

## 12. NOISE AND VIBRATION

### 12.1 Introduction

#### 12.1.1 Background & Objectives

This chapter of the EIAR describes the assessment undertaken of the potential noise and vibration impacts associated the proposed Cahermurphy Two Wind Farm Development (the 'Proposed Development'). The Proposed Development comprises up to 10 no. wind turbines with a maximum overall ground level to blade tip height of up to 170 metres, an electricity substation, construction compound and all ancillary infrastructure including the grid connection to the National Grid. A full description of the proposed development is provided in Chapter 4 of this EIAR.

There are 100 no. noise sensitive locations within 1.2 km of the proposed turbine locations. The nearest noise sensitive location (NSL) is located approximately 700m to the nearest proposed turbine location (i.e. Location H001 from proposed turbine T6). The next nearest NSLs are H075 and H092, which are located approximately 702m to the nearest proposed turbine locations at T01 and T10 respectively.

Noise impact assessments have been prepared for both the operational phase and also the construction and decommissioning phases of the Proposed Development to the nearest NSL's. To inform this assessment background noise levels have been measured at several representative noise sensitive locations in the vicinity of the site to assess the potential impacts associated with the operation of the Proposed Development. The current *Wind Energy Development Guidelines for Planning Authorities*, published by the Department of the Environment, Heritage and Local Government in 2006, defines a noise sensitive location as any occupied dwelling house, hostel, health building or place of worship and may include areas of particular scenic quality or special recreational amenity importance. In this instance all of the NSLs are dwellings.

Existing, under construction, permitted and proposed wind farm developments have been identified in the wider study area and the cumulative impact of these developments has been considered in this assessment. Other developments that did not significantly contribute to cumulative noise levels surrounding the site were excluded from the assessment in line with guidance set out in the IOA Good Practice Guide. Further details on each of these developments is provided in Chapter 2 of this EIAR.

#### 12.1.2 Statement of Authority

This chapter of the EIAR has been prepared by the following staff of Awn Consulting Ltd:

##### **Mike Simms**

Mike Simms (Senior Acoustic Consultant) holds a BE and MEngSc in Mechanical Engineering, and is a member of the Institute of Acoustics and of the Institution of Engineering and Technology. Mike has worked in the field of acoustics for over 19 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.

##### **Dermot Blunnie**

Dermot Blunnie (Senior Acoustic Consultant) holds a BEng (Hons) in Sound Engineering, MSc in Applied Acoustics and has completed the Institute of Acoustics (IOA) Diploma in Acoustics and Noise Control. He has been working in the field of acoustics since 2008 and is a member of the Institute of Engineers Ireland (MIEI) and the Institute of Acoustics (MIOA). He has extensive knowledge and experience in relation to commissioning noise monitoring and impact assessment of wind farms as well as a detailed knowledge of acoustic standards and proprietary noise modelling software packages. He

has commissioned noise surveys and completed noise impact assessments for numerous wind farm projects within Ireland.

## 12.2 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 (SPL) 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 3 dB.

The frequency of sound 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 defined in the international standard, BS ISO 226:2003 Acoustics. Normal Equal-loudness Level Contours has been found to provide the best correlations with human response to perceived loudness. SPL's 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 12-1.

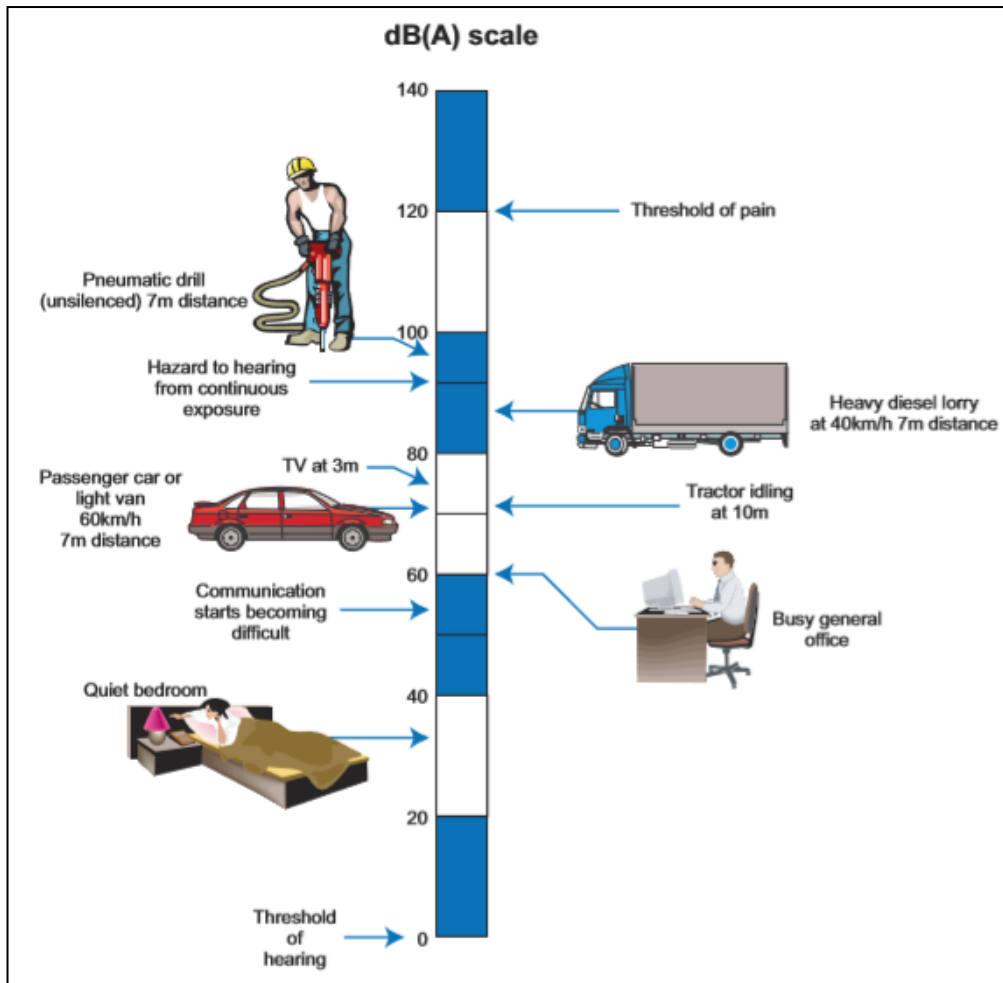


Figure 12-1 The level of typical common sounds on the dB(A) scale (NRA Guidelines for the Treatment of Noise and Vibration in National Road Schemes, 2004)

For a glossary of terms used in this chapter please refer to Appendix 12-1.

### 12.3 Methodology

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

In addition to the specific guidance documents mentioned above, the following guidelines were considered and consulted for the purposes of preparing this chapter:

- EPA Guidelines on the Information to be contained in Environmental Impact Statements, (EPA, 2002);
- EPA Advice Notes on Current Practice (in the preparation of Environmental Impact Statements), (EPA, 2003);
- EPA Guidelines on the Information to be contained in Environmental Impact Assessment Reports Draft August 2017 (EPA, 2017); and
- EPA Advice Notes for Preparing Environmental Impact Statements, (Draft, September 2015).

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

- Review of appropriate guidance to identify appropriate noise and vibration criteria for both the construction and operational phases;
- Characterise the receiving noise and vibration environment;
- Characterise the proposed development;
- Predict the noise and vibration impact and cumulative impacts associated with the proposed development, and;
- Evaluate the potential noise and vibration impacts and effects.
- Specify mitigation measures to reduce, where necessary, the identified potential outward impacts relating to noise and vibration from the proposed development; and
- Describe the significance of the residual noise and vibration effects associated with the proposed development.

### 12.3.1.1 Noise Model

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

#### 12.3.1.1.1 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 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).

#### 12.3.1.1.2 Input Data and Assumptions

The calculation settings, input data and any assumptions made in the assessment are described in the following sections. Additional information relating to the noise model inputs and calculation settings is provided in Appendix 12-2.

##### Turbine Details

Table 12-1 details the co-ordinates of the 10 no. proposed turbines that are being considered in this assessment.

Table 12-1 Proposed Cahermurphy Two Turbine Co-ordinates

Turbine Ref.	Co-ordinates (ITM)	
	Easting	Northing
T01	507,384	669,377
T02	507,942	669,771
T03	508,531	669,910
T04	507,794	669,044
T05	508,291	669,400
T06	508,921	669,600
T07	508,219	668,683
T08	508,998	668,990
T09	508,312	668,186
T10	509,012	668,538

For the purposes of this assessment, consideration has been given to several potential turbine technologies that have been identified as being suitable for the Proposed Development. The actual turbine to be installed on the site will be the subject of a competitive tender process and could include other turbines models not currently available. Regardless of the make or model of the turbine eventually selected for installation on site, the noise emission of the turbine shall be no greater than that used for the purposes of this assessment to ensure that the required noise limits are achieved at all noise sensitive locations.

Sound power levels ( $L_{WA}$ ) have been supplied for the various turbines under consideration. These levels have been reviewed and an envelope method used whereby the worst case, i.e. highest noise levels, for the proposed turbine models have been selected and input into the noise model. For the purposes of this assessment, a turbine hub height of 105m above ground has been used for noise calculations presented here. This in full accordance with the guidance, where the noise point source is modelled as being at the centre of the most significant noise-generating elements of the wind turbine, i.e. the nacelle itself and the wind turbine blades.

Table 12-2 details the noise spectra used for noise modelling purposes for the proposed Cahermurphy Two Wind Farm development. As outlined, appropriate guidance is couched in terms of a LA90 criterion. The turbine sound power levels provided are referenced in terms of the LAeq parameter. Best practice guidance contained within the Institute of Acoustics guidance document, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (2013) (hereafter called IoA GPG), states that “LA90 levels should be determined from calculated LAeq 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.

Table 12-2 Sound Power Level Spectra Used for Prediction Model – Cahermurphy Two Wind Farm

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB LWA
	63	125	250	500	1000	2000	4000	8000	
4	78.0	84.8	89.1	91.7	91.4	88.3	84.5	76.2	97.0
5	82.2	89.2	93.8	96.3	96.0	93.1	88.8	79.6	101.6
6	86.4	93.4	97.5	99.8	99.6	97.3	93.0	84.1	105.4
7	87.8	94.8	98.6	100.6	100.4	98.7	94.4	85.2	106.4
≥8	88.9	94.6	98.3	100.6	100.4	100.0	97.7	87.1	106.9

A list of existing, permitted and proposed windfarm developments in proximity to the subject site was provided at the early stages of the assessment process. A noise modelling exercise was carried out to address the potential for cumulative impacts associated with other windfarms in conjunction with the Cahermurphy development. Other developments that did not significantly contribute to cumulative noise levels surrounding the site were excluded from the assessment in line with guidance set out in the IOA Good Practice Guide.

In accordance with the guidance in IoA GPG Section 5, the following wind farms were included in the cumulative noise model: the neighbouring Cahermurphy One wind farm which is located to the east of the proposed development site and the Kiltumper wind farm, under construction to the southeast, at approximately 2.5 km distance. Although the Kiltumper wind farm is a sufficient distance from the proposed development and that cumulative impacts are unlikely, it has been included in the assessment in order to demonstrate that there are no significant impacts.

Table 12-3 and Table 12-4 detail the noise data used for noise modelling purposes for the Cahermurphy One and Kiltumper developments respectively.

Table 12-3 Sound Power Level Spectra Used for Prediction Model – Cahermurphy One Wind Farm

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB LWA
	63	125	250	500	1000	2000	4000	8000	
4	78.0	86.2	86.3	88.1	90.6	91.2	89.4	78.9	97.0
5	80.5	88.7	88.8	90.6	93.1	93.7	91.9	81.4	99.5
6	83.0	91.2	91.3	93.1	95.6	96.2	94.4	83.9	102.0
7	84.3	92.5	92.6	94.4	96.9	97.5	95.7	85.2	103.3
8	85.2	93.4	93.5	95.3	97.8	98.4	96.6	86.1	104.2
≥9	86.0	94.2	94.3	96.1	98.6	99.2	97.4	86.9	105.0

Table 12-4 Sound Power Level Spectra Used for Prediction Model – Kiltumper Wind Farm

Wind Speed (m/s)	Octave Bank Centre Frequency (Hz)								dB LWA
	63	125	250	500	1000	2000	4000	8000	
4	74.5	82.5	82.2	84.8	86.6	81.7	69.4	61.3	91.1
5	77.5	85.5	85.2	87.8	89.6	84.7	72.4	64.3	94.1
6	83.1	91.1	90.8	93.4	95.2	90.3	78.0	69.9	99.7
7	85.0	93.0	92.7	95.3	97.1	92.2	79.9	71.8	101.6
8	86.9	94.9	94.6	97.2	99.0	94.1	81.8	73.7	103.5
≥9	87.9	95.9	95.6	98.2	100.0	95.1	82.8	74.7	104.5

The manufacturer’s turbine sound power levels in Table 12-2, Table 12-3 and Table 12-4 are based on measurements in terms of the LAeq acoustic parameter<sup>1</sup>. In accordance with best practice guidance contained within the Institute of Acoustics Good Practice Guide (IoA GPG), an allowance for uncertainty in the measurement of turbine source levels of +2dB is added to all turbine sound power levels presented in the tables above.

Moreover, as explained below in Section 12.4.2.1, appropriate guidance is couched in terms of a LA90 criterion. Best practice guidance in the IoA GPG states that “LA90 levels should be determined from calculated LAeq levels by subtraction of 2 dB”. Therefore, a 2dB reduction has been applied to the noise model output. All predicted noise levels in this chapter are presented in terms of LA90, i.e. this reduction of 2dB is included in the values presented.

Finally, best practice specifies that should any tonal component be present, a penalty shall be added to the predicted noise levels. The level of this penalty is described in ETSU-R-97<sup>2</sup>, and is related to the level by which any tonal components exceed audibility. For the purposes of this assessment a tonal penalty has not been included within the predicted noise levels. A warranty will be provided by the manufacturers of the selected turbine to ensure that the noise output will not require a tonal noise correction under best practice guidance.

## 12.4 Guidance Documents and Assessment Criteria

The following sections review best practice guidance that is commonly adopted in relation to developments such as the one under consideration here.

### 12.4.1 Construction Phase

#### 12.4.1.1 Construction Noise

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

<sup>1</sup> For details, see IEC 61400 Wind turbine generator systems – Part 11: Acoustic noise measurement techniques.

<sup>2</sup> UK Department of Trade and Industry: ETSU-R-97 The assessment of rating of Noise from wind farms, 1996

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 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 noise sensitive location 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 12-5 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.

Table 12-5 Example Threshold of Potential Significant Effect at Dwellings

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

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.

For the appropriate period (e.g. daytime) the ambient noise level is determined and rounded to the nearest 5 dB. In this instance, with the rural nature of the site, properties near the development have daytime ambient noise levels that typically range from 40 to 50 dB  $L_{Aeq,1hr}$ . Therefore, as a precautionary approach, all properties will be afforded a Category A designation.

See Section 12.6.2 for the detailed assessment in relation to this site. If the specific construction noise level exceeds the appropriate category value (e.g. 65 dB  $L_{Aeq,T}$  during daytime periods) then a significant effect is deemed to have occurred.

### 12.4.1.2 Additional Vehicular Activity on Public Roads

There are no specific guidelines or limits relating to traffic related sources along the local or surrounding roads. Given that traffic from the 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 the development. To assist with the interpretation of the noise associated with additional vehicular traffic on public roads, Table 12-6, adapted from

Design Manual for Roads and Bridges (DMRB), Highways England Company Limited, Transport Scotland, The Welsh Government and The Department for Regional Development (Northern Ireland), 2011, offers guidance as to the likely impact in the long-term associated with any change in traffic noise level.

Table 12-6 Likely Impacts Associated with Change in Traffic Noise Level (Source DMRB, 2011)

Change in Sound Level	Magnitude of Impact	EPA Significance of Effect
0	No Change	Imperceptible
0.1 – 0.9	Negligible	Not significant
1.0 – 2.9	Minor	Slight/Moderate
3.0 – 4.9	Moderate	Significant
5+	Major	Very Significant

The guidance outlined in Table 12-6 will be used to assess the predicted increases in traffic levels on public roads associated with the construction of the proposed development. Where an impact is identified due to the change in traffic noise level, reference will be made to the overall predicted noise level from construction traffic in the context of the construction noise criteria outlined in Section Construction Noise 12.4.1.1.

### 12.4.1.3 Construction 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 this development, 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:

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

BS 7385 states that there should typically be no cosmetic damage if transient vibration does not exceed 15 mm/s at low frequencies rising to 20 mm/s at 15 Hz and 50 mm/s at 40 Hz and above.

BS 5228 recommends that, for soundly constructed residential property and similar structures that are generally in good repair, a threshold for minor or cosmetic (i.e. non-structural) damage should be taken as a peak particle velocity of 15 mm/s for transient vibration at frequencies below 15 Hz and 20 mm/s at frequencies above than 15 Hz. Below these vibration magnitudes minor damage is unlikely, although where there is existing damage these limits may be reduced by up to 50%. In addition, where continuous vibration is generated the limits discussed above may need to be reduced by 50%.

The Transport Infrastructure Ireland (TII) (formerly National Roads Authority (NRA)) document *Guidelines for the Treatment of Noise and Vibration in National Road Schemes* (NRA, 2004) also contains information on the permissible construction vibration levels during the construction phase as shown in Table 12-7.

Table 12-7 Allowable Transient Vibration at Properties

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

## 12.4.2 Operational Phase

### 12.4.2.1 Noise

The noise assessment summarised in the following sections has been based on guidance in relation to acceptable levels of noise from wind farms as contained in the document “*Wind Energy Development Guidelines*” 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 “*Wind Energy Development Guidelines*” publication where necessary.

#### 12.4.2.1.1 Wind Energy Development Guidelines

Section 5.6 of the *Wind Energy Development Guidelines* 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.”*

While this comment is noted it should be stated that the Guidelines give no specific advice in relation to what constitutes an ‘appropriate balance’. In the absence of this, guidance will be taken from alternative and appropriate publications.

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

As can be seen from the calculations presented later in this chapter the various issues identified in this extract have been incorporated into our assessment.

*“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 LA90, 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.

In summary, the Wind Energy Development Guidelines outlines the following guidance to identify appropriate wind turbine noise criteria curves at noise sensitive locations:

- Identify an appropriate absolute limit level for quiet daytime environments of 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.

While the caveat of an increase of 5dB(A) above background for night-time operation is not explicit within the current guidance it is commonly applied in noise assessments prepared and is detailed in numerous examples of planning conditions issued by local authorities and An Bord Pleanála. Therefore, a night-time 5dB(A) above background allowance has also been adopted for this assessment.

This set of criteria has been chosen as it is in line with the intent of the relevant Irish guidance. The proposed operational noise criteria curves for wind turbine noise at various noise sensitive locations are presented in Section 12.6.3.1.

#### 12.4.2.1.2 **The Assessment and 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 guidance document is based on the 1996 ETSU publication *The Assessment and Rating of Noise from Wind Farms (ETSU-R-97)*.

ETSU-R-97 calls for the control of wind turbine noise by the application of noise limits at the nearest noise sensitive properties. 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, *"...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 development in the area should be included in the assessment.

#### 12.4.2.1.3 **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 noise sensitive locations 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 operation impact assessment for wind turbine noise.

#### 12.4.2.1.4 **Future Potential Guidance Change**

In December 2019, the Draft Revised Wind Energy Development Guidelines December 2019 were published for consultation and therefore have yet to be finalised. It is important to note that as part of the public consultation a number of concerns in relation to the proposed approach have been expressed by various parties and it is the opinion of the authors' of this assessment that the document does not outline a best practice approach in terms of the assessment of wind turbine noise. Specific concerns expressed by a cross party group of interested professionals can be reviewed at:

<https://www.ioa.org.uk/wind-energy-development-guidelines-wedg-consultation-irish-department-housing-planning-community-and>

The following statement is of note from the above submission:

*“a number of acousticians working in the field have raised serious concerns over the significant amount of technical errors, ambiguities and inconsistencies in the content of the draft WEDG and these were highlighted during the consultation process by a group of acousticians”*

Therefore, in line with best practice, which includes ESTU and IoA methodologies as described above the assessment presented in the ELAR is based on the current best practice guidance outlined in Section 5.6 of the Wind Energy Development Guidelines for Planning Authorities, 2006.

#### 12.4.2.1.5 **World Health Organisation (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*”.

The objective of the World Health Organisation (WHO) Environmental Noise Guidelines for the European Region that was published in October 2018 is to provide recommendations for protecting

human health from exposure to environmental noise from transportation, wind farm and leisure sources of noise. The guidelines present recommendations for each noise source type in terms of  $L_{den}$  and  $L_{night}$  levels above which there is risk of adverse health risks.

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 policymakers 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’, the recommendations are therefore conditional.

The WHO Environmental Noise Guidelines aim to support the legislation and policy-making process on local, national and international level, thus shall be considered by Irish policy makers for any future revisions of Irish National Guidelines.

There is potential 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 an existing or proposed wind turbine development in Ireland.

## 12.4.2.2 Special Characteristics of Turbine Noise

### 12.4.2.2.1 Infrasound/Low Frequency Noise

Low Frequency Noise is noise that is dominated by frequency components less than approximately 200Hz whereas Infrasound is typically described as sound at frequencies below 20Hz. In relation to Infrasound, the following extract from the EPA document *Guidance Note for Noise Assessment of Wind Turbine Operations at EPA Licensed Sites* (NG3) (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, 2013)<sup>3</sup> found that the level of infrasound from wind turbines is insignificant and no different to any other source of noise, and that the worst contributors to household infrasound are air-conditioners, traffic and noise generated by people.

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

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

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

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

A German report<sup>4</sup>, 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.”*

<sup>3</sup> EPA South Australia, 2013, *Wind farms* [https://www.epa.sa.gov.au/files/477912\\_infrasound.pdf](https://www.epa.sa.gov.au/files/477912_infrasound.pdf)

<sup>4</sup> Report available at [https://www4.lubw.baden-wuerttemberg.de/servlet/is/262445/low-frequency\\_noise\\_incl\\_infrasound.pdf?command=downloadContent&filename=low-frequency\\_noise\\_incl\\_infrasound.pdf](https://www4.lubw.baden-wuerttemberg.de/servlet/is/262445/low-frequency_noise_incl_infrasound.pdf?command=downloadContent&filename=low-frequency_noise_incl_infrasound.pdf)

<sup>5</sup> DIN 45680:2013-09 – Draft “Measurement and Assessment of Low-frequency Noise Emissions” November 2013

#### 12.4.2.2.2 **Amplitude Modulation**

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

- > ‘Normal’ AM, and;
- > ‘Other’ AM (sometimes referred to ‘Excessive’ AM).

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

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

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

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

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

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

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

Transient stall represents a fundamentally different mechanism from blade swish and can be heard at relatively large distances, primarily downwind of the rotor blade.

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 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, and a possible issue at a further 8, of 133 sites in the UK that were operational at the time of the study and considered within the review. At the 4 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 to date, 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 ‘Reference Method’ for measuring AM outlined in the IoA AMWG document 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.

## 12.4.2.3 Comments on Human Health Impacts

### 12.4.2.3.1 The National Health & Medical Research Council

The relevant Australian authority on health issues, the National Health and Medical Research Council (NHMRC), conducted a comprehensive independent assessment of the scientific evidence on wind

farms and human health, the findings are contained in the NHMRC Information Paper: *Evidence on Wind Farms and Human Health* 2015, this report concluded:

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

#### 12.4.2.3.2 **Health Canada**

Health Canada, Canada’s national health organisation, released preliminary results of a study into the effect of wind farms on human health in 2014<sup>6</sup>. The study was initiated in 2012 specifically to gather new data on wind farms and health. The study considered physical health measures that assessed stress levels using hair cortisol, blood pressure and resting heart rate, as well as measures of sleep quality. More than 4,000 hours of wind turbine noise measurements were collected and a total of 1,238 households participated.

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

#### 12.4.2.3.3 **New South Wales Health Department**

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

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

#### 12.4.2.3.4 **The Australian Medical Association**

The Australian Medical Association put out a position statement, *Wind Farms and Health* 2014<sup>7</sup>. The statement said:

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

#### 12.4.2.3.5 **Journal of Occupational and Environmental Medicine**

The review titled, *Wind Turbines and Health: A Critical Review of the Scientific Literature* was published in the *Journal of Occupational and Environmental Medicine*, 2014. An independent review

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<sup>6</sup> *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>

<sup>7</sup> *Australian Medical Association*, 2014, *Wind farms and health*. Available at <https://ama.com.au/position-statement/wind-farms-and-health-2014>

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.

#### 12.4.2.4 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, “*Low Frequency Noise incl. Infrasound from Wind Turbines and Other Sources*”, conducted vibration measurements study for an operational Nordex N117 – 2.4 MW 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 nearest NSLs to any of the turbines in the proposed development 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 proposed development.

#### 12.4.2.5 EPA Description of Effects

The significance of effects of the proposed development shall be described in accordance with the EPA guidance document *Draft Guidelines on the information to be contained in Environmental Impact Assessment Reports (ELAR), Draft, August 2017*. Details of the methodology for describing the significant of the effects are provided in Chapter 1 – Introduction.

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

### 12.5 Receiving Environment

This stage of the assessment was to determine typical background noise levels at representative NSL’s surrounding the development site. The background noise survey was conducted through installing unattended sound level meters at five locations in the surrounding area.

All measurement data collected during the background noise surveys has been carried out in accordance with the IoA GPG and the accompanying Supplementary Guidance Note 1: Data Collection (2014).

#### 12.5.1 Choice of Unattended Measurement Locations

The noise monitoring locations were identified by preparing a preliminary noise model contour at an early stage of the assessment. Any locations that fell inside the predicted 35 dB L<sub>A90</sub> noise contour were considered for noise monitoring in line with current best practice guidance outlined in the IoA GPG. The selection of the noise monitoring locations was informed by site visits and supplemented by reviewing of aerial images of the study area and other online sources of information (e.g. Google Earth).

The selected locations for the noise monitoring are outlined in the following sections. Coordinates for the noise monitoring locations are detailed in Table 12-8 and illustrated in Figure 12-2.

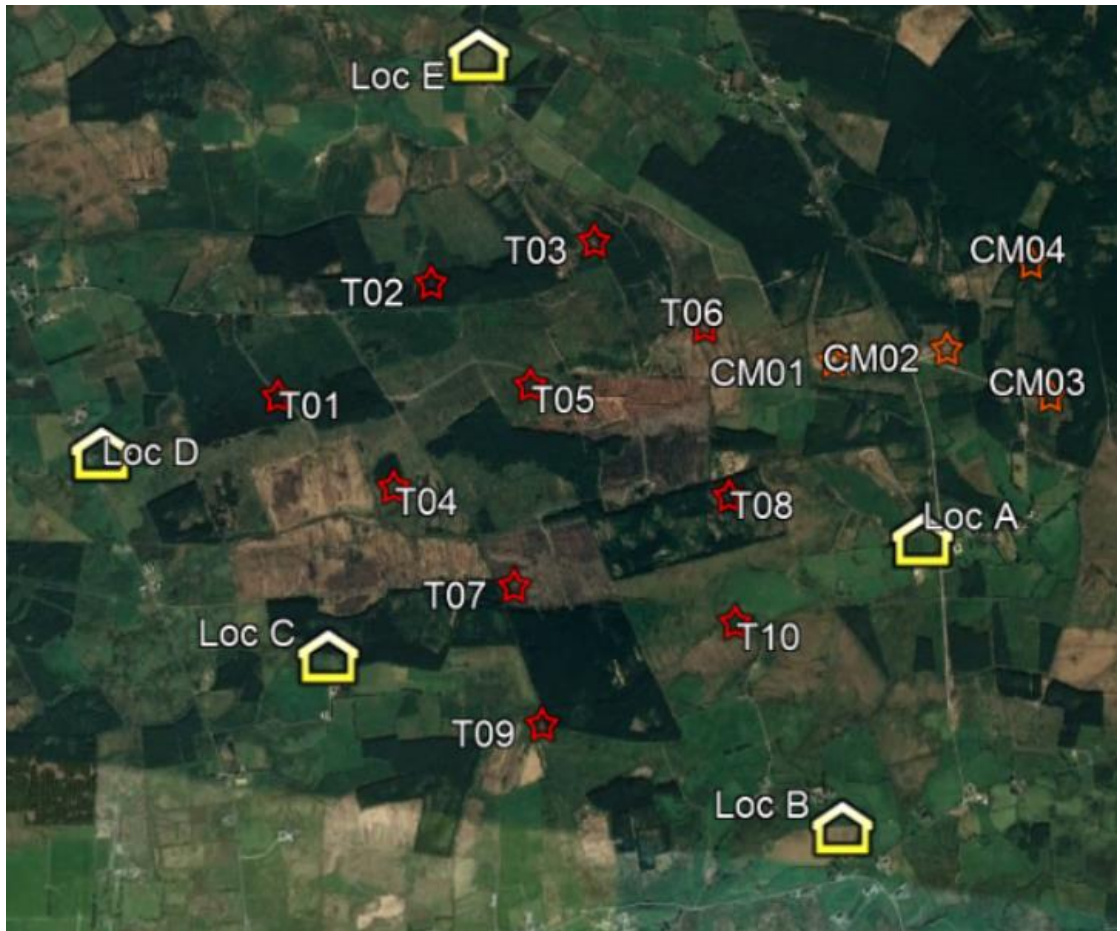


Figure 12-2 Indicative measurement locations (A, B, C, D, and E).

Table 12-8 Measurement Location Coordinates

Location	Coordinates – Irish Grid (ITM)	
	Easting	Northing
A (H029)	509684	668702
B (H016)	509379	667675
C (H023)	507544	668324
D (H075)	506744	669064
E (H028)	508122	670462

Significant noise sources in this area 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.

There were no perceptible sources of vibration noted at any of the survey locations.

Plate 12-1 to Plate 12-7 illustrate the installed noise monitoring kits. In the descriptions that follow, all distances are approximate.

The noise meter at Location A was positioned approximately 20m south-west of the dwelling, 15m west of a farmyard shed, 65m from the local road and 1.5m above the low level vegetation in the immediate area.



Plate 12-1 Location A (H029)

Location B was positioned 10m southwest of the dwelling, 30m northwest of a strong hedgerow and 65m from the local road and 1.5m above the low-level vegetation in the immediate area.



Plate 12-2 Location B (H016)

On 20 August, the meter was moved to an alternate equivalent location to allow the use of the field for cattle. This small change in the position of the meter did not have a significant effect on the measured noise levels.



Plate 12-3 Location B (H016) – second location

Location C was positioned 15m west of the dwelling and 1.5m above the low-level vegetation in the immediate area.



Plate 12-4 Location C (H023)

On 20 August, the meter was moved to an alternate equivalent location to allow the use of the field for cattle.



Plate 12-5 Location C (H023) – second location

Location D was positioned on a lawn at 15m to the south east of the dwelling and 10m from the local road edge and 1.5m above the surrounding lawn.



Plate 12-6 Location D (H075)

Location E was positioned in grassland at 20m dwelling and 20m from the local road edge and 1.5m above the surrounding grassland.



Plate 12-7 Location E (H028)

## 12.5.2 Measurement Periods

Noise measurements were conducted at each of the monitoring locations over the periods outlined in Table 12-9.

Table 12-9 Measurement Periods

Location	Start Date	End Date
A (H029)	26 July 2019	30 August 2019
B (H016)	26 July 2019	30 August 2019
C (H023)	26 July 2019	30 August 2019
D (H075)	26 July 2019	30 August 2019
E (H028)	26 July 2019	30 August 2019

A variety of wind speed and weather conditions were encountered over the survey periods in question. Figure 12-3 illustrates the distributions of wind speed and wind direction standardised to 10 metre height over the survey period detailed in Table 12-9.

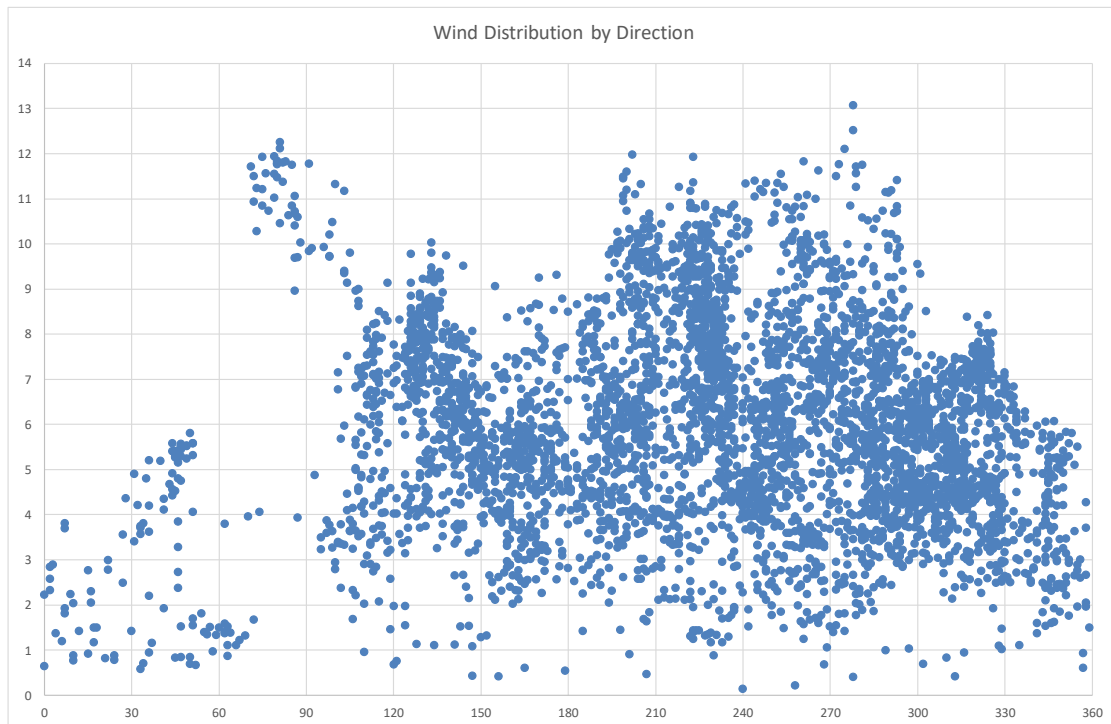


Figure 12-3 Distributions of Wind Speeds and Directions Over the Survey Period

### 12.5.3 Personnel and Instrumentation

AWN Consulting installed and removed the noise monitors at all locations. Battery checks and meter calibrations were carried out part-way through the survey periods. The following instrumentation was used at the various locations:

Table 12-10 Instrumentation Details

Location	Equipment	Serial Number
A (H029)	RION – NL-52	186667

Location	Equipment	Serial Number
B (H016)	RION – NL-52	186668
C (H023)	RION – NL-52	186669
D (H075)	RION – NL-52	186671
E (H028)	RION – NL-52	586944

Before and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator where appropriate. Instruments were calibrated on each interim visit and any drift noted. Relevant calibration certificates are presented in Appendix 12.3.

Rain fall was monitored and logged using a Texas Instruments TR-525 console and a data logger that was installed on-site for the duration of the surveys. This allows for the identification of periods of rain fall to allow for the removal sample periods affect by rainfall from the noise monitoring data sets in line with best practice when calculating the prevailing background noise levels.

Wind data was measured at a meteorological mast located within the site of the proposed development and was supplied to AWN for data analysis.

#### 12.5.4 Procedure

Measurements were conducted at five locations over the survey periods outlined in Table 12-9. Data samples for all measurements (noise, rainfall and wind) were logged continuously at 10-minute interval periods for the duration of the survey.

Survey personnel noted potential primary noise sources contributing to noise build-up during the installation and removal of the sound level meters from site. Description of the observed noise environment at each of the monitoring locations is presented below.  $L_{Aeq,10min}$  and  $L_{A90,10min}$  parameters were measured in this instance.

#### 12.5.5 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. The issue of wind shear has been considered in this assessment and followed relevant guidance as outlined in the IoA GPG. It is standard procedure to reference noise data to standardised 10 metre height wind speed.

Wind speed measurements at 90m and 75m heights have been corrected to a height of 105m (i.e. the assumed 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:

Shear Exponent Profile:  $U = U_{ref} \times [(H \div H_{ref})]^m$

Where:

- 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 =  $\log(U/U_{ref})/\log(H/H_{ref})$

The Calculated hub height wind speeds have been standardised to 10 m height using the following equation:

Roughness Length Shear Profile:  $U_1 = U_2 \times [(\ln(H_1 \div z))/(\ln(H_2 \div z))]$

Where:

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

Note: A roughness length of 0.05m is used to standardise hub height wind speeds to 10m 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.

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

## 12.5.6 Analysis of Background Noise Data

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, operation of gardening equipment etc. In addition, sample periods affected by rainfall or when rainfall resulted in prolonged periods of atypical noise levels have also been screened from the data sets. The 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 are:

- all evenings from 18:00 to 23:00hrs;
- Saturday afternoons from 13:00 to 18:00hrs, and;
- all day Sunday from 07:00 to 18:00hrs.

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

In accordance with the guidance, noise from existing operational windfarms must not form part of the background noise. The data sets collected at all locations have been directionally filtered to exclude periods where the measurement locations were downwind of Kiltumper Wind Farm. As such, the lowest background noise conditions are captured to provide a worst-case assessment. Cahermurphy One had not yet been constructed at the time of the noise survey.

## 12.5.7 Background Noise Levels

The following sections present an overview and results of the noise monitoring data obtained from the background noise survey in accordance with the methodology discussed above. Observations made on site during installation, interim visits and collection are presented below for each monitoring location. Site visits were carried out during the morning and afternoon time and therefore no observations were made during night-time periods.

### 12.5.7.1 Location A (H029)

#### 12.5.7.1.1 Daytime Quiet Periods

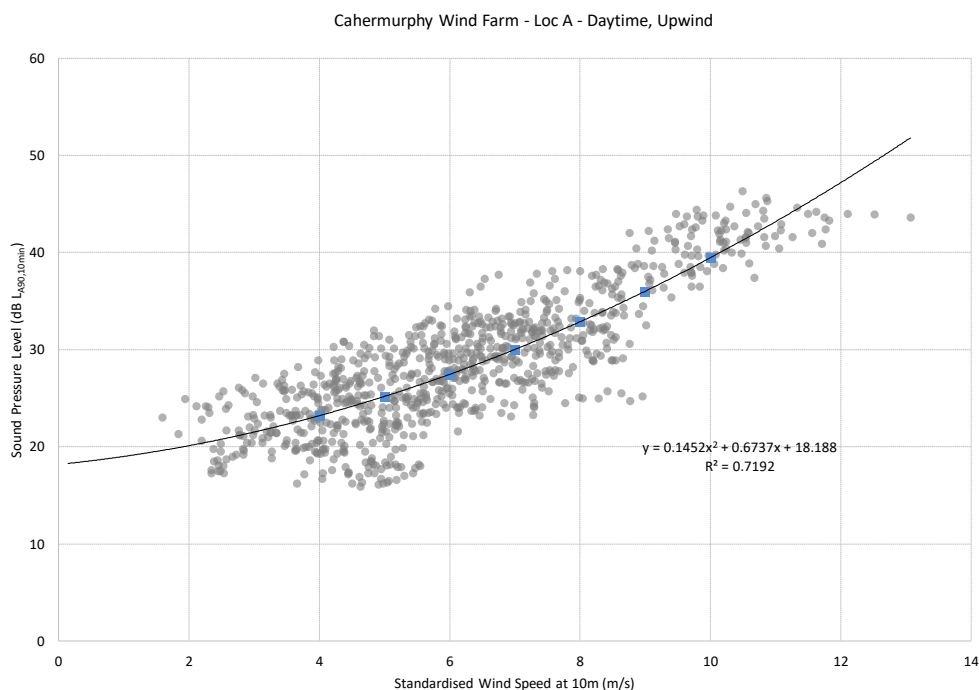


Figure 12-4 Location A (H029) Background Noise Levels  $L_{A90, 10 \text{ min}}$  dB – Daytime

### 12.5.7.1.2 Night-time Periods

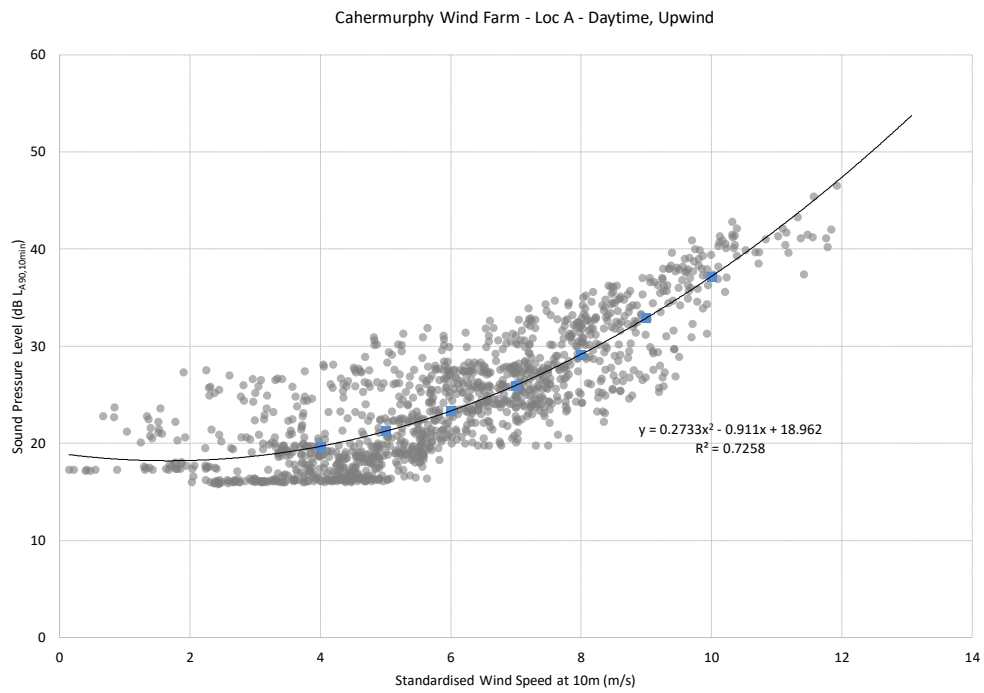


Figure 12-5 Location A (H029) Background Noise Levels  $L_{A90, 10 min}$  dB –Night-time

### 12.5.7.2 Location B (H016)

#### 12.5.7.2.1 Daytime Quiet Periods

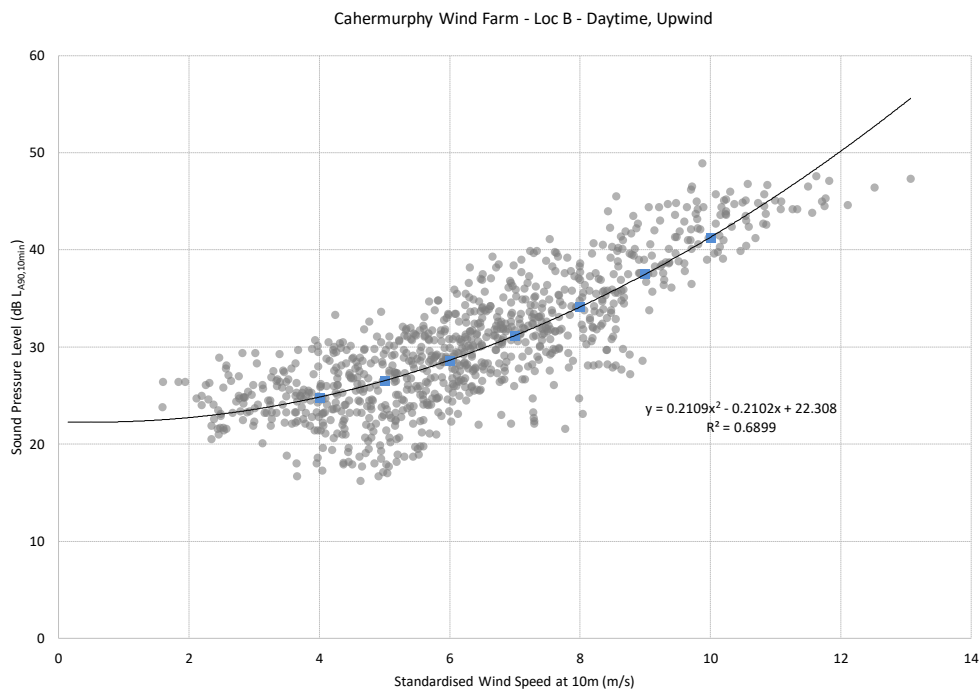


Figure 12-6 Location B (H016) Background Noise Levels  $L_{A90, 10 min}$  dB – Daytime

12.5.7.2.2

### Night-time Periods

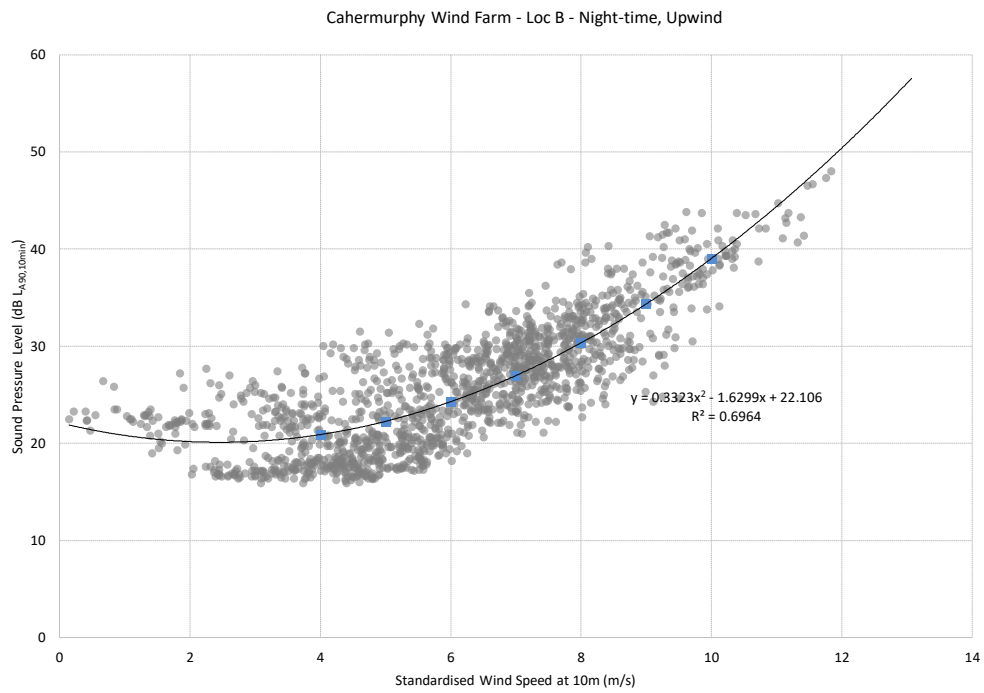


Figure 12-7 Location B (H016) Background Noise Levels LA90, 10 min dB –Night-time

### 12.5.7.3 Location C (H023)

12.5.7.3.1

### Daytime Quiet Periods

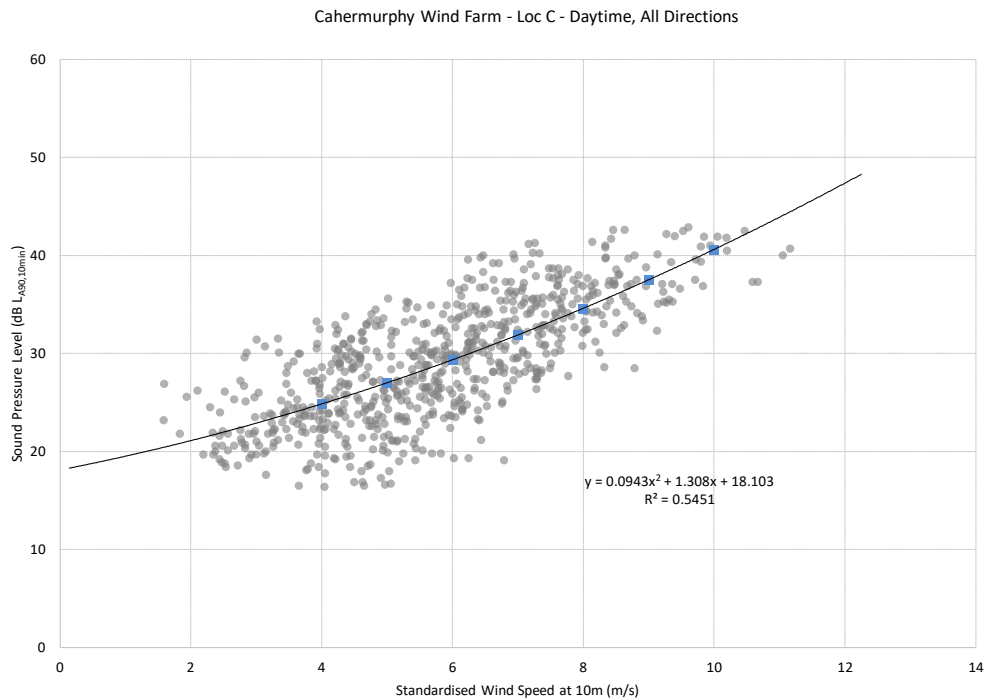


Figure 12-8 Location C (H023) Background Noise Levels LA90, 10 min dB –Daytime

12.5.7.3.2

### Night-time Periods

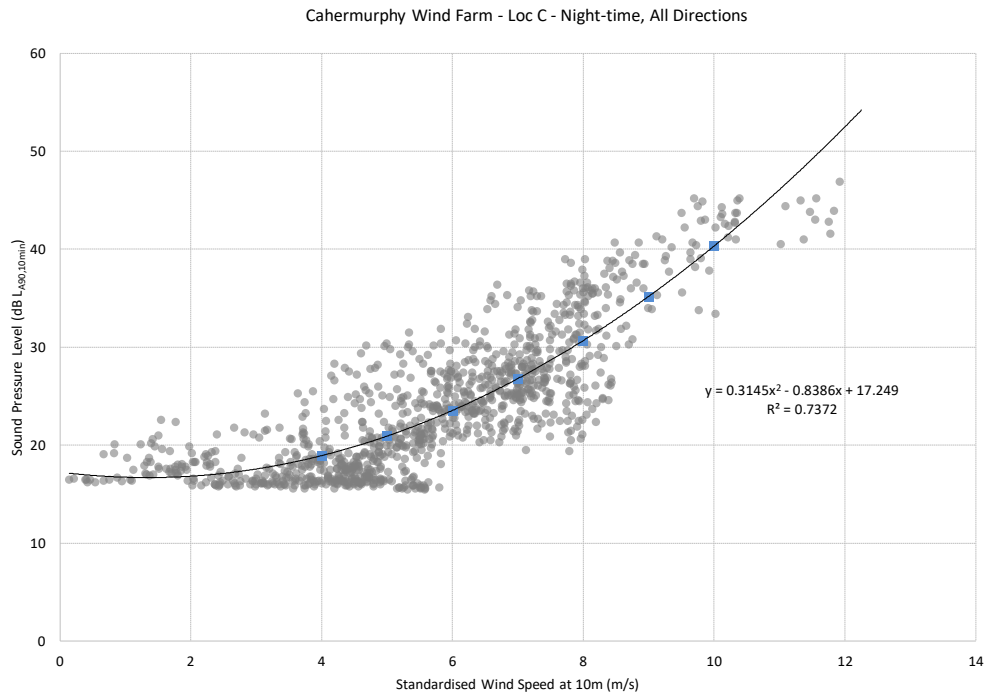


Figure 12-9 Location C (H023) Background Noise Levels  $L_{A90, 10 \text{ min}}$  dB -Night -time

### 12.5.7.4 Location D (H075)

12.5.7.4.1

### Daytime Quiet Periods

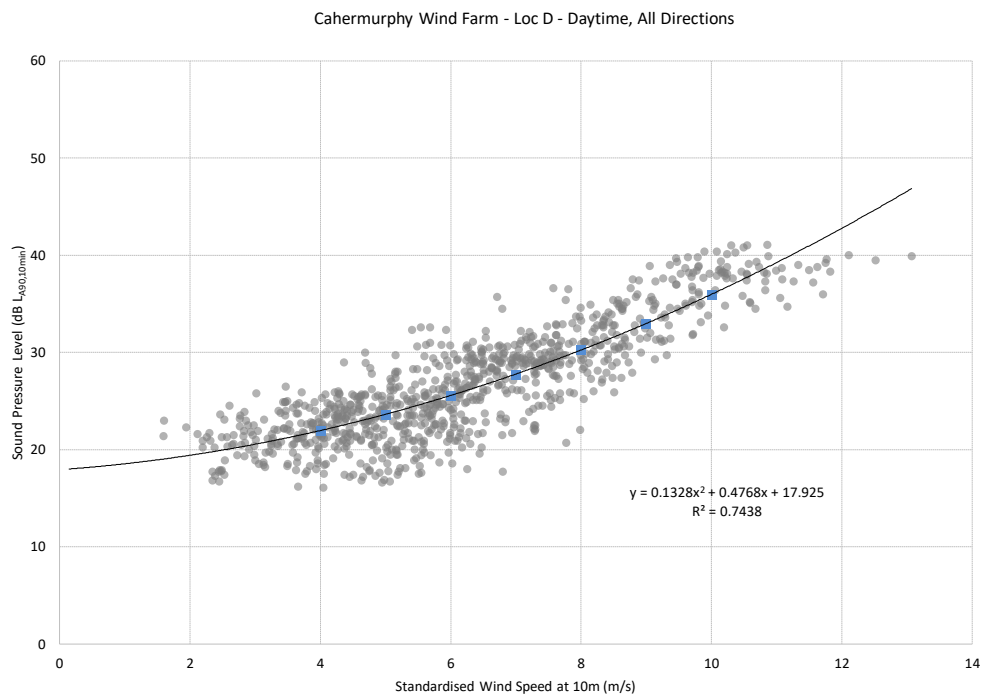


Figure 12-10 Location D (H075) Background Noise Levels  $L_{A90, 10 \text{ min}}$  dB -Daytime

12.5.7.4.2

### Night-time Periods

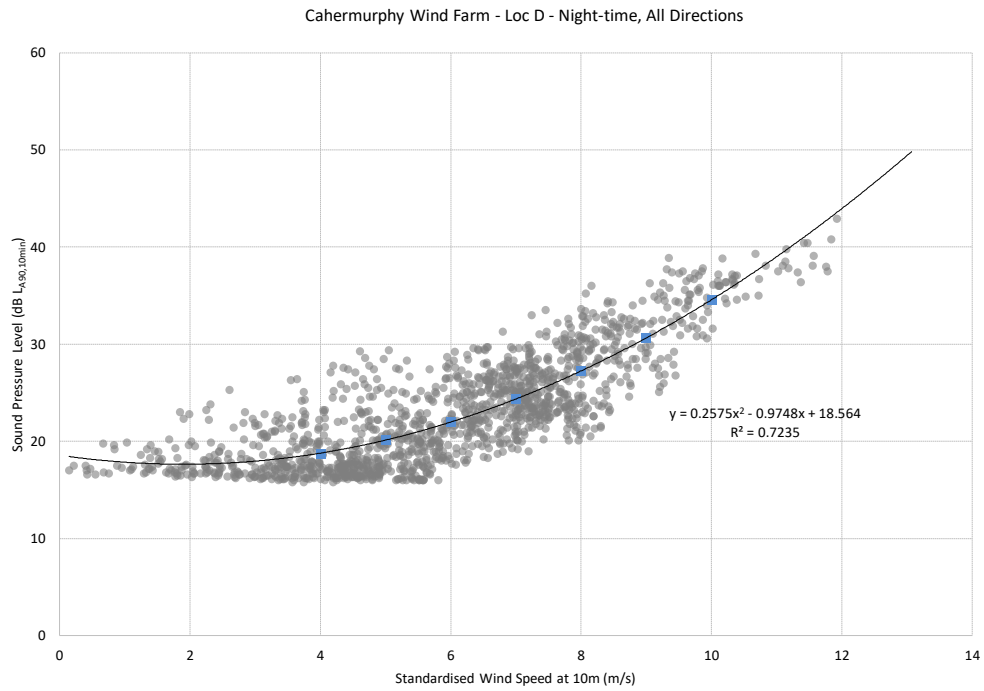


Figure 12-11 Location D (H075) Background Noise Levels LA90, 10 min dB – Night-time

### 12.5.7.5 Location E (H028)

12.5.7.5.1

### Daytime Quiet Periods

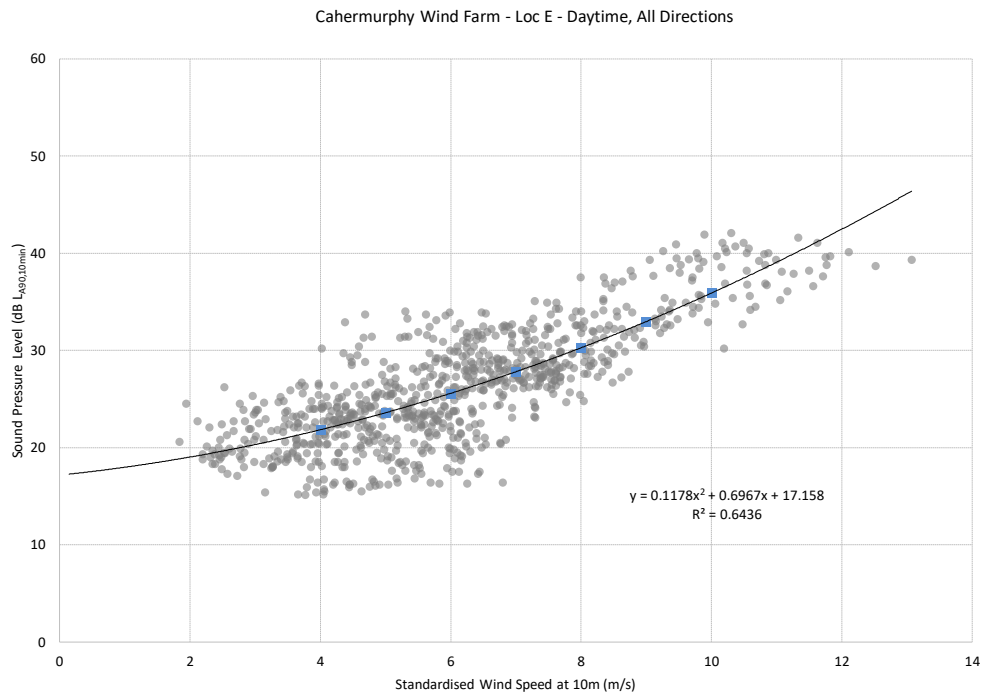


Figure 12-12 Location E (H028) Background Noise Levels LA90, 10 min dB – Daytime

12.5.7.5.2

### Night-time Periods

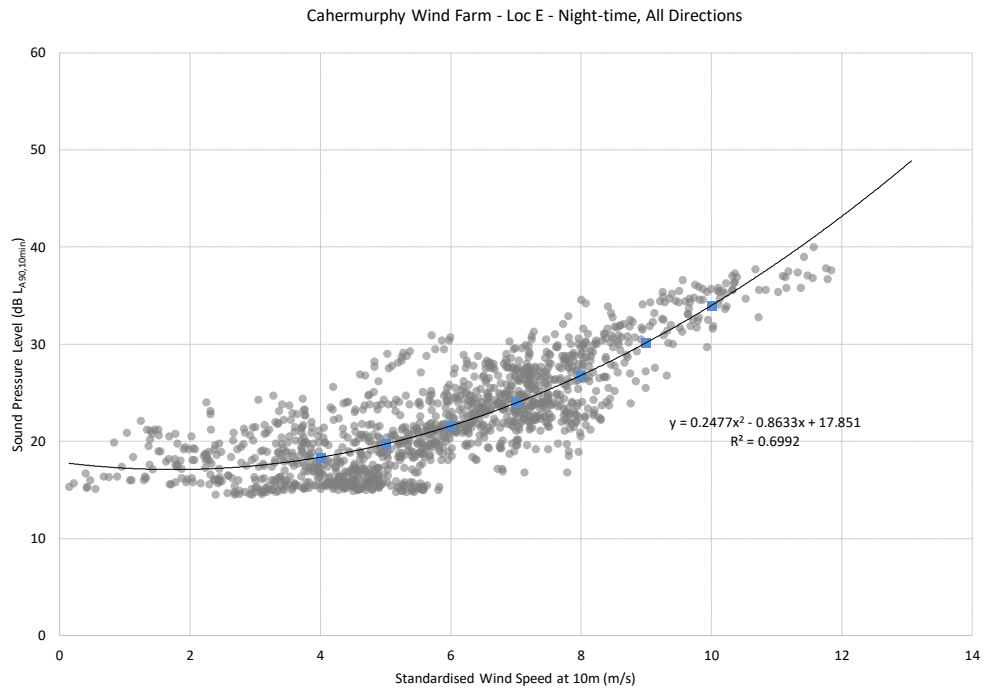


Figure 12-13 Location E (H028) Background Noise Levels LA90, 10 min dB – Night-time

### 12.5.7.6 Summary

Table 12-11 presents the various derived LA90,10min 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 sets in line with guidance contained the IoA GPG and its SGN No. 2 Data Collection.

Table 12-11 Derived Noise Levels of LA90,10min for Various Wind Speeds

Location	Period	Derived LA90, 10 min Levels (dB) at various Standardised 10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
A (H029)	Day	21.5	23.2	25.2	27.5	30.0	32.9	36.0	39.4
	Night	18.8	19.8	21.3	23.3	26.0	29.1	32.9	37.2
B (H016)	Day	23.6	24.8	26.5	28.6	31.2	34.1	37.5	41.3
	Night	20.2	20.9	22.3	24.3	27.0	30.3	34.3	39.0
C (H023)	Day	22.9	24.8	27.0	29.3	31.9	34.6	37.5	40.6
	Night	17.6	18.9	20.9	23.5	26.8	30.7	35.2	40.3
D (H075)	Day	20.6	22.0	23.6	25.6	27.8	30.2	33.0	36.0
	Night	18.0	18.8	20.1	22.0	24.4	27.2	30.6	34.6

Location	Period	Derived L <sub>A90, 10 min</sub> Levels (dB) at various Standardised 10m Height Wind Speed (m/s)							
		3	4	5	6	7	8	9	10
E (H028)	Day	20.3	21.8	23.6	25.6	27.8	30.3	33.0	35.9
	Night	17.5	18.4	19.7	21.6	23.9	26.8	30.1	34.0
Envelope	Day	20.3	21.8	23.6	25.6	27.8	30.2	33.0	35.9
	Night	17.5	18.4	19.7	21.6	23.9	26.8	30.1	34.0

The background noise data is used to derive appropriate noise limits for each of the noise sensitive locations. In a situation where measurements have been conducted near another receiver, the background noise levels measured nearby have been deemed representative for establishing appropriate noise limits. At all remaining locations, the worst-case envelope based on the lowest average levels across the various locations at each wind speed is used, considered separately for daytime and night-time. The assignment of background noise levels to noise-sensitive locations is presented in Table 12-12.

Table 12-12 Assignment of background noise curves to noise-sensitive locations

Representative Background Noise Levels	Noise Sensitive Location (NSL)
A	H029, H030, H031, H032 and H033
B	H016
C	H023
D	H075
E	H028
Envelope	All other locations

## 12.6 Likely Significant Effects and Associated Mitigation Measures

### 12.6.1 Do-Nothing Scenario

If the development were not to proceed then the existing noise environment will remain largely unchanged considering the permitted wind turbine developments and commercial forestry operations in the area.

## 12.6.2 Construction Phase

A variety of items of plant will be in use for the purposes of site preparation, construction of turbines, hardstanding, roads, substation, met mast, temporary construction compound, internal cables, tree felling, borrow pits and grid connection option. 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 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 proposed development.

### 12.6.2.1 General Construction – Turbines, Hardstanding, Met Mast and Construction Compound

#### 12.6.2.1.1 Noise

As the construction programme has been established in outline form only, it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, it is possible to predict typical noise levels using guidance set out in BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.

Turbine foundation works are anticipated at a distance of some 700m from the nearest NSL, H001, at turbine T06. The next nearest NSLs are H075 and H092, which are located approximately 702m to the nearest proposed turbine locations at T01 and T10 respectively.

Several indicative sources that would be expected on a site of this nature have been identified and noise predictions of their potential impacts prepared to nearby houses. The assessment is representative of a worst-case, construction noise levels will be lower at properties located further from the works.

Table 12-13 outlines the noise levels associated with typical construction noise sources assessed in this instance along with typical sound pressure levels and spectra from BS 5228 – 1: 2009. Calculations have assumed an on-time of 66% for each item of plant i.e. 8 hours over a 12-hour assessment period.

Table 12-13 Typical Construction Noise Emission Levels – Turbines and Hardstanding and Met Mast and Construction Compound

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB L <sub>Aeq,T</sub> ) <sup>8</sup>
HGV Movement (C.2.30)	Removing soil and transporting fill and other materials.	79
Tracked Excavator (C.4.64)	Removing soil and rubble in preparation for foundation.	77
Excavator-mounted Rock Breaker (C9.12)	Excavation in rocky areas	85

<sup>8</sup>

All plant noise levels are derived from BS 5228: Part 1

Item (BS 5228 Ref.)	Activity/ Notes	Plant Noise Level at 10m Distance (dB L <sub>Aeq,T</sub> ) <sup>8</sup>
Piling Operations (C.12.14)	Standard pile driving.	88
General Construction (Various)	All general activities plus deliveries of materials and plant.	84
Dewatering Pumps (D.7.70)	If required.	80
JCB (D.8.13)	For services, drainage and landscaping.	82
Vibrating Rollers (D.8.29)	Road surfacing.	77

Assuming as a worst-case that all turbines and hardstands, met mast and construction compound were to be constructed simultaneously, the noise levels for the houses with the top 5 levels are presented in Table 12-14.

Table 12-14 Worst-case predicted noise levels for turbine and hardstands and met mast construction

NSL Ref	Predicted Noise Level (dB L <sub>Aeq,T</sub> )
H023	45
H028	43
H057	43
H026	43
H088	43

The values are well below the construction noise criteria in Table 12-5 for daytime and for evening time. It is concluded that there are no significant noise impacts associated with the construction of the turbine hardstands, construction compound and met mast and therefore no specific mitigation measures are required, over and above the best practice measures described in Section 12.6.2.8.

#### 12.6.2.1.2 Vibration

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

### 12.6.2.2 Construction of Internal Roads (including Tree Felling and laying of underground cables)

It is proposed to upgrade existing internal roads and also to construct new internal roads, lay underground cables and to fell trees as part of the development. Review of the road layout has identified that the nearest NSL to any point along the proposed roads is approximately 200m to location H029 (509696E, 668726N). The nearest NSL to tree felling is H029 509696E, 668726N. All other locations are at greater distances with the majority at significantly greater distances. The full description of the new roads is outlined in Chapter 4 of the EIAR.

#### 12.6.2.2.1 Noise

Table 12-15 outlines the typical construction noise levels associated with the proposed works for this element of the construction. Calculations have assumed an on-time of 66% for each item.

Table 12-15 Typical Construction Noise Emission Levels – Internal Roads, tree felling and laying of underground cables

Item (BS 5228 Ref.)	Plant Noise Level at 10m Distance (dB LAeq,T) <sup>9</sup>	Highest Predicted Noise Level at 200m from Edge of Works (dB LAeq,T)
Petrol-driven chainsaw	86	54
HGV Movement (C.2.30)	79	47
Excavator Mounted Rock Breaker (C9.12)	85	53
Vibrating Rollers (D.8.29)	77	45
<b>Total Construction Noise (cumulative for all activities)</b>		<b>57</b>

At the nearest noise sensitive location, the predicted noise levels from construction activities are of the order of 57 dB LAeq,T, below the significance threshold of 65dB LAeq,1hr. Given the variations of on-site activities, the number of plant items operating at any one time and the location of upgrading road works only operating along the closest boundaries for a limited duration of the overall development, the calculated noise levels presented are considered to present a worst-case scenario. As these works will progress along the route the worst-case predicted impacts will reduce. It is envisioned that they would be at the closest position to the nearest NSL for no more than 2 to 3 days. The resulting noise impact is not significant.

#### 12.6.2.2.2 Vibration

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

<sup>9</sup>

All plant noise levels are derived from BS 5228: Part 1

### 12.6.2.3 Borrow Pits

#### 12.6.2.3.1 Noise

To inform this aspect of the proposal a comparative noise assessment has been prepared and is outlined in the following paragraphs. Two situations have been considered as follows:

- Scenario A      Blasting operation<sup>10</sup>
- Scenario B      Rock breaking operation

In terms of these activities please note the following:

- A mobile crusher will operate on site for both options.
- In Scenario B that two rock breakers will be in use on site during daytime periods for an estimated three-month period.
- For the purposes of this assessment we have assumed the plant is working in the vicinity of the potential borrow pits location indicated Table 12-16.
- Table 12-17 outlines the assumed noise levels for the plant items as extracted from BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.

Table 12-16 Proposed Borrow Pit Locations

Borrow Pit ID	Co-ordinates	
	Easting	Northing
BOR 1	508564	669588
BOR 2	509253	668690

Table 12-17 Typical Plant Noise Levels

Item	BS 5228 Ref:	dB Lw Levels per Octave Band (Hz)								dB(A)
		63	125	250	500	1k	2k	4k	8k	
Crusher	Table C1.14	121	114	107	109	103	99	94	87	110
Rock Breaker	Table C9.11	119	117	113	117	115	115	112	108	121

A construction noise model has been prepared to consider the expected noise emissions from the proposed construction works for the two scenarios outlined above. A percentage on-time of 66% has been assumed for the noise calculations. The predicted levels are detailed in Table 12-18 at the 10 no. closest NSL's to the borrow pits acting together.

<sup>10</sup> Note that blasting may be required at some turbine base locations. If this is the case the mitigation measures detailed in the relevant section of this chapter will be applicable to these activities. The assessment presented here for borrow pit activities will be comparable to those expected in relation to works associated with turbine foundations.

Table 12-18 Typical Plant Noise Levels Borrow Pits

Borrow Pit 1 and Borrow Pit 2			
Loc.	Predicted Construction Noise Level LAeq,1hr		Diff. dB(A)
	Scenario		
	A	B	
H029	40	51	-11
H030	39	49	-10
H031	38	48	-10
H032	37	48	-11
H033	37	47	-10
H034	36	46	-10
H092	36	45	-9
H035	35	44	-9
H003	33	42	-9
H012	33	42	-9

Review of the data contained in Table 12-18 confirms the following:

- Predicted construction noise levels for both Scenario A and B at all borrow pits are well within the best practice construction noise criteria outlined in Table 12-5. It is assumed that construction works at the borrow pits will only occur during daytime periods only (07:00 to 19:00hrs).
- The blasting proposal results in lower levels of construction noise since the use of the rock breaking plant is not required in this instance. Predicted noise levels are lower at all assessed locations for Scenario A.
- It is accepted that the individual blast events will be audible at some locations. Blast events will be designed and controlled such that the best practice noise and vibration limit values outlined in the mitigation section of this chapter are not exceeded.

#### 12.6.2.3.2 **Vibration**

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

## 12.6.2.4 Substation

### 12.6.2.4.1 Noise

The substation is to be constructed at one of two possible locations: either Option A in Carrownagry South townland or Option B in Cahermurphy townland, as shown in Figure 4.11 and Figure 4.12 in Chapter 4 of the EIAR. The noise impact at the nearest NSL has been assessed to identify the potential greatest impact associated with each option.

The nearest NSL to the Option A substation site is at approximately H001 at approximately 440m to the northeast. The nearest NSL to the Option B substation is H029 at approximately 250m to the southeast. Taking Option B as a worst-case example and assuming the same construction activities as outlined in Section 12.6.2.1, it is predicted that the likely worst-case potential noise levels from construction activities associated with the substation will be in the order of 57 dB  $L_{Aeq,T}$  at Location H029. This level of noise is significantly below the daytime construction noise criterion outlined in Table 12-5.

### 12.6.2.4.2 Vibration

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

## 12.6.2.5 Grid Connection Construction

### 12.6.2.5.1 Noise

The onsite substation will connect to the existing Booltiagh 110kV substation located approximately 7 kilometres to the southeast of the site. Connection via the Booltiagh route will comprise underground cabling, measuring approximately 12.1 km in total, located on existing forestry and agricultural land and within the public road corridor. The full description of the proposed grid connection arrangements for the proposed development is outlined in Chapter 4 of the EIAR.

Construction activities will be carried out during normal daytime working hours (i.e. weekdays 0700 – 1900hrs and Saturdays 0700 – 1300hrs).

Table 12-19 outlines the noise levels associated with typical construction noise sources assessed with the proposed works for the grid connection at varying distances from the cable route.

Table 12-19 Indicative Noise Levels from Construction Plant at Nearest NSL from the Grid Connection Works

Item (BS 5228 Ref.)	Highest Predicted Plant Noise Level <sup>11</sup> (dB $L_{Aeq,T}$ )				
	15m Distance	20m Distance	30m Distance	45m Distance	60m Distance
Mini Excavator with Hydraulic Breaker (C5.2)	75	72	67	63	61
Wheeled loader (C2.28)	68	65	60	56	54

<sup>11</sup>

All plant noise levels are derived from BS 5228: Part 1

Item (BS 5228 Ref.)	Highest Predicted Plant Noise Level <sup>11</sup> (dB L <sub>Aeq,T</sub> )				
	15m Distance	20m Distance	30m Distance	45m Distance	60m Distance
Tracked excavator (C2.8)	62	59	54	50	48
Dozer (C2.13)	70	67	62	58	56
Dump truck (C2.30)	71	68	63	59	57
Road Roller (C2.30)	67	64	59	55	53
HGV Movements (20 per hour)	51	48	43	39	37
<b>Total Construction Noise</b>	<b>78</b>	<b>75</b>	<b>71</b>	<b>66</b>	<b>64</b>

At distances between 15 and 45m, the predicted cumulative noise levels from construction activities are of the range of 66-78dB L<sub>Aeq,T</sub>, which are above the significance threshold of 65dB L<sub>Aeq,1hr</sub>. Given the variations of grid connection activities, the number of plant items operating at any one time and the location of upgrading road works only operating along the closest boundaries for a limited duration of the overall development, the calculated noise levels presented are considered to present a worst-case scenario. As these works will progress along the route the worst-case predicted impacts will reduce. At locations at 65m or further from the works, the predicted noise levels are in the order of 64dB L<sub>Aeq,T</sub>, which is below the significance threshold of 65dB L<sub>Aeq,1hr</sub>.

Where a noise sensitive location is within 45m of works detailed consideration to potential construction noise impacts will be required and appropriate mitigation measures implemented in order to manage associated impacts. Typical mitigation measures that can be considered are outlined in the mitigation section of this document with further guidance contained within the BS 5228 standards. It should be noted that these works will progress along the route and it is envisioned that would be carried out and completed in the vicinity of any property in 2 to 3 days.

#### 12.6.2.5.2 **Vibration**

Due to the distance of the proposed works from sensitive locations significant vibration effects are not expected.

### 12.6.2.6 **Construction Traffic**

#### 12.6.2.6.1 **Noise**

This section has been prepared in order to review potential noise impacts associated with construction traffic on the local road network. The information presented in Chapter 15 Material Assets has been used to inform the assessment here. The following situations are commented upon here:

- Stage 1a – Site Preparation – Concrete Pouring
- Stage 1b – Site Preparation & Ground Works

- > Stage 2a – Turbine Construction Stage – Extended Artic Deliveries
- > Stage 2b – Turbine Construction Stage – Other Conventional Deliveries

Please note stage 1 includes for the preparation, groundworks and construction of the turbine foundations, internal cabling and grid connection, access roads, met mast foundations, substation foundations/construction, construction compound and tree felling.

Stage 2 includes for turbine delivery and all other conventional deliveries associated with construction of all other elements of the project such as met mast and sub-station.

Table 12-20 Assumptions for Construction Traffic Noise Assessment

Route	Stage	Traffic Units	%HGV
1 N68 – Ballyduneen	Existing	7,043	8%
	1a	7,473	12%
	1b	7,136	8%
	2a	7,148	9%
	2b	7,103	8%
	2 R484 – Ballyduneen	Existing	2,038
1a		2,468	21%
1b		2,131	9%
2a		2,143	10%
2b		2,098	8%
3 Creegh Road – Creegh North		Existing	350
	1a	350	15%
	1b	350	15%
	2a	410	28%
	2b	350	15%
	4 Casltepark Road	Existing	230
1a		660	60%
1b		323	18%
2a		275	13%
2b		290	17%

Based on the assumptions presented above changes in noise level based on the existing flows have been estimated and is presented in Table 12-20.

Table 12-21 Estimated Changes in Traffic Noise Levels

Route	Stage	Change in Traffic Noise Level dB(A)	Estimated Number of Days
1 N68 – Ballyduneen	1a	0.3	10
	1b	0.1	245
	2a	0.1	30
	2b	0.0	10
2 R484 - Ballyduneen	1a	0.8	10
	1b	0.2	245
	2a	0.2	30
	2b	0.1	10
3 Creegh Road – Creegh North	1a	0.0	10
	1b	0.0	245
	2a	0.7	30
	2b	0.0	10
4 Castlepark Road	1a	4.6	10
	1b	1.5	245
	2a	0.8	30
	2b	1.0	10

The increase in noise levels due to additional construction traffic on each of the routes is predicted to be less than 1.1 dB or less for most Stages along most of the routes. With respect to the assessment criteria outlined in Section 12.4.1.2 the magnitude of this impact is negligible. During Stage 1a, the predicted increase in noise levels is of the order of 4.6 dB (along Castlepark Road). With respect to the appropriate assessment criteria, the magnitude of this impact is moderate.

#### 12.6.2.6.2 **Vibration**

No significant vibration impacts are expected from due to construction traffic.

#### 12.6.2.7 **Construction Phase General Mitigation Measures**

Regarding construction activities, reference will be made to BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*, which offers detailed guidance

on the control of noise & vibration from demolition and construction activities. It is proposed that various practices be adopted during construction, including:

- Managing the hours according to the CEMP [Appendix 4-4] during which site activities likely to create high levels of noise or vibration are permitted;
- Establishing channels of communication between the contractor/developer, Local Authority 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;
- Keeping site access roads even to mitigate the potential for vibration from lorries.

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

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

### 12.6.2.8 Construction Phase Mitigation Measures – Noise

The contract documents will clearly specify that the Contractor undertaking the construction of the works will be obliged to take specific noise abatement measures and comply with the recommendations of British Standard 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 considered, where necessary, to ensure compliance with the relevant construction noise criteria:

- No plant used on site will be permitted to cause an on-going 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 is 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 detailed in Table 12-5 using methods outlined in British Standard BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Noise*.
- The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall generally be restricted to between 7:00hrs and 19:00hrs weekdays and between 7:00hrs and 14:00hrs on Saturdays. However, to ensure that optimal use is made of good weather periods or at critical periods within the programme (i.e. concrete pours, rotor/tower deliveries) it could occasionally be necessary to work out of these hours.

Where rock breaking is employed in relation to the proposed borrow pit location, the following are examples of measures that will be employed, where necessary, to mitigate noise emissions from these activities:

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

Air overpressure from a blast is difficult to control, however, because of its variability much can be done to reduce the effect. A reduction in the amount of primer cord used, together with the adequate burial of any that is above the ground, can give dramatic reduction to air overpressure intensities especially in the audible frequency range. Most complaints are likely to be received from an area downwind of the blast site, and therefore, if air blast complaints are a continual problem, it would be advisable to postpone blasting during unfavourable weather conditions if possible. As air blast intensity is a function of total charge weight, then a reduction in the total amount of explosives used can also reduce the air overpressure value.

Further guidance will be obtained from the recommendations contained within BS 5228: Part 1 and the European Communities (Construction Plant and Equipment) (Permissible Noise Levels) Regulations 1988 in relation to blasting operations.

The methods used to minimise impacts will consist of the following:

- Restriction of hours within which blasting can be conducted (e.g. 09:00 – 18:00hrs).
- Notification to nearby residents before blasting starts (e.g. 24-hour written notification).
- The firing of blasts at similar times to reduce the ‘startle’ effect.
- On-going circulars informing people of the progress of the works.
- The implementation of an onsite documented complaints procedure.
- The use of independent monitoring by external bodies for verification of results.
- Trial blasts in less sensitive areas to assist in blast designs and identify potential zones of influence.

### 12.6.2.9 Construction Phase Mitigation Measures – Vibration

It is recommended that vibration from construction activities be limited to the values set out in Table 12-7. 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%.

Considering the large distances between locations where piling may take place and the nearest noise sensitive locations, no significant impact will be experienced. Therefore, no mitigation measures are proposed for piling operations.

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

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

## 12.6.3 Operational Phase

### 12.6.3.1 Wind Turbine Noise Criteria Curves

With respect to the relevant guidance documents outlined in Section 12.4.2.1 the following noise criteria curves have been identified for the proposed development. The criteria curves have been derived following a detailed review of the background noise data conducted at the nearest noise sensitive locations.

It is proposed to adopt a lower daytime threshold of 40 dB  $L_{A90,10min}$  for low noise environments where the background noise is less than 30 dB(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.
- It is reiterated that the 2006 Wind Energy Development Guidelines 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.

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

- 40 dB  $L_{A90,10min}$  for quiet daytime environments of 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.

Table 12-22 outlines the derived noise criteria curves based on the information contained within Table 12-11 and the assignments of background noise levels to noise-sensitive locations as presented in Table 12-12.

Table 12-22 Noise Criteria Curves

Location	Period	Noise Criteria $L_{A90, 10 \text{ min}}$ (dB) at various Standardised 10m Height Wind Speeds (m/s)							
		3	4	5	6	7	8	9	10
H029, H030, H031, H032, H033	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H016	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.0	46.3
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.0
H023	Day	40.0	40.0	40.0	40.0	45.0	45.0	45.0	45.6
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.3
H075	Day	40.0	40.0	40.0	40.0	40.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H028	Day	40.0	40.0	40.0	40.0	40.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
All other locations	Day	40.0	40.0	40.0	40.0	40.0	45.0	45.0	45.0
	Night	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

### 12.6.3.2 Turbine Noise Assessment

The noise levels for the proposed site have been calculated for all noise sensitive receivers identified within 1.2 km of the proposed turbines.

A worst-case assessment has been completed assuming all noise locations are downwind of all turbines at the same time. The predicted noise levels include Cahermurphy 1 and Kiltumper wind farms. The predicted levels have been compared against the adopted noise criteria curves as detailed in Table 12-22. Table 12-23 presents the details of the exercise at all 100 no. noise sensitive locations considered as part of this assessment.

Table 12-23 Review of Cumulative Predicted Turbine Noise Levels against Relevant Criteria

House ID	Description	Predicted Noise Level dB $L_{A90}$ at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	$\geq 9$
H01	Dwelling	34.7	38.4	41.8	42.8	43.1	43.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	1.8	2.8	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	0.1	0.4
H02	Dwelling	33.6	37.6	41	42	42.3	42.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	1	2	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H03	Dwelling	33.5	37.6	41	42	42.2	42.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	1	2	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H04	Dwelling	33.2	37.5	41	42	42.2	42.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	1	2	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H05	Dwelling	32.7	37	40.5	41.5	41.7	41.7
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.5	1.5	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H06	Dwelling	32.2	36.4	39.8	40.9	41	41.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.9	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H07	Dwelling	32.3	36.6	40.1	41.1	41.3	41.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.1	1.1	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H08	Dwelling	27.1	31.3	34.9	35.9	36	36.1
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H09	Dwelling	28.6	33	36.6	37.6	37.6	37.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H010	Dwelling	30.2	34.6	38.3	39.2	39.3	39.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H011	Dwelling	28.9	33.3	36.9	37.9	38	38
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H012	Dwelling	29.7	33.8	37.4	38.5	38.7	38.9
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H013	Dwelling	29	33.1	36.7	37.8	38.1	38.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H014	Dwelling	29.3	33.5	37.1	38.1	38.4	38.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H015	Dwelling	29.9	34.1	37.7	38.8	39	39.1
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H016	Dwelling	28.8	33.1	36.7	37.7	37.9	38
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H017	Dwelling	27.1	31.3	35	36	36.3	36.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H018	Dwelling	28.2	32.5	36.1	37.1	37.3	37.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H019	Dwelling	27.6	31.9	35.6	36.7	36.9	37
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H020	Dwelling	26.4	30.6	34.3	35.4	35.7	35.9
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H021	Dwelling	26.6	30.8	34.4	35.5	35.8	36
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H022	Dwelling	32.2	36.7	40.3	41.3	41.4	41.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.3	1.3	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H023	Dwelling	33.7	38.3	42	42.9	43	43
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	2	2.9	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H024	Dwelling	31.9	36.4	40	41	41	41
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	1	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H025	Dwelling	32.6	37.1	40.7	41.7	41.8	41.8
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.7	1.7	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H026	Dwelling	32.9	37.4	41.1	42.1	42.1	42.1
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	1.1	2.1	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H027	Dwelling	32	36.5	40.1	41.1	41.2	41.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.1	1.1	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H028	Dwelling	33	37.5	41.2	42.1	42.2	42.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	1.2	2.1	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H029	Dwelling	34.7	38.5	41.9	43	43.3	43.5
	Daytime Criterion	40	40	40	45	45	45
	Daytime Excess	-	-	1.9	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	0.3	0.5
H030	Dwelling	34.3	38	41.4	42.4	42.8	43
	Daytime Criterion	40	40	40	45	45	45
	Daytime Excess	-	-	1.4	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H031	Dwelling	34.5	38.2	41.4	42.5	42.9	43.2
	Daytime Criterion	40	40	40	45	45	45
	Daytime Excess	-	-	1.4	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	0.2
H032	Dwelling	35.1	38.6	41.7	42.9	43.3	43.7
	Daytime Criterion	40	40	40	45	45	45
	Daytime Excess	-	-	1.7	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	0.3	0.7
H033	Dwelling	34.3	37.8	41	42.2	42.6	43
	Daytime Criterion	40	40	40	45	45	45
	Daytime Excess	-	-	1	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H034	Dwelling	34.6	38	41.1	42.3	42.7	43.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	1.1	2.3	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	0.2

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H035	Dwelling	34.3	37.5	40.6	41.8	42.3	42.7
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.6	1.8	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H036	Dwelling	27.2	31.3	34.9	36	36.3	36.5
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H037	Dwelling	31	35.5	39.1	40.1	40.2	40.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.1	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H038	Dwelling	30.8	35.3	39	40	40.1	40
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H039	Dwelling	31.3	35.8	39.4	40.4	40.5	40.5
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.4	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H040	Dwelling	30.5	35	38.6	39.6	39.7	39.7
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H041	Dwelling	25.9	30.4	34.1	35.1	35.2	35.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H042	Dwelling	25.3	29.7	33.4	34.5	34.6	34.7
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H043	Dwelling	30.9	35.4	39	40	40.1	40.1
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H044	Dwelling	30.8	35.3	39	40	40	40
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H045	Dwelling	30.5	35	38.7	39.7	39.7	39.7
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H046	Dwelling	30.4	34.9	38.6	39.5	39.6	39.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H047	Dwelling	26.7	31.2	34.9	35.9	36	36
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H048	Dwelling	27.9	32.4	36.1	37.1	37.1	37.1
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H049	Dwelling	28.4	32.9	36.6	37.6	37.6	37.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H050	Dwelling	28.9	33.4	37	38	38.1	38
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H051	Dwelling	29.1	33.6	37.2	38.2	38.3	38.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H052	Dwelling	29.5	34	37.6	38.6	38.7	38.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H053	Dwelling	28.8	33.4	37	38	38	38
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H054	Dwelling	28.7	33.2	36.9	37.9	37.9	37.9
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H055	Dwelling	29.5	34	37.7	38.7	38.7	38.7
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H056	Dwelling	30	34.6	38.2	39.2	39.2	39.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H057	Dwelling	33	37.5	41.2	42.2	42.2	42.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	1.2	2.2	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H058	Dwelling	31.2	35.7	39.4	40.4	40.4	40.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.4	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H059	Dwelling	31	35.6	39.2	40.2	40.3	40.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.2	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H060	Dwelling	31.3	35.9	39.5	40.5	40.5	40.5
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.5	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H061	Dwelling	31.3	35.8	39.5	40.5	40.5	40.5
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.5	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H062	Dwelling	31.4	36	39.6	40.6	40.6	40.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.6	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H063	Dwelling	31.2	35.7	39.4	40.4	40.4	40.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.4	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H064	Dwelling	30.9	35.5	39.1	40.1	40.2	40.1
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.1	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H065	Dwelling	26.2	30.7	34.4	35.4	35.4	35.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H066	Dwelling	26.1	30.6	34.2	35.2	35.3	35.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H067	Dwelling	26.4	30.9	34.6	35.6	35.6	35.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H068	Dwelling	26.3	30.8	34.4	35.4	35.4	35.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H069	Dwelling	26.7	31.2	34.9	35.9	35.9	35.9
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H070	Dwelling	28.1	32.6	36.3	37.3	37.3	37.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H071	Dwelling	26.6	31.1	34.8	35.8	35.8	35.8
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H072	Dwelling	27.7	32.2	35.8	36.8	36.9	36.8
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H073	Dwelling	27.9	32.4	36.1	37.1	37.1	37.1
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H074	Dwelling	28.2	32.7	36.4	37.4	37.4	37.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H075	Dwelling	31.4	35.9	39.6	40.6	40.6	40.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.6	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H076	Dwelling	31.2	35.8	39.4	40.4	40.5	40.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.4	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H077	Dwelling	31	35.6	39.2	40.2	40.3	40.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.2	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H078	Dwelling	29.2	33.7	37.4	38.4	38.4	38.4
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H079	Dwelling	28.8	33.3	37	37.9	38	37.9
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H080	Dwelling	28.6	33.1	36.7	37.7	37.8	37.7
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H081	Dwelling	28.4	32.9	36.6	37.5	37.6	37.5
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H082	Dwelling	28.2	32.7	36.3	37.3	37.4	37.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H083	Dwelling	27.1	31.6	35.2	36.2	36.2	36.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H084	Dwelling	30.8	35.3	39	40	40	40
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H085	Dwelling	29.8	34.2	37.8	38.8	38.9	38.9
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H086	Dwelling	30.1	34.7	38.3	39.3	39.3	39.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H087	Dwelling	31.1	35.6	39.3	40.2	40.3	40.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.2	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H088	Dwelling	32.8	37.3	40.9	41.9	41.9	41.9
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.9	1.9	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H089	Dwelling	32.7	36.7	40.1	41.2	41.4	41.5
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.1	1.2	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H090	Dwelling	32.8	37	40.5	41.5	41.6	41.8
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.5	1.5	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H091	Dwelling	31.1	35.6	39.3	40.3	40.3	40.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	0.3	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H092	Dwelling	32.1	36.5	40.1	41.1	41.2	41.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	0.1	1.1	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H093	Dwelling	27.3	31.5	35	36	36.1	36.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H094	Dwelling	26.4	30.9	34.5	35.5	35.6	35.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H095	Dwelling	26.9	31.4	35.1	36.1	36.1	36.1
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H096	Dwelling	27.4	31.9	35.5	36.5	36.6	36.6
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H097	Dwelling	27.5	32	35.6	36.6	36.7	36.7
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H098	Dwelling	27.7	32.2	35.8	36.8	36.9	36.8
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

House ID	Description	Predicted Noise Level dB LA90 at Standardised Wind Speed at 10m A.G.L.					
		4	5	6	7	8	≥9
H099	Dwelling	26	30.5	34.2	35.2	35.2	35.2
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-
H100	Dwelling	25.9	30.4	34.1	35.1	35.2	35.3
	Daytime Criterion	40	40	40	40	45	45
	Daytime Excess	-	-	-	-	-	-
	Night time Criterion	43	43	43	43	43	43
	Night time Excess	-	-	-	-	-	-

A noise contour for standard mode operation rated power wind speed (i.e. highest noise emission) has been presented in Appendix 12.4.

The cumulative predicted noise levels at various wind speeds have been compared against the noise criteria curves outlined in Table 12-22. The predicted omni-directional noise levels for all turbines operating in standard mode has identified some exceedances at noise sensitive locations at certain windspeeds.

When considering noise impacts of wind turbines, the effects of propagation in different wind directions can be considered. As previously stated the day to day operations of the proposed development will not result in a worst-case condition of all noise locations being downwind of all turbines at the same time i.e. omni-directional predictions. Therefore, to address this issue, a review of expected noise levels downwind of the turbines has been prepared for various wind directions in accordance with the IoA GPG Guidance.

For any given wind direction, a property can be assigned one of the following classifications in relation to turbine noise propagation:

- Downwind (i.e.  $0^\circ \pm 80^\circ$ );
- Crosswind (i.e.  $90^\circ \pm 10^\circ$  and  $270^\circ \pm 10^\circ$ );
- Upwind (i.e.  $180^\circ \pm 70^\circ$ ).

Figure 12-14 illustrates the directivity attenuation factor that has been applied to turbines when considering noise propagation in downwind conditions.

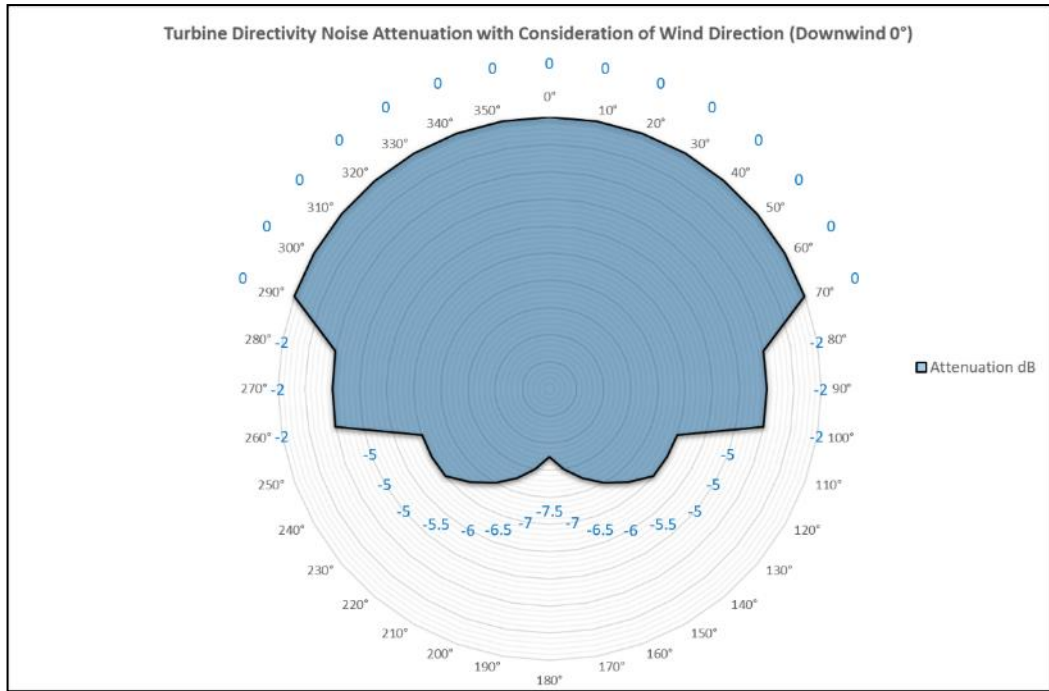


Figure 12-14 Turbine Directivity Attenuation with Consideration of Wind Direction

Directional noise predictions models have been developed to identify the number and magnitude of exceedances to the noise criteria at the various noise sensitive locations with the proposed turbines operating in standard mode. The full tabulated results of this assessment are shown in Appendix 12-5. The list of NSL's with predicted exceedances assuming all turbines operating in standard operating mode are presented Table 12-24 to Table 12-31 for each of the various wind direction sectors that have been assessed.

Table 12-24 Summary of Exceedances Standard Operating Mode in North Wind Direction (0°)

Location	Period	Noise Exceedances (dB LA90, 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H022	Day	-	-	0.3	1.3	-	-
	Night	-	-	-	-	-	-
H029	Day	-	-	1	-	-	-
	Night	-	-	-	-	-	-
H030	Day	-	-	0.6	-	-	-
	Night	-	-	-	-	-	-
H031	Day	-	-	0.5	-	-	-
	Night	-	-	-	-	-	-
H032	Day	-	-	0.8	-	-	-
	Night	-	-	-	-	-	-
H033	Day	-	-	0.1	-	-	-
	Night	-	-	-	-	-	-
H034	Day	-	-	0.3	1.5	-	-
	Night	-	-	-	-	-	-
H035	Day	-	-	-	1.2	-	-
	Night	-	-	-	-	-	-
H037	Day	-	-	-	0.1	-	-
	Night	-	-	-	-	-	-
H039	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
	Day	-	-	0.7	1.7	-	-

Location	Period	Noise Exceedances (dB LA90, 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H057	Night	-	-	-	-	-	-
H091	Day	-	-	-	0.3	-	-
	Night	-	-	-	-	-	-
H092	Day	-	-	-	0.9	-	-
	Night	-	-	-	-	-	-

Table 12-25 Summary of Exceedances Standard Operating Mode in Northeast Wind Direction (45°)

Location	Period	Noise Exceedances (dB LA90, 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H022	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H034	Day	-	-	-	0.7	-	-
	Night	-	-	-	-	-	-
H035	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H037	Day	-	-	-	0.1	-	-
	Night	-	-	-	-	-	-
H039	Day	-	-	-	0.3	-	-
	Night	-	-	-	-	-	-
H057	Day	-	-	1.2	2.2	-	-
	Night	-	-	-	-	-	-
H058	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H059	Day	-	-	-	0.2	-	-
	Night	-	-	-	-	-	-
H060	Day	-	-	-	0.5	-	-
	Night	-	-	-	-	-	-
H061	Day	-	-	-	0.5	-	-
	Night	-	-	-	-	-	-
H062	Day	-	-	-	0.6	-	-
	Night	-	-	-	-	-	-
H063	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H064	Day	-	-	-	0.1	-	-
	Night	-	-	-	-	-	-
H075	Day	-	-	-	0.5	-	-
	Night	-	-	-	-	-	-
H076	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H077	Day	-	-	-	0.2	-	-
	Night	-	-	-	-	-	-
H091	Day	-	-	-	0.3	-	-
	Night	-	-	-	-	-	-
H092	Day	-	-	-	0.1	-	-
	Night	-	-	-	-	-	-

Table 12-26 Summary of Exceedances Standard Operating Mode in East Wind Direction (90°)

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H025	Day	-	-	-	0.6	-	-
	Night	-	-	-	-	-	-
H026	Day	-	-	-	1	-	-
	Night	-	-	-	-	-	-
H028	Day	-	-	-	0.9	-	-
	Night	-	-	-	-	-	-
H057	Day	-	-	0.9	1.9	-	-
	Night	-	-	-	-	-	-
H058	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H059	Day	-	-	-	0.2	-	-
	Night	-	-	-	-	-	-
H060	Day	-	-	-	0.5	-	-
	Night	-	-	-	-	-	-
H061	Day	-	-	-	0.5	-	-
	Night	-	-	-	-	-	-
H062	Day	-	-	-	0.6	-	-
	Night	-	-	-	-	-	-
H063	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H064	Day	-	-	-	0.1	-	-
	Night	-	-	-	-	-	-
H075	Day	-	-	-	0.6	-	-
	Night	-	-	-	-	-	-
H076	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H077	Day	-	-	-	0.2	-	-
	Night	-	-	-	-	-	-
H088	Day	-	-	-	0.8	-	-
	Night	-	-	-	-	-	-

Table 12-27 Summary of Exceedances Standard Operating Mode in Southeast Wind Direction (135°)

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H001	Day	-	-	0.5	1.5	-	-
	Night	-	-	-	-	-	-
H002	Day	-	-	-	0.9	-	-
	Night	-	-	-	-	-	-
H003	Day	-	-	-	1	-	-
	Night	-	-	-	-	-	-

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H004	Day	-	-	0.1	1.1	-	-
	Night	-	-	-	-	-	-
H005	Day	-	-	-	0.6	-	-
	Night	-	-	-	-	-	-
H007	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H024	Day	-	-	-	1	-	-
	Night	-	-	-	-	-	-
H025	Day	-	-	0.6	1.6	-	-
	Night	-	-	-	-	-	-
H026	Day	-	-	1	2	-	-
	Night	-	-	-	-	-	-
H027	Day	-	-	0.1	1.1	-	-
	Night	-	-	-	-	-	-
H028	Day	-	-	1.1	2	-	-
	Night	-	-	-	-	-	-
H057	Day	-	-	-	0.3	-	-
	Night	-	-	-	-	-	-
H075	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H076	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H077	Day	-	-	-	0.2	-	-
	Night	-	-	-	-	-	-
H087	Day	-	-	-	0.2	-	-

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
	Night	-	-	-	-	-	-
H088	Day	-	-	0.9	1.9	-	-
	Night	-	-	-	-	-	-
H098	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H090	Day	-	-	-	0.6	-	-
	Night	-	-	-	-	-	-

Table 12-28 Summary of Exceedances Standard Operating Mode in South Wind Direction (180°)

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H001	Day	-	-	1.6	2.6	-	-
	Night	-	-	-	-	-	0.2
H002	Day	-	-	1	2	-	-
	Night	-	-	-	-	-	-
H003	Day	-	-	1	2	-	-
	Night	-	-	-	-	-	-
H004	Day	-	-	1	2	-	-
	Night	-	-	-	-	-	-
H005	Day	-	-	0.5	1.5	-	-
	Night	-	-	-	-	-	-
H006	Day	-	-	-	0.9	-	-
	Night	-	-	-	-	-	-
H007	Day	-	-	0.1	1.1	-	-
	Night	-	-	-	-	-	-
H024	Day	-	-	-	1	-	-

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
	Night	-	-	-	-	-	-
H025	Day	-	-	0.7	1.7	-	-
	Night	-	-	-	-	-	-
H026	Day	-	-	1.1	2.1	-	-
	Night	-	-	-	-	-	-
H027	Day	-	-	0.1	1.1	-	-
	Night	-	-	-	-	-	-
H028	Day	-	-	1.2	2.1	-	-
	Night	-	-	-	-	-	-
H087	Day	-	-	-	0.2	-	-
	Night	-	-	-	-	-	-
H088	Day	-	-	0.9	1.9	-	-
	Night	-	-	-	-	-	-
H098	Day	-	-	0.1	1.2	-	-
	Night	-	-	-	-	-	-
H090	Day	-	-	0.5	1.5	-	-
	Night	-	-	-	-	-	-

Table 12-29 Summary of Exceedances Standard Operating Mode in Southwest Wind Direction (225°)

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H001	Day	-	-	1.3	2.3	-	-
	Night	-	-	-	-	-	-
H002	Day	-	-	0.7	1.7	-	-
	Night	-	-	-	-	-	-

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H003	Day	-	-	0.7	1.7	-	-
	Night	-	-	-	-	-	-
H004	Day	-	-	0.8	1.8	-	-
	Night	-	-	-	-	-	-
H005	Day	-	-	0.3	1.3	-	-
	Night	-	-	-	-	-	-
H006	Day	-	-	-	0.6	-	-
	Night	-	-	-	-	-	-
H007	Day	-	-	-	1	-	-
	Night	-	-	-	-	-	-
H024	Day	-	-	-	0.3	-	-
	Night	-	-	-	-	-	-
H025	Day	-	-	-	0.9	-	-
	Night	-	-	-	-	-	-
H026	Day	-	-	0.4	1.4	-	-
	Night	-	-	-	-	-	-
H027	Day	-	-	-	0.3	-	-
	Night	-	-	-	-	-	-
H028	Day	-	-	0.4	1.3	-	-
	Night	-	-	-	-	-	-
H029	Day	-	-	0.5	-	-	-
	Night	-	-	-	-	-	-
H088	Day	-	-	0.2	1.2	-	-
	Night	-	-	-	-	-	-
H098	Day	-	-	-	1	-	-

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
	Night	-	-	-	-	-	-
H090	Day	-	-	0.2	1.2	-	-
	Night	-	-	-	-	-	-

Table 12-30 Summary of Exceedances Standard Operating Mode in West Wind Direction (270°)

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H001	Day	-	-	0.6	1.6	-	-
	Night	-	-	-	-	-	-
H002	Day	-	-	0.1	1.1	-	-
	Night	-	-	-	-	-	-
H003	Day	-	-	0.1	1.1	-	-
	Night	-	-	-	-	-	-
H004	Day	-	-	-	0.9	-	-
	Night	-	-	-	-	-	-
H005	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H007	Day	-	-	-	0.1	-	-
	Night	-	-	-	-	-	-
H022	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H029	Day	-	-	1.2	-	-	-
	Night	-	-	-	-	-	-
H030	Day	-	-	0.6	-	-	-
	Night	-	-	-	-	-	-

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H031	Day	-	-	0.5	-	-	-
	Night	-	-	-	-	-	-
H032	Day	-	-	0.5	-	-	-
	Night	-	-	-	-	-	-
H034	Day	-	-	-	1	-	-
	Night	-	-	-	-	-	-
H035	Day	-	-	-	1	-	-
	Night	-	-	-	-	-	-
H089	Day	-	-	-	0.3	-	-
	Night	-	-	-	-	-	-
H090	Day	-	-	-	0.4	-	-
	Night	-	-	-	-	-	-
H092	Day	-	-	-	0.7	-	-
	Night	-	-	-	-	-	-

Table 12-31 Summary of Exceedances Standard Operating Mode in Northwest Wind Direction (315°)

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
H022	Day	-	-	0.2	1.2	-	-
	Night	-	-	-	-	-	-
H029	Day	-	-	1.7	-	-	-
	Night	-	-	-	-	0.1	0.3
H030	Day	-	-	1.2	-	-	-
	Night	-	-	-	-	-	-
H031	Day	-	-	1.1	-	-	-

Location	Period	Noise Exceedances (dB L <sub>A90</sub> , 10min), at various Standardised 10m Height Wind Speed (m/s)					
		4	5	6	7	8	9
	Night	-	-	-	-	-	-
H032	Day	-	-	1.3	-	-	-
	Night	-	-	-	-	-	0.3
H033	Day	-	-	0.8	-	-	-
	Night	-	-	-	-	-	-
H034	Day	-	-	1	2.2	-	-
	Night	-	-	-	-	-	0.1
H035	Day	-	-	0.6	1.8	-	-
	Night	-	-	-	-	-	-
H039	Day	-	-	-	0.3	-	-
	Night	-	-	-	-	-	-
H057	Day	-	-	-	0.2	-	-
	Night	-	-	-	-	-	-
H091	Day	-	-	-	0.1	-	-
	Night	-	-	-	-	-	-
H092	Day	-	-	-	1	-	-
	Night	-	-	-	-	-	-

Following review of the exceedances to the criteria in the various wind direction sectors, the following comments are presented.

In the prevailing wind direction (south west) exceedances are noted at sixteen NSLs. In the southeast wind direction the number of houses with exceedances is highest at nineteen houses. In the northwest wind direction, the number of houses is lowest, at twelve houses. It is reiterated that this initial review has considered a turbine operating in standard mode.

Wind turbines can be programmed to run in reduced modes of operation (or low noise modes) in order to achieve noise criteria during certain periods (i.e. day or night) and in specific wind conditions (i.e. wind speed and direction). The turbine technology that has been assumed for this assessment offers various low noise modes of operation which typically will have an associated energy output reduction.

Operating the turbines in reduced modes is generally referred to as curtailment and in the context of this EIAR is a proven effective mitigation to ensure noise limits are complied with. A detailed curtailment strategy matrix will be finalised as part of the detailed design for the selected turbine

technology to achieve the noise criteria at each of the noise sensitive locations. To demonstrate the principle of curtailment, a typical curtailment strategy matrix has been developed and is presented in Table 12-32 for south-westerly winds to address the exceedance listed in this wind direction sector. The required noise emission reductions to the relevant turbines are summarised in Table 12-32.

Table 12-32 Indicative Turbine Curtailment Matrix for South West Wind Direction

Wind Direction Sector	Period	Turbine Curtailment (dB) at Standardised Wind Speeds (m/s)					
		4	5	6	7	8	9
South	Day	-	-	T02: -0.5 T03: -4.5 T06: -5 T08: -2	T02: -0.5 T03: -4.5 T05: -4 T06: Off T08: -4	-	-
	Night	-	-	-	-	-	T06: -1

Assuming the implementation of the above or similar, it is not considered that a significant effect is associated with the operation of this development, since the predicted noise levels associated with the proposed development will be within the relevant best practice noise criteria curves for wind farms. As previously discussed, the following guidance is relevant for this assessment, “*Wind Energy Development Guidelines*” published by the Department of the Environment, Heritage and Local Government in 2006 and in the Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) publication “*The Assessment and Rating of Noise from Wind Farms*” (1996).

While noise levels at low wind speeds will increase due to the development the predicted levels will remain low, albeit a new source of noise will be introduced into the soundscape.

### 12.6.3.3 Site Roads

Considering that there is no significant traffic expected on site roads during the operational phase and the significant distances from any site road to the nearest NSL; there are no noise and vibration impacts anticipated from site roads during the operational phase.

### 12.6.3.4 Substation

As previously stated, there are two substation options, only one of which will ultimately be constructed. The proposed substation locations are indicated in Table 12-33 below.

Table 12-33 Proposed Substation Locations

Substation Option Ref.	Irish Grid Co-ordinates	
	Eastings	Northing
Carrownagry	508977	669931
Cahermurphy	509501	668874

As part of the development the substation will be typically operational 24/7. The noise emission level associated with a typical substation that would support a development of this nature is the order of 93 dB(A) L<sub>w</sub> as detailed in Figure 12-15.

<h1>S</h1>											
<b>MADE BY SIEMENS, S.A.</b>											
Transformer type	TLPN7747	Nr.	LEL 111748	Year of manuf.	2013	Specification	IEC 60076				
Rated power	40 000 / 50 000 kVA	---		U <sub>m</sub>	52 / 24 kV	AC	95 / 50 kV	LI	250 / 125 kV		
Vector-group symbol	Dyn11	Continuous		Rated frequency	50 Hz	Cooling method ONAN/ONAF					
Position	Voltage			Current			Impedance voltage				
1	43 890 V	---		526 / 658 A	---			%			
10	37 500 V	20 960 V		616 / 770 A	1102 / 1377 A			%			
21	29 690 V	---		778 / 972 A	---			%			
Max. altitude above sea level	1000 m			Upper limit of overcurrent (HV)	6.7 kA	Duration of short-circuit 2 s					
Temp. Rise (oil/winding)	60 / 65 K			Total mass	64 t	Mass of insul. oil 13 t					
Number of phases	3			Untaking mass	38 t	Transportation mass 56 t					
Sound power level	93 dB (A)			Temp. rise oil / winding	60 / 65 K	Ambient temp. max. 40 °C					
Tank and conservator full vacuum resistant	---			---			Type of oil Nynas Nytro Taurus				
Type of on-load tap changer	VV III 600D-76-12233G			Rated current	600 A	U <sub>m</sub>	76 kV	Revol. of driving shaft per step 33			

Figure 12-15 Statement of L<sub>w</sub> for Typical Sub Station Used for Assessment

An iteration of the noise model has been developed to consider the expected noise level from the plant at the nearest noise sensitive locations to the proposed substation. The predicted noise levels at the closest 10 no. receivers are presented in Table 12-34 and Table 12-35.

Table 12-34 Predicted Substation Noise Levels (Carrownagry Option)

House ID	Height (m)	Predicted LAeq,T dB
H001	4	19
H003	4	19
H002	4	19
H004	4	18
H090	4	18
H005	4	17
H089	4	17
H006	4	17
H007	4	16
H028	4	11

Table 12-35 Predicted Substation Noise Levels (Cahermurphy Option)

House ID	Height (m)	Predicted LAeq,T dB
H029	4	25

House ID	Height (m)	Predicted LAeq,T dB
H030	4	23
H031	4	22
H032	4	22
H033	4	20
H034	4	19
H035	4	17
H092	4	12
H012	4	11
H015	4	11

The worst case predicted level is expected to be the order of 22-25dB(A) at H029, H030, H031 and H32. These noise levels will be in line with or less than prevailing background noise levels. At other locations the predicted level is 20dB or less. Noise from the operation of a substation will not have any significant cumulative impact on the overall noise levels associated with the operation of the proposed development at any noise sensitive location.

The operation of the substation will not produce any significant vibration, therefore at the distances between either option and the nearest house (>200m), no vibration effects from the substation are expected.

### 12.6.3.5 Operational Phase Mitigation Measures

An assessment of the operation noise levels has been undertaken in accordance with best practice guidelines and procedures as outlined in Section 12.4.2 of this Chapter. The findings of the assessment confirmed that the predicted operational noise levels will be within the relevant best practice noise criteria curves for wind farms at all locations. Therefore, beyond a curtailment scheme such as that outlined in section 12.6.3.2, no additional mitigation measures are required.

If alternative turbine technologies are considered for the site an updated noise assessment will be prepared to confirm that the noise emissions associated with them will comply with the noise criteria curves as per best practice guidance outlined in Section 12.4.2 and/or the relevant operational criteria associated with the grant of planning for the Development. If necessary suitable curtailment strategies will be designed and implemented for alternative technologies to ensure compliance with the relevant noise criteria curves, should detailed assessment conclude that this is necessary.

In the unlikely event that an issue with low frequency noise is associated with the proposed development, it is recommended that an appropriate detailed investigation be undertaken. Due consideration should 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, the operator shall employ an independent acoustic consultant to

assess the level of AM in accordance with the methods outlined in the Institute of Acoustics (IoA) Noise working Group (Wind Turbine Noise) Amplitude Modulation Working Group (AMWG) namely, *A Method for Rating Amplitude Modulation in Wind Turbine Noise* (August 2016) or subsequent revisions (August 2016).

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.

#### 12.6.3.5.1 **Monitoring**

Commissioning noise surveys are recommended to ensure compliance with any noise conditions applied to the development. In the unlikely instance that an exceedance of these noise criteria is identified, the assessment guidance outlined in the IoA GPG and *Supplementary Guidance Note 5: Post Completion Measurements (July 2014)* should be followed and relevant corrective actions will be taken. For example, implementation of noise operational modes resulting in curtailment of turbine operation can be implemented for specific turbines in specific wind conditions to ensure predicted noise levels are within the relevant noise criterion curves/planning conditions. Such curtailment can be applied using the wind farm SCADA system without undue effect on the wind farm operations.

For post-commissioning of the proposed turbine units, it is recommended that the noise monitoring detailed in the relevant section of this report be repeated with consideration of the guidance outlined in the IoA GPG and Supplementary Guidance Note 5.

### 12.6.4 **Decommissioning Phase**

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

Considering that in all aspects of the construction and decommissioning the predicted noise levels are expected to be below the appropriate Category A value (i.e. 65dB  $L_{Aeq,T}$ ) at current noise sensitive locations for the decommissioning phase. The resulting noise and vibration impacts are not significant.

#### 12.6.4.1 **Decommissioning Phase Mitigation**

The mitigation measures that will be considered in relation to any decommissioning of the site are the same as those proposed for the construction phase of the development, i.e. as per Section 12.6.2.

### 12.7 **Description of Residual Effects**

#### 12.7.1 **Do-Nothing Scenario**

If development were not to proceed then the existing noise environment will remain largely unchanged considering the existing and permitted wind turbine developments in the area. In areas where traffic noise is a significant source in the noise environment, increases in traffic volumes on the local road network would be expected to result in slight increases in overall ambient and background noise in the area over time.

#### 12.7.2 **Construction and Decommissioning Phases**

During the construction and decommissioning phases of the project there will be some effect on nearby noise sensitive properties due to noise emissions from site traffic and other construction activities.

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

With respect to the EPA’s criteria for description of effects, in terms of these construction activities, the potential worst-case associated effects at the nearest noise sensitive locations associated with the various elements of the construction phase are described below.

### 12.7.2.1 General Construction – Turbines, Hardstanding, Met Mast and Construction Compound

The predicted construction noise and vibration effects associated with on-site construction activities including are temporary and not significant and is summarised as follows:

Quality	Significance	Duration
Negative	Slight	Short-term

### 12.7.2.2 Construction of Internal Roads (including Tree Felling and laying of underground cables)

The predicted worst-case noise and vibration effects associated with proposed internal construction operations at NSL’s are summarised as follows:

Quality	Significance	Duration
Negative	Moderate	Temporary

The above effects should be considered in terms that the effect is variable and that this assessment considers one location with the greatest potential impact.

At all other noise sensitive locations, the following effect is associated with the internal construction of roads:

Quality	Significance	Duration
Negative	Slight	Temporary

### 12.7.2.3 Borrow Pit Activity

The predicted worst-case noise and vibration effects associated with proposed borrow pit construction at NSL’s are summarised as follows:

Quality	Significance	Duration
Negative	Slight	Temporary

#### 12.7.2.4 Substation Construction

The predicted worst-case noise and vibration effects associated with proposed substation construction at NSL's are summarised as follows:

Quality	Significance	Duration
Negative	Slight	Temporary

#### 12.7.2.5 Grid Connection Construction

The predicted worst-case noise and vibration effects associated with proposed grid connection construction at NSL's are summarised as follows:

Quality	Significance	Duration
Negative	Moderate	Temporary

The above effects should be considered in terms that the effect is variable and that this assessment considers six locations with the greatest potential impact.

At all other noise sensitive locations, the following effect is associated with the internal construction of roads:

Quality	Significance	Duration
Negative	Slight	Temporary

#### 12.7.2.6 Construction Traffic

The effects associated with the overall noise levels from construction traffic is summarised as follows, for the worst-case phase of the construction:

Quality	Significance	Duration
Negative	Moderate	Temporary

### 12.7.3 Operational Phase

#### 12.7.3.1 Noise

##### 12.7.3.1.1 Wind Turbine Noise

The predicted noise levels associated with the proposed development will be within best practice noise criteria curves recommended in Irish guidance 'Wind Energy Development Guidelines for Planning Authorities' it is not considered that a significant effect is associated with the development.

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

The predicted residual operational turbine noise effects are summarised as follows at the closest noise sensitive locations to the site:

Quality	Significance	Duration
Negative	Moderate	Long-term

The above effect should be considered in terms that the effect is variable and that this assessment considers periods of the greatest potential effect.

For most of the locations assessed here the effect of the operational turbines are as follows:

Quality	Significance	Duration
Negative	Slight	Long-term

#### 12.7.3.1.2 Substation Noise

The associated effect from the day to day operation of the substation is summarised as follows:

Quality	Significance	Duration
Negative	Not significant	Long-term

#### 12.7.3.2 Vibration

There are no expected sources of vibration associated with the operational phase of the proposed development, from either the wind turbines nor the substation. In relation to of vibration the associated effect is summarised as follows:

Quality	Significance	Duration
Negative	Imperceptible	Long-term

#### 12.7.4 Cumulative Effects

This assessment of wind turbine noise presented in this chapter has included the potential cumulative impacts of the proposed development in combination with other wind energy developments in the area as required by best practice guidance discussed in Section 12.4.2.1.

Other potential sources of noise in the cumulative context are the ongoing surrounding commercial forest management activities on Coillte-owned lands including felling and replanting of trees. Noise from commercial forest management will be managed in line with the operational conditions of the felling licence and therefore no long-term cumulative noise impacts are anticipated between the

proposed development in combination with commercial forestry activities. It is noted that all general forestry activity will be curtailed on the site during the construction of the proposed development.

The replanting lands are located in counties Roscommon, Clare, Galway and Cavan and therefore are not likely to contribute to potential cumulative impacts with the proposed wind farm development in terms of noise impacts. The potential direct, indirect and cumulative impacts of replanting lands on noise has been assessed in the Section 10 of Appendix 4-3 Assessment of Forestry Replacement Lands.