mobile Telescopic Crane (C.4.39)	Turbine Erection	77	80	41
Dewatering Pumps (D.7.70)	If required	80	80	44
JCB (D.8.13)	For services, drainage and landscaping.	82	100	47
Vibrating Rollers (D.8.29)	Road surfacing	77	80	41
Total				56

[1]Typical/best practice assumption.

No screening correction has been applied.

At the nearest NSL, the predicted noise levels from individual items of plant range between 39 to 50dB with a total worst-case construction level of the order of 56dB.

The assessment is considered worst-case were all plant to operate simultaneously with construction noise decreasing commensurately with distance from the works.

The predicted noise levels at the nearest NSL are below the appropriate criteria outlined in Table 12-2. Nevertheless, noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

12.6.2.3 Substation & BESS

A battery energy storage system (BESS) will be developed adjacent to the 110kV Substation as described in Section 2.4.15 and 2.4.16 of Chapter 2 of the EIAR.

The construction of the Substation and BESS will follow a similar process to the construction of the turbine foundations/hardstanding set out in Table 12-7 above with the exception of piling, however the distance to the nearest NSL is c200m to the east, and therefore the resultant noise level differs

The location of the compound is shown in Figure 12-18

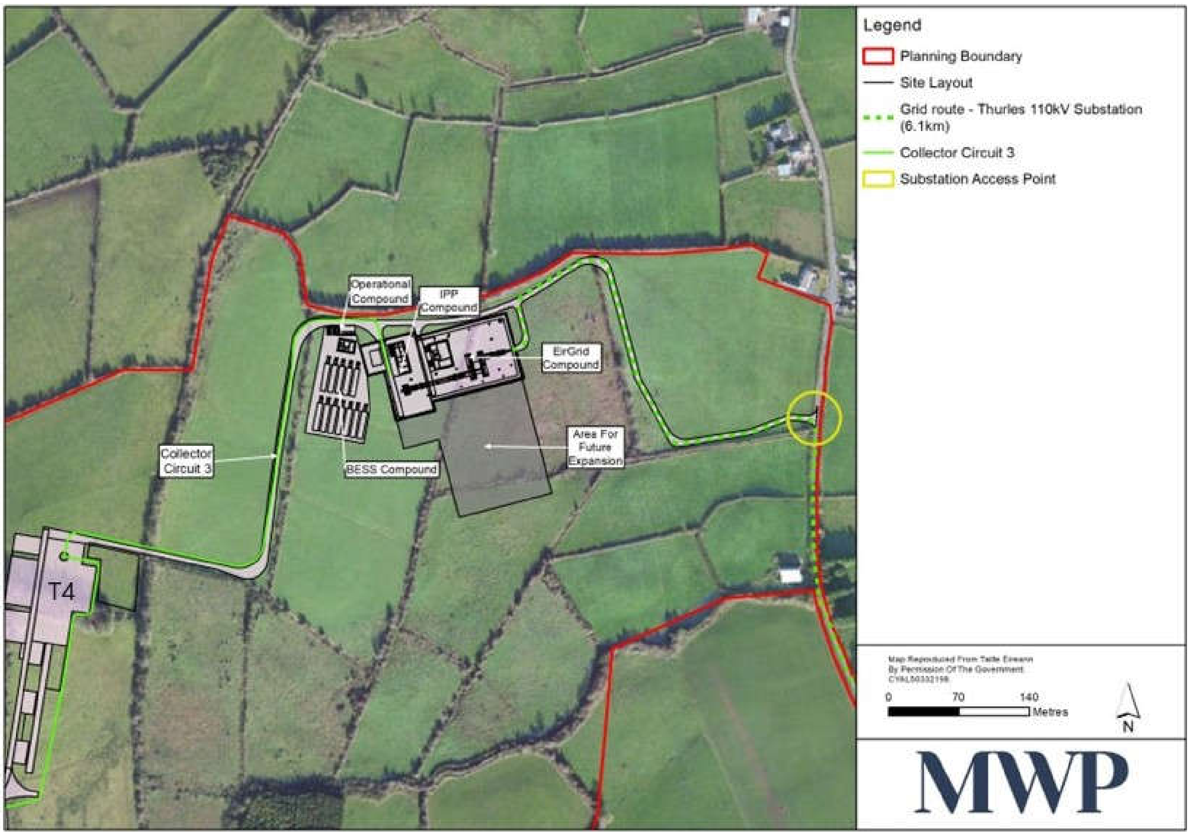

Figure 12-18. Location of Substation and BESS.

The calculated worse case noise level at the nearest NSL is 60dB LAeq.

The The predicted noise levels at the nearest NSL are below the appropriate criteria outlined in Table 12-2 Nevertheless, noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

12.6.2.4 Temporary Construction Compound

Two (2no.) temporary construction compounds and welfare facilities will be set up as set out in Section 2.4.8 of Chapter 2 of the EIAR. The construction will follow a similar process to the construction of the turbine foundations/hardstanding set out in Section 2.4.1.4 with the exception of piling, however the distance to the nearest NSL is c500m, and therefore the resultant noise level differs.

The nearest NSL is c500m from the temporary compound and the calculated worse case noise level at the nearest NSL is 53dB L_{Aeq}.

The predicted noise levels at the nearest NSL are below the appropriate criteria outlined in Table 12-2. Nevertheless, noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

12.6.2.5 Site Access and Internal Tracks

Internal site access tracks are required to connect elements of the site and allow access to all wind turbines and wind farm infrastructure. Existing tracks will be upgraded, and new tracks will be constructed to access each of the turbines, substation compound and meteorological mast.

Details of the site access roads are given in Section 2.4.3 of the EIAR and the nearest NSL to the works is c125m.

Indicative noise sources have been identified and predictions of the potential noise emissions at the closest NSL have been calculated and are given in Table 12-9

Table 12-9. Indicative Site Access and Internal Road Noise Emission Levels

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dBA)	% on-time[1]	Predicted Noise level at nearest NSL (dBA)
Dozer (35 tonne) (C5.14)	Ground excavation earthworks.	86	80	62
Wheeled loader (C10.5)	Loading Lorries.	80	80	56
Tigit dump truck (40 tonne) (C9.24)	Distribution of Material	85	80	61
Backhoe mounted hydraulic breaker C5.1)	Breaking Road Surface	88	80	64
Dozer (14 tonne) (C5.12)	Spreading Chipping / fill	77	80	53
Road planer (17 tonne) (C5.7)	Road Planing	82	80	58
Road roller (22 tonne) (C5.19)	Rolling and compaction	80	80	56
Asphalt paver (+ tipper lorry) (C5.32)	Paving	84	80	60
Total				70
[1]*Typical/best practice assumption.* *No screening correction has been applied.*				

At the nearest noise sensitive location, the predicted noise levels from individual items of plant range between 53 to 62dB with a total worst-case construction level of the order of 70dB. The predicted noise levels at the nearest NSL exceed the criteria outlined in Table 12-2. However, since the works are likely to be completed within a few days, the assessment assumes the worst-case scenario where all equipment operates simultaneously. Construction noise is anticipated to decrease as distance from the construction site increases. commensurately with distance from the works.

12.6.2.6 Borrow Pit

One (1no.) proposed on-site borrow pit location has been identified to provide the majority of the required fill material for internal roads, passing bays, hardstands, foundations, and temporary compound. Details are provided in Chapter 2 of the EIAR and the nearest NSL is c400m. The extraction of rock from the borrow pit may, subject to ground inspection, be undertaken by a combination of rock breaking, ripping, and blasting.

As set out in Chapter 3, two situations for breaking out material in potential borrow pit locations are proposed and have been considered as follows:

- Scenario A: Rock breaking operations/Ripping
- Scenario B: Blasting operations

<u>Rock Breaking Operations</u>

Indicative noise sources have been identified and predictions of the potential noise emissions at the closest NSL have been calculated and are given in Table 12-10.

Table 12-10. **Indicative Rock-breaking Noise Emission Levels**.

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dBA)	% on-time[1]	Predicted Noise level at nearest NSL (dBA)
Diesel Pump (C4.88)	Pump Water	68	100	36
Tracked Hydraulic Excavator (37t) (C10.1)	Face shovel extracting / loading dump trucks	80	80	47
Rock Breaker (C9.12)	Rock breaking	85	50	50
Crusher (C1.14)	Crushed materials	82	100	50
Tracked Excavator (21t) (C4.65)	Trenching	71	80	38
Dozer (41t) (C2.10)	Ground excavation / earthworks	80	80	47
Articulated Dump Truck (23t) (C2.33)	Distribution of materials	81	50	46
Total				55
[1]Typical/best practice assumption. *No screening correction has been applied.*				

The calculated worst case noise level at the nearest NSL is 55dB L_{Aeq}.

The predicted noise levels at the nearest NSL are below the appropriate criteria outlined in Table 12-2. Nevertheless, noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

The magnitude of source vibration levels, ground attenuation and distance to the nearest NSL are such that no significant vibration impact will occur calculated worst case noise level at the nearest NSL is 55dB L_{Aeq}.

Blasting Operations

If required, blasting may be carried out at the borrow pit areas. It may also be required at wind turbine foundations where bedrock is present near the ground surface, which is not expected at this site. If this is the case the mitigation measures detailed in the Section 12.7 will be adopted and set out in the CEMP. The assessment presented here for borrow pit activities will be comparable to those expected in relation to works associated with turbine foundations. The extent of any blasting will depend on the rock type and depth in the area.

It should be noted that while blasting has a higher intermittent noise level then rock breaking, it decreases the amount of breaking/ripping required with a subsequent reduction in time to extract material and the associated overall noise levels. Therefore, a combination of the two techniques minimises the noise effects.

Noise – Air Overpressure (AOP)

Air overpressure is energy transmitted as pressure waves. This is a similar process to sound wave transmission but with fluctuations exceeding the ambient air pressure level. The maximum excess pressure in this wave is known as the peak air overpressure and is expressed in terms of dB (Lin).

The majority of the energy is at frequencies of less than 20Hz and therefore inaudible but is sensed as pressure.

The intensity of AOP from blasting relates to blast design and set up (e.g., detonating cord, stemming release and gas venting) and physical properties of the site (rock density, movement and reflection of stress waves). The transmission of the pressure wave through the atmosphere is highly dependent on meteorological conditions (temperature, cloud cover, humidity, wind speed and direction etc.). Due to the large variability in these conditions, it is not possible to reliably calculate AOP. The control of its intensity is therefore undertaken at source through careful blast design.

It should be noted that *BS 5228-2:2009* reports that there is no known evidence of structural damage to buildings from excessive air overpressure levels from quarry blasting.

Ground-borne Vibration

The level of vibration at a receiver location from a blast depends predominately on the distance from the blast, the maximum instantaneous charge (MIC), sequencing of charges and ground conditions between the blast area and the receiver location.

Empirical data on the effects of blasting in relation to large-scale mineral extraction e.g. quarries, is available in *BS5228:2009*. For example, for a 100kg blast charge a vibration level of 6mm/s PPV at 200m can be expected which is below the 8mm/s PPV vibration limit set out in Table 12-4.

For the proposed project, the scale of the required rock-breaking is considerably less than for a quarry scenario considered in *BS5228-2:2009*, and the distance to the nearest NSL is also greater. Therefore the vibration levels at the NSLs are expected to be negligible. Nevertheless, noise control and mitigation measures provided in *BS 5228-2:2009* and described in Section 12.7.1.2 will be adopted are set out in the CEMP.

12.6.2.7 Vibration

The most significant source of vibration is associated with the potential piling and blasting phases with general construction activities being considerably less.

Empirical data provided in *BS5228-2:2009* demonstrates that ground borne vibration waves are attenuated rapidly as they propagate from a source through the substrate. An examples of the maximum vibration levels from piling activity is given as 5.6mm/s PPV at 20m from the source which is below the 8mm/s PPV vibration limit set out in Table 12-3. Given that the nearest NSL is c570m away, vibration levels at the NSLs are therefore expected to be negligible.

12.6.2.8 Horizontal Directional Drilling

Horizontal Directional Drilling (HDD) will be involved at 2 no. river crossings at the Wind Farm site (for the internal underground cables) and at 2 no. stream crossings (for the grid connection route). Details of the locations for HDD are given in Section 2.4.4 of the EIAR.

The nearest NSLs to the works are as follows:

- c30m from the bridge points.
- c680m from the river crossings.

Indicative noise sources have been identified and predictions of the potential noise emissions at these distances have been calculated, and are given in Table 12-11

Table 12-11. Indicative HDD Noise Emission Levels

Item (BS 5228 Ref.)	% on-time[1]	Predicted Noise level at 30m (dB)	Predicted Noise level at 680m (dB)
Directional drill (C.2.44)	66	66	39
Mud Pump (D.7.70)	66	69	42
Diesel Pump (C4.88)	66	57	30
Tractor (D.10.220)	66	75	48
Dumper Truck (C.4.4)	66	65	38
Total		76	49

[1]Typical/best practice assumption.

No screening correction has been applied.

The calculated worst case L_{Aeq} noise level at 30m distance is 76dB and 49dB at 680m.The former is above the appropriate criteria outlined in Table 12-2 and the latter is below.

These levels assume no mitigation measures have been applied and the noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

12.6.2.9 Forestry Felling

Felling of some hedgerows and portions of existing woodland is required within and around wind farm infrastructure to accommodate the construction of the turbine foundations and associated hardstands, access tracks, and turbine assembly and turbine delivery routes. The description is given in Section 2.4.12 of the EIAR.

The nearest NSLs to the felling area vary considerably and it is therefore appropriate to calculate the potential noise emissions at various distances. Indicative noise sources have been identified and predictions of the potential noise emissions have been calculated and are given in Table 12-12

Table 12-12. Indicative Grid Connection Noise Emission Levels.

Item (BS 5228 Ref.)	Noise Emission Levels[1] (dBA) at Various Distances				
	10m	20m	30m	40m	75m
Forwarder	77	71	68	65	60
30-50T Excavator	77	71	68	65	60
Chainsaw	81	75	72	69	64
Total	84	78	74	72	66

[1]*Typical/best practice 66% on-time applied.*

The maximum calculated worst case noise level at the NSLs at 10m is 84dB L_{Aeq} which exceeds the appropriate criteria outlined in Table 12-2

It should be noted however that the extent of the works at the closest distances is limited and is anticipated to be completed in less than one day. Any noise exceedance is therefore expected to be brief.

Noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

12.6.2.10 Construction Traffic

Most of the material delivered to site will consist of aggregate for the construction of roads and crane hardstands and concrete for the construction of the turbine bases. A summary of the approximate aggregate is provided in Section 2.9.1 of the EIAR. There will be 3 new site entrances on the L8017 local road for construction and one new entrance on the L4120 for operational access to the substation.

It has been estimated from the spoil excavation and construction material volumes given in Chapter 3 that that a maximum of 20no. Heavy Good Vehicles (HGVs) will access the site to deliver materials i.e., 40no. movements per day. Assuming deliveries take place in the mornings only over the course of 4hrs i.e., 10no. deliveries per hour, using formula F.2.5 from *BS 5228-1:2009+A1:2014* the noise level associated with the HGV movements has been calculated as 55dB L_{Aeq} at 10m from the haulage route.

The predicted noise levels at the nearest NSL are below the appropriate criteria outlined in Table 12-2. Nevertheless, noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

Additional light goods and contractor related vehicles would be expected in the morning and evening peak periods. The impact from these vehicle movements is expected to be negligible.

12.6.2.11 Grid Connection Cable Trenching and Jointing Bays

The grid connection route to Thurles Substation is described in Section 2.3.4 and 2.4.14 of Chapter 2 of the EIAR.

The nearest NSLs to the route vary considerably and it is therefore appropriate to calculate the potential noise emissions at various distances. Indicative noise sources have been identified and predictions of the potential noise emissions have been calculated, and are given in Table 12-13.

Table 12-13. Indicative Grid Connection Noise Emission Levels.

Item (BS 5228 Ref.)	Noise Emission Levels[1] (dBA) at Various Distances				
	10m	20m	30m	40m	75m
HGV Movement (C.2.30)	69	63	60	57	52
Tracked Excavator (C.4.64)	68	62	59	56	51
Excavator Mounted Rock Breaker (C9.12)	77	71	68	65	60
Vibrating Rollers (D.8.29)	76	70	67	64	59
Total	80	74	71	68	63
[1] *Typical/best practice 66% on-time applied.*					

The maximum calculated worst case noise level at the NSLs at 10m is 80dB L_{Aeq} which exceeds the appropriate criteria outlined in Table 12-2.

It should be noted however that the active construction area is proposed to be only along a 100-200m stretch of any roadway at any one time and will quickly progress. Any noise exceedance is therefore expected to be temporary.

Noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

12.6.2.12 Turbine Delivery Route

The components for each turbine are expected to be delivered from Foynes Port along the route is described in Section 2.3.5 and 2.4.5 of Chapter 2 of the EIAR. Due to their abnormal size, blades and towers will be delivered at night to avoid disruption to daytime traffic.

Twenty-two pinch points have been identified along the route where various works will be required. These include the following:

- The temporary removal of traffic signs and lights
- The temporary removal of electricity poles, bollards and lamp posts
- Hedges and tree removal or trimming
- Temporary land take
- Temporary Fence removal
- Road widening

The items of plant used for the junction upgrade works are similar to those used for the internal site roads as set out in Section 12.6.2.5. Noise levels closer than 150m from the works have been predicted to exceed the criteria in Table 12-2. However, since the works are proposed to be completed within a few days, the assessment assumes the worst-case scenario where all equipment operates simultaneously. Construction noise is anticipated to decrease as distance from the construction site increases.

Night Time Deliveries

Due to their abnormal size, blades and towers are proposed to be delivered at night to avoid disruption to daytime traffic. Using formula F.2.5 from BS 5228-1:2009+A1:2014 the noise level associated with these deliveries has been calculated as 35dB L_{Aeq} at 10m from the haulage route which is above the typical night-time background noise level of 30dB L_{A90}.

Nevertheless, the predicted noise level is below the 45dB maximum façade noise level recommended by the World Health Organisation to prevent sleep disturbance.

Noise control and mitigation measures provided in *BS 5228-1:2009* and described in Section 12.7 will be adopted and set out in the CEMP.

12.6.2.13 Summary of Construction Noise Effects

The potential worst-case effects associated with the above aspects of the construction phase are derived by comparing the predicted noise levels with the existing ambient levels given in Section 12.5.2. The criteria given in Section 12.2.1 is applied and the results are presented in Table 12-14. Vibration effects are assessed against background vibration levels which are typically imperceptible.

Table 12-14. Summary of Description of Construction Noise Effects.

Aspect	Quality	Significance	Duration
Turbines, Hardstands and Meteorological Mast	Negative	Very Significant	Temporary
Substation & BESS	Negative	Very Significant	Temporary
Temporary Construction Compound	Negative	Significant	Temporary
Site Access and Internal Tracks	Negative	Very Significant	Temporary
Rock-breaking (noise)	Negative	Significant	Temporary
Blasting (noise)	Negative	Very Significant	Momentary
Blasting (vibration)	Negative	Not Significant	Temporary
Grid Connection	Negative	Very Significant	Brief
Forestry Felling	Negative	Very Significant	Brief
Construction Traffic	Negative	Significant	Temporary
Turbine Delivery Route	Negative	Very Significant	Temporary
Night-time Deliveries	Negative	Not Significant	Brief
Vibration	Negative	Imperceptible	Temporary

12.6.3 Operational Phase

Once operational, the wind turbines and the substation facility will generate noise which will propagate into the receiving environment. The potential effects are described in the following sections.

12.6.3.1 Wind Turbines

There are 3 no. candidate wind turbine types to be considered as set out in Table 12-15.

Table 12-15: Candidate Turbine Types

Turbine Type Identifier	Tip Height	Hub Height
A	180	105m
B	180	102.5m
C	180	105m

<u>Wind Turbine Noise Criteria</u>

Following a detailed review of the background noise data set out in Section 12.5.2, appropriate noise criteria for the operational phase of the proposed project have been calculated and are given in Table 12-16.

Table 12-16. Summary of WEDG-06 Noise Criteria.

Location	Period	Noise Limit Criteria (dB) at Standardised 10m Wind Speeds									
		3	4	5	6	7	8	9	10	11	12
NSL1	Day	45	45	45	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43	43	43
NSL2	Day	45	45	45	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43	43	43
NSL3	Day	45	45	45	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43	43	43
NSL4	Day	45	45	45	45	45	45	45	45	45	45
	Night	43	43	43	43	43.	43	43	43	43	43
NSL5	Day	45	45	45	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43	43	43
NSL6	Day	45	45	45	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43	43	43
NSL7	Day	45	45	45	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43	43	43
Nominal	Day	45	45	45	45	45	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43	43	43

The Nominal criteria is the minimum value derived from the data. This criteria is applicable to all NSLs considered within the study area and therefore represents a worst case assessment.

A comparison of the predicted noise levels with the noise criteria for daytime and night-time periods at the NSLs are presented in Section 12.6.3.1.

The assessment has been undertaken in accordance with best practice guidance outlined in the IOA GPG and calculated to the ISO 9613-2 standard. It should be noted that the predicted noise levels assume that all receptors (Noise Sensitive Locations) are downwind of all turbines simultaneously and therefore represents a worst-case assessment for each turbine type.

Noise Prediction

A computer-based noise propagation model has been prepared to predict the noise levels from the proposed turbines. This section discusses the methodology behind the noise modelling process and presents the results

Noise Prediction Software

The proprietary software used, Brüel & Kjær Type 7810-C Predictor, calculates noise levels in accordance with *ISO 9613:1996 Acoustics – Attenuation of sound during propagation outdoors*.

The resultant noise levels are calculated considering a range of factors affecting the propagation of the sound, including:

- The magnitude of the noise source in terms of A-weighted sound power levels (L_{WA});
- The distance between the source and the receiver;
- Topography;
- The presence of obstacles such as screens or barriers in the propagation path;
- The presence of reflecting surfaces;
- The acoustic property of the ground between the source and receiver;
- Attenuation due to atmospheric absorption

Input Data Assumptions

Sound power levels (L_{WA}) are provided by the manufacturers' for Sound Optimised Modes (blades with serrated trailing edge). Some data are provided at standardised reference 10m wind speeds, others at hub height wind speeds. The latter are converted where required following guidance set out in Section 12.3.2 and are presented in Table 12-17.

Table 12-17. LWA levels at V10 wind speeds.

Turbine Type	Wind speed (vs) at a height of 10m (m/s)							
	3	4	5	6	7	8	9	10
A	94.1	96.9	100.0	103.7	103.9	104.0	104.0	104.0
B	94.8	98.8	102.1	105.0	105.0	105.0	105.0	105.0
C	94.4	95.2	99.8	104.2	105.6	105.6	105.6	105.6

A total of 10 no. turbines at the locations in Table 12-18 are provided.

Table 12-18: Turbine Co-ordinates

Turbine Ref.	Co-ordinates	
	ITM X	ITM Y
T1	612041	663334
T2	612606	663390
T3	613136	663262
T4	613561	663879
T5	613713	663346
T6	612471	662850
T7	613279	662778
T8	612712	662499
T9	613093	662195
T10	613167	661578

The noise impacts for each Turbine Type will be assessed separately.

Appendix 12D provides information on the noise model calculation parameters and settings.

<u>Predicted Noise Levels</u>

Predicted noise levels are given in terms of the L_{Aeq} parameter and best practice guidance in the IoA GPG states that:

> *"L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2dB."*

Therefore, a 2dB conversion has been applied to the predicted noise levels and all levels in this report are therefore presented in terms of $L_{A90,10min}$.

<u>Uncertainty</u>

Uncertainty in the noise assessment ought to be considered and following the GPG in the absence of specific information, the data used in this report has an uncertainty of +2dB applied.

Cumulative Assessment

The IOA GPG states that cumulative noise exceedances should be avoided and where existing or permitted development is at the noise limit any new turbine noise sources should be designed to be 10 dB below the limit value.

Section 5.1 of the relevant IoA GPG states the following:

"…absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question…

If an existing wind farm has permission to generate noise levels up to ETSU-R-97 limits, planning permission noise limits set at any future neighbouring wind farm would have to be at least 10 dB lower than the limits set for the existing wind farm to ensure there is no potential for cumulative noise impacts to breach ETSU-R-97 limits (except in such cases where a higher fixed limit could be justified)". Such an approach could prevent any further wind farm development in the locality, and a more detailed analysis can be undertaken on a case-by-case basis.

During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. If the proposed wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.

Equally, in such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary."

The identified wind farm developments listed in Section 1.6.4.6 of Chapter 1 of the EIAR were considered. The most significant for the purposes of the cumulative noise assessment were identified as follows:

- Lisheen 1: 18no. Vestas V90
- Lisheen 1a: 12no. Vestas V90
- Lisheen 3: 8no. Vestas V136
- Bruckana: 16no. Siemens SWT-3.0-101
- Borrisbeg: 9no. Nordex N163

Operational turbine information for these sites including models, hub height and sound power data was made available, and noise levels predicted following the same methodology set out in Section 12.2.1.

As a worst-case, the cumulative noise levels from these wind farms at the maximum rated power (8 m/s) was predicted and it was found that a maximum noise level of 30 dB(A) occurred at the following NSLs:

845	870	871	882	883	884	915
916	917	918	919	941	942	968

These NSLs lie to the northeast of the proposed project , the closest being c5.2km from Lisheen 1's nearest turbine. A map illustrating these NSLs is given in Figure 12-19.

Figure 12-19. Map of NSLs with maximum cumulative effect.

The 30 dB(A) level is at least 10dB lower than both the predicted level from the proposed project and the noise limit criteria at the rated power wind speed for all wind turbine types. A cumulative assessment is therefore not required.

Tonality

A warranty will be sought from the eventual supplier of turbines for the proposed project that the turbines will emit no tonal component.

Turbine Noise Levels Assessment

A total of 1002 no. noise sensitive locations (NSLs) were identified within the study area and noise levels for each turbine type was predicted to the NSLs for wind speeds between cut-in and rated power (3m/s to 8m/s).

The maximum predicted noise levels were found at NSL No. 868 – a map illustrating this location is shown in Table 12-19.

Figure 12-20. Map of NSLs with exceedances.

This property satisfies the criteria as being 'financially involved' in the proposed project and, as set out in Section 12.3.2.3, it is appropriate to apply a night-time criteria of 45dB(A).

That being the case, the predicted noise levels do not exceed the criteria at any wind speed at all NSLs for both daytime and night-time periods.

A list of coordinates for all NSLs is given in Appendix 12C.

Colour noise contour plots for each turbine type are provided in Appendix 12E.

Description of Effects

Notwithstanding that operational noise criteria will not be exceeded as has been demonstrated above, for the purposes of quantifying the significance of effects, the range of effects per number of NSLs is given in Table 12-19. These are generated by comparing the predicted noise levels to the ambient (L_{Aeq}) levels.

Table 12-19. Summary of Range of Effects per No. of NSLs.

Category	Noise Level Change (dB)	No. of effected N SLs per Category[1]	Comments
Imperceptible/Not-Significant	<2.9	808 (80.6%)	WEDG-06 operational noise limits not exceeded.
Slight/Moderate	3.0 - 4.9	108 (10.8%)	WEDG-06 operational noise limits not exceeded.
Significant	5.0 - 9.9	84 (8.4%)	WEDG-06 operational noise limits not exceeded.
Very Significant/Profound	>10	2 (0.2%)	These are the two closest NSLs (Nos. 0851 and 0868) and are financial involved. WEDG-06 operational noise limits not exceeded.
[1]Total number of NSLs: 1002			

A summary of the description of effects is presented in Table 12-20.

Table 12-20. Summary of Description of Effects (Wind Turbine Operational Phase).

Aspect	Quality	Significance[1]	Duration
Wind Turbine Operations	Negative	Imperceptible – Very Significant depending on distance from turbines to NSL.	Long-term

Operational noise emissions assume no special audible characteristics including Amplitude Modulation, Tonality or Infrasound/Low Frequency Noise apply.

12.6.3.2 Substation and BESS

The noise impact assessment methodology for the Substation and Battery Energy Storage System (BESS) differs from wind turbines and as set out in Section 12.2.1, the methodology provided in BS4142:2014 is appropriate.

See Section 12.6.2.3, Figure 12-18 for details of the site.

Substation

A 110kV transformer is proposed for the Substation compound.

Noise measurements of an indicative model of the transformer being proposed were taken at an operational site near Kilteel, Co. Kildare on 15-2-2023. An image of the unit is below in Figure 12-21.

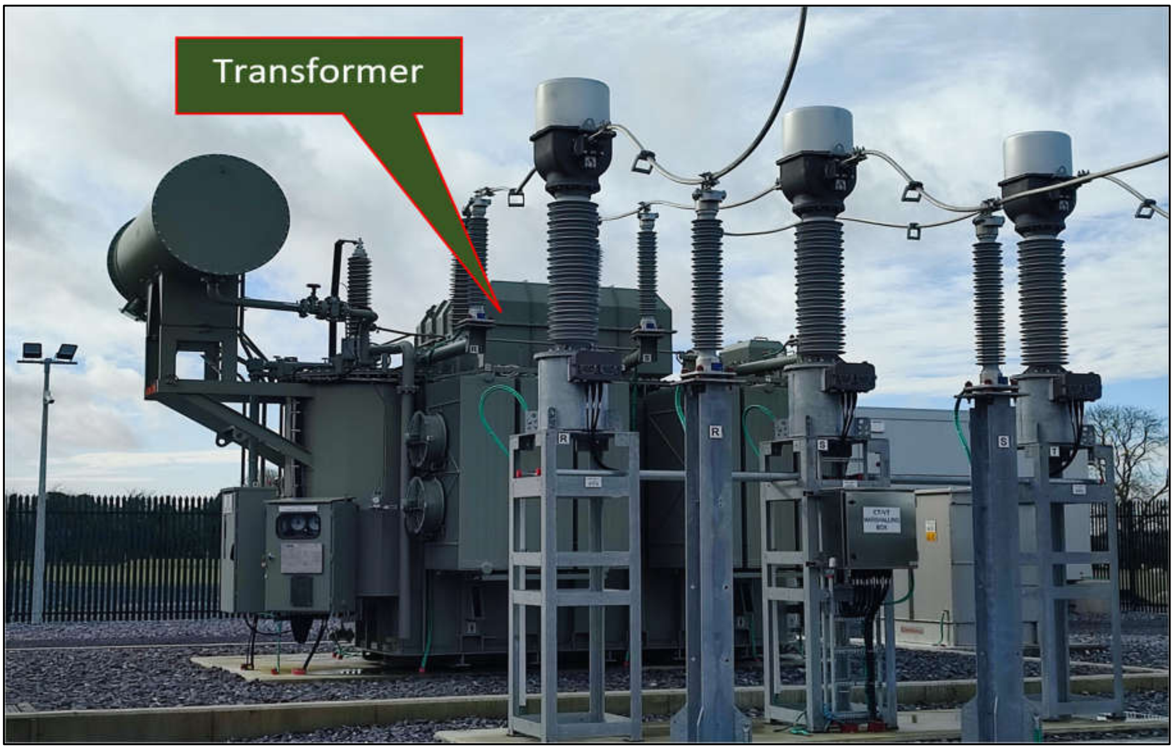

Figure 12-21. Indicative 110kV Transformer Unit.

Battery Energy Storage System (BESS)

The BESS consists of 12 no. battery storage units each with a separate external unit which incorporates an Inverter, Integrated Transformer and Climate Control.

The exact rating and design of the selected units will be subject to a separate planning application to Tipperary County Council, however, for the purposes of quantifying the noise impact of the BESS, indicative noise sources associated with a typical scheme is considered.

The battery units themselves emit little or no noise and the principal noise sources are as follows:

- 12no. Invertors (including transformer and climate control unit)

Noise measurements of indicative models of the units being proposed were taken at an operational site near Kilteel, Co. Kildare on 15-2-2023. Images of the units are below in Figure 12-22.

Figure 12-22. Typical Invertor and Battery Storage Units.

The measured Sound Power Levels (L_{WA}) of the Inverter and 110kV Transformer units are given in Table 12-21 below.

Table 12-21. Octave band sound power data of principal sources.

Plant Item	Z-weighted Octave Band Sound Power Level, Hz (dB)								Overall L_{WA} (dB)
	63	125	250	500	1K	2K	4K	8K	
Inverter	78.2	74.3	75.6	76.4	77.0	75.4	69.9	62.6	81.3
Transformer	74.2	75.8	77.8	74.5	71.0	64.7	60.7	55.1	76.1
dB re. 10^{-12} W									

A noise propagation model of the proposed Brittas Transformer and BESS was developed, and noise levels predicted following the same methodology set out in the section which follows.

The nearest NSL is c410m from the Substation and c452m from the closet Inverter. The predicted noise emission level at the closest NSL is 29dB L_{Aeq}

<u>Substation and BESS Noise Impact Assessment</u>

Following BS 4142:2014 guidance, the Specific (L_{Aeq}) noise level at the nearest NSLs as a result of the emissions from the Substation and BESS is compared with the measured Background (L_{A90}) noise levels.

The derivation of Background (L_{A90}) noise level is described in Section 8.1 of BS414:2014 as:

"the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods".

The typical Background (L_{A90}) noise levels derived from the noise survey data are set out in Section 12.5.2. As the units may operate at any time, it is appropriate to assess the night-time period as a worst case. The Background (L_{A90}) is therefore 30dB.

Acoustic Characteristics

Various acoustic characteristics may warrant a penalty being applied to the predicted noise levels at the NSLs to give the Rated Level (L_{Ar}).

The guidance sets out methodologies for the assessment of tonality and it is appropriate to use the 1/3 octave methodology here. This provides the following criteria for any 1/3 octave bands being greater then both adjacent bands:

- 15dB in low-frequency one-third-octave bands (25Hz to 125Hz);
- 8dB in middle-frequency bands (160Hz to 400Hz), and
- 5dB in high-frequency bands (500Hz to 10,000Hz).

A graph of the averaged measured 1/3 octave bands from the Inverter and Transformer is given in Figure 12-23. The average distances to the measurement locations were 1m and 2m respectively.

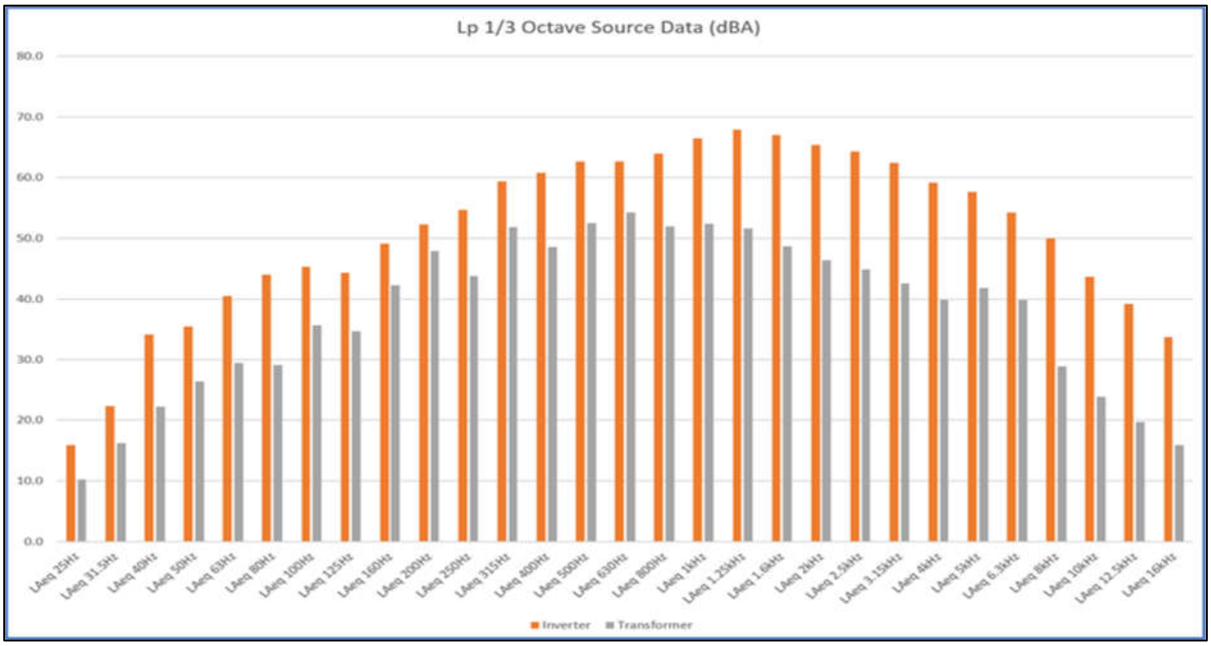

Figure 12-23. Noise Source 1/3 Octave Bands (L_{Ap})

It can be seen that the criteria for a tonal component are not satisfied and therefore no such penalty is applicable.

In addition, there is no Impulsivity or Intermittency characteristic associated with the operation of the Substation and BESS and therefore such penalties are not applicable.

A summary of the *BS4142:2014* impact assessment is given in Table 12-22.

Table 12-22. BS4142 Impact Assessment Summary.

Parameter	Results	Commentary
Measured background sound level, (L_{AF90})	30 dB	Typical night-time level
Calculated specific sound level, Ls (LAeq)	27 dB	At closest NSL
Acoustic feature correction	0 dB	Tone Standard: ISO 1996-2:2007 (simplified)
Manual correction	0 dB	N/A
Rating level, L_{Ar}	29 dB	
Excess of rating over background sound level	-3 dB	
Assessment indicates a likely adverse impact?	No, not likely	
Context of the assessment		No adverse impact is likely.

Description of Effects

The potential worst-case effects associated with the Substation and BESS are derived by comparing the predicted noise levels with the existing ambient levels given in Section 12.5.2. The criteria given in Section 12.2.1 is applied and the results are presented in Table 12-23.

Table 12-23. Summary of Description of Effects (Substation and BESS).

Aspect	Quality	Significance	Duration
Substation and BESS	Negative	Imperceptible	Long-term

12.7 Mitigation and Monitoring Measures

The assessment of potential impact has demonstrated that the proposed project is expected to comply with the adopted criteria for the construction, operational and decommissioning phases without mitigation. Nevertheless, to ameliorate any noise and vibration effects, a schedule of noise and vibration control measures should be formulated for both construction and operational phases.

12.7.1 Construction Phase

Regarding construction activities, reference shall be made to *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise,* which offers guidance on the control of noise and vibration from construction activities. It is proposed that best practices be adopted during construction as required, including the following:

- The construction programme will be managed to ensure that plant with the highest levels of noise and vibration emissions are not operated simultaneously and for the minimum amount of time as practicable;
- Channels of communication between the contractor/developer, Local Authority and residents will be established;
- A site representative responsible for matters relating to noise and vibration will be appointed; and
- Keeping the surface of the site access roads even to mitigate the potential for vibration from lorries.

Furthermore, a variety of practicable noise control measures will be employed. These include:

- Selection of plant with low inherent potential for generation of noise and/or vibration;
- Placing of noisy/vibratory plant as far away from sensitive properties as permitted by site constraints

12.7.1.1 Noise

The contract documents shall specify that the Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures when deemed necessary to comply with the recommendations of *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction on open sites – Noise.* The following list of measures will be implemented to ensure compliance with the relevant construction noise criteria:

- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working for the duration of the contract.
- Compressors will be attenuated models, fitted with properly lines and sealed acoustic convers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers.
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use.
- Any plant, such as generators or pumps, which is required to operate before 07:00hrs or after 19:00hrs will be surrounded by an acoustic enclosure or portable screen.
- During the construction programme, supervision of the works will include ensuring compliance with the limits detailed in Section 0 using methods outlined in *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.*
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall be restricted to between 07:00hrs and 19:00hrs weekdays and between 07:00hrs and 14:00hrs on Saturdays. However, to ensure that optimal use is made of good weather period or at

critical periods within the programme (i.e., concrete pours) or to accommodate delivery of large turbine component along public routes it could be necessary on occasion to work outside of these hours. Any such out of hours working will be agreed in advance with the local Planning Authority.

12.7.1.2 Vibration

Distances between construction locations and the nearest NSLs are such that vibration levels as a result of construction activities including any necessary piling will be below the values set out in Table 12-4. No mitigation measures are therefore proposed.

12.7.1.3 Blasting

The following mitigation measures will be employed to control the impact during blasts:

- Trial blasts will be undertaken to obtain scaled distance analysis.
- Ensuring appropriate burden to avoid over or under confinement of the charge.
- Accurate setting out and drilling.
- Appropriate charging.
- Appropriate stemming with appropriate material such as sized gravel or stone chipping.
- Delay detonation to ensure small maximum instantaneous charges.
- Decked charges and in-hole delays.
- Blast monitoring to enable adjustment of subsequent charges.
- Good blast design to maximise efficiency and reduce vibration.
- Avoid using exposed detonating cord on the surface.

12.7.2 Operation Phase

An assessment of the operation noise levels has been undertaken in accordance with best practice guidelines and procedure as outlined in Section 12.3.2.

As has been demonstrated the operation of the proposed project is not expected to exceed the daytime or night-time noise criteria at any of the NSLs considered, and therefore no specific mitigation measures need apply.

Furthermore, if the proposed project is permitted and constructed, a post-commissioning noise survey with the selected wind turbines operating will be carried out and any exceedances of the planning conditions which can be attributed to the Wind Farm will be mitigated by curtailment.

In the unlikely event that an issue with any special audible characteristic is associated with the proposed project, an appropriate detailed investigation will be undertaken and due consideration shall be given to the appropriate guidance on conducting such an investigation outlined in Section 12.3.2.7.

12.7.2.1 Substation and BESS

The impact assessment has demonstrated that there is no significant effect and therefore no mitigation is required.

12.7.3 Decommissioning Phase

Activities and noise levels associated with the decommissioning phase are expected to be similar to the construction phase. The mitigation measures that will be considered in relation to any decommissioning of the site are the same as those proposed for the construction phase of the development.

12.7.4 Compliance Monitoring

12.7.4.1 .Construction Phase

Noise and vibration monitoring in accordance with the guidance contained in BS 5228-1:2009 during the construction and decommissioning phases shall be undertaken to ensure compliance with the criteria or if noise complaints are received.

12.7.4.2 Operational Phase

If a noise complaint or evidence of an exceedances of the noise limits were to occur, a detailed assessment following the guidance outlined in the IOA GPG and Supplementary Guidance Note 5: Post Completion Measurements (July 2014) will be followed, and relevant corrective actions will be taken. For example, implementation of operational modes resulting in curtailment of turbine operations can be implemented for specific turbines in specific wind conditions to ensure noise levels are within the relevant noise criterion/planning conditions.

12.8 Residual Effects

This section summarises the likely residual noise and vibration effects associated with the proposed project following the implementation of mitigation measures.

12.8.1 Operational Phase

The predicted noise levels associated with the wind turbines of the proposed project are anticipated to operate within best practice noise criteria recommended in Irish guidance *'Wind Energy Development Guidelines for Planning Authorities, 2006'*, and has been assessed following guidance from ETSU-R-97 and the IOA GPG and its supplementary guidance notes.

In the event of a noise exceedance or complaint, an option to mitigate using with a curtailment programme is available. This would not necessarily reduce the effect significance but will ensure that it does not increase.

The post mitigation range of residual noise effects is expected to remain between Imperceptible to Very Significant depending on the distance to the NSL.

12.8.2 Construction / Decommissioning Phase

During the construction/decommissioning phases of the project, the significance of noise effect ranges from Imperceptible to Very Significant depending on the activity and distance to the NSL.

After the proposed mitigation measures have been put to practice, the range of residual noise effects is expected to be reduced to Imperceptible to Significant. Furthermore, the application of binding noise limits and hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that noise and vibration effect is kept to a minimum.

Substation & BESS

The significance of noise effects from the operation of the Substation and BESS is expected to be Imperceptible at even the closet NSL. No mitigation measures are required and so the residual noise effects will remain as imperceptible

Vibration

The significance of vibration effect range from Imperceptible for construction activities, to Not Significant for blasting activities. No mitigation measures are set out and so the residual vibration effects will remain as Imperceptible/Not Significant.

There are no sources of vibration associated with the operational phase of the proposed project. The residual vibration effect will therefore remain as Imperceptible.

12.8.3 Cumulative Effects of other Wind Farms

This assessment has considered the potential cumulative impacts of the proposed project in combination with other wind energy developments in the area as required by best practice guidance discussed in Section 12.3.2.1. There is no other wind farm development, existing or proposed within 5km of the proposed project. It is therefore considered that a significant effect is not associated with the proposed project in combination with other wind farm developments

12.9 Conclusion / Summary

When considering a project of this nature, the potential noise and vibration effects on the surrounding area must be considered for two scenarios: the short-term construction/decommissioning and the long-term operational phase.

The assessment of construction noise and vibration and has been conducted in accordance best practice guidance contained in BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise and BS 5228-2:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Vibration. Subject to good working practice as recommended in the EIAR, noise and vibration levels associated with the construction phase are not expected to exceed to recommended limit values and are not expected to cause a significant adverse effect.

Based on detailed information on the site layout, turbine noise emission levels and turbine height, worst-case cumulative turbine noise levels have been predicted at NSLs for a range of operational wind speeds. Noise criteria have been derived following the Irish Wind Energy Development Guidelines (2006) and assessed following guidance in ETSU-R-97 and Institute of Acoustic Guidelines published in 2014. The predicted operational noise levels are not expected to exceed the noise criteria. No significant vibration effects are associated with the operation of the site.