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Chapter 11 – Noise & Vibration

Ballynisky Wind Farm

Ballynisky Green Energy Ltd.

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11. Noise

11.1 Introduction

The purpose of the chapter is to assess any likely significant effects on the environment as a result of noise and vibration from the proposed development. The proposed development is a wind farm and associated grid connection within the townlands of Ballynisky, Graigoor, Ballyegny More, Kilbradran, Ballysteen, Dunmoylan, Carrons and Lisbane, to the west of Coolcappa, Co. Limerick. It lies approximately 9km north of Newcastle West and 6km northwest of Rathkeale. The development comprises six (6) wind turbines with a total overall height of 158m, an on-site 38kV electrical substation and two grid connection options. Option A is an underground electrical connection to an existing 38kV substation at the nearby Carrons Wind Farm which is connected to the National Grid. Option B is to loop into the existing 38kV overhead line that transects the site. The line would be cut, and an underground line ran to the proposed 38kV substation on site and back out to connect to the existing line continuing towards the Rathkeale 110kV substation

The nearest existing residential dwelling to a turbine is approximately 648m north of Turbines 1 and 6, which is greater than four times the turbine tip height.

Noise and vibration impact assessments have been prepared for the construction, operational and decommissioning phases of the proposed development. To inform this assessment, 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.

Other wind farm developments (operational, permitted or proposed) with the potential for cumulative impacts were identified and assessed as part of this assessment. Two developments were identified with the potential for cumulative impacts. Following best practice guidance contained within the Institute of Acoustics (IoA) document, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (2013)*, the cumulative impact of the other wind farm developments has been included in the operational noise impact assessment of the proposed development.

11.1.1 Statement of Authority

This assessment was prepared in accordance with the EIA Directive 2011/92/EU as amended by Directive 2014/52/EC, current EPA guidelines and best practice by the following staff of Enfonic Ltd.

Gary Duffy, BEng, MIOA (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.

Patricia Redondo (Acoustic Consultant) holds a BEng in Communication Systems Engineering, MSc in Acoustic Engineering and is an associate member of the Institute of Acoustics (AMIOA). She has considerable expertise in the assessment of wind turbine noise and has conducted many similar impact assessments for EIARs.

11.1.2 Fundamentals of Acoustics

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 130dB (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 to do this. An 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 indicated in **Table 11-1**.

Table 11-1: Indication of the level of Common Sounds

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 11A** of **Volume III** of the **EIAR.**

11.2 Assessment Methodology and Significance Criteria

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

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

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

- 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 development; and
- Describe the significance of the residual noise and vibration effects associated with the proposed development.

In addition, the following guidelines were considered and consulted for the purposes of this chapter:

- EPA Guidelines on the Information to be contained in Environmental Impact Assessment Reports (2022) and;
- EPA Advice Notes on Current Practice (in the preparation of Environmental Impact Statements), (2003).

11.2.1 Description of Effects

The significance of effects of the proposed development shall be described in accordance with the Environmental Protection Agency (EPA) guidance document *Guidelines on the information to be contained in Environmental Impact Assessment Reports* (EIAR), 2022.

The EPA guidelines do not 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).

Table 11-2 presents the degree of effect matrix from the IEMA guidelines and **Table 11-3** presents the effect descriptions.

Table 11-2: Degree of Effect Matrix (IME, 2014)

Magnitude / Scale of Change	Sensitivity of Receptor			
	High	Medium	Low	Negligible
Large	Very Substantial	Substantial	Moderate	None
Medium	Substantial	Substantial	Moderate	None
Small	Moderate	Moderate	Slight	None
Negligible	None	None	None	None

Table 11-3: Effects Descriptions (IMEA, 2014)

Effect	Description
Very Substantial	Greater than 10 dB LAeq change in sound level perceived at a receptor of great sensitivity to noise
Substantial	Greater than 5 dB LAeq change in sound level at a noise-sensitive receptor, or to a 5 to 9.9 dB LAeq change in sound level at a receptor of great sensitivity to noise
Moderate	A 3 to 4.9 dB LAeq change in sound level at a sensitive or highly sensitive noise receptor, or a greater than 5 dB LAeq change in sound level at a receptor of some sensitivity
Slight	A 3 to 4.9 dB LAeq change in sound level at a receptor of some sensitivity
None/Not Significant	Less than 2.9dB LAeq change in sound level and/or all receptors are of negligible sensitivity to noise or marginal to the zone of influence of the proposals.

For this assessment, it has been assumed that dwellings have high sensitivity. **Table 11-4** presents the impact scale adopted in this assessment as well as the corresponding significance of impact based on definitions presented in the *Guidelines on the Information to be contained in Environmental Impact Assessment Reports (EPA, 2022).*

Table 11-4: Effects Descriptions (IMEA, 2014 and EPA 2022)

Noise Level change dB(A)	IEMA Guidelines	EPAs Significance of Effects
Less than 2.9	None/Not significant	Imperceptible
		Not Significant
3.0 – 4.9	Slight	Slight
	Moderate	Moderate
5.0 – 9.9	Substantial	Significant
Greater than 10.0 dB	Very Substantial	Very Significant
		Profound

For the purposes of this assessment, effects rated as '**Significant**' or above are deemed Significant in EIA terms. Effects identified as 'Moderate' significance or below are '**Not Significant**' in EIA terms.

11.3 Guidance

The assessment of impacts for the proposed development have been undertaken with reference to the most appropriate guidance documents relating to environmental noise and vibration. In addition to guidance detailed in **Chapter 02 Background** of the **EIAR**, the following guidelines in particular were considered and consulted for the purposes of this assessment:

- EPA Guidelines on the Information to be contained in Environmental Impact Assessment Reports (May 2022);
- EPA Advice Notes for Preparing Environmental Impact Statements;
- BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites - Part 1 – Noise;
- BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites - Part 2 -Vibration;
- British Standard BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground borne vibration reference;
- Minerals Policy Statement 2: Controlling and Mitigating the Environmental Effects of Minerals Extraction in England, 2005;
- NRA/TII Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes 2014;
- Design Manual for Roads and Bridges (UK): 2020 (DMRB);
- ISO 1996: 2017: Acoustics - Description, Measurement and Assessment of Environmental Noise;
- The Assessment and Rating of Noise from Wind Farms (1996) published by Department of Trade & Industry (UK) Energy Technology Support Unit;

- Institute of Acoustics' Good Practice Guides to the Application of ETSU-R-97;
- Wind Energy Development Guidelines from the Department of Housing, Local Government and Heritage; and
- Limerick Development Plan 2022-2028.

11.3.1 Construction Phase Noise

11.3.1.1 BS5228

To set appropriate construction noise limits for the proposed development, reference has been made to *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise*. This 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. One suggested method for determining threshold noise levels is known as 'ABC method'. This 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 11-5**.

Table 11-5: BS 5228 – Example of significant effect at dwellings

Assessment category and threshold value period (LAeq)	Threshold value, in decibels (dB)		
	Category A (A)	Category B (B)	Category C (C)
Night-time (23.00–07.00)	45	50	55
Evenings and weekends D)	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 LAeq 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 LAeq 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.			

11.3.2 Construction Phase Vibration

Vibration emissions are limited to the construction phase of the proposed development and the grid connection route. There are no significant adverse vibration impacts expected from the proposed development once operational.

To prevent structural damage to buildings, suitable criteria can be found in the following guidance:

- BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from ground-borne vibration (1993); and

- BS 5228 – Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration (2009+A1:2014).

The relevant criteria used for building protection is expressed in terms of Peak Particle Velocity (PPV) in mm/s. These standards provide different criteria for the prevention of cosmetic damage as set out in Error! Reference source not found..

Table 11-6: Summary of British Standard Vibration Criteria

Standard	Freq. Range 1 / Limit	Freq. Range 2 / Limit	Freq. Range 3 / Limit
BS 7385	<10Hz 8mm/s	10-50Hz 12.5mm/s	>50Hz 20mm/s
BS 5228	<15Hz 15mm/s	>15Hz 20mm/s	N/A

11.3.2.1 NRA/TII Good Practice Guidance

The *NRA/TII Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes 2014,* goes on to recommend that to prevent the potential for vibration induced damage to buildings during construction, vibration from road construction activities should be limited to the values set out in **Table 11-6**.

Table 11-6: Allowable Vibration at Sensitive Properties

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

These values have been derived through consideration of the various standards discussed above; compliance with this guidance should ensure that there is little to no risk of even cosmetic damage to buildings.

11.3.3 Operational Phase Noise

The noise assessment summarised in this chapter is based on 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.

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.

11.3.3.1 Wind Energy Development Guidelines for Planning Authorities

Section 5.6 of the *Wind Energy Development Guidelines for Planning Authorities* ("Wind Energy Development Guidelines") published by the Department of the Environment, Heritage and Local Government (2006) outlines the appropriate noise criteria in relation to 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 the Guidelines in relation to what constitutes an 'appropriate balance'. Guidance will be taken from alternative and appropriate publications.

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 $L_{A90,10min}$ 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(A) $L_{A90,10min}$ for low noise environments where the background noise is less than 30 dB(A).

This follows a review of on-going developments in terms of Irish guidance on the issue of wind turbine noise and is considered appropriate in light of the following:

> *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.*

Based on a review of the aforementioned EPA NG4 national guidance in relation to acceptable noise levels in areas of low background noise, it is considered that the criteria adopted as part of this assessment are appropriate.

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).

- 43dB for night-time periods or a maximum increase of 5dB above background noise (whichever is the higher).[1]

Period definitions from the IoA GPG are as follows:

- Daytime Amenity hours are:
    - All evenings from 18:00 to 23:00hrs;
    - Saturday afternoons from 13:00 to 18:00hrs; and
    - All day Sunday from 07:00 to 18:00hrs.
- Night-time hours are 23:00 to 07:00hrs.

11.3.3.2 Future Potential Guidance Changes

Proposed changes to the assessment of noise impacts associated with onshore wind energy developments were issued in December 2019. As part of the public consultation process of the *Draft Revised Wind Energy Development Guidelines December 2019* guidance, 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 is 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 core of the assessment presented in this report is based on the only guidance currently in force outlined in Section 5.6 of the *Wind Energy Development Guidelines for Planning Authorities 2006*.

11.3.3.3 Local Planning Guidance

Limerick City & County's Development Plan 2022-2028 (section 11.7.2.1 Wind Energy) states the following in relation to planning applications for renewable energy schemes:

> "They will be considered in the context of current Government policy on the subject but will take into account other, often competing, Council policies and any relevant guidelines issued from time-to-time by the Department of Housing, Local Government and Heritage."

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

> "When assessing planning applications for wind energy developments the Planning Authority will have regard to the Wind Energy Development Guidelines for Planning Authorities (2006).
>
> Background noise surveys shall be carried out in accordance with A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (2013), unless current guidelines require otherwise.
>
> Noise levels, including the addition of any penalties for special audible characteristics, shall comply with current guidelines;
>
> Any proposed lower fixed noise limit for night-time at noise sensitive properties shall not exceed 38 dB(A) L90 or 5dB(A) above background noise levels, whichever is the greater;

[1] While the caveat of an increase of 5dB above background 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. For the purposes of this assessment consideration will be given to the commonly adopted approach of also applying the 5dB(A) above background allowance for night-time periods as well as the daytime period.

> Cumulative low frequency noise levels for one-third octave bands between 10 Hz and 160 Hz ($L_{pA,LF}$) from wind turbines shall not exceed 20 dB(A) at evening and night (19:00 to 07:00 hours) and 25 dB(A) during the day (07:00 to 19:00 hours), at any wind speed inside habitable rooms of noise sensitive properties when measured at locations meeting the requirements of the Environmental Noise Regulation of Denmark (Orientering nr. 45);
>
> Where noise levels interfere with the amenities of the area, the operator shall comply with any requirements of the Planning Authority to undertake an investigation (including shutting down wind turbines for background noise monitoring if required) and implement mitigation measures, up to and including taking turbine(s) out of operation."

This criteria suggests that where special characteristics or rated levels are to be considered, the rated noise levels should comply with the existing WEDG06 criteria identified above, but where it is a fixed LA90 limit the 38dB or 5dB above the background should be applied. This is consistent with the conservative consideration of the maximum 5dB penalty difference between the rated level and measured LA90, but it does provide a different night-time limit level when comparing the Development Plan to WEDG06.

11.3.3.4 The Assessment and Rating of Noise from Wind Farms – ETSU-R-97

The core of the noise guidance contained within the Wind Energy Development Guidelines document is based on the 1996 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.

11.3.3.5 Institute of Acoustics' Good Practice Guidance (GPG)

The original ETSU-R-97 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* including six 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 guidance contained within the Institute of Acoustics (IoA) document, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (2013) (GPG)*, and *Supplementary Guidance Notes* are considered to represent best practice and have been adopted for this assessment. The IOA GPG states, that at a minimum, continuous background noise monitoring should be carried out at the nearest NSLs, for typically a two-week period, and should capture a representative sample of wind speeds in the area (i.e. cut in speeds to wind speed of rated sound power of the proposed turbine). Background noise measurements (i.e. $L_{A90,10min}$) should be related to wind speed measurements that are collected at the site of the wind turbine development. A best-fitting polynomial curve is applied to these data sets, to derive background noise levels at various wind speeds to establish the appropriate daytime and night-time noise criterion limits.

The study area is defined in the Good Practice Guide 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."*

11.3.3.6 ISO 9613: Acoustics – Attenuation of sound outdoors

Noise emissions associated with the wind turbine(s) can be predicted in accordance with *ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation (1996)*. This is a noise prediction standard that considers noise attenuation offered, amongst others, by distance, ground absorption, directivity and atmospheric absorption. Noise predictions and contours are typically prepared for various wind speeds and the predicted levels are compared against the relevant noise criterion curve to demonstrate compliance with the appropriate criteria.

Where noise predictions indicate that reductions in noise emissions are required in order to satisfy any adopted criteria, consideration can be given to detailed downwind analysis and operating turbines in low noise mode, which is typically offered by modern wind turbine units.

11.3.3.7 World Health Organisation (WHO) Noise Guidelines for the European Region

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."*

11.3.3.8 Noise Limits

The recommendations for wind turbine noise are therefore conditional and based on the professional competence and expertise of the authors, the combination of guidance provided in WEDG 2006, ETSU, IOA GPG and SGNs is considered best practice and have been adopted for this assessment.

The noise limits for the Ballynisky Green Energy Project are set out in **Section 11.6.3.2** below.

11.3.3.9 Special Audible Characteristics

Wind turbine noise emissions may exhibit some 'Special Audible Characteristics' which would render the noise more annoying than the equivalent noise emission level without such characteristics. It may therefore be appropriate to apply a rating penalty to a noise level to account for this factor.

Warranties from the supplier will be sought to ensure some characteristics can never be present e.g. tonality. Others may be controlled by curtailment e.g. Amplitude Modulation. In all cases, it is not possible to predict the occurrence of any special characteristic at the planning stage. Post-construction monitoring programmes and campaigns following prescribed guidelines can objectively investigate these characteristics. It should also be noted that these are rare events associated with a limited number of wind farms. Nevertheless, the details and assessment of each is set out below.

1. <u>Infrasound/Low Frequency Noise</u>

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, 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."*

2. <u>Amplitude Modulation</u>

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.

'Normal' AM

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 RenewableUK AM project (RenewableUK, 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.

'Other' AM

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 RenewableUK 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

Prediction of AM

It should be noted that AM is associated with wind turbine operation under site specific conditions, and there is currently no mechanism 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 unlikely and is the exception rather than the rule.

RenewableUK 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 above reasons AM is not considered in this noise impact assessment.

3. <u>Tonal Noise</u>

Tonality is a characteristic that is applicable to a wide range of sound descriptions, such as 'humming', 'droning', 'whining', 'whistling', 'buzzing' etc., depending on the frequencies in the sound and its harmonic structure. These sounds are associated with concentrations of energy into very narrow parts of the frequency spectrum, which may include a single tone or multiple tones.

Tonal noise from wind turbines, characterized by a distinct "hum" or "whine" at a steady pitch, is relatively rare in modern turbines. This type of noise is typically caused by mechanical components or unusual wind currents interacting with turbine parts. Advances in turbine design have significantly reduced the occurrence of tonal noise, making it much less common in newer models. 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. In the event of a complaint regarding tonality, a detailed assessment following the guidance outlined in the IOA GPG and Supplementary Guidance Note 5: Post Completion Measurements (July 2014) will be followed.

Furthermore, a guarantee will be required in the procurements of the turbine to be used onsite, stating that there should be no clearly tonal or impulsive components audible at any noise sensitive receptor location.

4. <u>Assessment of Operational Special Characteristics</u>

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

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; and*

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

A suitable Noise Complaint Monitoring Programme (NCMP) will be implemented for the proposed development. Should a noise complaint or evidence of an exceedance of the noise limits occur, a detailed assessment and appropriate mitigation measures such as a curtailment programme on the wind turbine operations will be undertaken. The NCMP will follow the guidance outlined in the IOA GPG and Supplementary Guidance Note 5: Post Completion Measurements (July 2014).

11.3.3.10 Comment on Health Impacts

1. <u>The National Health and Medical Research Council</u>

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".*

2. <u>Health Canada</u>

Health Canada, Canada's national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014. 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.

3. <u>New South Wales Health Department</u>

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.

4. <u>The Australian Medical Association</u>

The Australian Medical Association put out a position statement, *Wind Farms and Health 2014*. 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."*

5. <u>Journal of Occupational and Environmental Medicine</u>

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.

6. <u>Health Service Executive (HSE) Public Health Medicine Environment and Health Group</u>

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."

11.3.4 Operational Phase Vibration

Ground borne vibration waves are attenuated rapidly as they propagate from a source through the substrate. During operation, modern wind turbines do not generate sufficiently high levels of vibration to be perceptible at any distance much beyond the turbine foundations. Typically, at a distance of 100 m from a 1 MW turbine unit the level of operational vibration is the order of 5-10 mms-1 which would be imperceptible.

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. Considering that the shortest distance measured from an existing sensitive receptor external amenity to a turbine hardstanding is greater than 648m for the proposed development, the level of vibration will be significantly below the threshold for perceptibility and operational vibration levels would be imperceptible. Therefore, they are excluded from this assessment.

11.3.5 Assessment of Cumulative Turbine Noise Impacts

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:

> *"5.1.1 ETSU-R-97 states at page 58, "…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…"*
>
> *5.1.2 The HMP[2] Report states that "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.*
>
> *5.1.3 As with the assessment of noise for all wind farm developments, sequential steps need to be taken, but such steps require more detailed attention due to the added complexity of cumulative noise impacts. The advice of the EHO[3] could be invaluable to this part of the assessment."*

Cumulative impact assessment necessary

> *5.1.4 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*

[2] HMP: Hayes McKenzie Partnership Ltd. Report on "Analysis of How Noise Impacts are considered in the Determination of Wind Farm Planning Applications" Ref HM: 2293/R1 dated 6th April 2011
[3] Environmental Health Officer

10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.

5.1.5 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."

11.3.5.1 Noise Conditions for Other Wind Farm Developments

It is a requirement that turbine noise emissions from all existing, permitted and proposed wind energy developments are included in the cumulative noise impact assessment. Two wind farms have been identified in the cumulative assessment review as follows:

- Carrons Wind Farm:
    - The Carrons wind farm comprises two (2) Enercon E82 Wind turbines, with 85m hub height; and
    - The planning condition noise limit is 45dBA (no reference period mentioned).
- Grouse Lodge Wind Farm:
    - The Grouse Lodge wind farm comprises six (6) Nordex N90 Wind turbines, with 80m hub height; and
    - The planning condition noise limit is 45dBA (no reference period mentioned).

11.4 Decommissioning Phase

In relation to the decommissioning phase, the criteria and limits outlined in the construction phase with respect to noise and vibration for the proposed development would be applicable, as similar tools and the equipment will be used albeit for a shorter period of time.

11.5 Baseline Noise Survey of the Receiving Environment

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

1. Appropriate wind-speed dependant LA90 values are used to derive the operational cumulative noise limits for the wind turbines, and;

2. The average ambient Daytime LAeq,T noise levels are used:

a) to derive the construction noise limits and;

b) for the purposes of describing the effects of the operational phase of the Proposed Development.

11.5.1 Study Area

The initial study area is defined in the IOA GPG as:

"The study area should cover at least the area predicted to exceed 35dB LA90 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 total of 152no. NSLs were identified and the schedule of locations is provided in **Appendix 11C**.

A map showing the NSLs is provided in **Figure 11-1**.

MWP

Figure 11-1: Noise Sensitive Locations

11.5.2 Baseline Noise Survey

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

A review of the NSLs provided an understanding of the range of ambient noise conditions within the study area. For example, some NSLs are located closer to agglomerations, roads or other noise sources then than others. Using this information, a range of suitable Noise Monitoring Locations (NMLs) were selected to serve as proxy locations and therefore in the expert opinion of the author, are representative of the ambient noise conditions at all NSLs within the study area.

A noise monitoring programme was conducted at 5no. NMLs. 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.

This was done through installing unattended Noise Monitoring Terminals (NMTs) at representative locations in the surrounding area of the site between 3-Mar-2022 and 22-Mar-2022. There have been no significant developments or change in activities since and it is therefore considered that the measured noise levels remain valid.

In addition, wind speed data at hub height was provided by an on-site LiDAR scanner which allows for later analysis of wind speed dependant noise levels. The locations are shown in in **Figure 11-2** and detailed in **Table 11-7**.

MWP

Figure 11-2: Noise Monitoring Locations

Table 11-7: NMTs coordinates and descriptions

Location	Grid Coordinates		Description
	ITM (X)	ITM (Y)	
NMT 1	529523	643758	In open area c20m north of farm building.
NMT 2	531008	643120	c50m west of farm building containing cattle.
NMT 3	530945	642308	Within courtyard c20m north of house.
NMT 4	530536	641494	In open space, c20m north of house
NMT 5	529093	642648	C5m east of stables

No significant sources of vibration were observed at any of the survey locations. Observed noise sources at all locations included agricultural activities, livestock, wind induced noise in foliage, occasional local traffic, distant traffic, bird song and domestic activities associated with occupied dwellings.

11.5.3 Instrumentation

The equipment installed at each Noise Monitoring Location (NML) consisted of a Class 1 Sound Level Meter (SLM), outdoor microphone, secondary (double) windscreen, batteries etc. which fully met the requirements set out in ETSU and IOA GPG.

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

Rainfall was monitored using a rain gauge installed at NML3 and NMT4. These locations where chosen to ensure suitable coverage across the study area which 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.

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

Noise levels in terms of measurement parameters $L_{Aeq,10min}$ and $L_{A90,10min}$ were logged by each SLM. Instrumentation details, calibration certificates and photographs of the installations are given in Appendix 11B.

11.5.4 Measurement Periods

The survey was conducted in general accordance with *ISO 1996: 2017: Acoustics - Description, Measurement and Assessment of Environmental Noise* and followed the methodology contained in EPA NG4.

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."

Specific details are set out below.

The monitoring periods for each site is outlined in Table 11-8.

Table 11-8: Noise Measurements Periods

Location ID	Start date	End date
NMT1	03/03/2022	07/04/2022
NMT2	03/03/2022	07/04/2022
NMT3	03/03/2022	07/04/2022
NMT4	03/03/2022	07/04/2022
NMT5	03/03/2022	07/04/2022

A variety of wind speed and weather conditions were encountered over the survey period. **Figure 11-3** shows a sample distribution of wind speed and direction recorded between 3-3-2022 and 28-3-2022, at a hub height of 90m.

It was confirmed that the survey periods were of sufficient duration to measure adequate data to determine suitable representations of typical background noise levels.

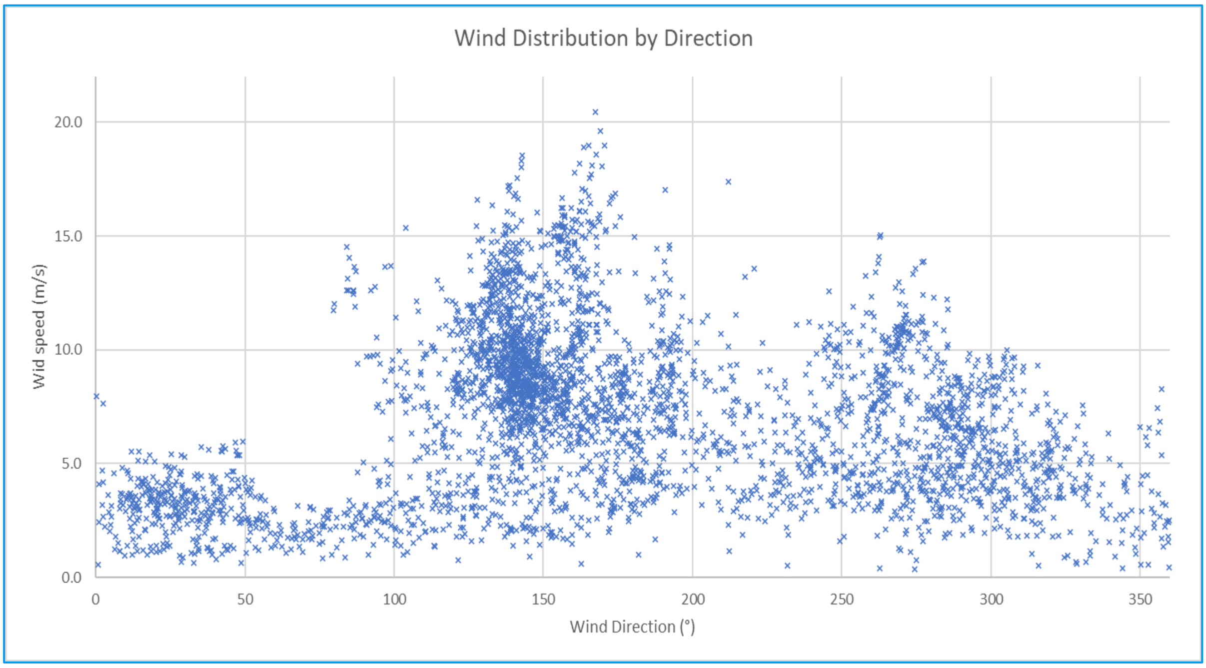

Figure 11-3: Sample of Distribution of Wind Speed/Direction at 90m

11.5.5 Instrumentation

Each NMT consisted of a class 1 Sound Level Meter (SLM), outdoor microphone, secondary windscreen, batteries etc. which fully met the requirements set out in ETSU and IoOA guidance. Details of the SLMs used are given in **Table 11-**.

Table 11-10: Noise Measurement Instrumentation

Location	Equipment	Serial Number
NMT1	Brüel & Kjær Type 2250 G4 SLM	3010911
NMT2	Brüel & Kjær Type 2250 G3 SLM	2567756
NMT3	Brüel & Kjær Type 2250 G4 SLM	3007000
NMT4	Brüel & Kjær Type 2250 Light G4 SLM	3001350
NMT5	Brüel & Kjær Type 2250 G4 SLM	2820751

Before and after the measurements, the instruments were field calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator. Refer to **Appendix 11B** Noise Survey Details and Calibration Certs.

Rainfall was monitored using two rain gauges installed at NMT3 and 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.*

11.5.6 Consideration of Wind Shear

Wind shear is defined as the increase of wind speed with height above ground. As part of robust wind farm noise assessment, due consideration should be given to the issue of wind shear. The issue of wind shear has been considered in this assessment and followed relevant guidance as outlined in 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 types.

The background noise data has been analysed with respect to a 10m standardised height based on an assessment hub height of 90m in accordance with the guidance contained in the IoA GPG, *Supplementary Guidance Note (SGN) 4: Wind Shear, July 2014*.

Any reference to wind speed in the following sections of this chapter should be understood to be the 10m height standardised wind speed reference unless otherwise stated.

11.5.7 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.

11.5.8 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 the amenity periods.

11.5.8.1 Background Noise Levels Results

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. This is done for the daytime and night-time periods and are set in **Figure 11-4** to **Figure 11-13**.

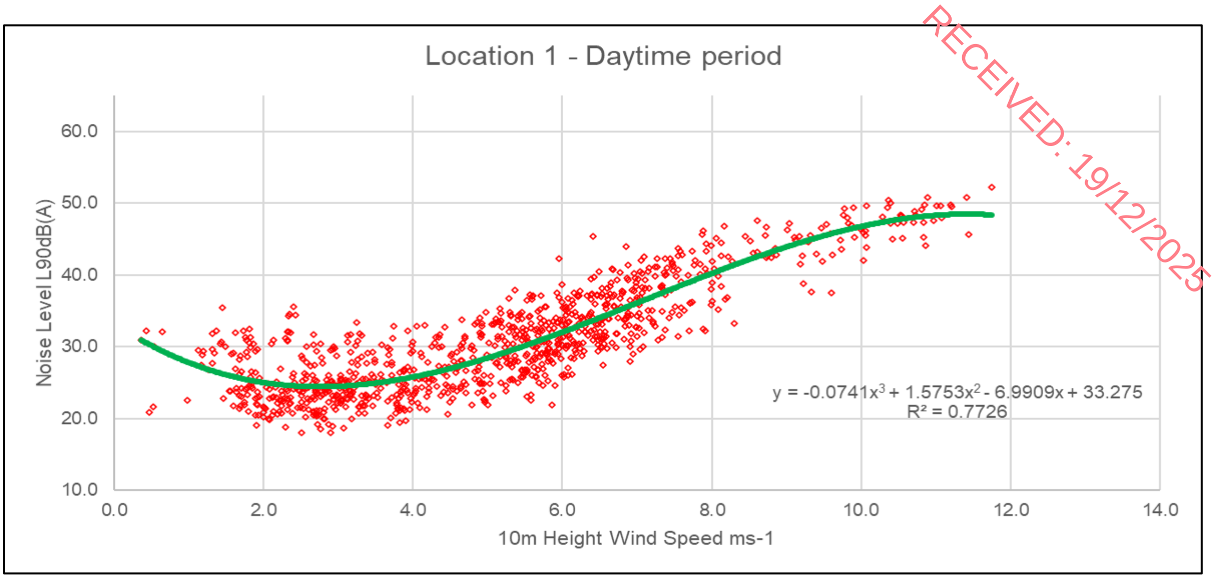

Figure 11-4: Location NMT 1 – Background noise – Daytime Period

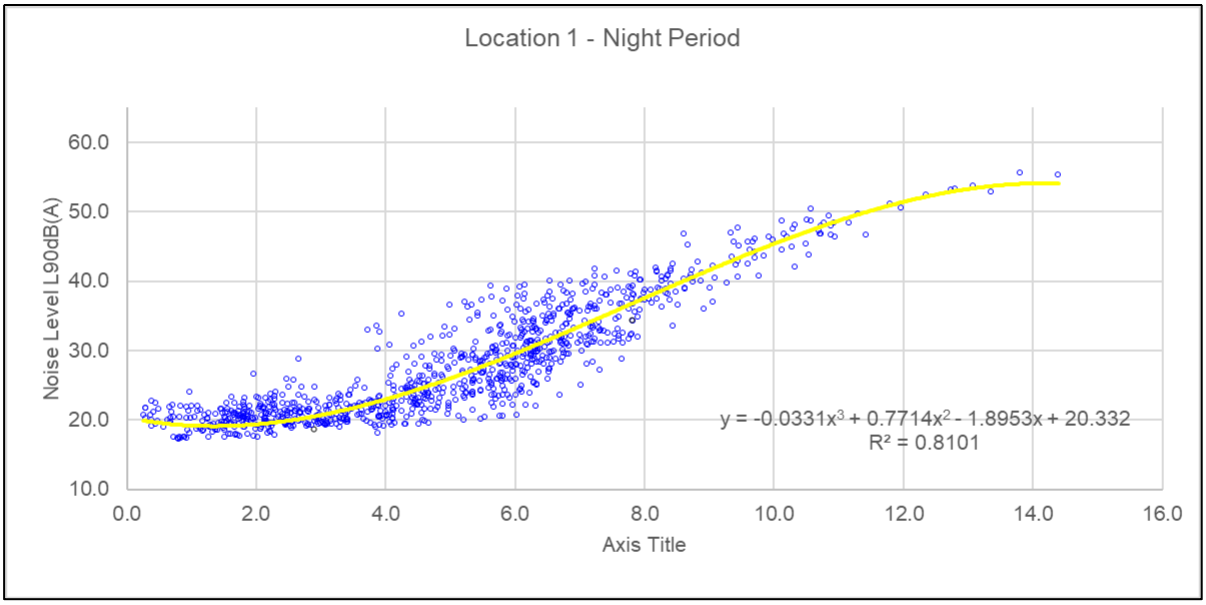

Figure 11-5: Location NMT1 – Background noise – Night-time period

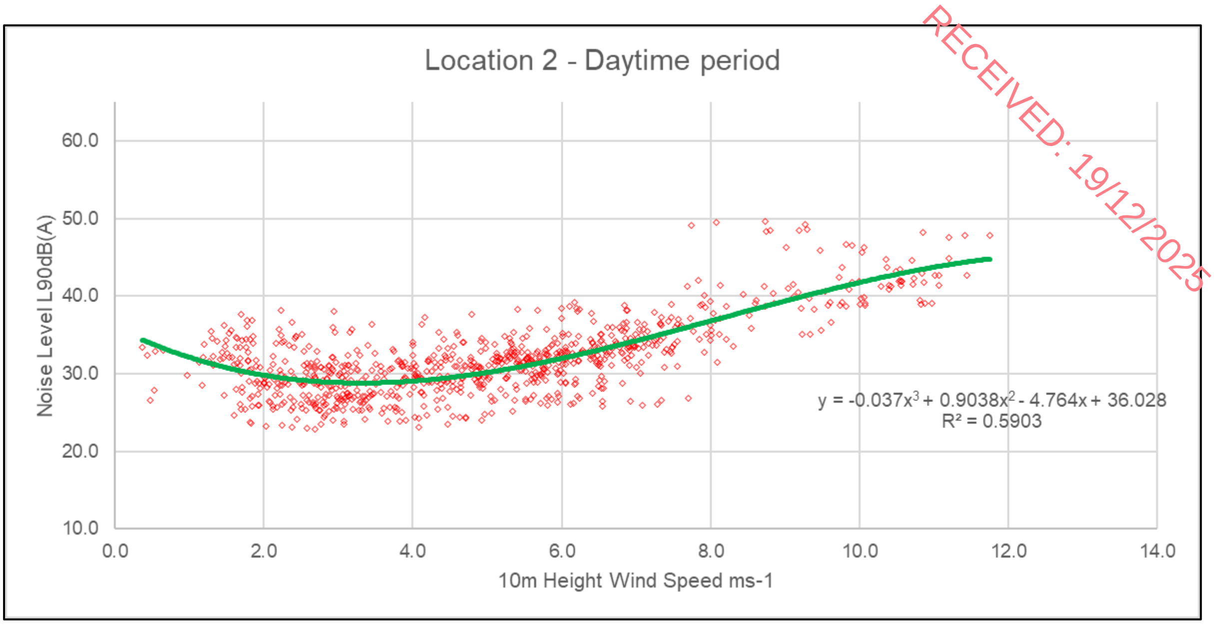

Figure 11-6: Location NMT2 – Background noise – Daytime period

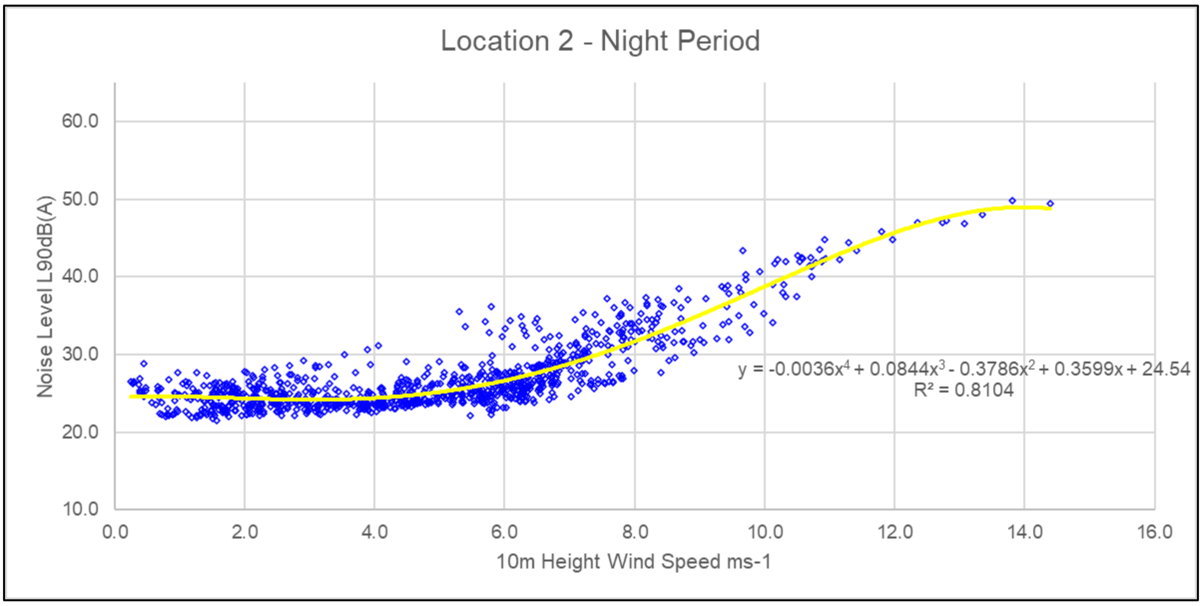

Figure 11-7: Location NMT2 – Background noise – Night-time period

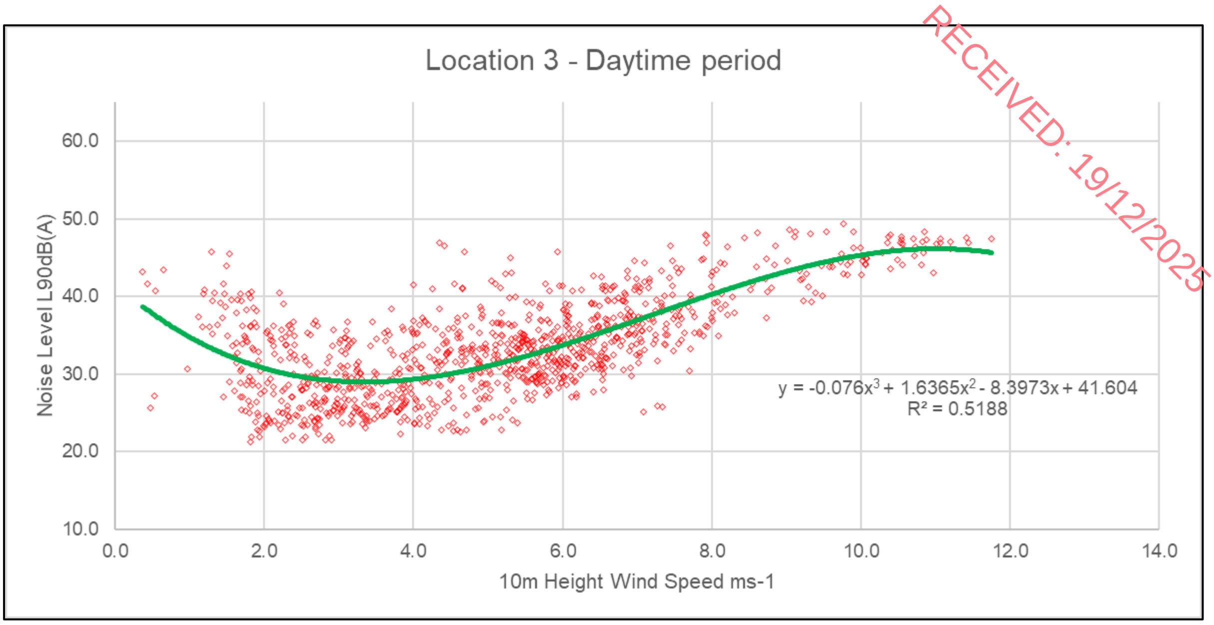

Figure 11-8: Location NMT3 – Background noise – Daytime period

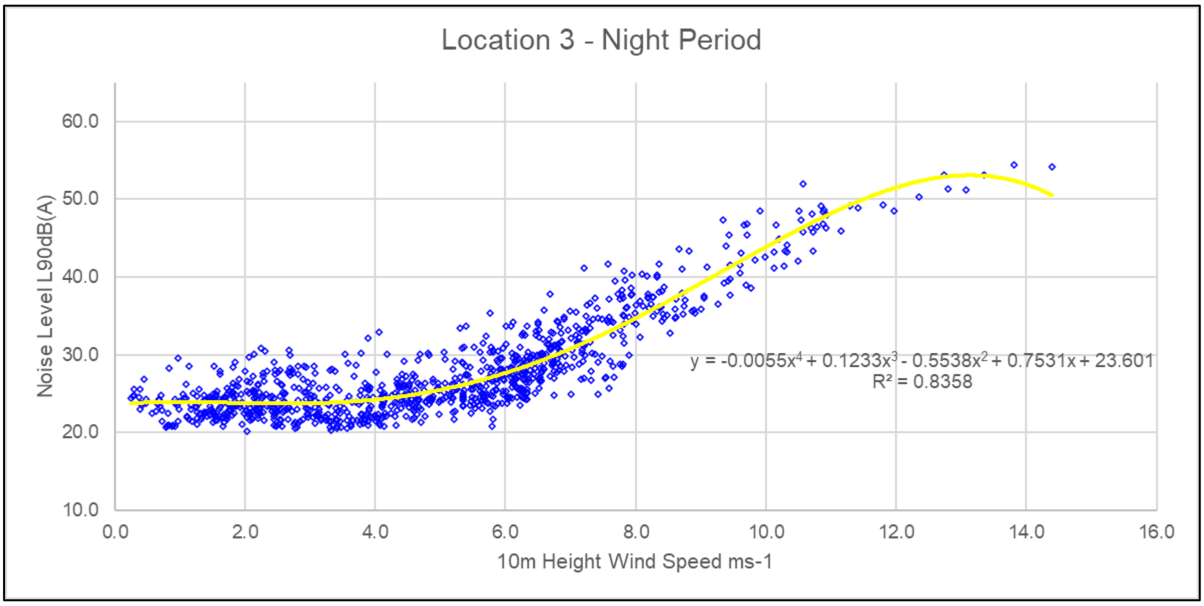

Figure 11-9: Location NMT3 - Background noise – Night-time period

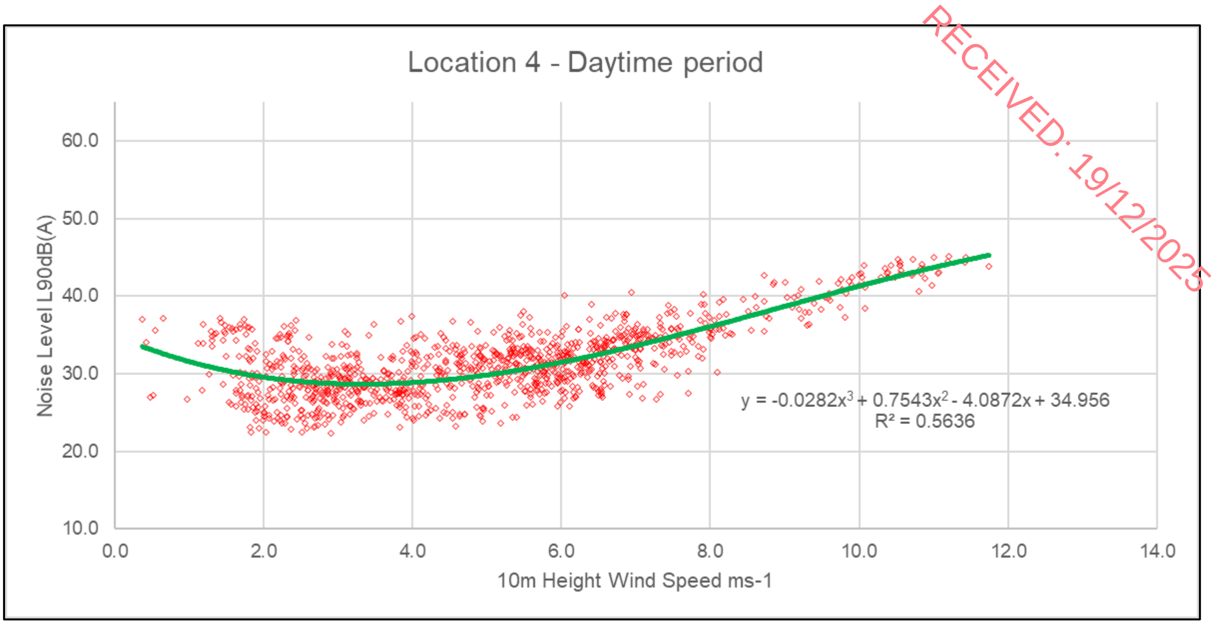

Figure 11-10: Location NMT4 – Background noise – Daytime period

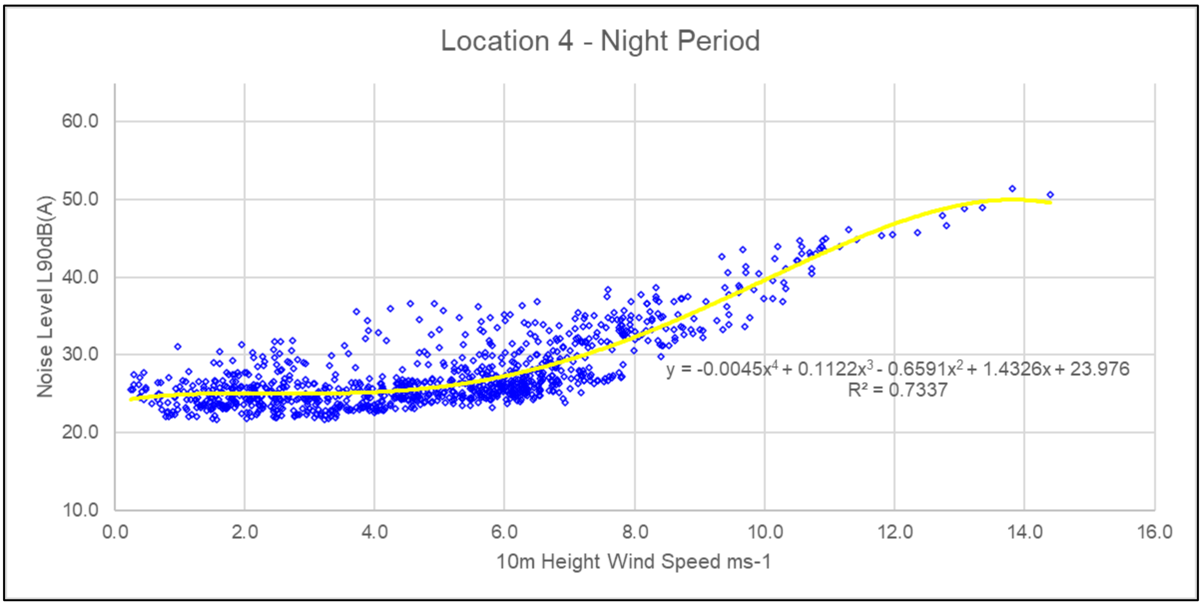

Figure 11-11: Location NMT4 – Background noise – Night-time period

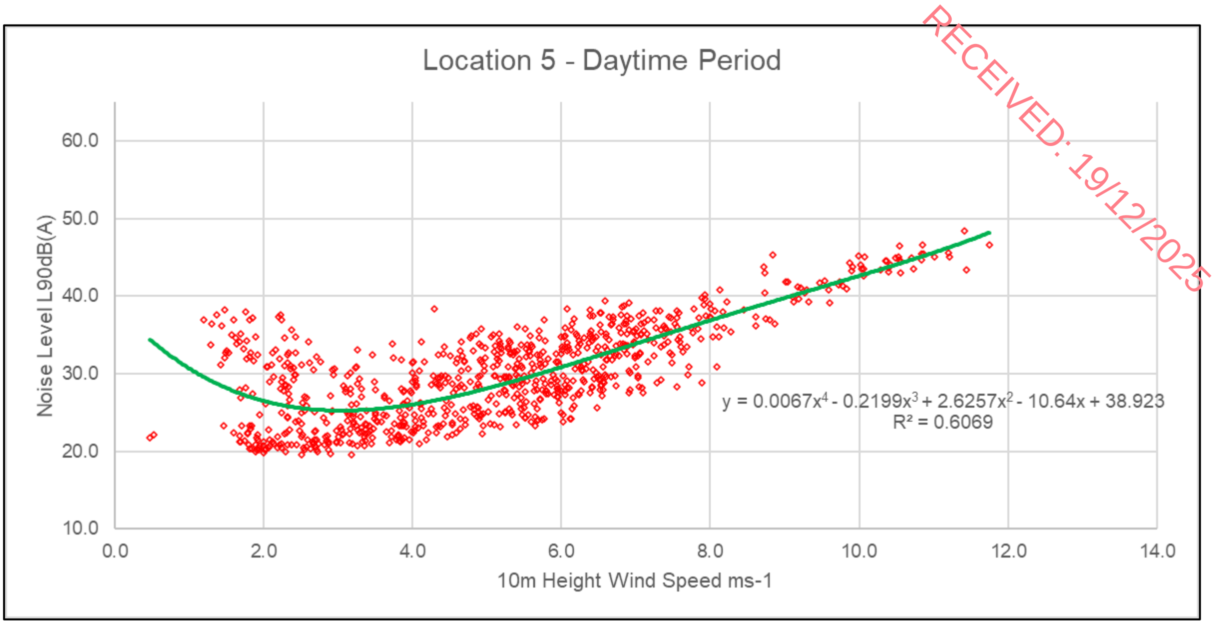

Figure 11-12: Location NMT5 – Background noise – Daytime period

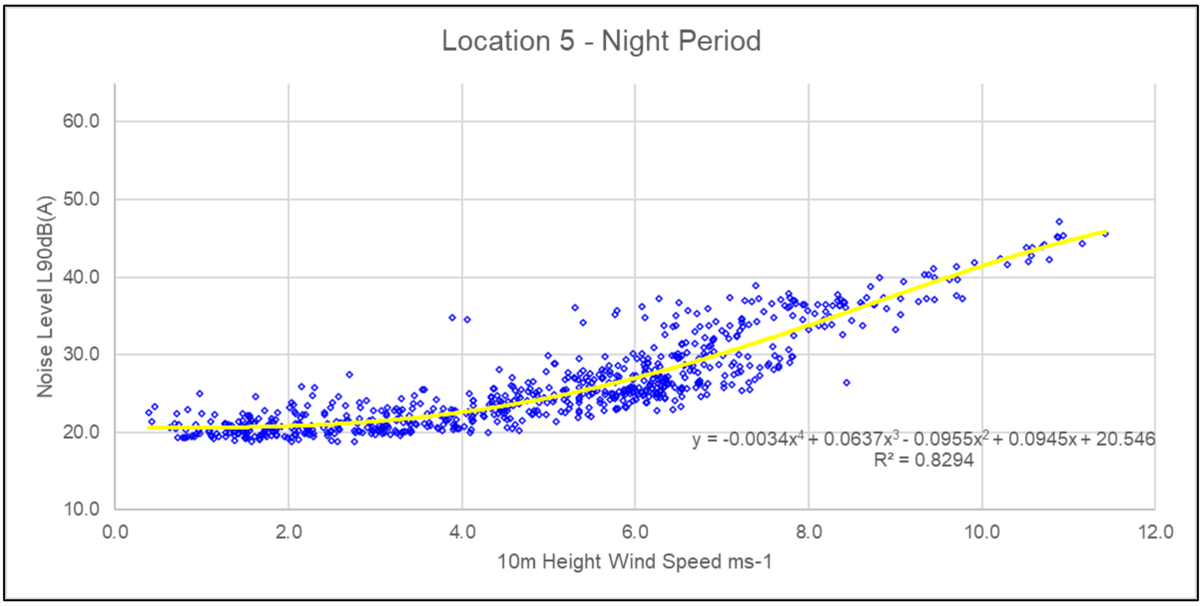

Figure 11-13: Location NMT5 – Background noise – Night-time period

The derived $L_{A90,10min}$ noise levels for each of the monitoring locations for daytime and night-time amenity hours is presented in Table 11-.

Table 11-11: Derived levels of $L_{A90,10min}$ for Various wind speeds

Location	Period	Derived $L_{A90,10min}$ Levels (dB) at Various Standardised 10m Height Wind Speeds						
		4m/s	5m/s	6m/s	7m/s	8m/s	9m/s	10m/s
NMT 1	Day	26	28	32	36	40	44	47
	Night	23	26	30	34	38	42	45
NMT 2	Day	29	30	32	34	37	39	42
	Night	24	25	27	29	32	35	39
NMT 3	Day	29	31	34	37	40	43	45
	Night	24	25	28	31	35	39	44
NMT 4	Day	29	30	31	34	36	39	41
	Night	25	26	27	29	32	36	40
NMT 5	Day	26	28	31	34	37	40	43
	Night	23	24	27	30	34	38	41
Nominal	Day	26	28	31	34	36	39	41
	Night	23	24	27	29	32	35	39

The Nominal criteria is the lowest background level from all NMTs per wind speed 'bin'[4]. The Nominal criteria are used to set the noise limits for all Noise Sensitive Locations and a worst-case impact is therefore assessed.

It should be noted that the criterion for daytime low noise conditions as discussed in **Section 11.3.5**, is satisfied at wind speeds between 4m/s and 5m/s.

11.5.9 Ambient Noise Levels

Noise levels in terms of LAeq and LA90 parameters are derived from the measured noise data following the guidance set out in ISO 1996-1:2016. The results are used to establish the following:

- The appropriate construction noise limit (LAeq);
- The baseline level for the BS4142 impact assessment of the Substation (LA90).

The Ambient (LAeq) and Background (LA90) noise levels (rounded to the nearest integer) as measured at each NML and the averages are given in **Table 11-9**.

Table 11-9: Summary of Noise Levels

Noise Monitoring Location	Daytime (07:00-19:00)		Night-time (23:00-07:00)	
	LAeq (dB)	LA90 (dB)	LAeq (dB)	LA90 (dB)
1	42	35	35	32
2	42	36	34	31
3	48	40	38	33
4	35	41	31	34
5	42	35	34	31
Average	42	37	34	32

[4] Includes a range of speeds from -0.5 to +0.5 of the stated wind speed.

11.6 Potential Effects

11.6.1 Do-Nothing Effects

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 development, increases in traffic volumes on the local road network would be expected over time and would likely result in slight but imperceptible increases in the overall baseline noise levels.

11.6.2 Construction Phase

The duration and phasing of the construction of the proposed development is provided in the Construction Environmental Management Plan (CEMP) (**Volume III**, **Appendix 3D**) of this EIAR and the noise impacts associated with each activity are assessed in this section.

11.6.2.1 Construction Noise Limits

Using the Ambient noise levels from **Table 11-9** and following the methodology from BS 5228-1:2009+A1:2014 set out in **Table 11-5**, the appropriate noise category has been established as Category A (the lowest limit) for all locations.

A summary of the construction noise criteria is therefore as follows:

- Monday to Friday 07:00 – 19:00: $L_{Aeq,\ 1hr}$ 65dB
- Saturdays 07:00 – 13:00: $L_{Aeq,\ 1hr}$ 65dB
- Saturdays 13:00 – 14:00 $L_{Aeq,\ 1hr}$ 55dB

11.6.2.2 Construction Working Hours

As set out in the CEMP of this EIAR, construction activities will occur within the hours 07.00am – 7.00pm, Monday to Friday and 07.00am to 2.00pm on Saturdays. Due to the requirement for the concrete pours to be continuous, the working day may extend outside normal working hours in order to limit the traffic impact on other road users, particularly peak period school and work commuter traffic. Such activities are limited to the day of turbine foundation concrete pours, which are normally complete 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 proposed development and any changes in hours will be agreed with the Local Authority.
Works along public roads will be from 9.00a.m. to 5.00p.m. Monday to Friday and 9.00a.m. to 2.00p.m. on Saturdays.

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

11.6.2.3 Construction Methodology

Details on the construction methods are fully set out in the **CEMP** provided in **Appendix 3D**. A summary is provided in **Table 11-10**.

Table 11-10: Summary of Proposed Construction Methods

Phase	Activity	Duration
Phase 1	Vegetation clearance (to be completed prior to set-up of construction site)	1 month
Phase 2	Site preparation, pre-construction activities, temporary compound, site entrances	2 months
Phase 3	Construction of internal tracks, watercourse crossing & drainage infrastructure	3 months
Phase 4	Crane hardstand construction	2 months (1.5 weeks per turbine)
Phase 5	Turbine foundation construction	4 months (3 weeks per turbine)
Phase 6	Trenching & ducting – on-site	2 months
Phase 7	38kV Substation construction	6 months
Phase 8	Met mast construction	1 month
Phase 9	Turbine delivery	3 months
Phase 10	Turbine erection	4 months
Phase 11	Trenching & ducting – off-site for cable route	1 month
Phase 12	Wind farm commissioning	4 months
	Total	12 - 16 months

The noise impact associated with each construction stage phase is estimated using expected typical construction methods and items of plants. These have been acquired from similar constructions, expertise of the author and/or 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.*

Using this information the noise impacts can be predicted at the closest NSLs to the works and the results compared with the construction noise limit. Noise Sensitive Locations further away will have a reduced noise impact so worst case assessments are presented in the following sections.

No mitigation measures e.g. site hoarding, have been included in the predictions unless otherwise stated and, all noise sources are assumed to operate simultaneously and the results therefore represent a worst case assessment.

The appropriate effect categories based on the construction noise limit being satisfied for each stage are summarised at the end of this section in **Section 11.6.2.2**.

11.6.2.4 Temporary Site Construction Compound

One (1no.) temporary construction compound and welfare facility will be constructed as set out in the CEMP of this EIAR. The distance to the nearest NSL (NSL10) from the construction compound is c 200m south as shown in **Figure 11-13**.

MWP

Figure 11-14: Location of nearest NSL to Temporary Construction Compound

The associated items of construction plant, their noise emission levels, estimated operation on-times during a typical construction period and the predicted combined noise impact at the closest NSL are given in **Table 11-14**.

Table 11-11: Indicative Temporary Compound Construction Noise Emission Levels.

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dBA)	% on-time[1]	Predicted Noise level at nearest NSL (dBA)
Telescopic Handler (C2.35)	71	80	44
Mobile Crane (C3.29)	70	80	43
Tracked Excavator (22 t) (C6.10)	79	80	52
Tracked Excavator (22 t) (C2.3)	78	80	51
Vibratory Roller (12t) (C5.21)	80	80	53
Articulated Dump truck (C4.2)	78	80	51

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dBA)	% on-time[1]	Predicted Noise level at nearest NSL (dBA)
Tractor (towing trailer) (C4.75)	79	80	52
Wheeled Excavator (14 t) (C4.12)	77	80	50
Mini tracked excavator (5 t) (C4.68)	69	80	42
Diesel Generator (C4.76)	61	80	34
Total			60
[1]*Typical/best practice assumption.* *No screening correction has been applied.*			

A total construction noise level of 60dB LAeq at the nearest NSL has been predicted which is below the limit of 65dB $L_{Aeq,1hr}$.

The predicted noise level is below the limit and the effect is therefore expected to be **Not Significant** and the duration **Temporary**.

11.6.2.1 Site Access, Internal Site Tracks and Water Management

The noise impact associated with the construction of site entrances, internal site tracks, and water management are considered here. New site tracks will be constructed to access each of the turbines, substation compound and meteorological mast.

A temporary site entrance will be established for the construction phase and a permanent site entrance will be established to provide access to the wind farm during operation. The temporary entrance will be located to the northwest of the site on the L1219 close to its junction with the L1220 and will only be used for the duration of the construction works (12-16 months). The permanent site entrance, which utilises an existing farm track, will be located further east on the L1219 local road for access during the operational life of the wind farm.

The distance to the nearest NSL from an access track or site entrance, or any works associated with the water management is c45m south of NSL09 as shown in **Figure 11-14**Error! Reference source not found..

Figure 11-15: Location of nearest NSL to Site Access

Details of the site access tracks are given in **Section 3.4.5** of **Chapter 03 Description of the Proposed Development** of the **EIAR** and the nearest NSL to the works is c45m.

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 11-15**.Error! Reference source not found.

Table 11-15: Indicative Site Access and Internal Track Noise Emission Levels

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dBA)	% on-time[1]
Dozer (35 tonne) (C5.14)	Ground excavation/earthworks	86	33
Wheeled loader (C10.5)	Loading lorries	80	33
Rigid dump truck (40 tonne) (C9.24)	Distribution of material	85	33
Dozer (14 tonne) (C5.12)	Spreading chipping/ fill	77	33
Vibratory Roller (12t) (C5.21)	Compaction	80	33
Mobile Crane (C3.29)	Lifting	70	33
Diesel Pump (C4.88)	Pump Water	68	100
Asphalt paver (+ tipper lorry) (C5.32)	Paving	84	33
[1]Worst-case/best practice assumption.			

The resultant noise level from slow-moving mobile plant operating in close proximity to a NSL varies as the plant moves. Suitable adjustment factors, as described in Methodology 2.7.1.3 of BS 5228-1:2009, have been applied in this assessment.

A total construction noise level of 63dB L_{Aeq} at the nearest NSL has been predicted which is below the limit of 65dB $L_{Aeq,1hr}$.

The predicted noise level is below the limit, therefore the effect is expected to be **Not Significant** and the duration is **Temporary**.

11.6.2.2 Traffic Management

The noise impact associated with the transportation of construction materials are considered here.

Most of the material delivered to site will consist of aggregate for the construction of tracks and crane hardstands, and concrete for the construction of the turbine bases. The supply quarries and the surrounding road network are shown in **Figure 3-7** of **Chapter 03 Description of the Proposed Development** of the **EIAR** and the load movements given in **Chapter 14 Material Assets**, **Table 14-8**. A temporary site entrance on the L1219 will be used for the construction phase only. The site entrance locations are illustrated on **Figure 3-5** of **Chapter 03 Description of the Proposed Development** of the **EIAR**.

Construction traffic will be carried on the existing public road network and the closest NSLs lie approximately 10m from the route. Using formula F.2.5 from BS 5228-1:2009+A1:2014, the associated noise level has been calculated as follows:

- Typical period (1 HGV per hour): 37dB
- Peak period (5 HGVs per hour): 43dB

To assess traffic noise impacts, it is appropriate and best practice to evaluate the change of noise level as a result of the increase in road traffic volumes associated with the delivery of material to the site rather than assess against the construction site's noise limit.

The IEMA Guidelines set out in **Table 11-4** consider a change in traffic noise levels of 3dB to 4.9dB would be noticeable, in excess of 5dBA would be clearly noticeable, and depending on the final noise level, the impact may be Slight/Moderate or Significant. A change in noise level of less than 3dB would be imperceptible.

The measured existing Ambient noise level was 42dB LAeq as set out in **Table 11-9**. Referencing the noise level change criteria provided in **Table 11-4**, the change in noise level ranges from 5dB below the ambient for the Typical period, to 1dB above the ambient for the Peak period.

The change in noise level during the typical and peak periods is therefore expected to be imperceptible which equates to a **Not Significant** impact. The effects associated with the Peak period will last for one week and the duration of the likely effect is therefore **Temporary**.

11.6.2.3 Wind Turbine Foundations and Hardstands

The noise impact associated with the construction of Turbine Hardstands and Foundations is considered here.

The works may, subject to ground inspection, be undertaken by general construction techniques or supplemented with piling. Both activities have been assumed as a worst-case assessment. The distance to the nearest existing NSL from a turbine is approximately 648m north of Turbine 6 (NSL16) as shown in **Figure 11-16**.

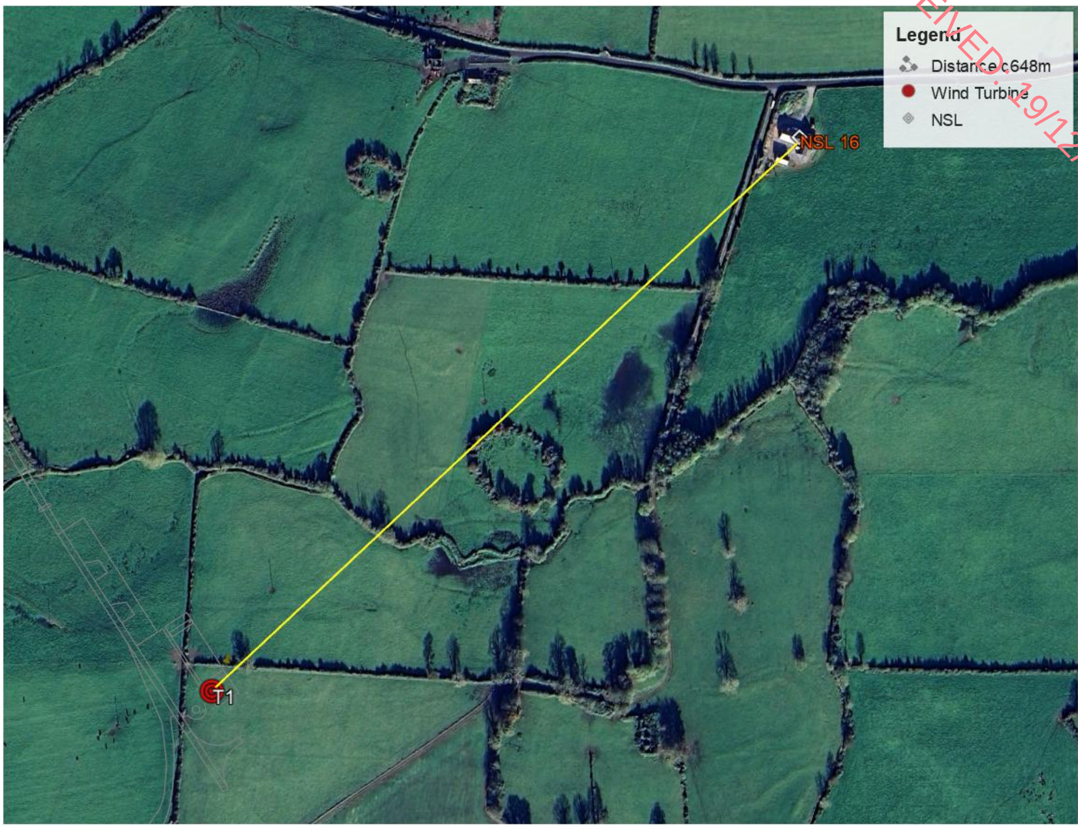

Figure 11-16: Location of nearest NSL to a Turbine

The identified items of construction plant, their noise emission levels, estimated operation on-times during a typical construction period and the predicted combined noise impact at the closest NSL are given in **Table 11-12**.

Table 11-12: Typical Foundation and Hardstanding Construction Noise Emission Levels

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dBA)	% on-time1	Predicted Noise level at nearest NSL (dBA)
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79	100	43
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77	80	40
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	47
Concrete Mixer Truck and Concrete Pump (C.4.27)	Turbine Foundations	75	80	38

Item (BS 5228 Ref.)	Activity/Notes	Plant Noise level at 10m Distance (dBA)	% on-time1	Predicted Noise level at nearest NSL (dBA)
Dumper Truck (C.4.4)	Backfilling Turbine Foundations	76	80	39
Dewatering Pumps (D.7.70)	If required	80	80	43
JCB (D.8.13)	For services, drainage and landscaping.	82	100	46
	Total			53
[1]Worst-case/best practice assumption.				

A total construction noise level of 53dB L_{Aeq} at the nearest NSL has been predicted which is below the limit of 65dB $L_{Aeq,1hr}$.

The predicted noise level is below the limit, therefore the effect is expected to be **Not Significant** and the duration is **Temporary**.

11.6.2.3.1 *Rock Breaking*

Indicative noise sources have been identified for rock breaking/ripping operations at the wind turbine locations and predictions of the potential noise emissions at the closest NSL (NSL16) have been calculated and given in **Table 11-17**.

Table 11-137: 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	32
Tracked Hydraulic Excavator (37t) (C10.1)	Face shovel extracting /loading dump trucks	80	75	43
Tracked crusher (90t) (C9.14)	Crushing/Screening	90	50	51
Crawler mounted dozer (48t) (C.6.28)	Ripping	85	50	46
Tracked Excavator (21t) (C4.65)	Trenching	71	50	32
Dozer (41t) (C2.10)	Ground excavation / earthworks	80	50	41
Articulated Dump Truck (23t) (C2.33)	Distribution of materials	81	50	42
Total				53
[1]Worst-case/best practice assumption.				

A total construction noise level of 53dB L_{Aeq} at the nearest NSL has been predicted which is below the limit of 65dB $L_{Aeq,1hr}$.

The predicted noise level is below the limit, therefore the effect is expected to be **Not Significant** and the duration is **Temporary**.

11.6.2.3.2 ***Blasting***

Subject to ground conditions, blasting may be carried out to supplement the breaking/ripping of material. If this is the case the mitigation measures detailed in **Section 11.7** will be adopted and set out in the CEMP. 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 may minimise the noise effects.

Blasting impacts relate to both ground vibration and air overpressure, the magnitude of which depends on a variety of factors.

11.6.2.3.2.1 Ground-borne Vibration

It is not possible to accurately predict the expected vibration levels to the NSLs because of many variables that cannot be quantified including the nature of the works, the rock type and the intervening substrate between the works and distance to the NSL. However, empirical data indicates that at distances greater than 200m the vibration criteria set out in **Section 11.3.2** is unlikely to be exceeded.

In the case of the proposed development, any blasting requirements will be designed and managed by a competent blasting supervisor. The blast charge will be designed to ensure the potential of ground-borne vibration is within the limits set out in **Section 11.3.2**.

Given the distance to the nearest NSL (NSL16) is c 648m, vibration levels are expected to be negligible. The effect is therefore expected to be **Not Significant** and the duration **Momentary**.

11.6.2.3.2.2 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.

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

The effect is expected to be **Not Significant** and the duration **Momentary**.

11.6.2.4 Wind Farm Substation

The noise impact associated with the construction of Wind Farm Substation compound and buildings is considered here.

The distance to the nearest NSL (NSL10) from the substation compound is c172m as shown in **Figure 11-16. Error! Reference source not found.**

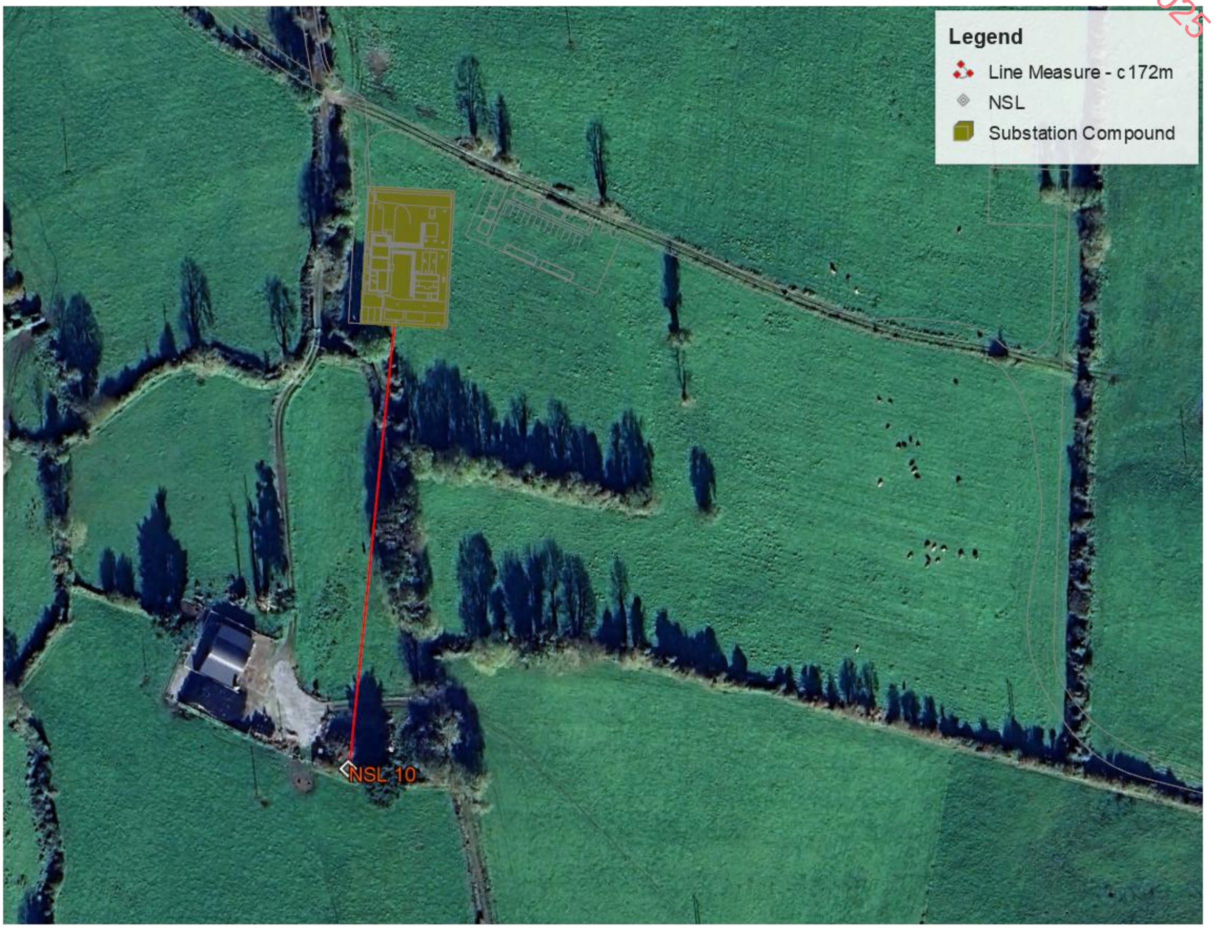

Figure 11-17: Location of nearest NSL to Substation Compound

The identified items of construction plant, their noise emission levels, estimated operation on-times during a typical construction period and the predicted combined noise impact at the closest NSL are given in **Table 11-18**Error! Reference source not found..

Table 11-14: Typical Substation Compound Construction Noise Emission Levels

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dBA)	% on-time1	Predicted Noise level at nearest NSL (dBA)
Telescopic Handler (C2.35)	71	80	45
Mobile Crane (C3.29)	70	80	44
Tracked Excavator (22 t) (C6.10)	79	80	53

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dBA)	% on-time1	Predicted Noise level at nearest NSL (dBA)
Tracked Excavator (22 t) (C2.3)	78	80	52
Vibratory Roller (12t) (C5.21)	80	80	54
Articulated Dump truck (C4.2)	78	80	52
Tractor (towing trailer) (C4.75)	79	80	53
Wheeled Excavator (14 t) (C4.12)	77	80	51
Mini tracked excavator (5 t) (C4.68)	69	80	43
Diesel Generator (C4.76)	61	80	35
Total			61
[1]Worst-case/best practice assumption.			

A total construction noise level of 61dB L_{Aeq} at the nearest NSL has been predicted which is below the limit of 65dB $L_{Aeq,1hr}$.

The predicted noise level is below the limit, therefore the effect is expected to be **Not Significant** and the duration is **Temporary**.

11.6.2.5 Grid Connection

Two potential options for grid connection routes are described in the CEMP – Option A and Option B. The construction works for Option A will involve insertion of ducting, backfilling of trenches and surface finishing along the public road network. No works along the public road are required for Option B. The works required for Option B, will be similar to construction works for access tracks etc. and are therefore not assessed separately.

The works for Option A along the public road can be separated into two phases:

1) trenching, duct works and filling and;

2) reinstatement.

Distances to the nearest NSLs along the route vary considerably and it is therefore appropriate to calculate the potential noise emissions at various distances. Within each phase a sequence of activities will take place and the identified items of construction plant, their noise emission levels, percentage on-times (accounting for the construction sequence) and the predicted combined noise impact at the closest NSL for each phase are given in **Table 11-19**.

Table 11-19: Indicative Grid Connection Noise Emission Levels – Phase 1

Item (BS 5228 Ref.)	Noise Emission Levels[1] at Various Distances		
	20m	30m	40m
HGV Movement (C.2.30)	62	58	56
Tracked Excavator (C.4.64)	61	57	55
Excavator Mounted Rock Breaker (D8.12)	70	66	64
Total	70	67	64
[1]Typical/best practice assumption.			

A maximum construction noise level of 70 dB L_{Aeq} at 20m has been predicted which exceeds the limit of 65dB $L_{Aeq,1hr}$. At distances greater than 40m the construction noise limit is not expected to be exceeded.

Table 11-20: Indicative Grid Connection Noise Emission Levels – Phase 2

Item (BS 5228 Ref.)	Noise Emission Levels[1] at Various Distances		
	20m	30m	40m
HGV Movement (C.2.30)	62	58	56
Tracked Excavator (C.4.64)	61	57	55
Vibrating Rollers (D.8.29)	69	65	63
Total	70	67	64
[1]Typical/best practice assumption.			

A maximum construction noise level of 70 dB L_{Aeq} at 20m has been predicted which exceeds the limit of 65dB $L_{Aeq,1hr}$. At distances greater than 40m the construction noise limit is not expected to be exceeded.

The significance of the effect will vary depending on the distance from the works, with effects being **Not Significant** at distances greater than 40m and **Slight** for receptors closer to the active construction area.

Approximately 100m of Grid Connection works is expected to be constructed per day and the duration of the likely effect is therefore **Brief**.

11.6.2.5.1 *Horizontal Directional Drilling*

The proposed export cable route (Option A) will require 2no. watercourse crossings. One of the crossings will be along the public road and the other will be in private land at the western end of the export cable route. Directional drilling will be employed to construct the watercourse crossings for the export cable route.

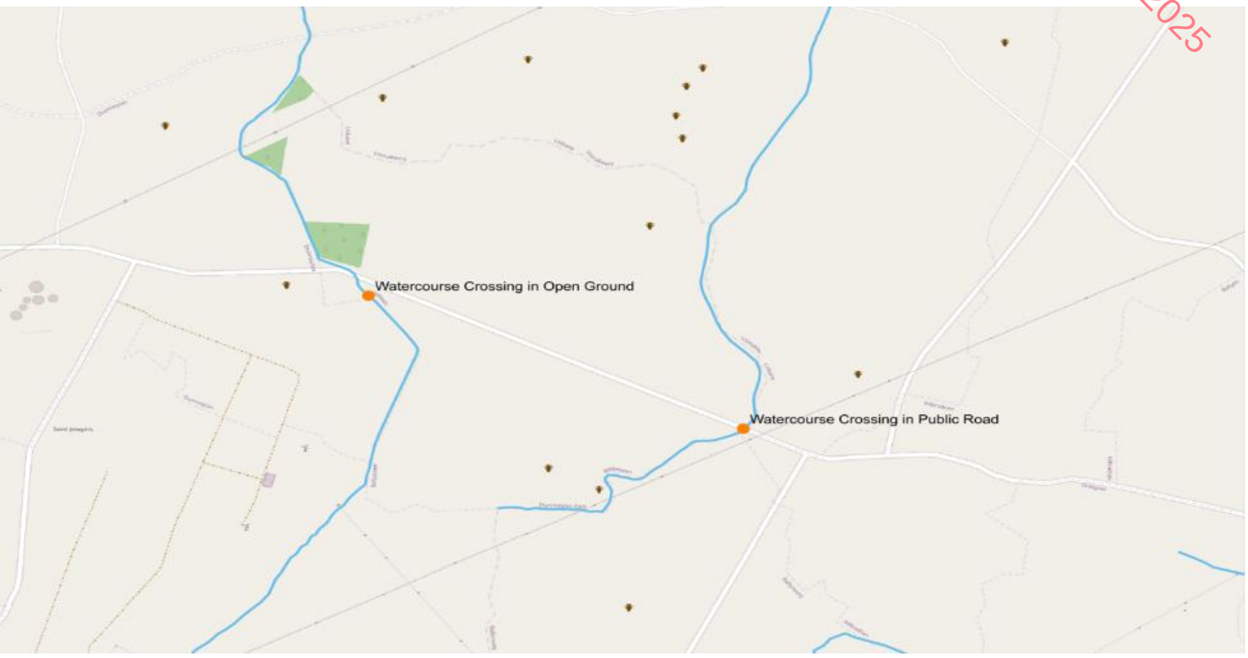

Figure 11-18: Locations for Horizontal Directional Drilling

The exact locations of the launch/receive pits are yet to be determined. However, as a working assumption, the nearest identified Noise Sensitive Location (NSL) is estimated to be approximately 80 m from the receive pit.

Indicative noise sources have been identified and calculated noise levels and estimated operation on-times during a typical construction period are given in **Table 11-21**.

Table 11-15: Indicative HDD Noise Emission Levels

Item (BS 5228 Ref.)	% on-time[1]	On-time Noise Level (dB)	Predicted Noise level at 80m (dB)
Directional drill (C.2.44)	66	75	57
Mud Pump (D.7.70)	66	78	60
Diesel Pump (C4.88)	66	66	48
Tractor (D.10.220)	66	84	66
Dumper Truck (C.4.4)	66	74	56
Total			68
[1]*Worst-casel/best practice assumption.*			

A total construction noise level of 68 dB LAeq has been predicted which exceeds the limit of 65dB LAeq,1hr.

The predicted noise level is above the limit and therefore the effect is expected to be impact is considered **Slight**. The works will progress at pace and are expected to be completed within less than a week at any one location. Therefore, the duration of the likely effect is **Temporary**.

11.6.2.6 Permanent Metrological Mast

The noise impact associated with the construction of Metrological (Met) Mast is considered here.

The distance to the nearest NSL (NSL11) from the Met Mast is c178 m as shown in **Figure 11-18**Error! Reference source not found..

Figure 11-19: Location of nearest NSL to Metrological (Met) Mast

The identified items of construction plant, their noise emission levels and estimated operation on-times during a typical construction period are given in **Table 11-22Error! Reference source not found.**.

Table 11-16: Typical Met Station Construction Noise Emission Levels

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dBA)	% on-time[1]	Predicted Noise level at nearest NSL (dBA)
Telescopic Handler (C2.35)	71	80	51

Item (BS 5228 Ref.)	Plant Noise level at 10m Distance (dBA)	% on-time[1]	Predicted Noise level at nearest NSL (dBA)
Mobile Crane (C3.29)	70	80	51
Tracked Excavator (22 t) (C6.10)	79	80	52
Vibratory Roller (12t) (C5.21)	80	80	52
Articulated Dump truck (C4.2)	78	80	52
Mini tracked excavator (5 t) (C4.68)	69	80	51
Diesel Generator (C4.76)	61	80	50
Total			60
[1]*Worst-case/best practice assumption.*			

A total construction noise level of 60dB L_{Aeq} at the nearest NSL has been predicted which is below the limit of 65dB $L_{Aeq,1hr}$.

The predicted noise level is below the limit, therefore the effect is expected to be **Not Significant** and the duration is **Temporary**.

11.6.2.7 Turbine Delivery Route

Due to their abnormal size, blades and towers are proposed to be delivered at night to avoid disruption to daytime traffic using a convoy of slow moving vehicles. The exact specification of the transport convoy is not yet defined at this stage of the Proposed Development but based on the author's expertise and professional judgement, the noise impact of this transporting operation can be suitably assessed using formula F.2.5 from BS 5228-1:2009+A1:2014.

The noise level associated with this operation has been calculated as 33dB L_{Aeq} at the closest NSLs (approximately 20m from the turbine delivery route).

This noise level is below the existing Ambient noise level of 42dB LAeq as set out in **Table 11-9**. The predicted level is also considerably below the 45dB maximum façade noise level recommended by the WHO to prevent sleep disturbance.

The significance of the effect is therefore **Not Significant**. The convoy will quickly move along the route and therefore the duration of the effect is **Brief**.

11.6.2.8 Turbine Erection

The noise impact associated with the wind turbine erection, as described in the CEMP are assessed here.

It is proposed that the erection of wind turbines will occur during the final months of the construction phase, with the process following a carefully coordinated schedule and using specialist lifting equipment with an average rate of one turbine being erected per week. The turbine erection process is a precision operation that relies on specialist plant and favourable weather conditions to ensure safe and accurate installation.

The distance to the nearest NSL (NSL 16) from a turbine erection is c. 648m. The identified items of construction plant, their noise emission levels, estimated operation on-times during a typical construction period and the predicted combined noise impact at the closest NSL are given in **Table 13-23**.

Table 11-17: Indicative Turbine Erection Construction Noise Emission Levels

Item (BS 5228 Ref.)	% on-time[1]	On-time Level (dB)	Predicted Noise level at nearest NSL (dB)
2no. Mobile Telescopic Cranes (C.4.39)	80	79	43
Total			43
[1]Typical/best practice assumption. No screening correction has been applied.			

A total construction noise level of 43dB LAeq at the nearest NSL has been predicted which is below the limit of 65dB LAeq,1hr.

The predicted noise level is below the limit and therefore the effect is expected to be **Not Significant**, and the duration **Temporary**.

11.6.2.9 Vibration – General Construction Works

There are no substantial sources of vibration associated with the plant and activities of the general construction works and the distances to the nearest NSLs are such that vibration effects will be negligible.

The effected is therefore expected to be **Not Significant** and the duration **Temporary**.

11.6.2.10 Vibration – Blasting Events

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.

In the case of the proposed development, any blasting requirements will be designed and managed by a competent blasting supervisor. The blast charge will be designed to ensure the potential of ground-borne vibration is within the limits set out in **Table 11-6**.

Therefore, the effect associated with blasting events at turbine foundations is considered to be **Not Significant** and **Brief**.

11.6.2.1 Decommissioning Phase

During the decommissioning phase of the proposed Project, there will be some effects 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 are used.

However, certain infrastructure components will not be decommissioned, meaning there will not be an associated noise impact at certain locations. Specifically, the Onsite Substation and the GCR will remain part of the national infrastructure and will not be removed.

The effect is expected therefore to be **Not Significant** and the duration **Temporary**.

11.6.2.2 Summary of Construction Phase Effects

With respect to the EPA's criteria for description of effects; the potential worst-case effects at the nearest noise sensitive location associated with the construction works, without implementation of appropriate mitigation are described in **Table 11-24**.

Table 11-18: Description of Effects

Aspect	Quality	Significant	Duration
Temporary Site Construction Compound	Adverse	Not Significant	Temporary
Internal Site Tracks	Adverse	Not Significant	Temporary
Traffic Management	Adverse	Not Significant	Temporary
Wind Turbines and Hardstands	Adverse	Not Significant	Temporary
Rock Breaking	Adverse	Not Significant	Temporary
Blasting (Noise)	Adverse	Not Significant	Momentary
Ground-borne Vibration	Adverse	Not Significant	Momentary
Noise – Air Over Pressure	Adverse	Not Significant	Momentary
Wind Farm Substation	Adverse	Not Significant	Temporary
External Grid Connection	Adverse	Not Significant to Slight (depending on distance)	Brief
Permanent Meteorological Mast	Adverse	Not Significant	Temporary
Turbine Delivery Route	Adverse	Not Significant	Brief
Turbine Erection	Adverse	Not Significant	Temporary
Vibration - General Construction Works	Adverse	Not Significant	Temporary
Vibration - Blasting Events	Adverse	Not Significant	Brief
Decommissioning Phase	Adverse	Not Significant	Temporary

11.6.3 Potential Effects – Operational Phase

Once operational, the wind turbines and the substation facility will generate noise which will propagate into the receiving environment. No rating penalties for special audible characteristics have been applied as these cannot be assessed at this stage as discussed. **Section 11.7.2** provides details of the assessment of operational noise in the event of such occurrence.

The potential effects are described in the following sections.

11.6.3.1 Turbine Details – Proposed Development

There is 1 no. candidate wind turbine type to be considered for the Proposed Development as set out in **Table 11-19**.

Table 11-19: Candidate Turbine Type

Turbine Type Identifier	Candidate Turbine Model	Tip Heights	Hub Height
A	**Vestas V-136**	**158m**	**90m**

The candidate turbine model is considered to be representative of the type of turbine that will be installed at the site and is assumed to include serrated trailing edge to the blades.

A total of 6no. turbines at the locations in **Table 11-20** are considered.

Table 11-20: Turbine Co-ordinates

Turbine Ref.	Co-ordinates	
	ITM X	ITM Y
T1	529899	643084
T2	529841	642685
T3	529655	642322
T4	530064	642172
T5	530232	642542
T6	530454	642876

11.6.3.1 Cumulative Assessment

This assessment has considered the potential cumulative effects of the Proposed Development in combination with other wind energy developments in the area as required by best practice guidance discussed in **Section 11.6.3.1**.

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 B 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."

An appraisal of the wider study area around the Proposed Development identified the nearest proposed, permitted and operational wind farms developments as follows:

- Grouse Lodge
- Carrons Wind Farm

These wind farms were considered for the cumulative assessment and following the same methodology set out in **Section 11.6.3.1**, the predicted noise levels from these turbines have been included in the noise levels from the Proposed Development at the NSLs.

Details of the wind farms are given below.

11.6.3.1.1 *Grouse Lodge*

A total of 6no. turbines (model: Nordex N90 at 80m hub height) at the locations in **Table 11-21** are considered.

Table 11-21: Grouse Lodge Turbine Co-ordinates

Turbine Ref.	Co-ordinates	
	ITM X	ITM Y
1	525351	641970
2	525330	641722
3	525158	641497
4	524933	641696
5	524998	641281
6	524756	641451

11.6.3.1.2 *Carrons*

A total of 2no. turbines (model: Enercon E82 at 85m hub height) at the locations in **Table 11-22** are considered.

Table 11-22: Carrons Turbine Co-ordinates

Turbine Ref.	Co-ordinates	
	ITM X	ITM Y
1	527484	643914
2	527356	643676

11.6.3.2 Noise Criteria

As outlined in **Section 11.3.3**, the recommended best practice noise limits for the proposed development, shall be a combination of guidance provided in WEDG 2006, ETSU, IOA GPG and SGNs. This is considered best practice based on the professional competence and expertise of the authors and has been adopted for this assessment.

Following a detailed review of the background noise data set out in **Table 11-**, noise criteria have been calculated appropriate noise criteria between cut-in and the rated power wind speeds for the candidate turbine type have been calculated and are given in **Table 11-23**.

Table 11-23: Summary of WEDG-06 Noise Criteria.

Location	Period	Noise Limit Criteria (dB) at Standardised 10m Wind Speeds					
		4	5	6	7	8	9
NSL 1	Day	40	40	45	45	45	49
	Night	43	43	43	43	43	47
NSL 2	Day	40	45	45	45	45	45
	Night	43	43	43	43	43	43
NSL 3	Day	40	45	45	45	45	48
	Night	43	43	43	43	43	44
NSL 4	Day	40	40	45	45	45	45
	Night	43	43	43	43	43	43
NSL 5	Day	40	40	45	45	45	45
	Night	43	43	43	43	43	43
Nominal	Day	40	40	45	45	45	45
	Night	43	43	43	43	43	43

The Nominal criteria is the minimum value derived from the data and is appliable at all NSLs. The Nominal criteria is used to set the wind turbine operational noise limits for all NSLs, and a worst-case impact is therefore assessed.

The assessment has been undertaken in accordance with best practice guidance outlined in the *IOA GPG*s 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. In reality this can never occur so this approach therefore represents a worst case assessment.

Assessment of Wind Turbine Noise

11.6.3.3 Noise Prediction

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

11.6.3.4 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 – Part 2: General method of calculation*.

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 (LwA);

- 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; and
- Meteorological effects such as wind gradient, temperature gradient and humidity.

11.6.3.5 Inputs Data Assumptions

Sound power levels (L_{WA}) have been provided by the manufacturer of the turbines and Error! Reference source not found. details the noise levels for Mode PO4-0S (blades with serrated trailing edge, in accordance with industry best practice).

Table 11-30: L_{WA} levels used – Vestas V136 model HH 90m

Turbine Type Identifier	Sound Power Levels (Lw dB) at Hub Height Wind speeds							
	3m/s	4m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s
A	90.9	91.1	92.8	95.9	99.5	102.8	103.9	103.9

For the purposes of the cumulative impact assessment of the Grouse Lodge and Carrons wind farms, the sound power values in Error! Reference source not found.**1** are assumed, based on publicly available data for the identified wind turbine models.

Table 11-31: L_{WA} levels used – Other wind farms

Sound Power (Lw for Vhub) (dB)	Wind speed (vs) at Standardised Height of 10m (m/s)							
	3m/s	4m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s
Grouse Lodge	92.5	96.5	99.5	101.5	102.5	103	103.3	103.5
Carrons	-	-	96.3	99.6	101.4	102	102	102

This noise data was taken from the manufacturers' data of the respective models.

Appendix 11D Noise Modelling Calculation Parameters provides information on the noise model calculation parameters and settings.

11.6.3.6 Noise Prediction

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 $L_{A90,10min}$.

11.6.3.7 Uncertainty

Uncertainty in the noise assessment ought to be considered and following Section 4.3.6 of the GPG, in the absence of specific information, the data used in this report has an uncertainty of +2dB applied.

11.6.3.1 Tonality

A guarantee will be required in the procurements of the turbine to be used onsite, stating that there should be no clearly tonal or impulsive components audible at any noise sensitive receptor location.

11.6.3.2 Predicted Noise Levels

It was found that the predicted cumulative noise levels from the Proposed Development, when combined with the noise emissions from the schedule of other wind farms provided in **Section 11.6.3.1**, were below the WEDG-06 noise limit criteria at all NSLs.

A summary of the 5no. NSLs with the highest predicted noise level 6m/s wind speed is provided in **Table 11-32** for information purposes.

Table 11-32: Turbine Identifier A – Summary of top 5 Cumulative Noise Levels at 6m/s.

	Criteria and Predicted Noise Levels (dB) at Standardised 10m Wind Speeds							
Criteria	**3 m/s**	**4 m/s**	**5 m/s**	**6 m/s**	**7 m/s**	**8 m/s**	**9 m/s**	**>10 m/s**
Daytime Limits	**40**	**40**	**40**	**45**	**45**	**45**	**45**	**45**
Night-time Limits	**43**	**43**	**43**	**43**	**43**	**43**	**43**	**43**
Location								
NSL 16	28.4	30.2	36.8	40.1	41.2	41.2	41.2	19.2
NSL 1027	28.1	30.1	36.6	39.9	40.9	41.0	41.0	22.8
NSL 93	27.5	29.5	36.0	39.3	40.3	40.4	40.4	23.1
NSL 51	27.3	29.0	35.7	39.0	40.1	40.1	40.1	18.6
NSL 58	27.2	29.0	35.6	38.9	40.0	40.0	40.0	18.8

A summary of the predicted noise levels at the schedule of Noise Sensitive Locations is provided in **Appendix 11E** – Predicted Noise Levels.

A noise contour plot at 4m height is presented in **Appendix 11F** of **Volume III** of the **EIAR**.

11.6.3.3 Description of Effects – Noise

As demonstrated above, the Proposed Development is expected to operate within the established noise criteria. Therefore, the effects are considered to be **Not Significant** and the duration **Long Term**.

11.6.3.1 Description of Effects – Vibration

Wind turbines generate only minimal vibration when operational, which is too weak to be felt by people or affect buildings and structures. Research indicates that any vibration diminishes rapidly with distance from the turbine.

As a result, no noticeable impact on nearby receptors or structures are anticipated, therefore, in EIA terms, there is **Imperceptible** effect.

11.6.3.2 Substation

The nearest NSL (NSL10) is located c. 172m from the proposed substation. There are no tonal or other special acoustic characteristics assumed and a warranty will be sought from the supplier of the 38kV transformer for the onsite substation. It is proposed the onsite substation will emit no adverse tonal component during the operational phase. Therefore, the effects are considered to be **Not Significant** and the duration **Long Term**.

11.7 Mitigation Measures

The assessment of potential impact has demonstrated that the proposed development is expected to comply with the adopted criteria for both the construction and operational phases. This section outlines mitigation measures that will be implemented as part of the proposed development, during the construction, operation and decommissioning phases, in line with best practice and proven techniques for Noise and Vibration.

11.7.1 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* and where appropriate, *Mineral Policy Statement 2*. BS 5822 offers detailed guidance on the control of noise and vibration from construction activities. Best management practices will be adopted during construction phase as required, including the following:

- Prior to the commencement of construction an active community engagement exercise shall be undertaken by the community liaison officer. Letter drops shall take place in advance of the works. The nature of the information letters will provide details of the proposed development, specifically:
    - Contractor name and contact details;
    - Project description;
    - Expected duration of works; and
    - A commitment to implement procedures and measures to minimise noise and vibration.

  This community notification exercise will be repeated in the event of an expected intensification of works in any area and/or in advance of works that occur outside of the permitted construction operating hours (any such works will be subject to prior agreement with the Local Authority).
- A site representative responsible for matters relating to noise and vibration will be appointed;
- 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;
- Limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
    - Normal construction activities will be undertaken within the hours 07.00am – 7.00pm, Monday to Friday and 07.00am - 2.00pm on Saturdays;
    - Works along public roads would be from 9.00a.m. to 5.00p.m. Monday to Friday and 9.00a.m. to 2.00p.m. on Saturdays;
    - Any changes in hours for certain construction works such as concrete pours will be agreed with the Local Authority.
- Keeping the surface of the site access tracks 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; and
- Management of deliveries to avoid significant peak periods.

11.7.1.1 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.* and *Mineral Policy Statement* 2 where appropriate. The following list of measures will be implemented, where necessary, to ensure compliance with the relevant construction noise criteria:

- 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 order for the duration of the contract;
- Compressors will be attenuated models, fitted with properly lined and sealed acoustic covers and will be kept closed whenever the machines are in use. 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 **Table 11-1** using methods outlined in *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise* and *Mineral Policy Statement* where appropriate.
- Erect site hoarding and temporary screens around noisy equipment.
- Acoustic enclosures or portable screens will be utilised for plant and equipment operating in close proximity to residential dwellings such as the HDD crossings along grid connection Option A.

11.7.1.2 Vibration

Vibration from construction activities will be limited to the values set out in **Table 11-6**.

With regards to piling should it be required, it is considered that, based on the large distances between locations where piling may take place and the nearest NSLs, no significant impact will be experienced. Therefore, no mitigation measures are proposed.

11.7.1.3 Blasting

The following mitigation measures will be employed to control the impact during blasts, if blasting is required:

- A blast management plan will be prepared and implemented during the construction phase;
- 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;
- Hours within which blasting can be conducted will be restricted;
- Prior to the commencement of any blasting activity an active community engagement exercise shall be undertaken by the community liaison officer, (e.g. 48 hours written notification);
- The firing of blasts at similar times will be implemented to reduce the 'startle' effect;
- On-going circulars informing people of the progress of the works will be issued;
- An onsite documented complaints procedure will be implemented; and
- Independent monitoring by external bodies for verification of results will be implemented.

11.7.2 Operational Phase

Wind Turbines - Noise

An assessment of the operation noise levels has been undertaken in accordance with best practice guidelines and procedure as outlined in **Section 11.6.3.**

As has been demonstrated, the operation of the proposed development is not expected to exceed the daytime or night-time noise criteria at any of the NSLs considered, in line with the current Wind Energy Development Guidelines 2006, and therefore no specific mitigation measures need apply to comply with these national guidelines.

In the unlikely event that an issue with low frequency noise is associated with the proposed development, an appropriate detailed investigation will be undertaken. Due consideration would be given to guidance on conducting such an investigation which is outlined in *Appendix VI* of the EPA document entitled *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities* (2016). This guidance is based on the threshold values outlined in the Salford University document *Procedure for the assessment of low frequency noise complaints*, Revision 1, December 2011.

In the unlikely event that an issue of AM is associated with the proposed development, an appropriate investigation shall be undertaken in accordance with the guidance outlined in 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)* or subsequent revisions.

As discussed in **Section 11.3.3.9**, a suitable NCMP will be implemented for the proposed development. Should a noise complaint or evidence of an exceedance of the noise limits occur, the operator shall comply with any requirements of the Planning Authority to undertake an investigation (including shutting down wind turbines for background noise monitoring if required) and the implementation of appropriate mitigation measures such as a curtailment programme on the wind turbine operations will be undertaken. The NCMP will follow the guidance outlined in the IOA GPG and Supplementary Guidance Note 5: Post Completion Measurements (July 2014). For more information on Post-Construction Monitoring please refer to **Section 11.8**.

Wind Turbines - Vibration

No mitigation measures are set out in relation to vibration emissions from the wind turbines and the residual vibration effects will remain as **Imperceptible/Not Significant**.

Substation

No mitigation measures are required in relation to the operation of the substation and the residual noise effects will remain as **Imperceptible**.

11.7.3 Decommissioning phase

Activities and noise levels associated with the decommissioning phase are likely to be broadly 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.

11.8 Operational Phase Monitoring

Compliance with the prescribed limits as set out in **Table 11-29** may be demonstrated by a suitable post-construction Noise Complaint Monitoring Programme (NCMP). The NCMP will adopt the guidance in *IOA SGN No.5 Post Completion Measurements*.

A detailed methodology shall be agreed in writing with the planning authority prior to the commissioning of the wind farm but the following are appropriate:

- Monitoring to be conducted under downwind conditions (45 degree sector);
- Wind turbines to operate in normal mode i.e. without any additional restrictions;
- Monitoring to be conducted at one or more Noise Monitoring Location(s) (where pre-commissioning background noise levels are available) or at representative/nearest Noise Sensitive Location(s); and
- Synchronised 10-minute wind speeds at standardised 10m height to be derived from upwind anemometer or from turbine power output curves.

It will usually be necessary to carry out noise monitoring for around 1 month to obtain the necessary range of wind speeds and wind directions to enable a conclusive evaluation of whether noise limits are being met for worst case downwind propagation conditions. However, extended periods of noise monitoring may be necessary to capture sufficient conditions and will be carried out as necessary.

Some periods of wind turbine shut-down may be required to facilitate the NCMP and will be carried out as necessary.

The instrumentation used will comply with *IOA SGN No. 1 Data Collection* and conducted by a professionally competent organisation.

Where the results of the measurements to demonstrate an exceedance of the permitted noise levels, a mitigation strategy will be formulated to reduce turbine noise levels to within the prescribed noise limits. The noise monitoring will then be repeated with such mitigation measures in place to demonstrate compliance with the conditions and for the operator to continue to run the site in this way unless circumstances change.

As outlined in **Section 11.3.3.9** Special Audible characteristics (such as OAM), is not a factor that can be foreseen at planning stage, but its presence can be measured and rated, typically in the event of a complaint, post construction. The NCMP will include standard practice methodology for OAM to be investigated, only in the event of complaint, and, where the investigation verifies its presence, mitigation measures will be put in place to address the identified turbine OAM noise characteristics. The most recent information in relation to assessing AM comes in the IEC TS 61400-11. The scope of this document includes an assessment of the sound characteristics of the noise and relies on an evolution of the Institute of Acoustics Reference Method (IoA RM) to quantify the AM level along with a penalty scheme. The methodology contained within the IoA RM, IEC 61400 and Draft Assessment and Rating of Wind Turbine Noise documents all allows quantification of all aspects of AM and the penalty scheme allows quantification of the mitigation required, if any. An appropriate penalty can be added onto the measured LA90 noise level, to allow direct comparison to an overall applicable noise limit. It can also allow a quantification of the mitigation required to reduce the rated noise levels from turbines, if exceedances are identified post the wind farm becoming operational.

11.9 Residual Effects

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

11.9.1 Do-nothing Scenario

If the proposed development were not to proceed, no changes would be made to the current land-use and the noise levels at noise-sensitive locations would remain largely unchanged.

11.9.2 Construction Phase

During the construction phase of the development there will be some effect on nearby noise sensitive properties due to noise emissions from site traffic and other construction activities. However, given the distances between the main construction works and nearby noise sensitive properties and the fact that the construction phase of the development is temporary in nature, it is expected that the various noise sources will not be excessively intrusive. Furthermore, the application of binding noise limits and hours of operation, along with implementation of appropriate noise and vibration control measures, will ensure that the noise and vibration effect is kept to a minimum.

11.9.3 Operational Phase

<u>Wind Turbine Operation</u>

The predicted noise levels associated with the proposed development will be within best practice noise criteria recommended in Irish guidance *'Wind Energy Development Guidelines for Planning Authorities, 2006'*, which has been supplemented with guidance from ETSU-R-97 and the IOA GPG and its supplementary guidance notes. It is not considered that a significant effect is associated with the development.

Notwithstanding that the operational noise criterion associated with the current national guidelines will not be exceeded, it should be noted that a new noise source will be introduced into the soundscape which may be noticeable at low wind speeds.

There are no expected sources of vibration associated with the operational phase of the proposed development.

11.10 Conclusion

When considering a development of this nature, the potential noise and vibration effects on the surrounding receptors must be considered for two stages: the short-term construction (decommissioning similar in nature) and the long-term operational phase.

The assessment of construction noise and vibration has been conducted in accordance with 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 outlined in the EIAR, noise and vibration effects associated with the construction and decommissioning phases are considered to be Not Significant.

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. The predicted operational noise levels are not expected to exceed the worst-case noise criteria and are in compliance with WEDG 2006, ETSU, IOA GPG and SGNs. The associated noise and vibration effects associated with the operation phases are considered to be Not Significant.

11.11 References

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