



Cush Wind Farm

Environmental Impact Assessment Report

Chapter 11: Noise & Vibration

Cush Wind Limited

Galetech Energy Services
Clondargan, Stradone, Co. Cavan Ireland
Telephone +353 49 555 5050
www.galetechenergy.com



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11.1 Introduction

11.1.1 Background & Objectives

This chapter describes the assessment undertaken of the likely noise and vibration effects arising from the Cush Wind Farm.

This chapter provides a baseline assessment of the environmental setting of the project in terms of noise and vibration and discusses the likely and significant effects that the construction, operation, and decommissioning of the project will have on them. Where required, appropriate mitigation measures to limit any significant identified effects on the noise and/or vibration environment are presented. The residual effects and cumulative effects of the project post-mitigation are also assessed.

11.1.2 Statement of Authority

This chapter has been prepared by Mike Simms BE MEngSc MIOA MIET, Principal Acoustic Consultant at AWN Consulting Ltd. Mike has worked in the field of acoustics for over 20 years. He has extensive experience in all aspects of environmental surveying, noise modelling and impact assessment for various sectors including, wind energy, industrial, commercial and residential.

The baseline noise monitoring was undertaken by Cormac McPhillips, Technical Services Manager at Galetech Energy Services (GES). Cormac has extensive experience of undertaking noise monitoring programmes in accordance with relevant standards and best practice methods.

11.1.3 Description of the Project

In summary, the project comprises the following main components as described in **Chapter 3**:-

- 8 no. wind turbines with an overall tip height of 200m, and all associated ancillary infrastructure;
- All associated and ancillary site development, excavation, construction, landscaping and reinstatement works, including provision of site drainage infrastructure and forestry felling.
- Temporary alterations to the turbine component haul route; and,
- Construction of an electricity substation, Battery Electricity Storage System and installation of 5.6km of underground grid connection to facilitate connection of the proposed electricity substation to the existing 110kV substation at Clondallow, County Offaly;

The project site is located in rural Co. Offaly, approximately 4km north of the town of Birr and c. 28km south-west of Tullamore, County Offaly. Off-site and secondary developments; including the forestry replant lands and candidate quarries which may supply construction materials; also form part of the project.

The turbine component haul route and associated temporary alteration works are located within counties Galway, Roscommon, Westmeath and Offaly. It is envisaged that the turbines will be transported from the Port of Galway, through the counties of Galway, Roscommon, Westmeath and Offaly, to the project site.

A full description of the project is presented in **Chapter 3**.

11.2 Methodology

11.2.1 Stepwise Approach

The following methodology has been adopted for this assessment:

- Review appropriate guidance in order to identify appropriate noise and vibration criteria for the site operations;
- Carry out baseline noise monitoring at representative locations to identify existing levels of noise in the vicinity of the project; and,
- Comment on predicted noise levels against the appropriate construction and operational phase criteria and outline required mitigation measures (if any).

Annex 11.1 (Volume II) presents a glossary of the acoustic terminology used throughout this chapter. In the first instance, it is considered appropriate to review some fundamentals of acoustics.

11.2.2 Fundamentals of Acoustics

A sound wave travelling through the air is a regular disturbance of the atmospheric pressure. These pressure fluctuations are detected by the human ear, producing the sensation of hearing. To take account of the vast range of pressure levels that can be detected by the ear, it is convenient to measure sound in terms of a logarithmic ratio of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB).

The audible range of sounds expressed in terms of Sound Pressure Levels is 0dB (for the threshold of hearing) to 120dB (for the threshold of pain). In general, a subjective impression of doubling of loudness corresponds to a tenfold increase in sound energy which conveniently equates to a 10dB increase in SPL. 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, which is the rate at which a sound wave oscillates, 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 decreases markedly as frequency falls below 250Hz. In order to rank the SPL of various noise sources, the measured level has to be adjusted to give comparatively more weight to the frequencies that are readily detected by the human ear. The 'A-weighting' system is defined in the international standard BS EN 61672-1:2013 *Electroacoustics Sound Level Meters Specifications*. BS ISO 226:2003 *Acoustics - Normal Equal-loudness Level Contours* has been found to provide the best correlations with human response to perceived loudness. SPLs measured using 'A-weighting' are expressed in terms of dB(A).

An indication of the level of some common sounds on the dB(A) scale is presented in **Figure 11.1**, which shows a quiet bedroom at around 35dB(A), a nearby (at 7m) noisy HGV at 90dB(A), and a pneumatic drill at about 100dB(A).

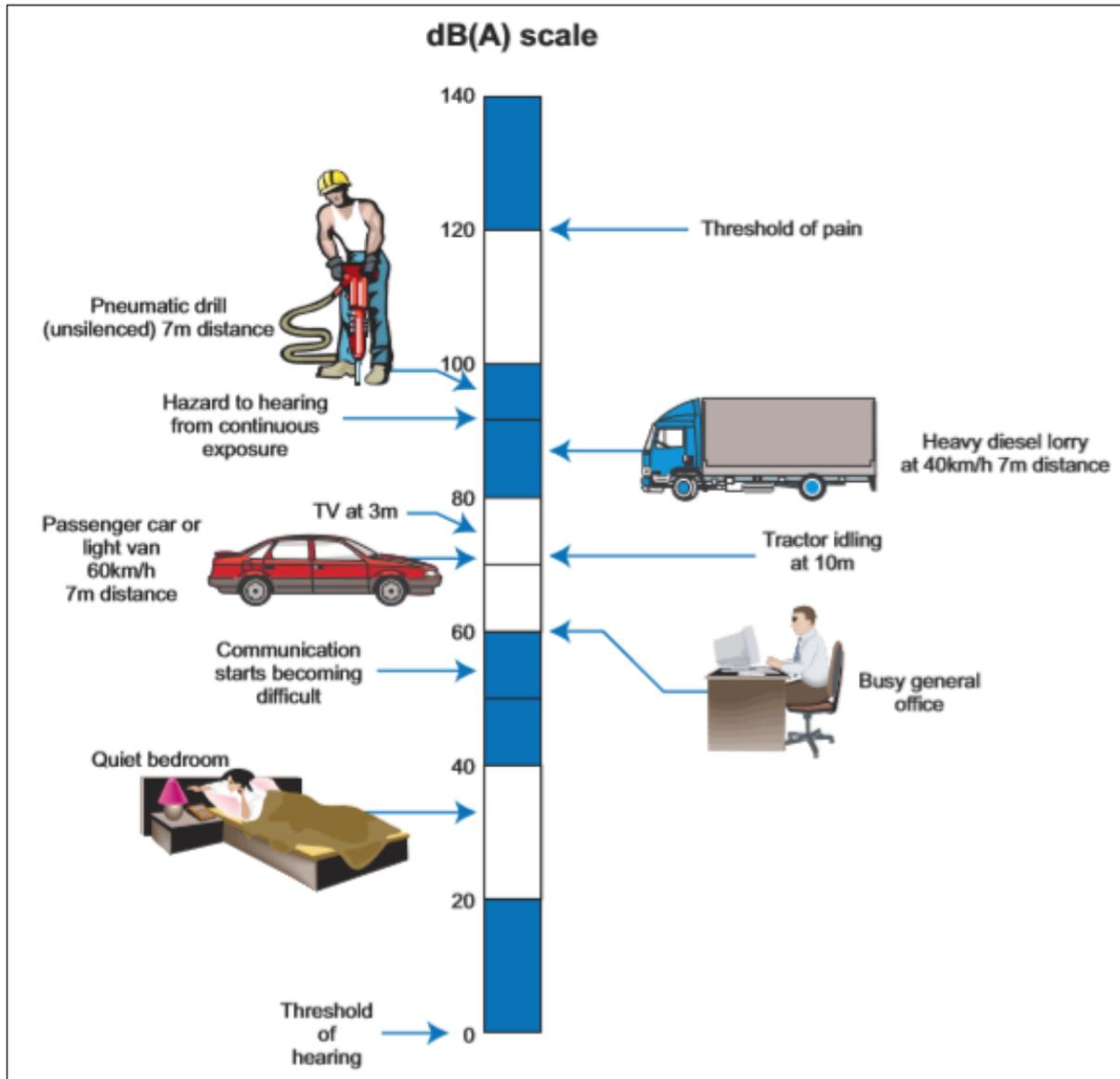


Figure 11.1: The Level of Typical Common Sounds on the dB(A) Scale

Source: NRA Good Practice Guidance for the Treatment of Noise during the Planning of National Road Schemes, 2014)

11.2.3 Noise Model

A series of computer-based prediction models have been prepared to quantify the cumulative noise level associated with the operation of the project. This section discusses the methodology of the noise modelling.

11.2.3.1 Noise Modelling Software

Proprietary noise calculation software was used for the purposes of this impact assessment. The selected software, DGMR iNoise Enterprise, calculates noise levels in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation* (ISO, 1996).

iNoise is a proprietary noise calculation software package for computing noise levels and propagation of noise sources. iNoise calculates noise levels in different ways depending on the selected prediction standard. In general, however, the resultant noise level is calculated considering a range of factors affecting the propagation of

sound, including:

- the magnitude of the noise source in terms of A weighted sound power levels (L_{WA});
- the distance between the source and receiver;
- the presence of obstacles such as screens or barriers in the propagation path;
- the presence of reflecting surfaces;
- the hardness of the ground between the source and receiver;
- attenuation due to atmospheric absorption; and,
- meteorological effects such as wind gradient, temperature gradient and humidity (these have significant impact at distances greater than approximately 400m).

The input data and assumptions made are described in the following sections.

11.2.3.2 Wind Turbine Details

Table 11.1 details the coordinates of the 8 no. wind turbines which will form the Cush Wind Farm.

Location	Coordinates (ITM)	
	Easting	Northing
T1	606,797	710,446
T2	606,312	709,829
T3	607,351	710,753
T4	607,060	710,033
T5	607,922	710,465
T6	607,844	709,967
T7	608,286	709,735
T8	608,427	710,195

Table 11.1: Project (Wind Farm) Turbine Coordinates

We are also aware of a number of wind energy developments to be located to the north of the subject project; these are:

- Cloghan (operational wind farm);
- Derrinlough (wind farm under construction); and,
- Meanwaun (operational wind farm).

Given the relative proximity of these developments to the subject project, this assessment also includes a comprehensive assessment of the likely significant cumulative effects.

Sound power levels (L_{WA}) for the selected wind turbine, the Vestas V172-7.2 have been supplied by Vestas. **Tables 11.2** detail the noise spectra used for noise modelling purposes. As outlined in **Section 11.3** (below), appropriate guidance is couched in terms of a $L_{A90,10min}$ criterion. The provided turbine noise is referenced in terms of the $L_{Aeq,T}$ parameter. 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) (IOA GPG) states that " L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2 dB". Therefore, in accordance with best practice guidance, a 2dB reduction has been applied to the

predicted results in this assessment.

For the purposes of all noise model predictions presented in this chapter, and to account for various uncertainties in the measurement of turbine source levels. In this instance, an allowance for uncertainty of +1 dB has been added to all the noise emission values based on information supplied by the manufacturer.

Values in the following tables do not include the uncertainty allowance, which is instead taken into account in the calculation process.

Wind Speed m/s	Octave-band Centre Frequencies, Hz								Overall, dB(A)
	63	125	250	500	1k	2k	4k	8k	
3	78.9	85.4	88.4	89.6	88.3	84.1	76.9	66.8	94.8
4	81.1	88.7	92.0	93.0	91.5	86.9	79.1	68.1	98.1
5	86.5	94.0	97.2	98.0	96.5	91.9	84.0	73.0	103.2
6	89.7	97.7	101.0	101.3	99.6	94.8	86.9	75.8	106.6
7	90.1	98.0	101.3	101.6	99.9	95.1	87.2	76.1	106.9
8	90.5	98.2	101.3	101.5	99.8	95.2	87.5	76.7	106.9
≥9	90.6	98.1	101.3	101.5	99.8	95.3	87.7	77.0	106.9

Table 11.2: Sound Power Level of the Vestas V172-7.2 with a Hub Height of 114m

Note: Referenced to wind speeds at standardised 10m above ground.

See **Annex 11.2** for turbine coordinates and sound power levels for Cloghan, Derrinlough, and Meanwaun wind farms.

11.2.3.3 Modelling Parameters

Prediction calculations for turbine noise have been conducted in accordance with ISO 9613: *Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation, 1996*.

In terms of calculation settings, the ground attenuation factor (general method) was set to 0.5, no metrological correction was used, and the atmospheric attenuation outlined in **Table 11.3** was used for all turbine noise calculations in accordance with guidance outlined in the IOA GPG. See **Annex 11.3** for further discussion of calculation parameters and settings.

Temp °C	% Humidity	Octave-band Centre Frequencies, Hz							
		63	125	250	500	1k	2k	4k	8k
10	70	0.12	0.41	1.04	1.93	3.66	9.66	32.77	116.88

Table 11.3: Atmospheric Attenuation Assumed for Noise Calculations (dB per km)

11.2.3.4 Additional Information

Noise Sensitive Locations (NSLs), ground topography and geographical features have been taken from survey information supplied by GES and from '10-metre resolution'

digital terrain data sourced from Ordnance Survey Ireland. **Annex 11.4** details the locations assessed as identified in a residential dwelling survey conducted of all properties within 2km (10-times tip height) of each of the project wind turbines. It is standard practice for all dwellings within 10-times rotor diameter to be assessed for likely noise effects; however, all dwellings within 10-times overall tip height, which is an extremely conservative and precautionary approach, have been assessed in this chapter. Noise predictions have been prepared for a range of wind speeds at these locations.

11.3 Guidance Documents & Assessment Criteria

The following sections review best practice guidance that is commonly adopted in relation to developments such as the subject project.

11.3.1 Construction Phase

11.3.1.1 Noise

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

In the absence of specific noise limits, appropriate criteria relating to permissible construction noise levels for a development of this scale may be found in the British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.

The approach adopted here calls for the designation of a NSL into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. This then sets a threshold noise value that, if exceeded (construction noise only), indicates a potential significant noise impact is associated with the construction activities.

Table 11.4 sets out the values which, when exceeded, potentially signify a significant effect at the facades of residential receptors as recommended by BS 5228 – 1. These levels relate to construction noise only.

Assessment category and threshold value period (T)	Threshold values, $L_{Aeq,T}$ dB		
	Category A <small>Note A</small>	Category B <small>Note B</small>	Category C <small>Note C</small>
Night-time (23:00 to 07:00hrs)	45	50	55
Evenings and weekends <small>Note D</small>	55	60	65
Daytime (07:00 – 19:00hrs) and Saturdays (07:00 – 13:00hrs)	65	70	75

Table 11.4: Example Threshold of Potential Significant Effect at Dwellings

Note A: Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.

Note B: Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.

Note C: Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.

Note D: 19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.

The following assessment method is only valid for residential properties. The approach is as follows: For the appropriate period (e.g. daytime), the ambient noise level is determined and rounded to the nearest 5dB. In this instance, given the rural nature of the project site, properties near the project have daytime ambient noise levels that typically range from 45 to 55dB $L_{Aeq,1hr}$. Therefore, the categories detailed in **Table 11.5** are appropriate in terms of the nearest noise sensitive locations being considered in this instance.

Period	Baseline Noise Category	Construction Noise Value Threshold Value $L_{Aeq,12hr}$ (dB)
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	A	65
Evening (19:00 to 23:00hrs)	A	55
Night time (23:00 to 07:00hrs)	A	45

Table 11.5: Rounded baseline noise levels and Construction Noise Thresholds

In order to assist with interpretation of Constructions Noise Thresholds ('CNTs'), **Table 11.6** includes guidance as to the likely magnitude of impact associated with construction activities, relative to the CNT. This guidance is derived from Table 3.16 of DMRB: Noise and Vibration and adapted to include the relevant significance effects from the EPA Guidelines (EPA 2022).

Construction Noise Level	Magnitude of Impact (DMRB)	EPA Significance of Effect
Below or equal Baseline Noise Level	Negligible	Not Significant
Above Baseline and below or equal to CNT	Minor	Slight – Moderate
Above threshold and below or equal to CNT + 5dB	Moderate	Moderate – Significant
Above CNT + 5dB	Major	Significant – Very Significant

Table 11.6: Description of the magnitude of impacts.

**Adapted from DMRB Table 3.16*

11.3.1.2 Vibration

Vibration standards come in two varieties: those dealing with human comfort and those dealing with cosmetic or structural damage to buildings. With respect to the project, the range of relevant criteria used for building protection is expressed in terms of Peak Particle Velocity (PPV) in mm/s.

Guidance relevant to acceptable vibration within buildings is contained in the following documents:-

- *British Standard BS 7385 – Evaluation and measurement for vibration in buildings – Part 2: Guide to damage levels from groundborne vibration (1993); and*
- *British Standard BS 5228 – Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration (2009+A1:2014).*

BS7385-2 and BS5228-2 advise that, for soundly constructed residential properties and

similar light-framed structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak component particle velocity (in frequency range of predominant pulse) of 15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz and 50 mm/s at 40 Hz and above for transient vibration. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table B.2 of BS5228-2 may need to be reduced by up to 50%. On a cautious basis, therefore, continuous vibration limits are set as 50% of those for transient vibration across all frequency ranges. For buildings or structures that are structurally unsound, lower vibration magnitudes will apply, typically 50% of those for structurally sound buildings. Protected or historic buildings are not automatically assumed to be more vulnerable to vibration unless they have existing structural defects. The values are summarised in **Table 11.7**.

Type of Building	Peak component particle velocity in frequency range of predominant pulse	
	4Hz to 15Hz	15Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings.	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures. Residential or light commercial building types.	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above.

Table 11.7: Transient Vibration Guide Values for Cosmetic Building Damage

**Note 1 Values referred to are at the base of the building.*

**Note 2 At frequencies below 4Hz, a maximum displacement of 0.6 mm (zero to peak) is not to be exceeded.*

BS 5228-2 and BS 7485-2 state that minor structural damage can occur at vibration magnitudes greater than twice those in **Table 11.7** and major structural damage can occur at vibration magnitudes greater than four times those in **Table 11.7**.

The guide values contained in **Table 11.7** relate to predominantly transient vibration which does not give rise to resonant responses in structures, and to low rise buildings.

11.3.1.3 Construction Traffic

There are no specific guidelines or limits relating to traffic related sources along the local or surrounding roads. Given that traffic from the construction of the Proposed Development will make use of existing roads already carrying traffic volumes, it is appropriate to assess the calculated increase in traffic noise levels that will arise because of vehicular movements associated with construction works.

In order to assist with the assessment of construction traffic noise, reference is made to the Design Manual for Roads and Bridges LA 111 (DMRB), Highways England Company Limited, Transport Scotland, The Welsh Government and The Department for Regional Development (Northern Ireland), (hereafter referred to as DMRB) The DMRB has been used to assess the likely magnitude of effect associated with changes in traffic noise levels along an existing road. **Table 11.8** below presents the likely effects associated with change in traffic noise level and is adapted from Table 3.17 of the DMRB to include a column on the significance of effects in EPA/EIAR terms.

Change in Sound Level (dB)	Subjective Reaction	DMRB Magnitude of Impact (Short-term)	EPA Significance of Effect
Less than 1 dB	Inaudible	Negligible	Imperceptible
1 – 2.9	Barely Perceptible	Minor	Not Significant
3 – 4.9	Perceptible	Moderate	Slight, Moderate
≥ 5	Up to a doubling of loudness	Major	Significant

Table 11.8: Classification of Magnitude of Traffic Noise Changes in the Short-term

In accordance with the DMRB Noise and Vibration Guidance, construction noise and construction traffic noise effects shall constitute a significant effect where it is determined that a major or moderate magnitude of effect will occur for a duration exceeding:

- Ten or more days or night in any 15 consecutive day or nights; and,
- A total number of days exceeding 40 in any six consecutive months.

11.3.2 Operation Phase

11.3.2.1 Noise

This noise assessment has been undertaken in accordance with guidance 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 Department of Trade & Industry (UK) 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 2006 Guidelines where necessary.

Wind Energy Development Guidelines for Planning Authorities 2006

Section 5.6 of the *Wind Energy Development Guidelines for Planning Authorities* published by the Department of the Environment, Heritage and Local Government (2006) addresses noise and outlines the appropriate noise criteria in relation to wind farm developments.

The following extracts from this document should be considered:-

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

“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.”

“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 curve 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 5dB(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 30dB(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 35–40dB(A).”

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

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

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

It is proposed to adopt a lower daytime threshold of 40 dB $L_{A90,10-min}$ for low noise environments where the background noise is less than 30 dB(A). This proposal follows a review of the prevailing baseline noise survey data contained in this assessment and 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: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)* 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; and,
- It should be reiterated that the *Wind Energy Development Guidelines for Planning Authorities 2006* states that “An appropriate balance must be achieved between power generation and noise impact.” Based on a review of other 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 robust.

In summary, the *Wind Energy Development Guidelines for Planning Authorities 2006* outline the following guidance to identify appropriate wind turbine noise criteria curves at NSLs:-

- Identify an appropriate absolute limit level between 35–40 dB $L_{A90,10min}$ for quiet daytime environments with background noise levels less than 30 dB $L_{A90,10min}$;
- 45 dB $L_{A90,10min}$ for daytime environments greater than 30 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher); and,
- 43 dB $L_{A90,10min}$ or a maximum increase of 5 dB above background noise (whichever is higher) for night-time periods.

It should be noted that while the caveat of an increase of 5dB(A) above background noise levels for night-time operation is not explicit within the current guidance, it is commonly applied to noise assessments prepared for wind energy developments and is detailed in numerous planning conditions issued by local planning authorities and An Bord Pleanála.

The proposed operational noise criteria curves for wind turbine noise at various NSLs are presented in **Section 11.5.3**.

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

As stated previously, the core of the noise guidance contained within the *Wind Energy Development Guidelines for Planning Authorities 2006* 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 through the application of noise limits at the nearest noise sensitive properties. ETSU-R-97 considers that absolute noise limits applied at all wind speeds are not suited to wind turbine developments and recommends that noise limits should be set relative to the existing background noise levels at noise sensitive locations. A critical aspect of the noise assessment of wind energy proposals relates to the identification of baseline noise levels through on-site noise surveys.

ETSU-R-97 states, on page 58, that “...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...”. Therefore, the noise contribution from all wind turbine developments in the area should be included in the assessment.

Institute of Acoustics Good Practice Guide

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)* (IOA 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 baseline 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 collated at the site of the wind turbine development. Regression analysis is then conducted on the data sets to derive background noise levels at various wind speeds to establish the appropriate day and night-time noise criterion curves.

Noise emissions associated with the wind turbine 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 noise 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.

Reference has been made to the IOA GPG for guidance on the methodology for the background noise survey and operational phase impact assessment for wind turbine noise.

Future Potential Guidance Changes

In December 2019, the *Draft Revised Wind Energy Development Guidelines* were published for consultation but have not yet to be finalised. Therefore, in accordance with best practice, which includes ESTU and IOA methodologies as described above,

the assessment presented in the EIAR is based on the current guidance outlined in Section 5.6 of the *Wind Energy Development Guidelines for Planning Authorities 2006*.

World Health Organization (WHO) Noise Guidelines for the European Region

The WHO *Environmental Noise Guidelines for the European Region* (2018) provide guidance on protecting human health from exposure to environmental noise. They set health-based recommendations based on average environmental noise exposure of several sources of environmental noise, including wind turbine noise. Recommendations are rated as either 'strong' or 'conditional'. A strong recommendation, "can be adopted as policy in most situations" whereas a conditional recommendation, "requires a policy-making process with substantial debate and involvement of various stakeholders. There is less certainty of its efficacy owing to lower quality of evidence of a net benefit, opposing values and preferences of individuals and populations affected or the high resource implications of the recommendation, meaning there may be circumstances or settings in which it will not apply".

In relation to wind turbine noise, the WHO Guideline Development Group (GDG) state the following:-

"For average noise exposure, the GDG conditionally recommends reducing noise levels produced by wind turbines below 45 dB L_{den} , as wind turbine noise above this level is associated with adverse health effects.

No recommendation is made for average night noise exposure L_{night} of wind turbines. The quality of evidence of night-time exposure to wind turbine noise is too low to allow a recommendation.

To reduce health effects, the GDG conditionally recommends that policy-makers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure. No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another."

The quality of evidence used for the WHO research is stated as being 'Low' and, as a result, the recommendations are therefore conditional.

The WHO *Environmental Noise Guidelines for the European Region* aim to support the legislation and policy-making process at a local, national and international level, and thus may be considered by Irish policy makers for any future revisions of Irish national guidelines.

There is potential for increased uncertainty due to the parameter used by the WHO for assessment of exposure (i.e. L_{den}) which, it is acknowledged, may be a poor characterisation of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes, as stated below.

"Even though correlations between noise indicators tend to be high (especially between L_{Aeq} - like indicators) and conversions between indicators do not normally influence the correlations between the noise indicator and a particular health effect, important assumptions remain when exposure to wind turbine noise in L_{den} is converted from original sound pressure level values. The conversion requires, as variable, the statistical distribution of annual wind speed at a particular height, which depends on the type of wind turbine and meteorological conditions at a particular geographical location. Such input variables may not be directly applicable for use in other sites. They are

sometimes used without specific validation for a particular area, however, because of practical limitations or lack of data and resources. This can lead to increased uncertainty in the assessment of the relationship between wind turbine noise exposure and health outcomes. Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} 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."

Based upon the review set out above, it is concluded that the conditional WHO recommended average noise exposure level (i.e. 45dB L_{den}) should not currently be applied as target noise criteria for the project.

11.3.2.2 Special Characteristics of Wind Turbine Noise

Infrasound/Low Frequency Noise

Low Frequency Noise is noise that is dominated by frequency components less than approximately 200 Hz whereas Infrasound is typically described as sound at frequencies below 20 Hz. In relation to Infrasound, the following extract from the Environmental Protection Agency (EPA) document *Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3)* (EPA, 2011) is noted here:-

"There is similarly no significant infrasound from wind turbines. Infrasound is high level sound at frequencies below 20 Hz. 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. In relation to the issue of infrasound, the article states the following:-

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

The article concludes that:-

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

A report released in January 2013 by the South Australian Environment Protection Authority namely, *Infrasound levels near windfarms and in other environments* (EPA, 2013¹) 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 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.

¹ EPA South Australia, 2013, Wind farms https://www.epa.sa.gov.au/files/477912_infrasound.pdf

The South Australian 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 which ran 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."

Amplitude Modulation

In the context of this assessment, amplitude modulation (AM) is defined in IOA Wind Turbine Noise Amplitude Modulation Working Group (AMWG) document *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (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 AM:-

- '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 1 Hz.

'Normal' AM is defined as where 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 is defined as where 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 'whoomping' at relatively low frequencies. On wind farm 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. The RenewableUK AM project report adopted the term 'Other AM' (OAM) for this characteristic. The terms 'enhanced' or 'excess' AM (EAM) have been used by others, although such definitions do not distinguish between the source mechanisms and presuppose a 'normal' level of AM, presumably relating back to blade swish as described in ETSU-R-97.

Frequency of Occurrence of AM

Research by Salford University commissioned by the United Kingdom Department of Environment Food and Rural Affairs (DEFRA), the Department of Business, Enterprise and Regulatory Reform (BERR) and the Department of Communities and Local Government (CLG) investigated the issue of AM associated with wind turbine noise. The results were reviewed and published in the report Research into Aerodynamic Modulation of Wind Turbine Noise (2007). The broad conclusions of this report were that aerodynamic modulation was only considered to be an issue at 4 no., and a possible issue at a further 8 no. of 133 no. sites in the UK that were operational at the time of the study and considered within the review. At the 4 no. sites where AM was confirmed as an issue, it was considered that conditions associated with AM might occur between about 7% and 15% of the time. It also emerged that for three out of the four sites the complaints have subsided, in one case due to the introduction of a turbine control system. The research has shown that AM is a rare and unlikely occurrence at operational wind farms.

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

RenewableUK Research Document states the following in relation to matter:-

Page 68, Module F *"even on those limited sites where it has been reported, its frequency of occurrence appears to be at best infrequent and intermittent."*

Page 6, Module F *"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."*

Page 61, Module F *"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 recent 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 Reference Method). 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 or 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. In the absence of published guidance, it is considered best practice to adopt the penalty rating and assessment scheme contained in an article published in the Institute of Acoustics publication *Acoustics Bulletin* (Vol. 42 No. 2 March/April 2017) titled, Perception and Control of Amplitude Modulation in Wind Turbines Noise.

Where it occurs, AM is typically an intermittent occurrence, therefore assessment may involve long-term measurements. The measurement method outlined in the IOA AMWG document, known as the 'Reference Method', will provide a robust and reliable indicator of AM and yield important information on the frequency and duration of occurrence, which can be used to evaluate different operational conditions including mitigation.

11.3.2.3 Comments on Human Health Impacts

The National Health & Medical Research Council

The 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"

New South Wales Health Department

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

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

The Australian Medical Association

The Australian Medical Association put out a position statement, *Wind Farms and Health 2014*² which stated:-

"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."

Health Canada

Health Canada, Canada's national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014³. 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.

Journal of Occupational & Environmental Medicine

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

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

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

11.3.2.4 Vibration

A recent report published in Germany by the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in 2016 titled *Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*, conducted a vibration measurement study for an operational Nordex N117-

² Australian Medical Association, 2014, Wind farms and health. Available at <https://ama.com.au/position-statement/wind-farms-and-health-2014>

³ Health Canada 2014, Wind Turbine Noise and Health Study: Summary of Results. Available at <https://www.canada.ca/en/health-canada/services/environmental-workplace-health/noise/wind-turbine-noise/wind-turbine-noise-health-study-summary-results.html>

2.4MW wind turbine. The report concluded 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 the distances from the nearest NSLs to any of the proposed turbines (the nearest NSL being c. 590m from the nearest turbine), the level of vibration will be significantly below any thresholds for perceptibility. Therefore, vibration criteria have not been specified for the operational phase of the project.

11.3.2.5 EPA Description of Effects

The significance of effects of the project shall be described in accordance with the EPA guidance document *Guidelines on the information to be contained in Environmental Impact Assessment Reports, May 2022*. Details of the methodology for describing the significance of the effects are provided in **Chapter 1**.

The effects associated with the project are described with respect to the EPA guidance in the relevant sections of this chapter.

11.4 Description of the Existing Environment

As outlined above, prior to undertaking noise prediction modelling, it is necessary to understand the typical background noise levels at the nearest NSLs to the project site. The background noise survey was conducted by installing unattended sound level meters at four representative locations surrounding the project site.

The installation, retrieval and management of all measurement instrumentation detailed in this section has been carried out by GES. GES has confirmed that all measurement data collected during the baseline noise surveys has been carried out in accordance with the IOA guidance document "A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise" (2013) and accompanying "Supplementary Guidance Note 1: Data Collection" (2014).

The analysis and assessment of all survey data has been carried out by AWN Consulting.

11.4.1 Choice of Measurement Locations

The noise measurement locations used were selected following consultation between GES and AWN Consulting. Noise monitoring locations were identified by preparing a preliminary noise model contour at an early stage of project development. Any locations that fell inside the predicted 35dB L_{A90} noise contour were considered as a noise monitoring location in line with current best practice guidance outlined in the IOA GPG. The selection of the noise monitoring locations was informed by a site visit and supplemented by reviewing aerial images of the study area and other online sources of information (e.g. Google Earth).

The locations selected for baseline noise monitoring are outlined in the following sections. Coordinates for the noise monitoring locations are detailed in **Table 11.9**.

Location	Coordinates - (ITM)	
	Easting	Northing
A (H057)	609,000	710,151
B (H032)	608,187	712,007
C (H014)	606,111	711,029

D (H084)	607,284	709,378
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Table 11.9: Measurement Location Coordinates

Significant noise sources, as heard during the site visit and installation of noise measurement equipment, at the survey locations were noted to be distant traffic movements, activity in and around the residences and wind generated noise from local foliage and other typical anthropogenic sources typically found in such rural settings. Operational wind farms were not audible at the survey locations.

There was no perceptible source of vibration noted at any survey location.

Figures 11.2 to 11.5 illustrate the installed noise monitoring equipment. The locations of the unattended noise monitors are illustrated at **Figure 11.6**



Figure 11.2: Location A (H057)



Figure 11.3: Location B (H032)



Figure 11.4: Location C (H014)



Figure 11.5: Location D (H084)



Figure 11.6: Noise Survey Locations

11.4.2 Measurement Periods

Noise measurements were conducted at each of the monitoring locations over the periods outlined in **Table 11.10**.

Location	Start Date	End Date
A (H057)	14:30 hrs. on 20 December 2022	12:30 hrs. on 24 January 2023
B (H032)	16:40hrs. on 20 December 2022	16:50 hrs. on 24 January 2023
C (H014)	13:00 hrs. on 20 December 2022	13:20 hrs. on 24 January 2023
D (H084)	14:00 hrs. on 20 December 2022	12:50 hrs. on 24 January 2023

Table 11.10: Measurement Periods

A variety of wind speed and weather conditions, which were identified from data gathered at the temporary meteorological mast installed at the project site, were encountered over the survey periods in question. **Figure 11.7** illustrates the distributions of wind speed and wind direction, standardised to 10-metre height, over the survey period detailed in **Table 11.10**.

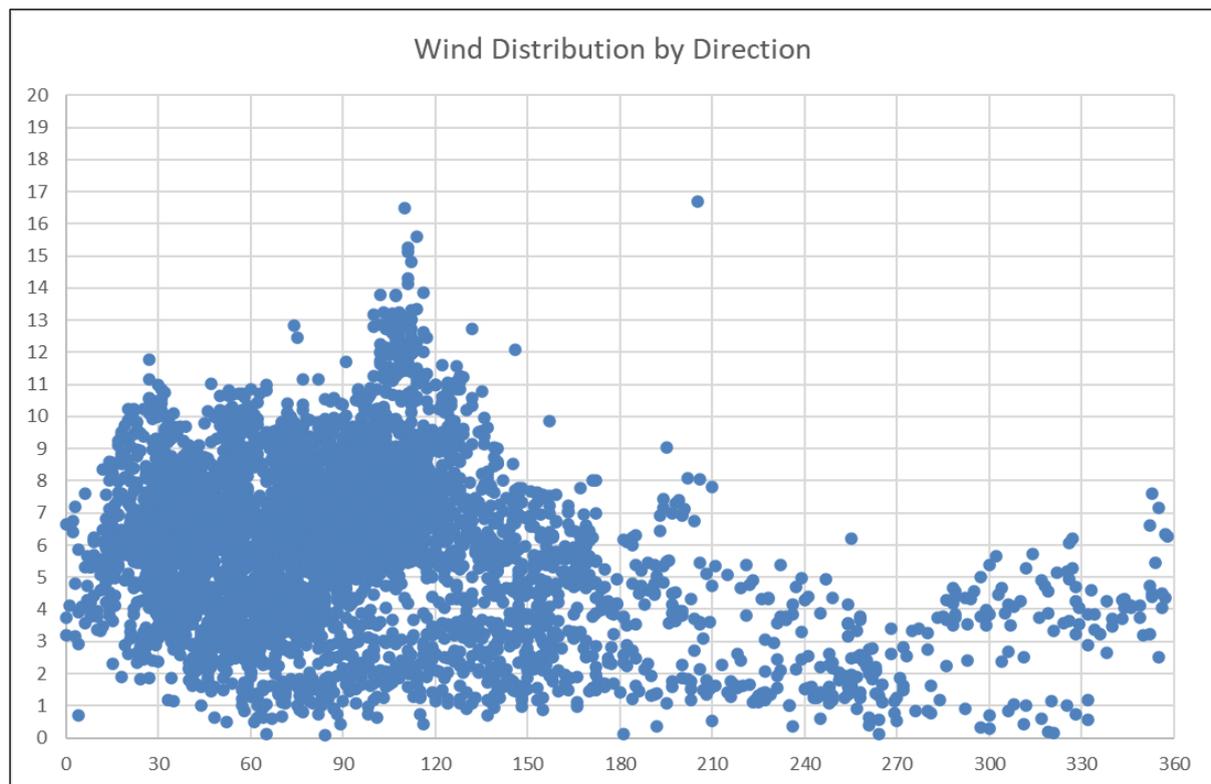


Figure 11.7: Distribution of Wind Speed & Direction Over the Survey Period

11.4.3 Instrumentation

All noise monitoring equipment was installed and removed by GES, with the following

instrumentation being used:-

Location	Equipment	Serial Number
A (H057)	Svantek 977A	96428
B (H032)	Larson Davis LxT	5837
C (H014)	Svantek 977C	92647
D (H084)	Svantek 977C	46009

Table 11.11: Instrumentation Details

Before and after the survey, the measurement apparatus was checked and calibrated using a sound level calibrator where appropriate. Relevant calibration certificates are presented in **Annex 11.5**.

Rainfall was monitored and logged using a 'Theodor Friedrichs 7041.00' tipping bucket rain gauge which was installed on the on-site meteorological mast. This allows for the identification of periods of rainfall to allow for the removal of affected sample periods from the noise monitoring data sets. This approach complies with best practice when calculating the prevailing background noise levels.

Wind data was measured at the meteorological mast with anemometers at 64.7m and 80m above ground level. This data was supplied by GES to AWN for analysis.

11.4.4 Procedure

Measurements were conducted at the 4 no. locations over the survey periods outlined in **Table 11.10**. Data samples for all measurements (noise, rainfall and wind) were logged continuously at 10-minute interval periods for the duration of the survey.

Where survey personnel noted potential primary noise sources contributing to noise build-up during the installation and removal of the sound level meters from site (e.g. identified significant noise sources in the area such as local traffic or wind/foliage noise), $L_{Aeq,10min}$ and $L_{A90,10min}$ parameters were measured in this instance.

11.4.5 Consideration of Wind Shear

Wind shear is defined as the increase of wind speed with height above ground. As part of a robust wind farm noise assessment, due consideration should be given to the issue of wind shear. In this assessment, relevant guidance has been followed as described in the IOA GPG. It is standard procedure to reference noise data to standardised 10 metre height wind speed.

Wind speed measurements at 80m and 64.7m heights have been corrected to a height of 114m (i.e. the hub height for this assessment) in accordance with Method B of the IOA GPG. The calculated hub height wind speeds were then corrected to standardised 10-metre height wind speed.

The IOA GPG presents the following equations in relation to the derivation of a standardised wind speed at 10m above ground level:-

<i>Shear Exponent Profile:</i>	$U = U_{ref} \times [(H \div H_{ref})]^m$ <p>Where:</p> <p>U Calculated wind speed U_{ref} Measured HH wind speed. H Height at which the wind speed will be calculated. H_{ref} Height at which the wind speed was measured. m shear exponent = $\log(U/U_{ref})/\log(H/H_{ref})$</p>
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The calculated hub height wind speeds have been standardised to 10 m height using the following equation:-

<i>Roughness Length Shear Profile:</i>	$U_1 = U_2 \times [(\ln(H_1 \div z)) / (\ln(H_2 \div z))]$ <p>Where:</p> <p>H₁ The height of the wind speed to be calculated (10m) H₂ The height of the measured or calculated HH wind speed. U₁ The wind speed to be calculated. U₂ The measured or calculated HH wind speed. z The roughness length.</p> <p>Note: A roughness length of 0.05m is used to standardise hub height wind speeds to 10-metre 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 turbines.</p>
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It is important to reiterate that any reference to wind speed in the following sections of this chapter should be understood to be the 10-metre height standardised wind speed reference, unless explicitly stated otherwise.

11.4.6 Analysis of Background Noise Data

The results of the background noise monitoring programme are extensive in nature.

The following sections present an overview and statistical analysis of the noise monitoring data obtained from the survey programme at each location for both daytime and night-time periods.

The data sets have been filtered to remove issues such as the dawn chorus and the influence of other atypical noise sources. An example of atypical sources would be short, isolated periods of raised noise levels attributable to local sources, agricultural activity, boiler flues and the operation of gardening or farm equipment.

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 assessment methods outlined above are in line with the guidance contained in the IOA GPG.

The results presented in the following sections refer to the noise data collated during 'quiet periods' of the day and night as defined in the IOA GPG. These periods are defined as follows:-

- Daytime amenity hours (quiet periods) are:-
 - All evening from 18:00 to 23:00hrs;
 - Saturday afternoons from 13:00 to 18:00hrs; and,
 - Sunday from 07:00 to 18:00hrs.
- Night-time hours are 23:00 to 07:00hrs.

11.4.7 Background Noise Levels

The following sections present the results of the noise monitoring data obtained from

the background noise survey in accordance with the methodology discussed above.

11.4.7.1 Location A (H057)

Daytime

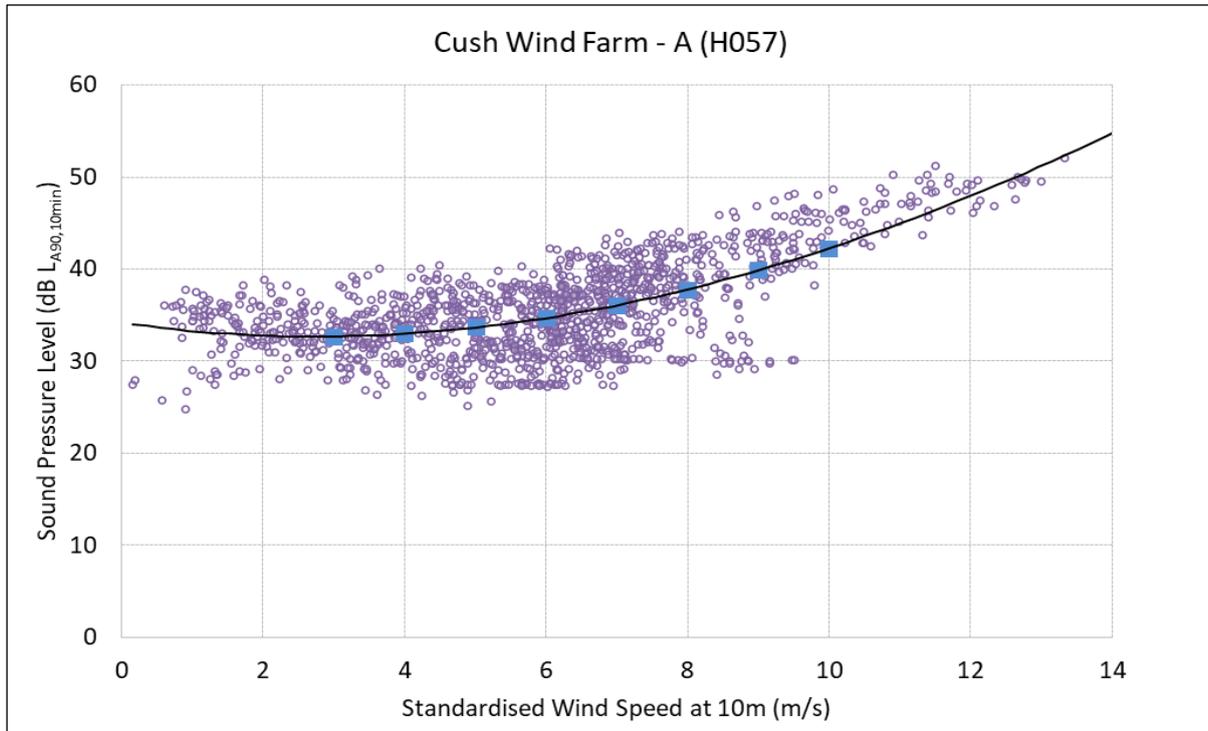


Figure 11.8: Background Noise Levels $L_{A90,10 \text{ min}}$ dB – Location A (H057) – Daytime

Night-time

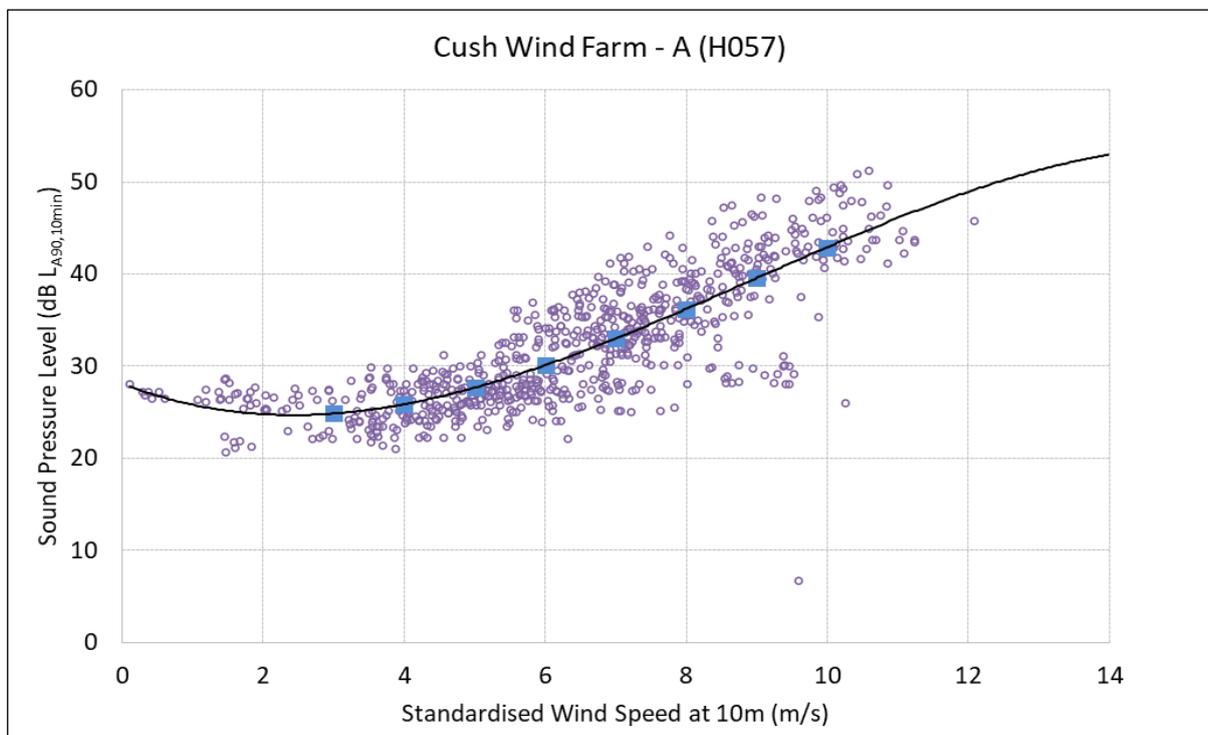


Figure 11.9: Background Noise Levels $L_{A90,10 \text{ min}}$ dB – Location A (H057) – Night-time

11.4.7.2 Location B (H032)

Daytime

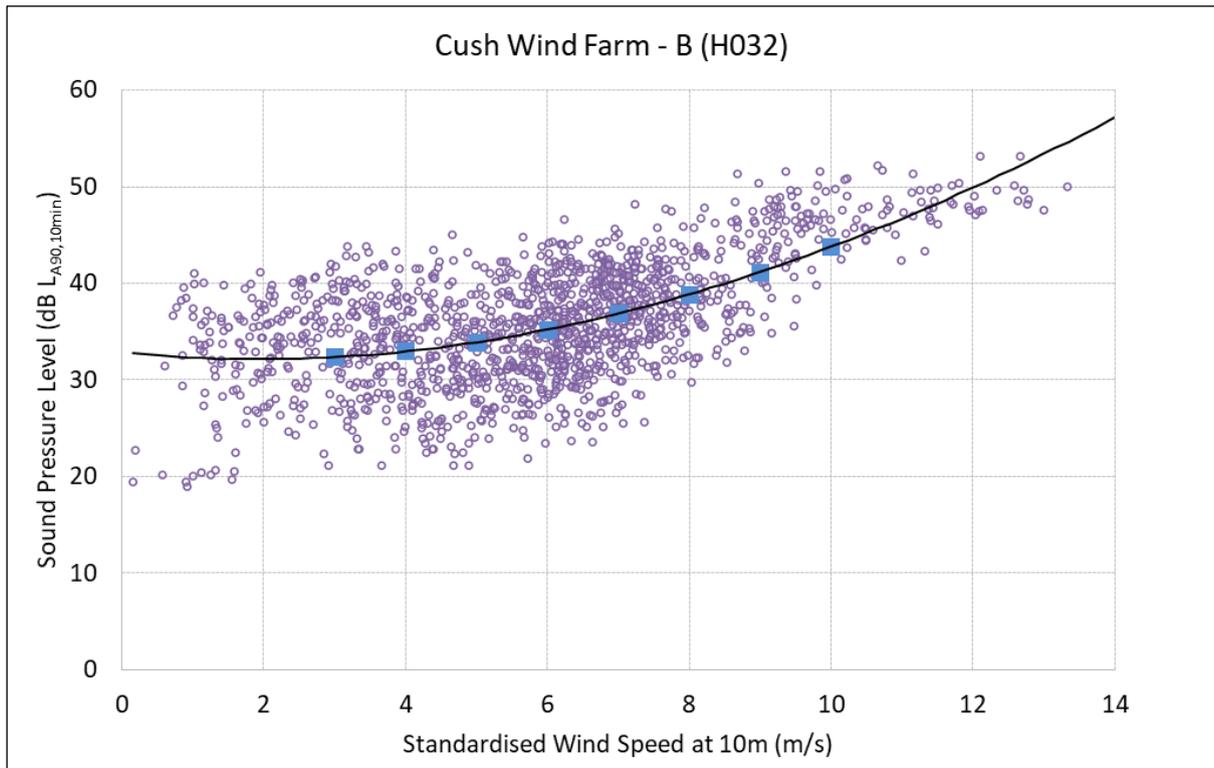


Figure 11.10: Background Noise Levels LA90,10 min dB – Location B (H032) – Daytime

Night-time

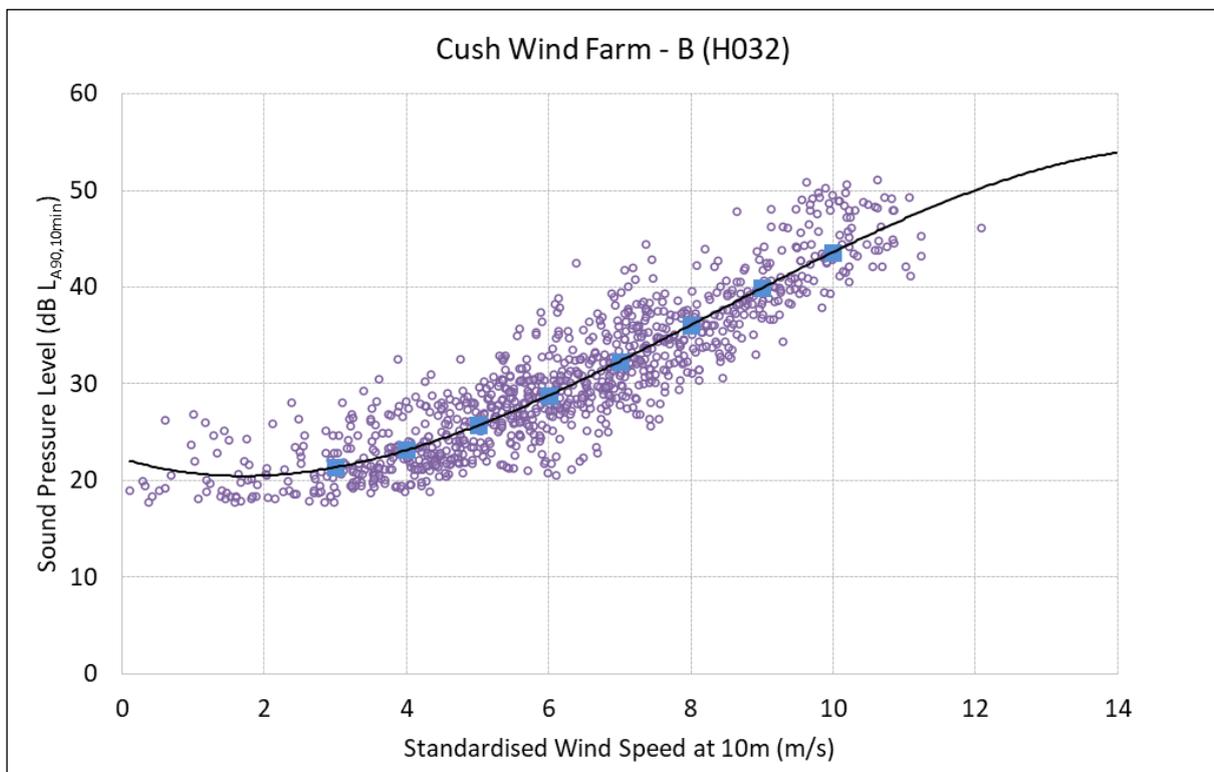


Figure 11.11: Background Noise Levels LA90,10 min dB – Location B (H032) – Night-time

11.4.7.3 Location C (H014)

Daytime

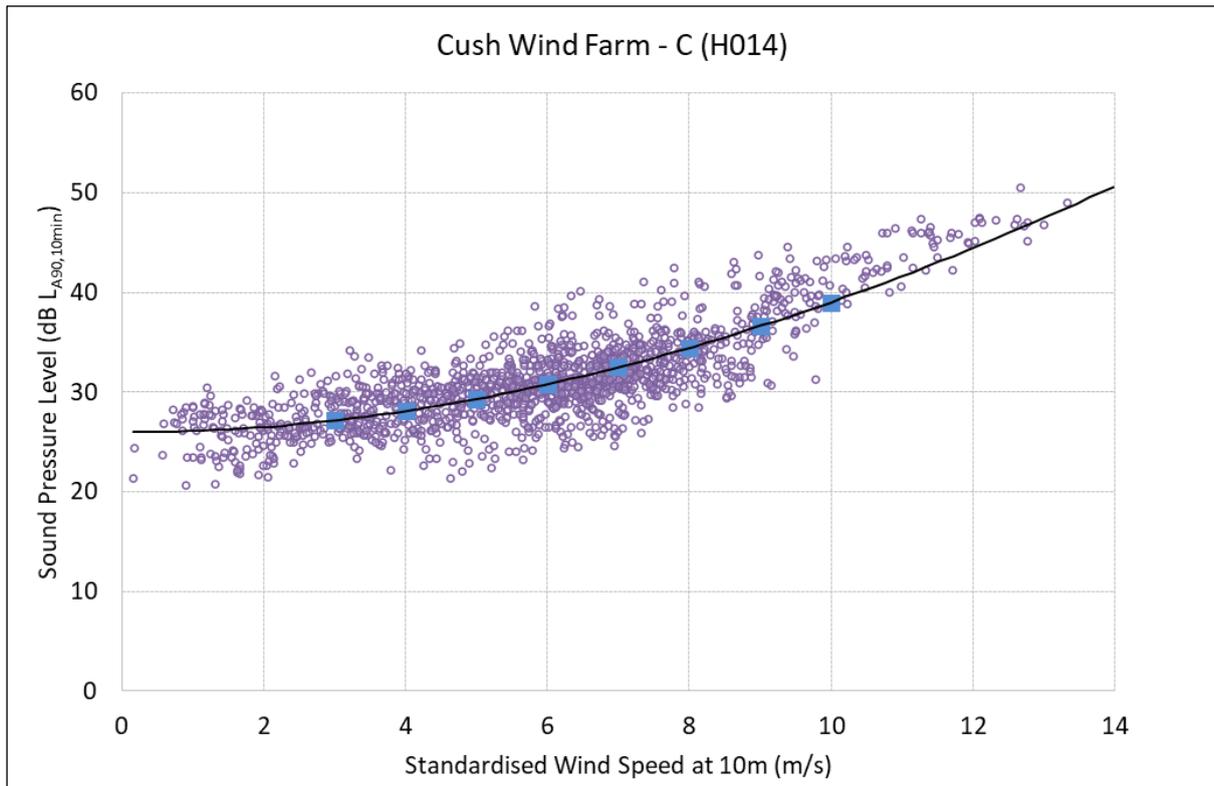


Figure 11.12: Background Noise Levels $L_{A90,10 min}$ dB – Location C (H014) – Daytime

Night-time

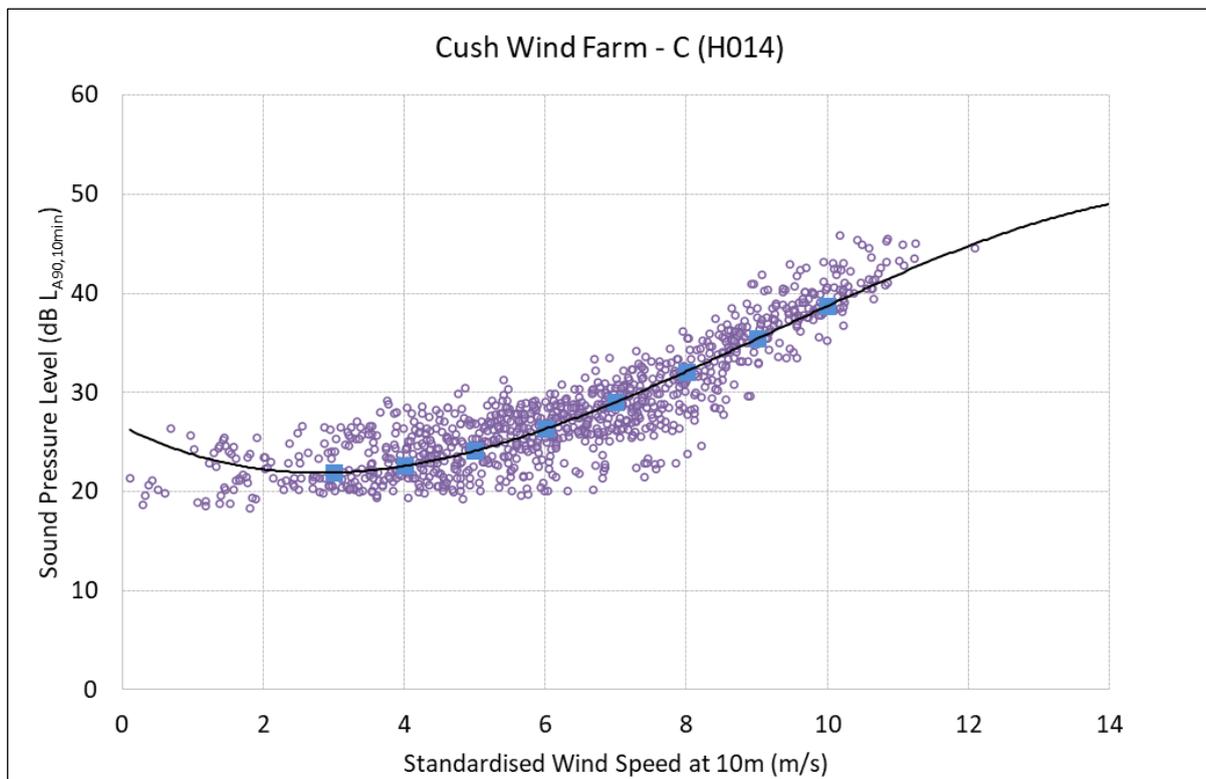


Figure 11.13: Background Noise Levels $L_{A90,10 min}$ dB – Location C (H014) – Night-time

11.4.7.4 Location D (H084)

Daytime

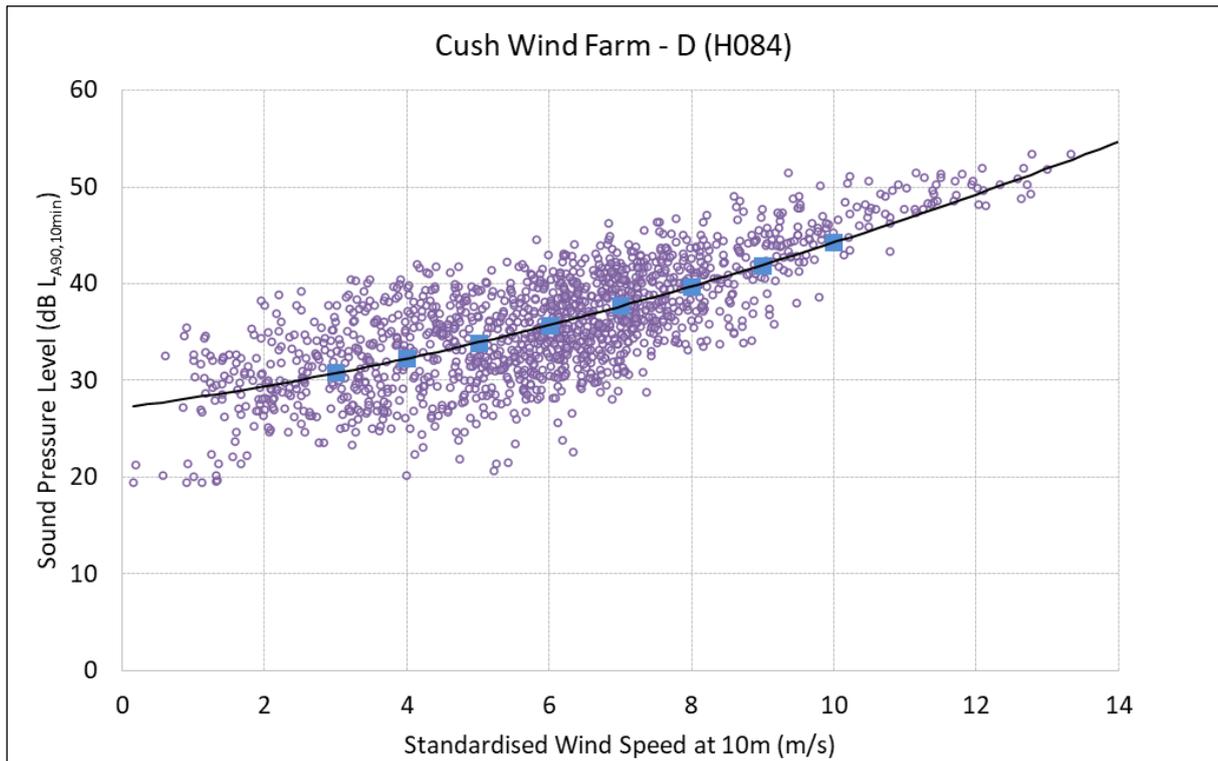


Figure 11.14: Background Noise Levels LA90,10 min dB – Location D (H084) – Daytime

Night-time

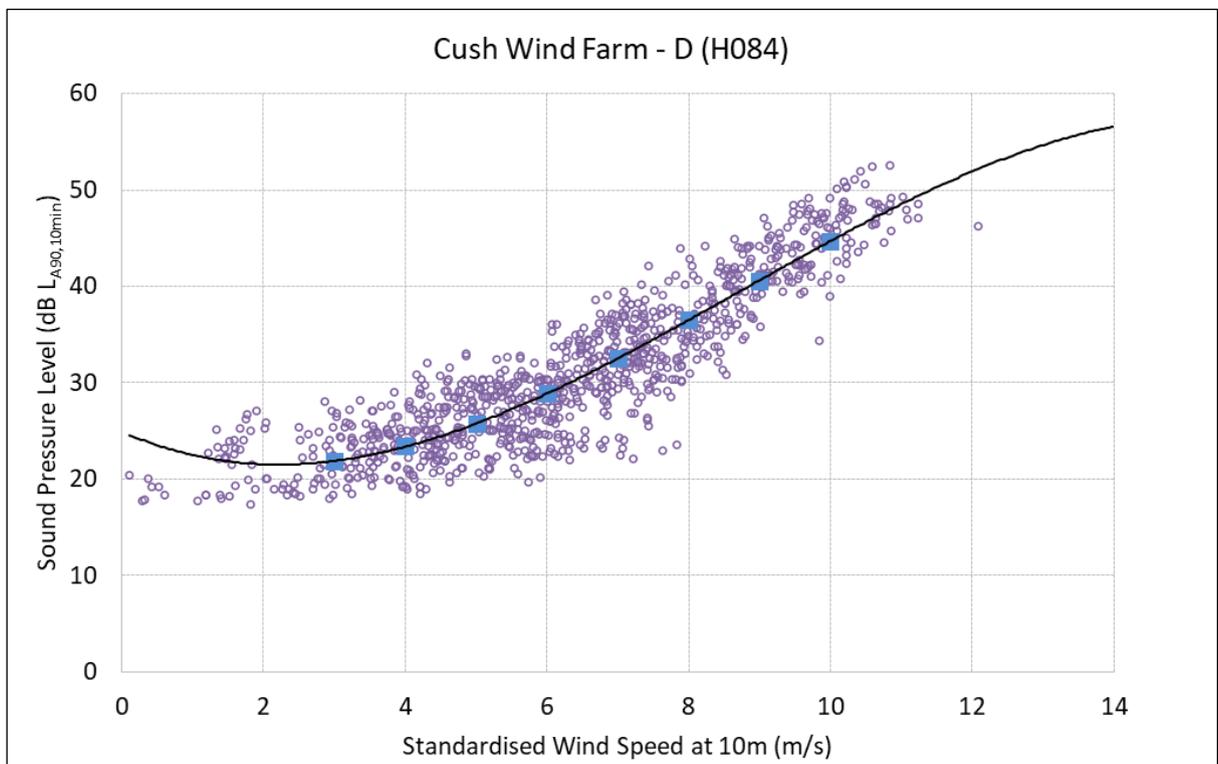


Figure 11.15: Background Noise Levels LA90,10 min dB – Location D (H084) – Night-time

Table 11.12 presents the various derived $L_{A90,10\text{min}}$ noise levels for each of the monitoring locations for daytime quiet periods and night-time periods. These levels have been derived using regression analysis carried out on the data gathered during the noise measurements surveys and in accordance with guidance contained the IOA GPG and its *Supplementary Guidance Note No. 2: Data Processing & Derivation of ETSU-R-97 Background Curves* (2014).

A worst-case envelope based on the lowest prevailing background levels at the various wind speeds for both day and night-time is also presented in **Table 11.11**.

11.4.7.5 Summary

Location	Period	Derived $L_{A90,10\text{min}}$ Levels (dB) at various Standardised 10m Height Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
A (H057)	Day	32.7	33.0	33.7	34.7	36.1	37.8	39.9	42.3
	Night	24.9	25.9	27.7	30.1	33.0	36.2	39.6	42.9
B (H032)	Day	32.4	33.0	33.9	35.2	36.9	38.9	41.2	43.8
	Night	21.4	23.2	25.7	28.8	32.3	36.1	39.9	43.6
C (H014)	Day	27.2	28.1	29.3	30.8	32.5	34.4	36.6	39.0
	Night	21.9	22.6	24.1	26.3	29.0	32.1	35.4	38.7
D (H084)	Day	30.8	32.3	33.9	35.7	37.7	39.7	41.9	44.3
	Night	21.9	23.4	25.8	28.9	32.5	36.5	40.6	44.7
Envelope	Day	27.2	28.1	29.3	30.8	32.5	34.4	36.6	39.0
	Night	21.4	22.6	24.1	26.3	29.0	32.1	35.4	38.7

Table 11.12: Derived Levels of $L_{A90,10\text{min}}$ for Various Wind Speeds

11.5 Description of Likely Effects

11.5.1 'Do-Nothing' Scenario

If the project is not progressed, the existing noise environment in the vicinity of the subject site and at noise sensitive receptors will remain largely unchanged.

11.5.2 Construction Phase

A variety of items of plant and machinery will be in use for the purposes of site preparation, construction of turbines, access tracks, grid connection, re-planting of forestry and other site works. There will be vehicular movements to and from the site that will make use of existing roads. Due to the nature of these activities, there is potential for the generation of significant levels of noise. These are discussed in the following sections.

The predicted noise levels referred to in this section are indicative only and are intended to demonstrate that it will be possible for the contractor to comply with current best practice guidance. It should also be noted that the predicted 'worst-case' levels are expected to occur for only short periods of time at a very limited number of properties. Construction noise levels will be lower than these levels for most of the time at most properties in the vicinity of the project.

11.5.2.1 Construction Activities within the Wind Turbine Locations (incl. forestry felling operations)

Noise

In this instance, the NSLs surround the site at varying distances with the nearest to the

proposed turbine locations (and associated foundations & crane hardstandings), the closest of which being H057 at a distance of c. 590m. Taking this as a worst-case, a variety of plant and machinery that would be expected on a construction site of this nature have been identified and noise predictions of their likely impacts assessed. The assessment is representative of a 'worst-case', with construction noise levels being slightly lower at properties located further than 590m from the works.

Table 11.13 presents, considering the anticipated methods of construction, the noise levels associated with typical construction noise sources along with typical sound pressure levels and spectra from BS 5228 – 1: 2009+A1 2014. The calculations assume that plant items are operating for 66% of the time and that there is no acoustic screening (i.e. barriers) in place between the site works and the NSL.

The total construction noise levels are predicted to be below the appropriate Category A value (i.e. 65dB $L_{Aeq,1hr}$) and therefore a significant effect is not predicted in relation to the nearest NSLs in terms of construction noise arising from the construction of the wind turbines. As all other NSLs are located at an increased distance from these construction activities, no significant effects are predicted as likely to arise.

There are no items of plant or machinery that would be expected to give rise to noise levels that would be considered out of the ordinary or in exceedance of acceptable levels.

Item (BS5228 ref)	Activity	Plant Noise Level at 10m Distance (dB $L_{Aeq,1hr}$)	Plant Noise Level at 590m Distance (dB $L_{Aeq,1hr}$)
HGV Movement (C.2.34)	Removing spoil and transporting fill and other materials.	80	43
Tracked Excavator (C.4.63)	Removing soil and rubble in preparation for foundation.	77	40
Rock Breaker (C9.12)	Removing Rock	85	48
General Construction (Various)	All general activities plus deliveries of materials and plant.	84	47
Concrete Mixer Truck and Concrete Pump (C.4.28)	Pouring turbine bases	75	38
Dumper Truck (C.4.4)	Moving earth	76	39
Mobile Telescopic Crane (C.4.39)	Turbine Construction	77	40
Dewatering Pumps (D.7.70)	If required.	80	43
Vibrating Rollers (C.5.24)	Crane Hardstanding surfacing.	84	47
Combined L_{Aeq}			54

Table 11.13: Typical Construction Noise Emission Levels

Based on guidance for the description of effects in **Table 11.6**, the likely effects at the nearest NSL associated with the construction of the wind turbines are assessed to be negative, temporary and slight to moderate.

Vibration

Considering the distances between these construction activities and nearby NSLs, vibration from these activities would not be perceptible and would be orders of magnitude below permissible levels, as described at **Section 11.3.1.2**, where cosmetic or structural damage would be expected.

11.5.2.2 Site Entrances and Access Tracks (Including Tree Felling)

Noise

During the construction phase, 2 no. temporary site entrances will be required to facilitate temporary access to the project site (wind farm), directly opposite each other on either side of the N62. The existing agricultural/forestry entrances at these locations will be upgraded in order to provide the construction phase entrances to the project. A further 2 no. site entrances, located along the L30033 and L300321 respectively, will be created to facilitate operational phase traffic. The provision of these entrances will also involve the upgrade of 2 no. existing agricultural access points. There are several NSLs located in the vicinity of these site entrances, and associated access tracks; the 3 no. nearest of which and their distances from construction activities are listed in **Table 11.14**.

Location Ref.	Coordinates (ITM)		Approximate Distance to Site Entrance or Access Track (m)
	Easting	Northing	
H084	607310	709373	275
H088	606500	708943	85
H057	609016	710126	260

Table 11.14: Nearest NSLs to Site Entrance & Access Tracks

Several items of plant and machinery will be required during construction works associated with the construction/upgrade of site entrances and access tracks which are likely to generate noise at the nearest NSLs.

Table 11.15 presents, considering the likely construction activities, the noise levels associated with same at a reference distance of 10m. The typical sound pressure levels and spectra used in this assessment have been taken from *BS 5228-1: 2009+A1:2014*. The calculations assume that plant items are operating for 66% of the time, that the ground between the works and the NSL is soft and that there is no acoustic screening (i.e. barriers) in place between the site works and the NSL.

Item (BS 5228 Ref.)	Stage	Plant Noise Level at 10m Distance (dB LAeq,1hr)
Tracked Excavator (C.4.63)	Site Clearing/Excavating	77
HGV Movement (C.2.34)		80
Petrol driven chain saw (D.2.14)		86
Dumper Truck (C.4.4)		76

General Construction (Various)		84
Tracked Excavator (C4.63)	Entrance/Access Track Construction	77
HGV Movement (C.2.34)		80
Dumper Truck (C.4.4)		76
Vibrating Rollers (C.5.24)		84
General Construction (Various)		84

Table 11.15: Typical Site Entrance/Access Track Construction Plant

Based on the assumptions outlined above the 'worst-case' predicted noise levels at each location are presented in **Table 11.15**.

Location Ref.	Stage	Predicted Noise Level (dB LAeq1hr)
H087 at 246 m	Site Clearing / Excavating	50
	Entrance/Access Track Construction	49
H088 at 88 m	Site Clearing / Excavating	61
	Entrance/Access Track Construction	60
H057 at 264 m	Site Clearing / Excavating	49
	Entrance/Access Track Construction	48

Table 11.16: Predicted Site Entrance/Access Track Construction Noise Emission Levels

Based on guidance for the description of effects in **Table 11.6**, the likely effects at the nearest NSLs associated with the construction of the site entrances and access tracks are assessed to be negative, temporary and slight to moderate.

Vibration

Considering the distances between these construction activities and nearby NSLs; and the transient nature and short-term duration of construction activities at these locations; vibration from these activities would not be perceptible and would be orders of magnitude below permissible levels, as described at **Section 11.3.1.2**, where cosmetic or structural damage would be expected.

11.5.2.3 Spoil Deposition

Noise

A number of spoil deposition areas, which will permanently store excavated material which cannot be reused in the reinstatement/landscaping process, have been identified: two lying near turbines T5 and T8 and another lying to the north of T1 and T3. This last deposition area, located to the west of the wind farm site, is, at its nearest point, c. 642m from the nearest NSL; the details of which are provided at **Table 11.17** below.

Location Ref.	Coordinates (ITM)		Approximate Distance to Spoil Deposition Area (m)
	Easting	Northing	
H11	605980	710676	681
H12	606002	710762	663
H13	605991	710967	725
H14	606089	711041	671
H23	606821	711514	676
H24	607091	711562	642
H31	607709	711650	772
H84	607310	709373	771

Table 11.17: Nearest NSLs to Spoil Deposition Area

Several items of plant and machinery will be required during construction works associated with the construction/upgrade of site entrances and access tracks which are likely to generate noise at the nearest NSLs.

Table 11.18 presents, considering the likely construction activities, the noise levels associated with same at a reference distance of 10m and at the distances to various NSLs in **Table 11.17**. The calculations assume that plant items are operating for 66% of the time and that there is no acoustic screening (i.e. barriers) in place between the site works and the NSL.

Item (BS5228 ref)	Plant Noise Level at 10m Distance (dB L _{Aeq,T})	Plant Noise Level at Distance (dB L _{Aeq,T})							
		681m	663m	725m	671m	676m	642m	772m	771m
Tracked Excavator (C.4.63)	77	38	39	38	38	38	39	37	37
Dumper Truck (C.4.4)	76	37	38	37	37	37	38	36	36
Combined L _{Aeq}		41	42	41	41	41	42	40	40

Table 11.18: Predicted Spoil Deposition Construction Noise Immission Levels

Based on guidance for the description of effects in **Table 11.6**, the likely effects at the nearest NSLs associated with spoil deposition works are assessed to be negative, temporary and slight.

Vibration

Considering the characteristics of the construction activities involved; vibration from these activities would not be perceptible and would be orders of magnitude below permissible levels, as described at **Section 11.3.1.2**, where cosmetic or structural damage would be expected.

11.5.2.4 Forestry Re-planting

The plant & machinery likely to be utilised in the re-planting of forestry, and the proximity to NSLs, are similar to those described at **Section 11.5.2.3** above, and, accordingly, these activities are not assessed as likely to give rise to significant noise or vibration effects.

11.5.2.5 Grid Connection

The installation of the proposed grid connection (i.e. 5.6km of underground electricity line and accompanying access track) between the 110kV electricity substation and the existing Clondallow 110kV substation in Co Offaly, will entail construction activities similar to those outlined above in relation to Site Entrance/Access Track Construction works.

In respect of the grid connection construction, it is highly unlikely that piling or other loud/high impact operations will be required. While these works, particularly in relation to trench excavation and the installation of underground electricity lines will occur within c. 100m of various residential dwellings along local roads; the short-term and transient nature of such works, combined with the absence of any particularly loud, unusual or impactful activities, will ensure that any noise and vibration effects which may be experienced are not likely to be significant or, in the case of vibration, be of a magnitude such that could result in cosmetic or structural damage.

11.5.2.6 N52/N62 Temporary Junction Alteration

Noise

Temporary junction alteration works, to accommodate a reverse manoeuvre during the delivery of turbine components, is proposed at the junction of the N62 and N52, known as Kennedy's Cross Roads, in the townland of Ballindown, at approximately 2.7 km to the south of the proposed construction phase site entrances. The nearest NSL to these works is a distance of approximately 105m. Based on the same methodology as for the calculation of Access tracks above, the predicted noise levels are 59 dB $L_{Aeq,1hr}$ for site clearing and 56 dB $L_{Aeq,1hr}$ for junction accommodation construction.

Based on guidance for the description of effects in **Table 11.6**, the likely effects at the nearest NSLs associated with junction accommodation works are assessed to be negative, temporary and slight to moderate.

Vibration

The proposed works will generate low levels of vibration due to the operation of construction machinery, most notably vibration rollers in the creation of hardcore areas. However, the levels of vibration likely to be experienced at any property are not assessed as likely to exceed the acceptable levels described at **Section 11.3.1.2**; and, therefore, in combination with the temporary duration of construction activities, significant levels of vibration are not assessed as likely.

11.5.2.7 Construction Phase Traffic Movements

Noise

This section has been prepared in order to assess likely noise effects associated with construction traffic using the local road network. Information presented at **Chapter 13**, regarding vehicle types and predicted traffic volumes, have been used to inform this assessment.

The likely noise effects of HGV movements are assessed through consideration of the

cumulative noise level associated with a series of individual events. The noise level associated with an event of short duration, such as a vehicle drive-by, may be expressed in terms of its Sound Exposure Level (SEL; L_{Ax}). The SEL can be used to calculate the contribution of an event or series of events to the overall noise level in a given period. The appropriate formula is as follows:-

$$L_{Aeq,T} = L_{Ax} + 10\log_{10}(N) - 10\log_{10}(T) - 10\log_{10}(r_2/r_1) \text{ dB}$$

Where:

$L_{Aeq,T}$	is the equivalent continuous sound level over the time period T (s).
L_{Ax}	is the "A-weighted" Sound Exposure Level of the event under consideration (dB).
N	is the number of events over the course of time period T.
r_2	is the distance from the edge of the entrance road to the facade of nearest property.
r_1	is the distance from vehicle to the point of original measurement.

The mean value of Sound Exposure Level for a HGV movement is of the order of 82dB L_{Ax} at a distance of 5m from the vehicle. This figure is based on a series of measurements conducted under controlled conditions.

Based on **Chapter 13**, the average number of daily HGV movements is c. 60 per day, which, when taking account of deliveries in to and out of the project site, equates to an average of c. 10 movements per hour. Predicted noise levels at 5m distance from the vehicle path are therefore, based on the above calculation, 59 dB $L_{Aeq,1hr}$, which is within the construction noise criteria of 65 dB $L_{Aeq,1hr}$.

The peak number of HGV movements per day will occur during the concrete pours for turbine foundation construction. During the eight days, that the concrete turbine bases are being poured, it is estimated that there will be up to c. 160 movements per day, which, when taking account of deliveries in to and out of the project site, equates to an average of c. 27 movements per hour. Predicted noise levels at 5m distance from the vehicle path are therefore 64 dB $L_{Aeq,1hr}$, which is within the construction noise criteria of 65 dB $L_{Aeq,1hr}$. It is emphasised that peak conditions apply for just eight days of the 18-month construction programme.

Vibration

Significant levels of vibration are not expected to arise due to the types of vehicles to be used. In addition, the carriageways of local roads are paved and of a reasonably high standard (noted also that local roads in the vicinity of the project will be upgraded) and, consequently, significant levels of vibration are not assessed as likely.

11.5.3 Operation Phase

11.5.3.1 Wind Turbine Noise Criteria Curves

With respect to the relevant guidance documents outlined in **Section 11.2**, the following noise criteria curves have been identified for the project. The criteria curves have been derived following a detailed review of the background noise data as surveyed at the nearest NSLs.

It is proposed to adopt a lower daytime threshold of 40dB $L_{A90,10\text{-min}}$ for low noise environments, i.e. where the background noise is less than 30 dB(A). This follows a review of the prevailing background noise levels and is considered appropriate in light of the following:-

- The EPA document *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)* 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; and

- It is reiterated that the *Wind Energy Development Guidelines for Planning Authorities 2006* states that “An appropriate balance must be achieved between power generation and noise impact.” Based on a review of other national guidance issued by the EPA 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 robust.

Following comparison of the previously presented guidance, the proposed operational limits in $L_{A90,10min}$ for the project are:-

- 40dB $L_{A90,10min}$ for quiet daytime environments of less than 30dB $L_{A90,10min}$;
- 45dB $L_{A90,10min}$ for daytime environments greater than 30dB $L_{A90,10min}$ or a maximum increase of 5dB above background noise (whichever is higher), and;
- 43dB $L_{A90,10min}$ or a maximum increase of 5dB above background noise (whichever is higher) for night-time periods.

This set of criteria has been chosen as it accords with the intent of the relevant Irish guidance and is comparable to noise conditions applied to similar developments by An Bord Pleanála.

A worst-case envelope, based on the lowest average levels at the various wind speeds for both day and night-time, is also presented in **Table 11.12**. Therefore, the noise criteria curves for this assessment will be based on this baseline noise level envelope for all NSLs where background noise measurement was not undertaken. This is considered to be an extremely conservative, precautionary, and worst-case approach.

The IOA GPG allows for the use of a background noise curve measured at one location to be used for other locations in a similar setting. In this instance, each of the survey locations H057, H032, H014 and H084 adopts noise criteria based on the measured background noise levels as discussed above. All remaining locations, adopt noise criteria based on the worst-case envelope, that is, the noise levels measured at the location with the lowest noise levels. **Table 11.19** outlines the derived noise criteria curves based on the information contained within **Table 11.12**.

Location	Period	Derived $L_{A90, 10 min}$ Levels (dB) at various Standardised 10m Height Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
A (H057)	Day	45	45	45	45	45	45	45	47.3
	Night	43	43	43	43	43	43	44.6	47.9
B (H032)	Day	45	45	45	45	45	45	46.2	48.8
	Night	43	43	43	43	43	43	44.9	48.6
C (H014)	Day	35-40	35-40	35-40	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43.7
D (H084)	Day	45	45	45	45	45	45	46.9	49.3
	Night	43	43	43	43	43	43	45.6	49.7
All Other Locations	Day	35-40	35-40	35-40	45	45	45	45	45
	Night	43	43	43	43	43	43	43	43.7

Table 11.19: Noise Criteria Curves

Moreover, the ETSU-R-97 guidance allows for a higher level of operational phase turbine noise at properties that have an involvement in the development, both as a higher fixed level of 45dB L_{A90} and/or a higher level above the prevailing background noise level. In line with the guidance, a higher threshold of 45dB $L_{A90,10min}$ is applicable to NSLs involved in the project. The set of NSLs corresponding to involved properties is as follows: H057, H082, H084, H085, H086, H087, and H088.

11.5.3.2 Noise Assessment

Wind Turbines

The noise levels generated by the operation of the project have been calculated for all NSLs identified within 2km of the wind turbines.

A 'worst-case' assessment has been completed assuming all noise locations are downwind of all turbines at the same time. The predicted levels have been compared against the adopted noise criteria curves as detailed in **Table 11.19**.

Table 11.20 below presents the predicted noise levels at the locations with the five highest noise levels at 9m/s standardised wind speed, that is, H011, H057, H081, H083 and H084.

Ref.	Parameter	Predicted Omni-directional $L_{A90, 10 min}$ Levels (dB) at various Standardised 10m Height Wind Speeds (m/s)						
		3	4	5	6	7	8	9
H011	Predicted	28.0	31.3	36.4	39.9	40.2	40.2	40.2
	Daytime Criterion	40	40	40	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H057	Predicted	30.0	33.4	38.5	41.9	42.2	42.2	42.2
	Daytime Criterion	45	45	45	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	44.6
	Night-time Excess	--	--	--	--	--	--	--
H081	Predicted	28.6	32.0	37.1	40.5	40.8	40.8	40.8
	Daytime Criterion	40	40	40	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H083	Predicted	28.9	32.3	37.4	40.8	41.1	41.1	41.1
	Daytime Criterion	40	40	40	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H084	Predicted	30.6	33.9	39.0	42.4	42.7	42.7	42.7
	Daytime Criterion	45	45	45	45	45	45	46.9
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	45.6
	Night-time Excess	--	--	--	--	--	--	--

Table 11.20: Predicted Omni-directional Noise Levels Arising from the Wind Turbines

In all cases the noise levels are within the criteria for both daytime and night-time periods.

Annex 11.6 presents the results of this noise prediction exercise at all 106 no. NSLs. A noise contour map for standard mode operation rated power at a wind speed of 9m/s (i.e. highest noise emission) is presented in **Annex 11.7**.

Electrical Control Building

The proposed development does not include a substation but does include a small electrical control building near the site entrance along the L30033. This building will be enclosed and will not emit any significant noise to the surroundings. The noise effects are neutral, imperceptible, and long-term.

Operational Phase Traffic Movements

There are no significant traffic volumes expected during the operational phase, with 1-2 visits to site by a light goods vehicle (LGV) per week. Therefore, there are no significant noise effects assessed as likely during the operational phase.

Cumulative Effects with Other Projects (Wind Farms)

The cumulative noise levels arising from the operation of the project along with the Cloghan, Meenwaun and Derrinlough developments have been calculated for the same set of NSLs. Details of the wind turbine locations and sound power levels used for the other wind farm developments are provided in **Annex 11.2**.

Similarly, a 'worst-case' assessment has been completed assuming all noise locations are downwind of all turbines at the same time. The predicted levels have been compared against the adopted noise criteria curves as detailed in **Table 11.19**.

Table 11.21 below presents cumulative predicted noise levels for the locations with the five highest noise levels, at 9m/s standardised wind speed, that is, H019, H020, H057, H083 and H084. NSLs H011 and H081 are also included for comparison with the non-cumulative scenario above.

Ref.	Parameter	Predicted Omni-directional $L_{A90, 10 \text{ min}}$ Levels (dB) at various Standardised 10m Height Wind Speeds (m/s)						
		3	4	5	6	7	8	9
H011	Predicted	28.7	31.9	36.9	40.4	40.7	40.7	40.7
	Daytime Criterion	40	40	40	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H019	Predicted	31.3	33.5	37.8	41.3	42.0	42.0	42.0
	Daytime Criterion	40	40	40	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H020	Predicted	30.6	32.9	37.2	40.7	41.4	41.5	41.5
	Daytime Criterion	40	40	40	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H057	Predicted	30.1	33.4	38.6	42.0	42.3	42.3	42.3

Ref.	Parameter	Predicted Omni-directional $L_{A90, 10 \text{ min}}$ Levels (dB) at various Standardised 10m Height Wind Speeds (m/s)						
		3	4	5	6	7	8	9
	Daytime Criterion	45	45	45	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	44.6
	Night-time Excess	--	--	--	--	--	--	--
H081	Predicted	28.7	32	37.1	40.6	40.9	40.9	40.9
	Daytime Criterion	40	40	40	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H083	Predicted	29.0	32.3	37.4	40.9	41.2	41.2	41.2
	Daytime Criterion	40	40	40	45	45	45	45
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	43
	Night-time Excess	--	--	--	--	--	--	--
H084	Predicted	30.6	33.9	39.0	42.5	42.8	42.8	42.8
	Daytime Criterion	45	45	45	45	45	45	46.9
	Daytime Excess	--	--	--	--	--	--	--
	Night-time Criterion	43	43	43	43	43	43	45.6
	Night-time Excess	--	--	--	--	--	--	--

Table 11.21: Predicted Cumulative Omni-directional Noise Levels

Similarly, in all cases the noise levels are within the criteria for both daytime and night-time periods.

The results of the cumulative operational phase noise assessment, at all 106 no. NSLs, is enclosed at **Annex 11.8**. A cumulative noise contour map for standard mode operation rated power at a wind speed of 9m/s (i.e. highest noise emission) is presented in **Annex 11.9**.

The cumulative predicted noise levels at various wind speeds have been compared against the noise criteria curves. The predicted noise levels at all locations for the various wind speeds are below the noise criteria curves adopted for this assessment, in accordance with standard best practice,

11.5.4 Decommissioning Phase

In relation to the decommissioning phase, similar overall noise levels as those calculated for the construction phase would be expected, as similar plant, machinery and equipment will be used.

In all instances, the total predicted decommissioning noise levels are anticipated to be below the appropriate Category A value (i.e. 65dB $L_{Aeq,1hr}$) and therefore a significant effect is not predicted in relation to the nearest NSLs in terms of decommissioning noise.

11.6 Mitigation & Monitoring Measures

11.6.1 Construction Phase

Construction activities will be completed in accordance with the provisions, where relevant, of *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control*

on construction and open sites – Noise which offers detailed guidance on the control of noise & vibration from demolition and construction activities. The relevant practices to be adopted during construction shall include:-

- Limiting the hours during which site activities likely to create high levels of noise or vibration are permitted;
- Establishing channels of communication between the contractor/developer, Local Authorities and residents;
- Appointing a site representative responsible for matters relating to noise and vibration;
- Monitoring typical levels of noise and vibration during critical periods and at sensitive locations; and
- Keeping site access tracks even to mitigate the potential for vibration from HGVs.

Furthermore, a variety of practical 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;
- Regular maintenance and servicing of plant items.

11.6.1.1 Noise

The various contractors involved in the construction phase will be obliged, under contract, to take specific noise abatement measures and comply with the recommendations of *BS 5228-1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise*. The following list of measures will be implemented, as relevant, to ensure compliance with the relevant construction noise criteria:

- No plant or machinery will be permitted to cause a public nuisance due to noise;
- The best means practicable, including proper maintenance of plant, will be employed to minimise the noise produced by on site operations.
- All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the contract;
- Compressors will be attenuated models fitted with properly lined and sealed acoustic covers which will be kept closed whenever the machines are in use and all ancillary pneumatic tools shall be fitted with suitable silencers;
- Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use;
- Any plant, such as generators or pumps, which may be required to operate outside of general construction hours will be surrounded by an acoustic enclosure or portable screen;
- During the course of the construction programme, supervision of the works will include ensuring compliance with the limits developed 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
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations, including the delivery of construction materials, shall generally be restricted to between 07:00hrs and 19:00hrs Monday to Friday and between 07:00hrs and 13:00hrs on Saturdays, with no operations on Sundays or public holidays. However, to ensure that optimal use is made of good weather periods, at occasional critical periods within the construction

programme (i.e. concrete pours, turbine component deliveries and turbine erection) or in the event of an emergency; activities may be necessary outside out of these hours.

Based on assessment of the geological composition of the site undertaken to date, it is assessed that significant levels of rock are not present and that rock breaking is unlikely to be required. If rock breaking is required, the following measures will be implemented, where necessary, to mitigate noise emissions:-

- Fit suitably designed muffler or sound reduction equipment to the rock breaking tool to reduce noise without impairing machine efficiency;
- Ensure all air lines are sealed;
- Use a dampened bit to eliminate a 'ringing' sound;
- Erect an acoustic screen between compressors or generators and noise sensitive area. When possible, line of sight between top of machine and reception point will be obscured; and
- Enclose the breaker or rock drill in portable or fixed acoustic enclosure with suitable ventilation.

11.6.1.2 Vibration

The level of vibration from construction activities shall be limited to the values set out in **Table 11.7**. It should be noted that these limits are not absolute but provide guidance as to magnitudes of vibration that are very unlikely to cause cosmetic damage. Magnitudes of vibration slightly greater than those in the table are normally unlikely to cause cosmetic damage, but construction work creating such magnitudes should proceed with caution. Where there is existing damage these limits may need to be reduced by up to 50%.

Given the substantial distances between locations where notable levels of vibration may take place (e.g. at turbine locations or extensive use of vibration rollers in access track construction) and the nearest NSLs, no likely significant effect will be experienced. Therefore, no specific mitigation measures are proposed in respect of vibration.

11.6.2 Operation Phase

11.6.2.1 Noise

An assessment of the operational phase noise levels, both specific to the project and in combination with the Cloghan, Meenwaun and Derrinlough wind farms has been undertaken in accordance with best practice guidelines and procedures. The findings of the assessment confirm that predicted operational phase noise levels will be within the relevant best practice noise criteria curves for wind farms. Therefore, noise mitigation measures are not required for the operational phase of this development.

If alternative turbine technologies are considered for installation, an updated noise assessment will be prepared to confirm that the associated noise levels comply with the noise criteria curves and/or the relevant operational noise criteria associated with any condition of consent.

In the unlikely event that an issue with low frequency noise is associated with the project, an appropriate detailed investigation, by an independent acoustic consultant, shall be undertaken. Due consideration shall 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* (NG4) (EPA, 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 a complaint is received which indicates potential amplitude modulation (AM) associated with turbine operation, an independent acoustic consultant shall be employed to assess the level of AM in accordance with the methods outlined in the IOA Wind Turbine Noise Amplitude Modulation Working Group (AMWG) document *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (IOA, 2016) or subsequent revisions, and suitable measures implemented as necessary.

11.6.2.2 Vibration

The project is not assessed as likely to give rise to significant vibration effects during the operational phase. There will be no requirement for impact machinery or significant numbers of HGV movements during this phase of development. Vehicles accessing the project site will typically be LGVs and, where HGVs may be required, the volume of movements will be imperceptible.

11.6.3 Decommissioning Phase

The mitigation measures to be implemented during the decommissioning of the project are the same as those proposed for the construction phase of the development.

11.6.4 Monitoring

11.6.4.1 Construction Phase

No specific monitoring of noise or vibration levels during the construction phase is proposed.

11.6.4.2 Operation Phase

Post-commissioning operational noise monitoring will be undertaken to demonstrate compliance with the relevant noise criteria. In relation to the assessment of operational phase wind turbine noise, the guidance outlined in the IOA GPG and *Supplementary Guidance Note 5: Post Completion Measurements* (July 2014) will be followed. Should the assessment identify any exceedances of the appropriate criteria, relevant corrective actions will be immediately implemented by the Developer. An Outline Noise Monitoring Programme has been prepared by GES and is enclosed at **Annex 11.10**.

11.6.4.3 Decommissioning Phase

No monitoring of noise or vibration levels during the decommissioning phase is proposed.

11.7 Residual Effects

This section outlines the likely residual noise and vibration effects associated with the project taking account of the mitigation measures.

11.7.1 'Do-Nothing' Scenario

If the project were not to proceed, the existing noise environment will remain unchanged.

11.7.2 Construction Phase

During the construction phase, it is likely that some NSLs will experience an increase in noise levels arising from emissions from site traffic and other construction activities.

However, given that the construction phase of the development is temporary in nature and the distances between the main construction activities and nearby noise sensitive properties, it is assessed that the noise generated will not be excessively intrusive. Furthermore, the application of binding noise limits and defined construction hours, along with implementation of widely-recognised effective noise and vibration mitigation measures, will ensure that noise and vibration effects are unlikely to be significant. The residual effects are assessed to be likely, negative, slight and short-term.

11.7.3 Operation Phase

11.7.3.1 Wind Turbine Noise

The predicted noise levels associated with the project, both individually and in combination with the other wind farm developments, will be within best practice noise criteria curves recommended in the *Wind Energy Development Guidelines for Planning Authorities 2006*. It is not assessed that a significant effect is associated with the operational phase of the project.

While noise levels at low wind speeds will increase due to the project, and specifically the operation of the turbines, the predicted levels will be low, albeit new sources of noise will be introduced into the soundscape.

For the majority of NSLs assessed, the likely effect of the operational wind turbines is negative, not significant and long-term, and for those that may experience slightly higher noise levels, the likely effect will be negative, slight and long-term.

11.7.3.2 Vibration

There is no expected source of vibration related with the operational phase of the project and therefore residual vibration effect is assessed as imperceptible.

11.7.4 Decommissioning Phase

During the decommissioning phase, noise effects will be similar to those of the construction phase and are assessed to be likely, negative, slight and short-term.

11.8 Summary

The noise environment at a set of representative noise-sensitive locations in the vicinity of the project has been quantified by an appropriate survey of background noise levels. The results of the background noise survey have been used to derive noise level criteria for these and other noise-sensitive locations.

Using sound emission data specific to the selected turbine model, and a proven noise propagation model, the operational noise levels at 106no. NSLs have been predicted both individually, in relation to the project, and cumulatively with the proposed other wind Farms. In all cases, predicted noise levels are within the adopted noise criteria. The noise impact of the development is not, therefore, assessed as likely to be significant.

